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ANALYSIS OF STATICALLY INDETERMINATE FLAT ARCHES

STUDIES OF THE TWO-HINGED ARCH AND ARCH WITHOUT HINGES—A UNIFORMLY DISTRIBUTED LIVE LOAD ASSUMED OVER PARABOLIC STRUCTURE.

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IT is assumed in this paper that the arches possess a vertical axis of symmetry, have a rise less than 1/7 to ⅛ of the span, and that the supports are at the same height. Further, the computation is based on the assumption that the live load can be considered as uniformly distributed as for passenger bridges, floors, roofs and similar structures; that the arch takes the form of a parabola, and that the moments of inertia do not vary significantly.

The results arrived at are also applicable to circular arches with sufficient accuracy, while for arches with considerable differences in the cross-section at various points the general formulæ for statically indeterminate structures must be applied. The formulae given here will, however, for this case, as a rule, serve as a useful guide for the determination of trial dimensions.

The types which will be considered are: (1) the arch with two hinges at the springing lines, and (2) the arch

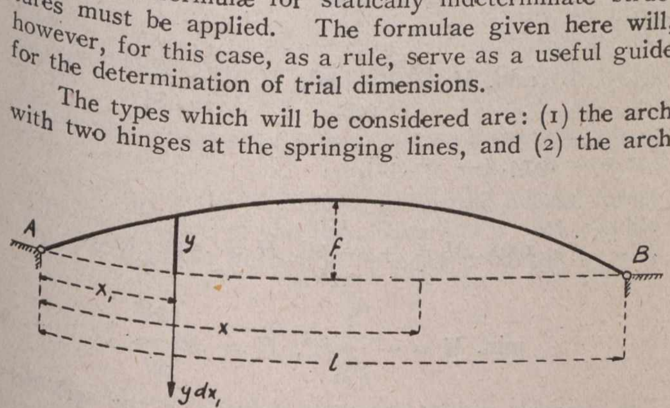

Fig. 1.

without hinges. The method followed in their analysis is the one developed by Professors Müller-Breslau and Ostenfeld.

The Two-Hinged Arch.—This arch has one statically indeterminate quantity and as such is chosen the horizontal pressure. The vertical components of the reactions are directly determinable by the statical equations and therefore not influenced by the dimensions of the cross-section of the arch nor by a slight yielding of the supports.

The equation of the line of influence of the horizontal pressure is $X = \frac{\delta_{ma}}{\delta_{aa}}$; δ_{ma} being the deflections of the various points, m, of the centre line of the arch, caused by a horizontal pressure of unity acting as sole load on the statically determinate auxiliary system. This system is, on account of the choice of the statically indeterminate quantity already referred to, a curved beam with one fixed and one roller end. δ_{aa} is the movement of the roller end produced by the same load.

From the general theory for statically indeterminate structures it is known that the deflections δ_{ma} can be determined as bending moments occasioned by the so-called "v" forces, acting on a simply supported beam with the same span as the arch; taking into account the assumptions mentioned in the introduction the "v" forces will be

$$v = ydx,$$

where y is the ordinate to the centre line of the arch, measured from the line between the hinges. The values of y corresponding to the various abscissæ x are given by the equation of the parabola which forms the centre line of the arch,

$$y = \frac{4f}{l^2} x (l - x),$$

f being the rise of the arch, l the span, and x the abscissa measured from a hinge. When these "v" forces act on a simply supported beam, they will produce reactions which are equal to half the area between the arch and the line connecting the hinges, or $\frac{1}{3}fl$; whence the bending moment ($= \delta_{ma}$) at the point with the abscissa x

$$\delta_{ma} = \tfrac{1}{3}flx - \int_0^x ydx_1 (x - x_1) \quad \text{(see Fig. 1.)};$$

and by application of the equation of the parabola

$$\delta_{ma} = \tfrac{1}{3}flx \left[1 - 2\left(\frac{x}{l}\right)^2 + \left(\frac{x}{l}\right)^3\right]$$

or

$$\delta_{ma} = \tfrac{1}{3}fx(l - x)\left[1 + \frac{x}{l} - \left(\frac{x}{l}\right)^2\right].$$

The denominator δ_{aa} of the expression for the statically indeterminate quantity is

$$\delta_{aa} = \int_0^l y^2 dx + li^2$$

where i is the constant radius of inertia.

By substituting for y

$$\delta_{aa} = 16 \frac{f^2}{l^4} \int_0^l (lx - x^2)^2 \, dx + li^2$$

or, $$\delta_{aa} = \frac{8}{15} f^2 l + li^2 = \frac{8}{15} f^2 l \left[1 + \frac{15}{8}\left(\frac{i}{f}\right)^2\right].$$

Introducing

$$\alpha = \frac{1}{1 + \frac{15}{8}\frac{i^2}{f^2}},$$

the equation for the line of influence of the horizontal pressure will be

$$X = \frac{5}{8} \alpha \frac{x(l-x)}{fl} \left[1 + \frac{x}{l} - \left(\frac{x}{l}\right)^2\right].$$

The last factor does not vary considerably; for $x = 0$ and $x = 1$ the value is 1 and its maximum value, reached for $x = \frac{1}{2}l$, is 1.25. No great error will therefore arise by taking this factor as a constant, which again leads to the line of influence becoming a parabola. The mean

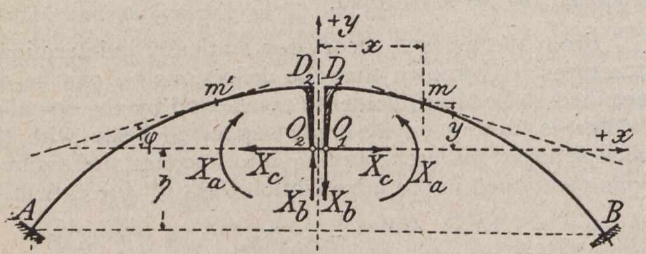

Fig. 2.

value of that factor used, is that which gives the same horizontal pressure for a uniformly distributed total load. It is calculated by either the exact equation of the approximation, whereby the equation for X attains the simple and suitable form

$$X = \frac{3}{4} \alpha \frac{x(l-x)}{lf}.$$

The line of influence of the bending moment M_m at the various points m is consequently easily derived from the general equation

$$M_m = M_{o_1m} - M_{a_1m} X,$$

where M_{o_1m} is the corresponding moment in the auxiliary system and M_{a_1m} is the moment produced by $X = -1$, which again is equal to the ordinate y of the point m, so that $M_m = M_{o_1m} - yX$.

The equation for the line of influence of the normal pressure N_m in the arch is $N_m = -X$, on account of the assumed small rise of the arch.

By means of these lines of influence the moments and horizontal pressures for different points of the arch and varying loading conditions have been determined as follows:

For a uniformly distributed load g per unit length acting over the entire span the horizontal pressure will be

$$H = \frac{gl^2}{8f} \alpha;$$

and the bending moment at a point of the centre line of the arch at a distance x from one of the hinges and having the ordinate y,

$$M = \frac{gl^2}{8f} y (1 - \alpha).$$

For $\alpha = 1$, which corresponds to the case where the shortening of the arch, due to the load on it, is so small that it can be neglected, $M = 0$ and consequently the maximum and minimum moments produced by a uniformly distributed live load have the same numerical values.

For a live load p per unit length the maximum moment at the crown of the arch is

$$\text{max. } M = \frac{1}{4} pl^2 \left[\frac{1-\alpha}{2} + \alpha \left(1 - \frac{2}{3\alpha}\right)^3\right];$$

and the corresponding horizontal pressure,

$$H = \frac{pl^2}{8f} \alpha \left[1 - 2\left(1 - \frac{2}{3\alpha}\right)^2 \left(1 + \frac{4}{3\alpha}\right)\right];$$

and,

$$\text{min. } M = -\frac{1}{4} pl^2 \alpha \left(1 - \frac{2}{3\alpha}\right)^3;$$

with

$$H = \frac{pl^2}{8f} . 2\alpha \left(1 - \frac{2}{3\alpha}\right)^2 \left(1 + \frac{4}{3\alpha}\right).$$

For $\alpha = 1$,

$$\text{max. } M = + \frac{1}{108} pl^2, \quad H = \frac{13}{27} \frac{pl^2}{8f};$$

and

$$\text{min. } M = - \frac{1}{108} pl^2, \quad H = \frac{14}{27} \frac{pl^2}{8f}.$$

For $\alpha = .974$, $\left(\frac{i}{f} = .12\right)$,

$$\text{max. } M = + \frac{1}{92} pl^2, \quad H = .54 \frac{pl^2}{8f};$$

$$\text{min. } M = - \frac{1}{130} pl^2, \quad H = .46 \frac{pl^2}{8f}.$$

The greatest possible bending moment in the arch acts at a point, the abscissa of which lies between $x = .23\,l$ and $.25\,l$, according to the value of α.

For $\alpha = 1$, the abscissa is $x = .23\,l$, and,

$$\text{max. } M = + \frac{1}{62} pl^2, \quad H = .40 \frac{pl^2}{8f};$$

and,

$$\text{min. } M = - \frac{1}{62} pl^2, \quad H = .60 \frac{pl^2}{8f}.$$

For $\alpha = .974$, $x = .24\,l$ and

$$\text{max. } M = + \frac{1}{58} pl^2, \quad H = .43 \frac{pl^2}{8f};$$

and,

$$\text{min. } M = - \frac{1}{67} pl^2, \quad H = .57 \frac{pl^2}{8f}.$$

When one-half of the arch is loaded, between hinge and crown, the horizontal pressure is

$$H = \frac{pl^2}{16f}\alpha;$$

and the bending moment at the crown,

$$M = \frac{1}{16}pl^2(1-\alpha).$$

The maximum and minimum moments act at the points

$$x = \frac{1}{4}l\frac{3-2\alpha}{2-\alpha} \text{ and } x = \frac{1}{4}l\frac{2\alpha-1}{\alpha},$$

and have the values

$$\text{max. } M = -\frac{1}{64}pl^2\frac{(3-2\alpha)^2}{2-\alpha},$$

$$\text{min. } M = -\frac{1}{64}pl^2\frac{(2\alpha-1)^2}{\alpha}.$$

Thus, for $\alpha = 1$ the numerical value is $\frac{1}{64}pl^2$.

For the maximum deflection and rise at the crown Müller-Breslau has given the following approximations, the arch being loaded with live load (p per unit length) only:

$$\text{maximum deflection } \frac{pl^4}{EJ}[.00034 + .15(\frac{i}{l})^2],$$

$$\text{maximum rise } \frac{pl^4}{EJ}[-.00034 + .10(\frac{i}{l})^2],$$

E being the modulus of elasticity and I the moment of inertia.

The effect of the bending moments and normal forces due to an increase of the temperature of $t°$ can readily be computed as the horizontal pressure produced by it is

$$X_t = \frac{\delta_{at}}{\delta_{aa}},$$

δ_{at} being the movement of the roller end of the auxiliary system for $t°$ increase of temperature, δ_{at} taken positive in the same direction as δ_{aa}.

As $\delta_{at} = EJ\epsilon t l$

$$X_t = EJ\frac{\epsilon t l}{\delta_{aa}} = \frac{15}{8}EJ\alpha\frac{\epsilon t}{f^2}$$

where ϵ is the elongation per unit length for one degree increase.

A yielding of the supports can be treated in a similar way; as already mentioned, it is only a movement in horizontal direction which has influence on the strains and stresses in the arch. A shortening of kl of the distance l between the hinges effects a horizontal pressure

$$X_s = EJ\frac{kl}{\delta_{aa}},$$

or by introducing the value of δ_{aa}

$$X_s = \frac{15}{8}EJ\alpha\frac{k}{f^2}.$$

The Arch Without Hinges.—This type of arch has three statically indeterminate quantities and as those are chosen the normal force X_a, the transverse force X_b, and the bending moment X_c at the crown of the arch, acting from a point O (see Fig. 2) in the axis of symmetry, so situated that each of the three equations, from which the values of the statically indeterminate quantities are calculable, will contain only one of them. Their form will then become similar to that for the horizontal pressure of the arch with two hinges.

$$X_a = \frac{\delta_{ma}}{\delta_{aa}}$$

$$X_b = \frac{\delta_{mb}}{\delta_{cc}}$$

$$X_c = \frac{\delta_{mc}}{\delta_{cc}},$$

the statically determinate auxiliary system being two curved beams with one fixed and one unsupported end.

The "v" forces for the type of arch considered here are:

$$v^a = dx$$

$$v^b = xdx$$

$$v^c = ydx,$$

which again are equivalent to the continuous loads

$$z^a = 1$$

$$z^b = x$$

$$z^c = y.$$

The distance η from the point O to the line AB (Fig. 2) is determined by the equation

$$\eta\int_0^1 Z^a\,dx = \int_0^1 Z^a\,y'\,dx$$

$$\therefore\ \eta = \frac{2}{3}f°,$$

y' being the ordinate of the centre line of the arch measured from AB. The equation for this centre line in the system of co-ordinates, as shown in Fig. 2 with O as origin is then

$$y = \frac{4f}{l^2}(\frac{1}{4}l^2 - x^2) - \eta = f[\frac{1}{3} - 4(\frac{x}{l})^2].$$

The deflections δ_{ma}, δ_{mb} and δ_{mc} are calculated as moments produced by the loads z, acting on a beam of length l, fixed at the centre and having unsupported ends (Fig. 3). For the left and right half of the arch respectively

$$\delta_{ma} = -\int_{-\frac{1}{2}l}^{x}(x-x_1)\,Z^a dx_1 \text{ and } = -\int_{x}^{-\frac{1}{2}l}(x_1-x)\,Z^a\,dx_1.$$

In these expressions x is the abscissa of the point for which δ_{ma} is calculated and x_1 the varying abscissa of the load element (see Fig. 3). The formulæ for δ_{mb} and δ_{mc} are analogous to that of δ_{ma}. The denominators of the equations for X_a, X_b and X_c are

$$\delta_{aa} = \int_{-\frac{1}{2}l}^{+\frac{1}{2}l} Z^a \, dx = l$$

$$\delta_{bb} = \int_{-\frac{1}{2}l}^{+\frac{1}{2}l} x^2 \, dx = \frac{1}{12} l^3$$

$$\delta_{cc} = \int_{-\frac{1}{2}l}^{+\frac{1}{2}l} y^2 \, dx + li^2 = \frac{4}{45} f^2 l + li^2.$$

The equations for the statically indeterminate quantities and now known:

for $x < 0$, $$X_a = -\frac{1}{8}(1 + 2\frac{x}{l})^2,$$

$$X_b = \frac{1}{2}(1 - \frac{x}{l})(1 + 2\frac{x}{l})^2.$$

For $x > 0$, $$X_a = -\frac{1}{8} l (1 - 2\frac{x}{l})^2,$$

$$X_b = -\frac{1}{2}(1 + \frac{x}{l})(1 - 2\frac{x}{l})^2.$$

For both $x < 0$ and $x > 0$,

$$X_c = \frac{15}{64}\frac{l}{f}\alpha(1 - 2\frac{x}{l})^2(1 + 2\frac{x}{l})^2,$$

$$\text{where } \alpha = \frac{1}{1 + \frac{45}{4}\frac{i^2}{f^2}}.$$

The bending moments and normal forces in the arch can then be computed. The normal force N is made equal to X_c

$$N = X_c = \frac{15}{4}\frac{l}{f}\alpha\left[(\frac{x}{l})^2 - \frac{1}{4}\right] = \frac{l}{f} N_1.$$

The value of N_1 depends solely on the value of the ratio $\frac{x}{l}$ and on the value of α. Below, N_1 is given for $\alpha = 1$ and $\alpha = .9$, and $\frac{x}{l}$ varying with differences of .1.

$\frac{x}{l} =$	0	.1	.2	.3	.4	.5
$\alpha = 1$; $N_1 =$	.2344	.2160	.1654	.0960	.0304	.0000
$\alpha = .9$; $N_1 =$	.2110	.1944	.1489	.0864	.0274	.0000

The line of influence of the bending moment M at a point of the arch with the co-ordinates x and y has the equation

$$M = l\left(\frac{M_o}{l} - \frac{X_a}{l} - \frac{x_1}{l} X_b - \frac{y_1}{f} H_1\right) = l M_1 ;$$

M_o being the corresponding ordinate of the line of influence of the bending moment in the statically determinate auxiliary system. M_1 depends only on the ratios $\frac{x_1}{l}$ and $\frac{x}{l}$, where x is the abscissa of the line of influence. In the table on page 657 is given the values of M_1 for varying $\frac{x}{l}$ and $\frac{x_1}{l}$ and for $\alpha = 1$ and .9 respectively.

By the aid of these lines of influence the maximum and minimum bending moments are finally determined

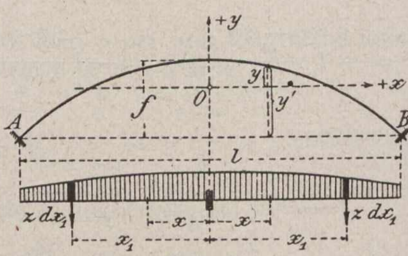

Fig. 3.

and also the simultaneously acting normal forces effected by a uniformly distributed live load p per unit length:

Maximum and Minimum Bending Moments.

	Max. M.	N.	Min. M.	N.
		$\alpha = 1$		
$\frac{x_1}{l} = -.5$	$+.0173\ pl^2$	$.0853\ \frac{pl^2}{f}$	$-.0173\ pl^2$	$.0397\ \frac{pl^2}{f}$
$-.4$	$+.0042$ "	.0591 "	$-.0042$ "	.0659 "
$-.3$	$+.0073$ "	.0317 "	$-.0073$ "	.0933 "
$-.2$	$+.0093$ "	.0497 "	$-.0093$ "	.0753 "
$-.1$	$+.0071$ "	.0661 "	$-.0071$ "	.0589 "
0	$+.0054$ "	.0631 "	$-.0054$ "	.0619
		$\alpha = .9$		
$\frac{x_1}{l} = -.5$	$+.0118\ pl^2$	$.0671\ \frac{pl^2}{f}$	$-.0203\ pl^2$	$.0454\ \frac{pl^2}{f}$
$-.4$	$+.0026$ "	.0355 "	$-.0065$ "	.0770 "
$-.3$	$+.0072$ "	.0283 "	$-.0076$ "	.0842 "
$-.2$	$+.0103$ "	.0476 "	$-.0080$ "	.0649 "
$-.1$	$+.0089$ "	.0661 "	$-.0053$ "	.0464 "
0	$+.0075$ "	.0686 "	$-.0034$ "	.0439

A uniformly distributed total load g per unit length gives

$$X_a = -\frac{gl^2}{24}, \quad X_b = 0, \quad X_c = \frac{gl^2}{8f}\alpha,$$

and the bending moment at the various points of the arch is

$$Mx_1 = \frac{1}{24} gl^2 \left(1 - 12\frac{x_1^2}{l^2}\right)(1 - \alpha).$$

For $\alpha = 1$, there are no bending moments and consequently the maximum and minimum moments produced by a uniformly distributed live load have the same numerical values.

An increase of the temperature of $t°$ gives

$$X_{at} = 0, \quad X_{bt} = 0, \quad X_{ct} = \frac{45}{4} E J \alpha \frac{\epsilon t}{f^2}.$$

The influence of a yielding of the supports is readily computed by resolving the movements of the supports A and B into (1) a sinking (Δ_a at A and Δ_b at B), (2) a turning ϕ_a of the tangents at A (positive clockwise) and ϕ_b at B (positive anti-clockwise), (3) and a lengthening kl of the distance AB. The statically indeterminate quantities will then be

$$X_{au} = -EJ\frac{\phi_a + \phi_b}{\delta_{aa}}$$

$$X_{bu} = -EJ\frac{\Delta_b - \Delta_a + \frac{1}{2}l(\phi_b - \phi_a)}{\delta_{bb}}$$

$$X_{cu} = -EJ\frac{kl - \eta(\phi_a + \phi_b)}{\delta_{cc}}$$

and the bending moments and normal forces in the arch are then directly computable.

VALUES OF M_1.

$\alpha = 1$

$\frac{x_1}{l}$ \ $\frac{x}{l}$ =	—.5	—.4	—.3	—.2	—.1	.0	+.1	+.2	.3	.4	.5
—.5	0	—.0607	—.0640	—.0367	.0000	+.0313	+.0480	+.0473	+.0320	+.0113	0
—.4	0	+.0255	—.0090	—.0179	—.0130	—.0031	+.0054	+.0093	+.0078	+.0031	0
—.3	0	+.0142	+.0538	+.0142	—.0086	—.0187	—.0198	—.0154	—.0086	—.0026	0
—.2	0	+.0053	+.0242	+.0595	+.0130	—.0156	—.0278	—.0269	—.0174	—.0059	0
—.1	0	—.0011	+.0022	+.0181	+.0518	+.0063	—.0186	—.0251	—.0186	—.0067	0
.0	0	—.0051	—.0120	—.0101	+.0080	+.0469	+.0080	—.0101	—.0120	—.0051	0

$\alpha = .9$

$\frac{x_1}{l}$ \ $\frac{x}{l}$ =	—.5	—.4	—.3	—.2	—.1	.0	+.1	+.2	.3	.4	.5
—.5	0	—.0627	—.0704	—.0477	—.0144	+.0157	+.0336	+.0363	+.0256	+.0093	0
—.4	0	+.0246	—.0119	—.0230	—.0196	—.0103	—.0012	+.0042	+.0049	+.0022	0
—.3	0	+.0141	+.0535	+.0138	—.0092	—.0193	—.0204	—.0158	—.0089	—.0027	0
—.2	0	+.0058	+.0259	+.0624	+.0167	—.0115	—.0241	—.0240	—.0157	—.0054	0
—.1	0	—.0002	+.0050	+.0229	+.0581	+.0132	—.0123	—.0203	—.0158	—.0058	0
.0	0	—.0041	—.0080	—.0046	+.0152	+.0547	+.0152	—.0046	—.0088	—.0041	0

PRELIMINARY ESTIMATES IN RAILROAD WORK.

Speaking from six years' experience as railroad engineer, Carl A. Gould, C.E., of the Northern Pacific R.R., states, in the Cornell Civil Engineer, that there are many items connected with the construction costs for which it is utterly impossible for even the most experienced to make provision at the time the first estimate is made.

With the growing tendency among the railroads to eliminate the old style of contract, containing prices for five or more classes of material, such as earth, hardpan, loose rock, shell rock, and solid rock, and place in its stead a contract containing only two classes of material, i.e., common excavation and solid rock, with the solid rock well defined and all material not coming under the solid rock definition classed as common excavation, it has left little chance for argument as to whether material encountered is of one class or another. As there is always a great difference in the prices for handling the different classes of material, naturally the contractor doing the work would feel that the man responsible for the final classification should be always on the alert to detect any difference in material and establish classification lines to be used on the final remeasured cross-section, on which is based the contractor's profit, or loss, as the case may be. As this method is practically impossible where all classes of material are encountered, the question resolves itself into one of personal opinion entirely. Now, as we are getting to a matter of dollars and cents, it is evident that it should require a man of some experience in handling material (in excavation) to arrive at what will be considered a fair percentage proportion for the work in question.

Even the most fair-minded contractors are apt to consider the engineers unfair, and on the other hand the engineers usually have good reason to think the contractors are asking too much. However, this condition is found, to a greater extent, among the smaller contractors and the engineers of limited experience. It is a fact, that it is a condition which arises on almost every piece of construction work where classification of material is made, and it behooves the engineer to become familiar with the character of the material to be moved, digging test-holes in cuts if necessary, in order that he may make a preliminary estimate which will compare favorably with the actual quantities of each class of material moved during the construction. Although the preliminary estimates are in no way binding on the railway company, this information should be furnished the contractor in order that he may place an intelligent bid, and thereby reduce the wrangling and friction with which so many of the construction jobs are closed.

There is another item which is often overlooked, and indeed difficult to determine at the outset, i.e., slides in cuts and settlement of soft ground under embankments. Allowance should be made for slides and settlements, especially where rainfall is heavy, cuts and fills deep, and ground water present. This allowance can only be approximate at best, but will be necessary when the engineer checks his final quantities with the preliminary estimates.

Over-haul is an item which is effected by all the variations in the quantities moved, and, therefore, the items above mentioned will all have an important part to play in the final over-haul quantity.

After the grading item comes the protection of the grading, of which there are many different kinds of construction. Cuts are protected by surface drains, ditches, track drains, bulkheads and retaining-wall, while in embankments the use of drains, retaining-walls, rip-rap and toe-walls are common. It requires much experience to foresee the necessity of protection against the possible conditions which may arise after the work has advanced.

Rock is usually used for the protection of the embankments, the rock varying in size from one cubic foot to five cubic yards. The most common use of rip-rap is placing it around masonry piers to prevent scouring; the river bed is here often washed out, thus letting the rock fall and requiring more rock than is contained within the slope limits.

There is also a considerable amount of rock which is lost in the handling. This, of course, would be governed more or less by the method of final measurement used, on which is based the contractor's estimate. Then, rock used for protection is an item on which a liberal allowance should be made for over-run. The writer has been on several pieces of rip-rap work and has never known the final quantity to be equal to, or less than, the original estimate. I would say that 20 per cent. is none too much to allow for over-run, from the theoretical sections, unless the contract states specifically the amount of rock to be used per unit, of length of line, which would amount to a "lump sum" bid for the work.

In tunnel costs we have something which contains a great many different items which can be figured from a knowledge of the excavation to be done, character of formation, etc., but there are many costs which cannot be foreseen, such as quicksand pockets, excess water, underground streams, and peculiar local formations, all items which it might be possible to overlook, even with the best of preliminary tests. This applies more to long tunnels than to short ones. Then in tunnels we have items which should be allowed for generously, and can only be properly estimated by the man who has had the conditions to deal with; it is impossible to use theoretical quantities without some allowance for the unexpected items of cost.

Super-structure of bridges is an item which can be accurately calculated as to weight, transportation, etc., while the foundations are always subjects requiring special study for the location in question. Anyone familiar with the different publications on bridge foundation work will note the great variation of unit costs of different bridges.

Although the condition should not exist, contractors usually look to the railroads to make good any loss on a piece of foundation work, in which unforeseen obstacles are met. As these obstacles are not figured in the original contractor's bid for the work, it may be fair for the railways to share some of the expense. Therefore, thorough testing of foundation sites should be made by the engineers, and contractors as well, in order to make an intelligent estimate of the cost of the work. Accurate preliminary estimates are accomplished only by the men of experience.

Drainage openings, such as arch culverts, pipes, box drains, and all sorts of pipe and tile drains are a constant source of trouble, both in construction and maintenance of railroad work.

Preliminary estimates should be made with a thorough investigation of the natural conditions surrounding the site of the drainage opening with a view to determining the nature of the ground, for foundation purposes, the accessibility to the site with materials, labor, and equipment, the necessity of maintaining a camp for one opening, and all local conditions which will in any way affect the location or construction of the opening. The preliminary work should be as familiar to the contractor as to the engineer, so that it will be thoroughly understood before the contract price is submitted.

Construction of the drainage openings may seem very simple at first sight, but often runs up into thousands of dollars for the simplest kinds of construction. The extra items which come up during the construction of the work and do not fall under any of the contract items, often increase the cost, of providing drainage, materially.

Protection of structures under high fills, washouts due to insufficient drainage, ground water seepage for which drainage has to be provided, stoppage of openings due to slides causing washouts, both in cuts and fills, are all items for which special provision should be made in preliminary estimates.

In Mr. Gould's own experience he has had 15,000 cubic yards of material washed from an embankment of 100 feet in length, due to an underground stream which was not detected until after the embankment material was placed and the weight forced the water back to the centre of the fill, where it broke out and caused the damage.

As a rule, the same engineer building the road-bed places the track and ballast. When ballasting, the line follows closely to the grading, it may be possible to keep the first cost estimate of ballast within the theoretical ballast limits. Often the road-bed is given a year to settle and acquire a more stable condition. This invariably requires more ballast, as it is impossible for the engineer to use a certain figure for shrinkage of embankments and have it agree exactly with the actual shrinkage which takes place. This, then, adds to the item of ballast.

In all construction work there is the item of waste which enters into the item of cost. With the very best instructions which can be given, and the best inspection which can be made, the engineer has, constantly, the item of waste to deal with.

Aside from the general construction work, there is the fluctuation of prices of materials, labor, machinery, etc. Although the railways in the West do not, as a rule, furnish materials, machinery, labor, etc., for construction work, it is not an uncommon occurrence. Small pieces of work, such as coal docks, water stations, depots, pipe culverts, are often done with railway company material.

After all, observes Mr. Gould, the engineer's life is one of continuous schooling and study along whatever line he may choose, and his value is measured by his ability to foresee conditions which will arise upon which he may plan and construct accordingly.

The Belgian Legation at Belgrade, Servia, reports that the town of Nisch proposes to raise a loan of £840,000 for canal works, construction of a line of tramways, and paving.

It is announced that Messrs. J. T. and C. Donohue have purchased all the stock of pulpwood formerly belonging to the East Canada Pulp Company, Limited, at Murray Bay, now in liquidation. The wood is in the yard booms and also uncut on the company's limits, on the Murray River and its tributaries. The purchasers have also acquired the new pulp mill

A comparison of the pulp industries in Canada and Denmark is interesting. In the little country of Denmark there are 230 pulp or paper mills. In Canada, according to the latest available statistics of the Dominion Forestry Branch, there are only 48 pulp mills in actual operation, though Canadian mills are many times larger than those in Denmark.

WATERPROOFING OF MASONRY AND BRIDGE FLOORS.

(Concluded from last week.)

Watertight Concrete Construction.—The results of laboratory experiments, supplemented by many examples from practice, have shown that watertight concrete can be made without the use of coatings, membranes or integral compounds. It is reasonable to assume that the porosity of concrete in certain cases is due to the fact that it contains small air spaces or voids throughout its mass, which are connected to each other more or less irregularly, and through which water passes, due either to the presence of the hydrostatic head or to capillary attraction. At the time of placing the concrete, some space is occupied by water carrying in suspension fine particles of cement. It is not necessary to assume that continuous capillary passages must be left in the concrete in order that as it dries the water may get out. It is probable that the excess of water passes out of the concrete in drying in such a state as to leave behind no pores through which water could again find access to the interior of the concrete or penetrate the structure.

The question of watertight concrete is then a problem of reducing the size and number of voids. Sands contain voids ranging from about 25 to 40 per cent. of the total volume of dry, loose sand. The proportions of cement to aggregate required to make a mixture of the maximum density with sands of these extreme values are about 1:1½ to 1:2½. Experience has demonstrated that mortars leaner than this are not suitable for work requiring considerable strength or density, so that the proportions used in ordinary engineering work are sufficiently rich to produce a watertight concrete, provided the aggregates possess the requisite qualities.

Samples of crusher-run limestone show 37 per cent. voids for each of two specimens, one having a maximum size stone passing 2½-in. sieve, the second passing 1¼-in. sieve. A broken stone passing a 2½-in. ring and retained on a ⅜-in. screen had 46 per cent. voids. Feret found about 52 per cent. voids in samples consisting of stones of about one size, for each of three different sizes. A similar variation in the percentage of voids with graduation in sizes of particles is found with gravel, for screened gravel of approximately one size of particles 40 per cent. to 45 per cent., for a well-graded gravel containing sand 25 per cent.

The amount of voids in a mixture of aggregate and cement is the least when the cement is just sufficient to fill the voids in the aggregate, since the cement paste itself is less dense than the coarse material of the aggregate.

A slight deficiency in cement produces a porous concrete because the unfilled voids are large enough to permit the passage of water, while properly-made concrete containing an excess of cement, though it may be of lower density than the former, is impermeable after hardening since the voids in the cement paste are too small to permit the passage of water.

Tests have failed to discover substances which, added to the concrete materials, will increase the density of the cement paste which fills the interstices between the particles of the aggregates, hence it is not believed that improvement as regards impermeability of concrete containing sufficient cement can be made by the addition of any material to the concrete mixture.

Some engineers apprehend that grading and proportioning according to ideal requirements necessitates extreme care and considerable expense, and, therefore, reject this method of obtaining watertight construction for one of the integral compounds, which is in reality based upon the same principle, or the results of which are uncertain as regards permanent impermeability and are detrimental to the strength of the concrete.

While it is true that concrete in which the amount of cement used is slightly in excess of the voids in the aggregate and in which the aggregate is so graded as to contain a minimum amount of voids, is an ideal mixture as regards density and strength, the requirements for watertight concrete do not demand the maintenance of exact proportions of this nature.

Experience has proved that materials, as supplied for large works, run uniformly enough to permit the proportioning and grading to be maintained at such a degree of excellence as to insure watertight construction at a very small expense for testing.

The following abstract from the results of laboratory tests made by the United States Bureau of Standards, Technologic Paper No. 3, are here quoted:—

These tests show that the permeability of concrete was not dependent entirely upon the quantity of cement used in proportion to the total aggregate, but depended also upon the ratio of coarse aggregate to fine aggregate. It will be observed in the case of sand No. 4, that the 1:1½:7½ proportion was decidedly more impermeable than the 1:2:4 proportion, although the former contains considerably less cement in proportion to aggregate.

Tests designed to show the effect of waterproofing materials, especially such as are added as fillers, should present a granulometric analysis of the aggregate, as comparisons are valueless without such information. It is to be expected that tests on mortar in which a sand was used having a deficiency of fine particles would show increased impermeability and increased strength upon the addition of a small amount of fine material. On the other hand, if the aggregate already contains as much fine material as it requires, addition of a fine material as waterproofing may be expected to decrease the strength and have no beneficial effect as a waterproofing material.

The method of proportioning the aggregate by mechanical analysis, which is described by Taylor & Thompson as exact and scientific, is recommended. The granulometric analysis requires a very inexpensive equipment and a complete analysis of an aggregate may be made in less than one hour's time. By its use definite data may be obtained upon which to base conclusions as to the necessity of and method of improving the concrete mixture.

In discussing the use of exterior coatings as against impermeable construction, the point is often advanced that although there is no doubt that watertight concrete can be made, the watertightness is of no avail when cracks occur in the structure.

The subject of cracking is one of design. Cracks are caused by failure to properly provide for primary stresses to which the structure is subjected, by faulty details, by settlement of foundation, by shrinkage of concrete when hardening in air, and by stresses developed in the concrete due to temperature changes.

Where concrete is to be deposited under circumstances which make it impracticable to construct watertight concrete, a special form of waterproofing should be provided.

Drainage.—The first requisite in designing any structure when water is to be kept out from the interior or from beneath, is to provide means of getting rid of the water as directly and as quickly as possible. Methods of providing drainage differ with the class of the structure.

During the construction of basements and pits, drainage can be maintained by pumping, and permanent drainage should be provided whenever a free outlet can be obtained.

Drainage of arches and culverts is provided by sloping the extrados to the back of the abutments and to the piers, placing down-spouts at piers and drain pipes behind abutments.

Drainage of retaining walls, abutments and subway walls is provided by one or more lines of drain pipes, placed at different elevations along the back of the walls.

In tunnels the extrados of the arch may be provided with sufficient slope to facilitate the flow of seepage water to the side walls. The back filling consists of porous materials, which will permit the ready passage of the water. Side-drains and connecting under-drains should be provided.

The drainage of subaqueous tunnels differs from the general problem of drainage, and is not concerned with waterproofing, in that it is a problem of handling water on the inside of the tunnel. This is usually accomplished by pumping from sumps.

The foundations of masonry reservoirs should be drained to insure the stability of the structure.

The solid floors of steel or reinforced concrete bridges may be drained by sloping the finished surface of the floor from the centre to each end, and carrying the water away back of the abutments, or the water can be carried away by downspouts at the intermediate points or supports.

Probably the commonest method of drainage solid-floor bridges is to slope the deck to one abutment or from a summit to both abutments. A continuous waterproofing layer extends over the deck and the top of the abutments and extends down over the back of the abutments to prevent the seepage of water at the bridge seat.

The surface of the waterproofing and its protection must have sufficient grade to carry away surface water. In the case of bridge floors, it is recommended that this grade be not less than 6 ins. in 100 ft. It is customary, when bridges are on sufficient grade to have the waterproofed surface at the same grade, the water being carried down over the back wall of the lower abutment, where drainage is provided by coarse backing and open-joint drains.

An objection to this method of drainage is made by some who find that in the spring, when the surface ice and snow melt and the filling back of the abutments is still in a frozen condition, the water does not escape freely, but accumulates and eventually seeps through at the end of the bridge and flows over the face of the abutment. Another objection is that in bridges having supports at curb lines and in the middle of the street, whether of flat slab construction or of steel troughs filled with concrete, cracks in the waterproof covering and in the concrete filling are likely to appear where joints are not provided over these supports, and where joints are provided, trouble is likely to be experienced in preventing the seepage of water.

When the troughs of steel bridges run transversely to the track and the filling in the troughs is omitted, the individual troughs may be drained through outlets in the bottom of the troughs into a drainage gutter suspended beneath the deck. These gutters may empty into pipes which run through the abutments and empty outside the embankment. Difficulty is found in obtaining a seal between the waterproofing and the drain pipe or opening in the trough.

When the troughs of solid floor steel bridges run parallel with the tracks, the water is usually carried over the abutments as in the concrete floor bridges.

A method sometimes used on solid-floor bridges in which the deck is filled up above the top of the steel with cement or bituminous concrete is to divide the floor of the bridge into rectangular sections, each of which is sloped to a drain pipe at one corner which carries the water through a down-spout at one of the supporting columns.

Much difficulty has been experienced with all types of waterproofing on steel bridges in preventing the leakage of water along the webs of girders. Although the concrete filling of the deck may be carried up above the top of the rail and great pains may be taken in providing a joint with a waterproofing material between the girder web and the concrete, leaks usually develop along the girder.

Several bridges have been built in which a special flashing angle or Z-bar extending the full length has been riveted to the inside of the girder to prevent the flow of water down the web of the girder. By carrying the concrete filling up underneath the outstanding leg of the flashing angle or Z-bar an efficient flashing is obtained. Good results have been obtained in the case of through girder bridges by carrying the concrete filling up under the top flange of the girder.

In considering the conclusions presented in Bulletin 64 in regard to reinforcing over supports, the following remarks of President Armstrong, of the Western Society of Engineers, are of interest:—

In large railroad structures it is impracticable to reinforce concrete so that there will be no cracks over a line of supports; good engineering would not permit such practice. It would be better to allow the concrete to crack or to leave a joint there, and then provide some means of keeping out the water. In the lighter structures, it is practicable to reinforce the concrete so that the reinforcement will prevent cracks at supports.

A joint in the waterproofing which will allow of movement of the ends of adjacent spans at supports is believed to be necessary. The use of a metal flashing between concrete slabs over joints has been used.

When the steel troughs run transversely to the track, a slight movement under traffic is to be expected at the connection of the troughs to the girders. Consequently, it would seem necessary to keep the water away from these connections by means of flashing and providing sufficient slope toward the centre of the floor, adjacent to the girders.

Figures show methods of waterproofing various structures.

Conclusions.—(1) Watertight concrete may be obtained by proper design, reinforcing the concrete against cracks due to expansion and contraction, using the proper proportions of cement and graded aggregates to secure the filling of voids and employing proper workmanship and close supervision.

(2) Membrane waterproofing, of either asphalt or pure coal-tar pitch in connection with felts and burlaps, with proper number of layers, good materials and workmanship and good working conditions, is recommended as good practice for waterproofing masonry, concrete and bridge floors.

(3) Permanent and direct drainage of bridge floors is essential to secure good results in waterproofing.

(4) Integral methods of waterproofing concrete have given some good results. Special care is required to properly proportion the concrete, mix thoroughly and deposit properly so as to have the void-filling compounds do the required duty; if this is neglected, the value of the compounds is lost and their waterproofing effect destroyed.

Careful tests should be made to ascertain the proper proportions and effectiveness of such compounds.

Integral compounds should be used with caution, ascertaining their chemical action on the concrete as well as their effect on its strength; as a general rule, integral compounds are not recommended, since the same results as to watertightness can be obtained by adding a small percentage of cement and properly grading the aggregate.

(5) Surface coatings, such as cement mortar, asphalt or bituminous mastic, if properly applied to masonry reinforced against cracks produced by settlement, expansion and contraction, may be successfully used for waterproofing arches, abutments, retaining walls, reservoirs and similar structures; for important work under high pressure of water these cannot be recommended for all conditions.

(6) Surface brush coating, such as oil paints and varnishes, are not considered reliable or lasting for waterproofing of masonry.

PROGRESS OF STREAM MEASUREMENTS IN WESTERN CANADA.

THE general scheme of stream measurement being carried out under the direction of F. H. Peters, C.E., Commissioner of Irrigation for the Department of the Interior, was outlined in *The Canadian Engineer* for November 3rd and 10th, 1910. The article referred to the report of P. M. Sauder, C.E., Chief Hydrographer. The department had been formed as a separate organization in the spring of 1909, with headquarters at Calgary. The article concerning it dealt with the organization, scope of the work, methods of measurement, etc. The investigation received further attention in our issue of May 30th, 1912, which issue contained an abstract of the progress report by Mr. Sauder, describing the various methods in use for determining discharge, mean velocity, etc.

The progress report for 1912 has just been issued and from it the following data, greatly condensed, has been extracted:—

Scope of Work.—The chief features of the stream measurement work are the collection of data relating to the flow of surface waters and a study of the conditions affecting this flow. Information is also collected concerning river profiles, the duration and magnitude of floods, irrigation, water-power, storage, seepage, etc., which may be of use in hydrographic studies.

This information is obtained by a series of observations at regular gauging stations which are established at suitable points. The selection of sites for these gauging stations and their maintenance depend largely upon the physical features and needs of the locality. If water is to be used for irrigation purposes the summer flow receives special attention; where it is required for power purposes, it becomes necessary to determine the minimum flow; if water is to be stored, information is obtained regarding the maximum flow. In all cases the duration of the different stages of the streams is recorded. Throughout the country gauging stations are maintained for general statistical purposes, to show the conditions existing through long periods. They are also used as primary stations, and their records in connection with short series of measurements will serve as bases for estimating the flow at other points in the drainage basin.

In the spring of 1912, field operations were commenced with 132 regular gauging stations on various streams in Alberta and Saskatchewan and 30 on irrigation ditches, and at present the regimen of flow is being studied at 139 regular gauging stations on streams and 40 on irrigation ditches. Winter records, which are so valuable for power investigations and municipal water supplies, have been given special attention latterly and records have been secured on almost all the important streams in these provinces during the past winter.

Organization.—The methods of carrying on the investigations were similar to those of previous years. Local residents were engaged to observe the gauge height at regular gauging stations. These observations were recorded in a book supplied by the department, and at the end of each week the observer copied the week's records on a postal card which was sent to the chief hydrographer by the first convenient mail. The district hydrographers made regular visits to the gauging stations, usually once in every three weeks. On these visits they examined the observer's records, made discharge measurements and collected such information and data as would be of use in making estimates of the daily flow at the station. The results of the gaugings were transmitted by a postal card to the chief hydrographer. In the office these reports of the gauge height observers and the hydrographers were copied from the postal cards to regular forms and filed. At the close of the open season, some of the hydrographers returned to the office and assisted in the final computations and estimates of run-off. Gauge height-area, gauge height-mean velocity, and gauge height-discharge curves were plotted and rating tables constructed. Tables of discharge measurements, daily gauge height and discharge, and monthly discharge were also compiled.

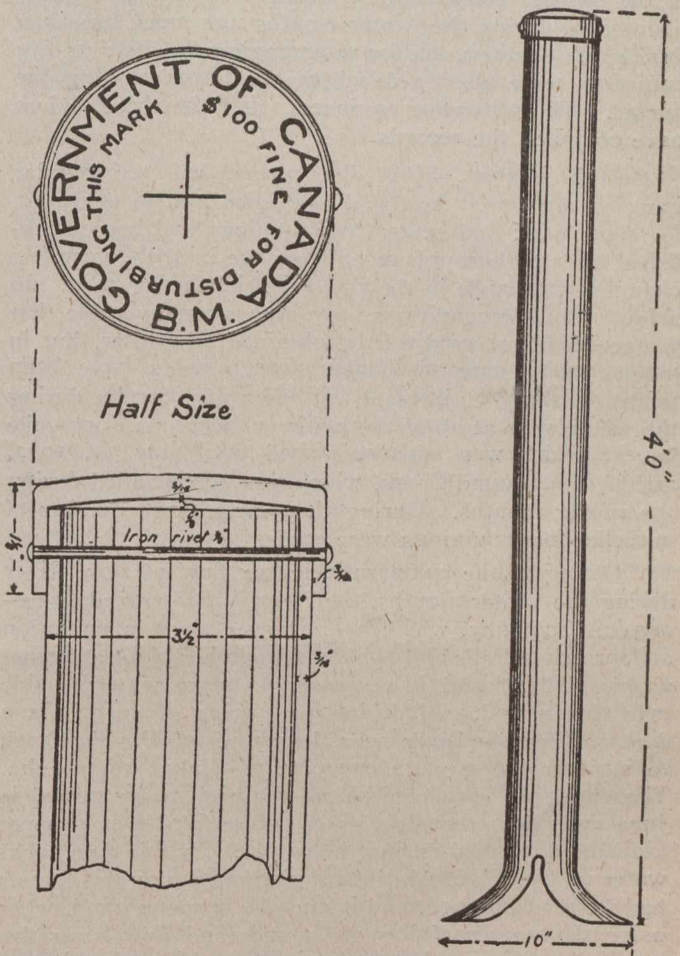

Fig. 1.—Permanent Benchmark Constructed of Iron, Adopted by the Irrigation Office.

The regular staff consisted of the chief hydrographer, ten assistant engineers, one recorder, one computor and one clerk. In order to overtake back work, three junior engineers were also employed for a portion of the year. The territory was divided for administrative purposes, into nine districts, viz., Banff, Calgary, Macleod, Cardston, Milk River, Western Cypress Hills, Eastern Cypress Hills, Moose Jaw, and Battleford. In each district there was an engineer and while in the field he had an assistant, and was equipped with the necessary gauging and surveying instruments. The tenth engineer was employed at rating meters and office work during the summer.

As winter records are of no value on a great many of the smaller streams the number of gauging stations maintained during the winter months was much less than during the summer, and by re-arranging the districts five engineers were able to do all the field work during the winter. The other five engineers and the three juniors have compiled the records.

Banff District.—This district included ten regular gauging stations. As the district has been in operation for some time, and several new stations had been established after a thorough reconnaissance in 1911, very few changes were made in the Banff district during 1912. In a few cases the conditions have been so unfavorable that gauge readings could not be obtained all winter, but in almost every case discharge measurements have been made regularly at intervals of about two weeks during the whole year at all of the stations excepting Forty-mile Creek, which was not established until July 31, 1912, and Jumpingpound Creek, which was not included during the winter months. During the year a large number of miscellaneous gaugings were made.

Owing to the comparatively low flow of Bow River during the winter months, the Calgary Power and Transmission Company, which has a power plant in operation at Horseshoe Falls and is building another plant at Kananaskis Falls, found it necessary to store water to tide over this period, and during the spring of 1912 built a dam on Cascade River near the mouth of Devil's Creek to increase the storage capacity of Lake Minewanka. The dam was completed before the high water period in June and the reservoir was therefore filled last summer (1912) and emptied during the winter. As this dam backs water up Devil's Creek the gauging station on this stream had to be abandoned, and it must be borne in mind, when using the records of flow of Cascade and Bow Rivers below Lake Minewanka reservoir, that after the first of June, 1912, the flow is affected by the operation of this reservoir and the records do not represent the true natural flow of the stream.

The town of Banff takes its domestic water supply from Forty-mile Creek, and as its requirements are gradually increasing it was thought advisable to take records of the flow of this stream. It is, however, impossible to get an observer above the intake of the waterworks and the station had to be established below the intake. The records, therefore, only represent the surplus flow which is not used by the town, and the consumption of the town has to be added to obtain the total natural flow of the stream.

Bath Creek is an important tributary of Bow River but no regular station has been established on it as it has been impossible in the past to secure an observer. This difficulty may not exist in future, and in such a case, a regular gauging station will be established.

Records will also be taken in future of the flow of Louise Creek, which is used by the Canadian Pacific Railway Company to develop power for use at the Lake Louise Chalet.

Further power development of Bow River depends very largely on the creation of storage reservoirs, to conserve flood water for use during the winter months, and during 1912 the Water Power Branch continued and completed its investigations of the upper regions of Bow River drainage basin. Whether any new stations are established in this district or any of the present ones are abandoned will depend largely on the report of the Water Power Branch and it is therefore awaited with much interest.

Calgary District.—This district included 18 regular gauging stations. It is the same as in 1911, except that a regular gauging station has been established on Highwood River above the mouth of Pekisko Creek. While this station was established primarily for statistical purposes, its records will probably be of considerable value in determining the possibilities of power development in this stream.

There were no special developments in this district during 1912, but as the canals being constructed by the Canadian Pacific Railway Company, the Southern Alberta Land Company, and the Alberta Land Company, are nearing completion, the value of the records of stream flow becomes more apparent. The first company will no doubt require more than the average low water flow of Bow River, and the other two depend entirely on the high water and flood discharge of the river for their water supply. Not only is it necessary to know the discharge of the river at these stages but also the duration of each stage.

The Southern Alberta Land Company and the Canadian Pacific Railway Company both anticipate the diversion of water throughout the whole of the open flow period, and anticipate a diversion that will approach the whole of the flow of the river so that the conditions of diversion for these large companies are becoming critical.

These problems cannot, however, be satisfactorily solved without records of stream flow covering a period of several years, and now that there are nearly five years' records of the flow of Bow River at Calgary approximate estimates can at least be made.

In designing a dam it is essential to know the maximum flood discharge of the stream in order to provide the necessary spillway to pass it without injury to the structure or adjoining property. During the past year all available data regarding the floods on Bow River was collected and estimates of the maximum flood discharge at different points were made.

Macleod District.—This district included 26 regular gauging stations. As it had been thoroughly reconnoitred during previous years it was not necessary to establish any new stations on rivers or creeks during 1912. As, however, some of the smaller streams in the Crow's Nest Pass are being used for domestic and industrial water supplies it will probably be advisable to establish regular gauging stations on some of these during the coming year.

Owing to the abundance of coal in this district, power is not very expensive and water power has not been developed. There are no great power possibilities but there are good opportunities for developing a small amount of power very cheaply. One very serious drawback to water power development is the absence of suitable sites for reservoirs to store water to augment the winter flow.

Irrigation is not generally required in this district and the developments in that line are therefore not very great.

Cardston District.—This district included 13 regular gauging stations.

In August, 1912, an arrangement was made with the United States Geological Survey by which regular gauging stations on St. Mary and Milk Rivers would in future be maintained jointly, each bearing half the cost of construction and maintenance. To get more accurate and satisfactory records it was decided to re-locate the stations at the best sites near the International Boundary and install automatic recording gauges.

There are only a few irrigation ditches in this district and the hydrographer therefore makes any inspections of these that are necessary. Unless urgent, they are usually made in the late summer or early fall when the streams are low and almost stationary, and need not be gauged as often as usual.

Milk River District.—The number of regular gauging stations in this district is comparatively small, 10 in number, but owing to shifting conditions at every one of them, it is necessary to make frequent gaugings in order to get reliable records, and as the distance between the stations is above the average the hydrographer cannot cover a larger district. The arrangement with the United States Geological Survey also includes gauging stations on Milk River and the South Branch of Milk River in this district.

Western Cypress Hills District.—This included 36 regular gauging stations.

Many of the ditch owners do not realize the value of records of the water used by them, and it has therefore been impossible to get good records on the ditches, but these will gradually improve, for, as irrigation increases, the irrigator will find the records very useful and will be only too glad to co-operate with the department in taking them.

This district includes a great many regular gauging stations on very small streams, but as every bit of available water will eventually be used for irrigation purposes, records on these are valuable.

While this is a rather large driving district, it can be covered satisfactorily except during the spring time. There is usually quite a large snow-fall in the hills during the winter and this usually runs off very quickly when spring opens up and the streams become quite high for a short time. Sometimes rains follow and keep the flow up, but not always, and the irrigators depending on high water and flood discharge of the stream should fill their reservoirs at the first opportunity. The records during early spring are therefore of considerable importance, but as the freshets are of short duration and travelling is difficult at that time, it is impossible for one hydrographer to cover the district properly. The hydrographer should be in the field on or shortly after the middle of March. This has not always been possible, owing to the fact that the fiscal year ends on the 31st of March and funds were not available. Provision should therefore be made in future estimates so that two hydrographers can be placed in this district during the spring and so that they can start field work about the middle of March.

Winter measurements would be of little value in this district and none have therefore been taken.

Eastern Cypress Hills District.—This district included 41 regular gauging stations. Beaver dams have become so numerous on some of the streams in it that it is difficult to get satisfactory records of the flow.

Moose Jaw District.—This district included 16 regular gauging stations.

The number of regular gauging stations in this district is comparatively small, but owing to the long distances between gauging stations and the importance of some of these it is impossible to increase the number.

There are now eight dams on Moose Jaw Creek in connection with domestic and industrial water supplies, and at least one other is contemplated. There is also about the same number of dams on Souris River. Though small and of an inferior quality, the water supply from these streams is very valuable. In order to intelligently administer the regulations and deal with new applications for water supply it is absolutely necessary to obtain continuous records of the flow of these streams at different points, and they are therefore being given special attention.

Winter records were taken only on Moose Jaw Creek near Moose Jaw, Qu'Appelle River at Lumsden, and South Saskatchewan River at Medicine Hat during January, February, and March, but were also obtained on Souris River at Estevan, and Swiftcurrent Creek at Swift Current in December. The station at Medicine Hat was included in the Macleod district, and the others in the Battleford district during January, February and March, but in December were a part of the new Moose Jaw district, which includes part of the old Battleford district.

Battleford District.—This district included 6 regular gauging stations. While there was no immediate use for records on the streams in this district when it was first started, the records are now of very great value to the Department of Public Works in their study of the North Saskatchewan River for navigation purposes, also to the Water Power Branch of this department and others interested in power development. There will be a good market for power in central Alberta, and many parties have been investigating the favorable water power sites and are awaiting records of the flow of the streams west and north of Edmonton.

During the winter almost continuous records were taken at all the regular gauging stations in this district. Those at Battleford, Prince Albert and Saskatoon were included in the new Moose Jaw district during December and the remainder in a new district called the Edmonton district. The Edmonton district included Red Deer River at Red Deer, North Saskatchewan River at Edmonton, and Athabasca River and its tributaries.

Bench Marks.—When the stream measurement work was first started, the gauges were usually referred to a bench mark on a wooden stake or stump of a tree. These were easily shifted or destroyed and were not satisfactory. In 1911, an iron bench mark of the type used by the United States Geological Survey was adopted, and was established as 62 regular gauging stations. During the past year, about 45 more were established and now almost all the gauges are either referred to a bench mark on a concrete pier or other permanent structure, or to one of these iron bench marks. Whenever an opportunity is afforded these are tied to the Canadian Pacific Railway or Dominion Government levels, to determine their elevation above sea level, and are therefore also a convenient reference for local levelling operations.

Fig. 1 shows the type and details of the permanent iron bench mark which is used. It is made of a piece of 3½-inch wrought iron pipe which is split at the bottom and expanded to a width of ten inches in order to anchor the tube solidly in the ground. The top is covered by a cap cast out of brass, or preferably aluminum bronze (10% Al. and 90% Cu.), which is secured to the top of the pipe by a long iron rivet. The inscription on the cap is cast in sunk-in letters giving a smooth surface to the cap. All the exposed surfaces of the iron pipe are given a good coat of a first quality rust-resisting paint, and the bench mark is set with six inches projecting above the ground.

The brass cap for the iron bench mark may be modified and made with a stem about three inches long projecting on the under side which can be cemented into a drill hole in solid rock or masonry, to form a permanent and convenient bench mark.

Office Work.—The reports of the gauge height observers and the hydrographers are transmitted to the office by postal cards. These are copied to office forms and filed in a cabinet, which is carefully indexed and where they can be referred to at any time without trouble. As the engineers complete their computations, the results are entered on convenient forms and filed in the same cabinet.

A cabinet made up of four styles of drawers is used for filing the records. The top section is used for filing the gauge height books of the observers and the current meter note books of the hydrographers. The gauge height books are filed alphabetically according to the names of the gauging stations, while the current meter note books are filed alphabetically, according to the names of the hydrographers. The next section contains the postal cards sent in by the observers and the hydrographers. Both of these are filed alphabetically, according to the names of the gauging stations. The third section is made up of map drawers and contains the gauge height-area, gauge height-mean velocity and gauge height-discharge curves, and plotted cross-sections which are filed alphabetically, according to the names of the gauging stations. The same section contains the maps showing the outlines of the drainage basins, filed numerically, according to the number of the sectional sheet. The rating curves for the current meters are also filed in this section numerically, according to the office numbers of the meters. The bottom section of the cabinet consists of letter size pockets, alphabetically arranged for each gauging station. The tables of gauge heights, discharge measurements, daily gauge height and discharge, monthly discharge, a description of the station, and memos of any changes are filed in these pockets. The different rating tables for each meter are also filed numerically in this section and another drawer contains the monthly reports of the meteorological service.

The copying and filing of the reports of the gauge height observers and the hydrographers is entrusted to the office recorder. While doing this he must carefully examine all records to see that there are no errors, and where there are doubtful or impossible records it is his duty to have the data corrected or ascertain the cause of the unusual condition. He also makes out the pay list for the observers and conducts the correspondence relating to the records.

All computations are checked before being used or published. For this reason, as far as possible, men with some technical education, or students in science, are engaged as helpers. The gaugings are computed by the helper and his work is checked by the hydrographer. In some instances where there is a great deal of driving and camping out, the hydrographer cannot secure a helper who can compute discharges, and in that case he computes the discharges himself and his computations are checked in the office.

Gaugings of the flow under ice are usually made by using the multiple point method, and vertical velocity curves have to be plotted to determine the mean velocity in the vertical. The computation by this method is long and tedious and cannot be done by the hydrographer in the field. There are, therefore, a great many computations to be made in the office and the services of a computer are required.

Future Work.—The stream measurement work will be continued during the coming year in all the old districts; and every effort will be made to extend the territory covered, but the scope of the work is, of course, limited by the appropriation and staff available.

There are a number of important streams which rise in the mountains west of the Calgary and Edmonton Branch of the Canadian Pacific Railway. With the advent of railways, industries will soon be started in this district and the water supply will be an important factor. During the coming year it is proposed to have a hydrographer make a thorough reconnaissance of this district and make a study of the water supply, particularly to get records of the flow of the North Saskatchewan River and its tributaries. No doubt there are possibilities of water power development in this district, and records of stream flow will be wanted.

During the past year some information has been secured regarding the flow of Athabasca, McLeod and Pembina rivers. It will be impossible to secure observers wherever desired, but it is hoped during the coming year to make a careful reconnaissance of Athabasca River and its tributaries and establish regular gauging stations wherever the value of the records will warrant the expense of obtaining them. As elsewhere, our investigations in this district during the past year show that the minimum flow which occurs during the winter is much below the general expectation, and as there is a large number of possible power sites on this stream winter records are of much value, and special efforts will be made to get records at the more important points during the next winter.

Fortunately, excessive floods do not occur very frequently on the streams in Alberta and Saskatchewan, but, nevertheless, it is most important that these should not be under-estimated when designing dams, headgates, bridges, and other works on the streams. Not only does their destruction cause heavy loss to the owners of the structures but the lives and property of many other people are endangered. As above intimated, special studies of the maximum floods on Bow and North Saskatchewan Rivers at certain points were made during the past year. In future this subject will be given special attention, all available data will be collected, and the estimates tabulated in convenient form for use in designing structures at different points on each large stream.

It might not be amiss to refer to the importance of studying the winter flow of some of the smaller streams in the more thickly populated districts. Domestic and industrial water supplies have been installed to take their supply from streams which, judging from their open water flow, would provide an ample supply at all times. In several instances waterworks have been installed without sufficient knowledge of the winter flow, with the result that the supply proved to be inadequate during the winter. When the supply is from open streams this can very often be overcome by creating storage reservoirs at a nominal cost, but in cases where the supply is from springs there is seldom any remedy. As many of the towns on the prairie are dependent for their water supply on streams with very small flow during the winter months, it is most important that they should know before designing their works exactly what that flow is, so that the scheme will include the necessary storage facilities. The railways are also becoming perplexed as to how to get enough water in some localities to operate their trains during the winter months and during the past winter had, in some instances, to haul water for very long distances, owing to the failure of their water supply at certain tanks. Records of the discharge of all the streams in these localities, even though very small, are very valuable during both summer and winter.

Many engineers make their estimates of stream flow from precipitation records. It should, however, be pointed out that precipitation records gathered at a few isolated points are of very little value in estimating the probable discharge of the streams in Alberta and Saskatchewan and very often are misleading. The physical features and the precipitation are so varied within the same drainage basin that no reliable estimates can be made. Streams, such as Bow River, for instance, very often have a comparatively large run-off during a comparatively hot, dry summer, due to the fact that a much larger quantity of snow and ice is melted in the mountains in a hot, dry summer than in a cold, wet summer. In a cold, wet summer the precipitation in the mountains often falls as snow and is stored instead of coming down to still further swell the already high streams. This same condition is found on the North Saskatchewan and all other large streams whose main sources are in the mountains. It is, for instance, impossible to estimate the probable discharge of the North Saskatchewan River at Prince Albert from precipitation records and the only reliable data to use are the records of stream flow.

To arrive at anything approaching a reliable estimate of the flow of a stream at different stages and the duration of those stages, a series of continuous records of discharge extending over a considerable period is absolutely necessary. George W. Rafter, in Water Supply Paper No. 80, published by the United States Geological Survey, says: "Further, it can be stated that for records from twenty years to thirty-five years in length the error may be expected to vary from 3.25 per cent. down to 2 per cent., and that, for the shorter periods of five, ten and fifteen years the probable extreme deviation from the mean would be 15 per cent., 8.25 per cent., and 4.75 per cent. respectively.

Mr. Rafter says, further, that with less complete records "Mr. Henry reached the conclusion that at least 35 to 40 years' observations are required to obtain a result that will not depart more than 5 per cent. from the true normal. The average variation of a 35-year period was found to be 5 per cent., and for a 40-year period 3 per cent."

The records of this office do not extend over a period of more than five years on any stream, and during that period interruptions have occurred, due to lack of funds and staff. Proper provision should be made so that this work will not in future be subject to these interruptions.

The water supply is one of the most important resources of a country, and an accurate knowledge of the flow of water in nearly all important streams is essential for the solution of many problems in connection with navigation, water-power, irrigation, domestic and industrial water supplies, sewage disposal, mining, bridge building, river-channel protection, flood prevention, and storage for conservation of flood waters. The records are being used quite extensively now by engineers and the field of operations should be extended to include other parts, if not the whole of Canada.

The work is in charge of P. M. Sauder, C.E., Chief Hydrographer. His first assistant since January 1st, 1913, has been G. H. Whyte, B.A.Sc., and his second assistant, G. R. Elliott, B.A.Sc.

PRESENT DAY WATER FILTRATION PRACTICE.

The two methods of water filtration; namely, by slow sand and by rapid sand filters, English and American types respectively, are traced in their development, are compared as to their relative applicability to meet varying sets of conditions and are discussed as to the features of operation upon which the efficiencies of both depend, in a paper to be presented by Mr. George A. Johnson, Consulting Engineer, New York City, at the coming meeting of the American Water-Works Association in Philadelphia. The writer dwells also to some extent upon the questions of comparative cost of filtered water as obtained by the two methods.

According to Mr. Johnson, the first municipal water filter was built at London 85 years ago. It was built to perform only the functions of a mechanical strainer for the removal of suspended matter. At that time the two most important water-borne diseases (typhoid fever and cholera) had not then been discovered, and the germ theory of diseases was not advanced until some 20 years later. The first official recognition of water filtration as a means of reducing the dangers in impure drinking water took the form of an Act of Parliament in 1852, which made compulsory the filtration of the entire water supply of the metropolitan district of London.

This filter, as well as all those which followed during the succeeding 50 years, was of the slow sand type. After considerable scientific investigation, particularly in Germany, this type found its way to America and appeared at Poughkeepsie, N.Y., about 1875, as the first municipal water filtration plant in America. Its adoption was slow, however, and, in 1890, only 35,000 people in America were being served with water so filtered.

A patent for a process in which a coagulant was added to the raw water before filtration was granted in 1884, and with the use of coagulating chemicals the mechanical or rapid sand filter developed.

Up to January, 1914, some 30 slow sand filtration plants were put in operation, or were at that date under construction in the United States. They have a daily filtration capacity of 840,000,000 gallons and are designed to serve a total population of 5,500,000. Of this population 73% is served by the filter plants installed in eight cities, while the remaining population is widely scattered through some twenty cities.

Mr. Johnson's paper takes into consideration the operation and efficiency of the plants at Lawrence, Mass.; Albany, N.Y.; Washington, D.C.; Philadelphia, Pa., and Pittsburgh, Pa., showing the difficulties under which filters of this type are obliged to work when called upon to treat muddy waters. It is noted that in every instance, with the sole exception of Lawrence, the original design has been improved upon and the preparatory treatment of the work made more complete. This preparatory treatment consisted in some instances of roughing filters, the use of coagulant, or both, while at practically all slow sand filter plants in the United States the final filtered product is sterilized with hypochlorites. Mr. Johnson states that with the exception of Lawrence, Providence and New Haven, it is becoming difficult to locate the slow sand filter plant which does not in some important respect depart from the original ideas of what constituted that system of water purification or which does not in some way make use of certain inherent ideas upon which are based the rapid sand system of water filtration.

Since the installation of the first municipal rapid sand filtration plant at Somerville, N.J., in 1885, upwards of 450 municipal filter plants of this type have been built or are now under construction in the United States. Those operating have a daily capacity totalling 1,745,000,000 gallons and approximately 12,000,000 people are being supplied with water so filtered.

Between 1890 and 1900 there was much scientific investigation into the merits of the new process. These studies were in no small measure responsible for the wonderful growth of rapid sand filtration during the past 15 years, as the theory of the process was thoroughly worked out and the idea placed upon solid footing.

The type of construction changed abruptly about 1900, rectangular concrete tanks frequently replacing the circular wooden or steel tanks formerly used. The new type necessitated the use of compressed air to agitate the sand layer while washing the filter and later the application of wash water at high velocities. These methods became general, supplanting the mechanical stirrers and wash water at low velocity used in the old type of rapid sand filters, and from which they had derived the name of mechanical filter.

Among the 450 plants mentioned above, the largest are situated at Little Falls, N.J.; New Orleans, La.; Cincinnati, Ohio; Louisville, Ky., and Columbus, Ohio, the respective daily capacities being 32, 44, 112, 36 and 30 million gallons daily. Mr. Johnson's paper describes the experiences of these five plants.

Relative Cost of Slow Sand and Rapid Sand Fltration.—Construction.—In discussing the cost of building water filtration works of the slow sand and rapid sand types, respectively, Mr. Johnson gives consideration only to those items referring to the filter plant proper. Cost of land, pumping machinery, outside connecting piping, intakes, etc., in fact everything outside the filtration plant proper, is not considered. The following is a summary of this portion of his paper:

For slow sand filter costs the items will include the necessary filter buildings and filters with all appurtenances, all inside piping, sand handling apparatus, preliminary sedimentation basins, preliminary filters and appurtenances and clear water reservoirs.

For rapid sand filter costs the items will include the filter buildings and filters with all appurtenances, all inside piping, filter washing apparatus, coagulating and clear water basins. Thus a fairly good idea may be had of the relative cost of building purification plants of the two types.

It is true that, on account of the much greater area required, the cost for land is far greater in the case of slow sand filtration systems than for rapid sand systems. Roughly, other things being equal, land will cost twenty times as much for a slow sand filter installation as for a rapid sand plant. Furthermore, in large projects, it is often difficult conveniently to locate a site for slow sand filters, while for a rapid sand filter plant it is a relatively easy matter as a rule. If it is necessary to go a long distance in locating an extensive and suitable area of land for a slow sand filter site there is incurred a large expense for a conduit to bring the filtered water to the city. This is very rarely necessary in the case of rapid sand filter projects. So that, in studying the comparative figures which follow, it must distinctly be borne in mind that the costs given for slow sand filter installations are really low, since the important considerations just mentioned are not charged against them.

Cost of construction of slow sand and rapid sand water filtration plants.

City.	Kind of sand filters.	Present daily filtering capacity.	Approximate cost per million gallons daily capacity.
Albany, N.Y.	Slow	20,000,000	$20,000 (a)
Pittsburgh, Pa.	Slow	200,000,000	26,000 (a)
Philadelphia, Pa.:			
Torresdale	Slow	250,000,000	37,700 (a)
Upper Roxborough	Slow	28,000,000	29,800
Lower Roxborough	Slow	17,000,000	26,300 (a)
Belmont	Slow	60,000,000	45,200 (a)
Washington, D.C.	Slow	100,000,000	30,000 (b)
Cincinnati, Ohio	Rapid	112,000,000	11,400 (c)
Columbus, Ohio	Rapid	30,000,000	13,000 (d)
Dallas, Texas	Rapid	15,000,000	13,000
Harrisburg, Pa.	Rapid	16,000,000	10,300
Little Falls, N.J.	Rapid	32,000,000	15,000
Lorain, Ohio	Rapid	6,000,000	14,000
New Milford, N.J.	Rapid	24,000,000	11,000
Watertown, N.Y.	Rapid	8,000,000	11,250
Weighted averages	Slow	....	$32,600
	Rapid	....	12,100

(a) Cost of preliminary filters included.
(b) Cost of Dalecarlia Reservoir not included. Cost of McMillan Park Reservoir included, and also cost of remodeling Georgetown Reservoir, as well as cost of coagulating basin.
(c) Cost of large plain sedimentation basin not included.
(d) Cost of softening works not included.

The above figures show that the approximate relative cost of building the slow sand and rapid sand filter plants mentioned was $32,600 and $12,100 respectively, per million gallons daily capacity. At 5 per cent. the fixed charges on these sums would amount to $4.47 and $1.66, respectively, per million gallons of water filtered.

Operation and Maintenance.—The cost of operation and maintenance of filtration plants in a large measure, varies, of course, with the quality of the raw water. In a general way the following examples will serve to show the charges ordinarily made against the operation and maintenance of representative water filter plants in this country.

Cost of operation and maintenance of slow sand and rapid sand filtration plants.

Year.	City.	Kind of sand filters.		Average volume of water filtered daily.	Cost of operation and maintenance per million gallons of water filtered.
1911	Albany, N.Y.	Slow		20,000,000	$2.50
1912	Pittsburgh, Pa.	Slow		100,000,000	3.41
1911	Philadelphia, Pa.	Slow	(a)	9,000,000	5.62
1911	Philadelphia, Pa.	Slow	(b)	13,000,000	3.59
1911	Philadelphia, Pa.	Slow	(c)	38,000,000	3.88
1911	Philadelphia, Pa.	Slow	(d)	202,000,000	1.91
1912	Washington, D.C.	Slow		62,000,000	4.01
1912	Cincinnati, Ohio	Rapid		50,000,000	4.12
1911	Harrisburg, Pa.	Rapid		9,000,000	3.93
1912	Little Falls, N.J.	Rapid		30,000,000	3.20
1912	Louisville, Ky.	Rapid		25,000,000	3.48
1912	New Orleans, La.	Rapid		16,000,000	6.32
Weighted Average		Slow		....	$2.86
		Rapid		....	4.04

(a) Lower Roxborough; (b) Upper Roxborough; (c) Belmont; (d) Torresdale.

To summarize, the average cost of building seven of the largest and most modern slow sand filter plants was $32,600 per million gallons daily capacity; and, likewise, the average cost of building six of the largest, and two medium size, rapid sand filtration plants was $12,100 per million gallons daily capacity. The average cost of operation and maintenance varied widely, of course, but averaged $2.86 and $4.04 per million gallons of water filtered by the slow sand and rapid sand filters, respectively. Adding these last figures to the fixed charge on the first cost of construction makes up the following totals:—

Slow sand filtration ....$7.33 per million gallons
Rapid sand filtration ....$5.70 per million gallons

Relative Hygienic Efficiency of Slow Sand and Rapid Sand Filters.—In former years the slow sand process of water purification was favored by the majority of sanitarians and engineers because it was considered that, as compared with the rapid sand process, the former process was more nearly a "natural" one and hence less liable to failure. The actual results obtained from both systems have long since shown this assumption to be unfounded. Both processes require careful and intelligent management, but there is no room for doubt that if there is any choice between the two as regards hygienic efficiency it belongs to the rapid sand process. Well designed and built plants of this type not only can purify water of any character, turbid, colored or clear, so that the filtered product will always be clear and colorless, but are less liable to show sharp diminution in bacterial (hygienic) efficiency in cold winter months, or when the character of the raw water is seriously contaminated with certain industrial wastes. Chemical treatment is an integral part of all rapid sand filter processes, but is a makeshift when used in conjunction with slow sand filter processes; and the more complicated the chemical treatment prior to filtration the more likely are the final slow sand filters to fail.

In brief, wherever chemicals are or should be used in the preparation of water for filtration, it is proof that the slow sand filter is out of its element and in a field which, on grounds of economy at least, belongs exclusively to the rapid sand system.

In support of the assertion that rapid sand systems are at least the equal of slow sand systems with respect to hygienic efficiency, Mr. Johnson presents a table showing the typhoid fever death rate in certain American cities using slow sand or rapid sand filters. It is seen that the residual typhoid in those cities having rapid sand filters is 27 per cent. less than in those having slow sand filters.

Comparative Growth of Rapid and Slow Sand Filtration in the United States.—The growth of water filtration in the United States, particularly during the last dozen years or so, has been remarkable. In 1900 but 1,860,000 people were being supplied with filtered water, and in 1905 the United States was inferior to Japan in this regard. Since 1900 the population so supplied has increased by 830 per cent.

In the decade 1900-1910 slow sand filtration showed a remarkable increase with respect to the population supplied from such plants. This was largely due to the construction of the plants in Philadelphia, Pittsburgh and Washington, these three cities contributing over 2,000,000 of the increased population served by that system of filtration noted in the decade 1900-1910, namely 3,523,000. The increase during the same period in the number of people supplied with water from rapid sand filter plants was even more remarkable, totaling 5,422,000, or 54 per cent. greater than in the case of the slow sand filter systems.

"Since 1910 the slow sand filter has failed to maintain the rate of increase noted during the previous decade, the additional population served at this date, as compared with 1910, being 1,515,000. During the same period the additional population served by rapid sand filters was 4,971,000. The proof is plain, therefore, that the slow sand filter has about reached its limit, while the rapid sand filter is growing faster each succeeding year."

The paper contains tables and diagrams serving to show how the practice of water filtration has grown, and the respective parts which slow sand and rapid sand filter processes have played in the development of this important branch of municipal sanitation.

It is to be noted that of 40.68 per cent. of urban population supplied with filtered water 27.98 per cent. is supplied from rapid sand filters.

GOOD ROADS PREVENT DISEASE.

Few persons, on first thought, would see any possible connection between good roads and good health. Yet the State Boards of Health of Ohio and Kansas say that by the removal of weeds and trash good roads can and will prevent disease. Weeds and trash prevent the prompt evaporation of moisture and promote retention of ground water. This makes ideal breeding spots for mosquitoes, flies and other insects, which are known as disease carriers, not to mention chinch bugs, hoppers and other insects which are crop damagers. Furthermore, an undergrowth of weeds invites the dumping of garbage and manure by offering concealment, of which fact careless and thoughtless people are prone to take advantage, thus increasing the facility of insect breeding and providing these insect carriers with proper material for disease transmission.

Good roads also prevent disease by providing good drainage. Many farms have no means of drainage except by ditches along roadways. Open ditches, clear of brush and debris, with hardened surface and proper fall, afford these farms the opportunity of ridding themselves of many a stagnant pool. The removal of weeds, proper road grading, surface hardening and oiling, insures prompt drainage of all pool, ditch and surface water, removing the possibility of insect breeders, for none can multiply without moisture. Road oiling in itself is destructive of insect larvæ, especially mosquitoes—a well-known fact. Dry roads offer pedestrians, and notably children who are compelled to walk to and from school, dry shoes and feet. While colds are due to specific germs, yet it is a well-known fact that cold, wet feet and chilled limbs lower the resistance of individuals and make them more favorable subjects for infections of the respiratory passages, including pneumonia and tuberculosis. Good roads prevent disease by setting an example to adjoining farm premises. Good roads promote travel and set an example to the farmer whose premises are bordered by them. The comparison of a well-graded, clean highway with an unkempt and trashy barnyard adjoining is sufficient to stimulate every landowner to a clean-up. Pride compels him to offer to passers-by a neat-appearing and attractive house and barnyard. Results are only too obvious. Good roads are active disease prevention agencies, aside from their financial and commercial value.

THE GRADING AND DRAINAGE OF ROADS.

DETERMINATION of the amount of grading to be done in connection with the improvement of any highway depends upon the amount and nature of the travel and the topography. Excessive grades increase the cost of transportation and also add a heavy burden of maintenance, and it is always advantageous to lengthen a road and eliminate an excessive grade. This, as a whole, should be governed by the axioms enumerated by S. D. Foster, Chief Engineer, Pennsylvania State Highway Department, in his paper to the American Road Builders' Association in December last. These axioms may be stated as follows:—

1. No greater load can be moved over a highway than is moved over the maximum grade. 2. It is generally true that a road over a hill is equal in length to one around the base. 3. If the tendency of the topography is toward a continued elevation, the grade line should never be allowed to have a descending grade, and vice versa.

Sacrifice of straightness or of grade will be dedependent upon the predominant nature of the travel. Where horse-drawn vehicles predominate, alignment should give way to the lessening of the grade, as horse-drawn vehicles demand easy grade in preference to straight roads; where motor travel predominates, the grades should give way to alignment, for the rapidly increasing use of motor vehicles places a new responsibility upon the roadmaker—the reduction of danger to life and property, which necessitates building highways with long, easy curves.

Drainage.—In determining the amount of drainage it is well to remember that the ability of earth or soils to sustain loads depends largely upon the moisture present. Most soils can be compacted to form a good, firm foundation as long as they are kept dry, but when wet they become soft and in a great measure lose their sustaining power. The main problem, therefore, in the construction of a highway is drainage, which is dependent upon proper location. If the ground is level and not subject to flood there is seldom difficulty in location, but marshy ground underlaid with quicksands is expensive to deal with and generally should be avoided, even though it involves a considerable detour. A quicksand well drained often makes an excellent foundation for a road; the drainage, however, must be thorough and rapid. If the ground is level and subject to flood, mainly by backwater, an adequate number of small drains will usually accomplish the desired result, except that it may cost a good deal to raise the grade of the road above flood level. Cases sometimes arise where it is more economical to build a road floodproof at a lower level and submit to an occasional interruption of traffic than to make a wide detour or go to the great expense of a fill or viaduct.

Roads Subjected to Floods.—If the ground is level and subject to floods running at high velocity great care is necessary. The natural channel of the stream is altogether insufficient to carry the flood water, and, if the bridge crossing the stream is made large enough to permit the flow to pass under it, extensive erosion is liable to take place. If overflow bridges are built they are very likely to cause formation of side channels. Usually, the best treatment is to build the bridge large enough to pass the whole stream in flood time, straighten and widen the channel of the stream as much as possible, remove obstructions and protect the banks at exposed points.

In some cases it may be necessary to allow the flood water to overflow the road at some points, which must, of course, be made floodproof. Where such overflow points are provided, they should be made long and shallow to reduce as much as possible the velocity of the current flowing over them; otherwise adjacent property will suffer unnecessarily. These low places should also be so located as to reduce the actual damage to the minimum, as it is the duty of the public official to protect the just rights of all parties. If the proposed road crosses a narrow valley with a rapid stream, it is almost always best to give the bridge ample waterway and fix the grade above the reach of high water, taking care, of course, to protect all exposed points against erosion. Where valleys are to be crossed it is always better to cross them where they are narrow and the streams rapid. Such conditions reduce the amount of embankment required and also the span of the bridge, requiring more substantial construction, but proving more economical and more enduring.

One other condition met with frequently upon the highways of Pennsylvania is that arising from the tendency of one stratum of soil to slip upon another and thus cause landslides. These are most difficult and expensive to deal with, and it is seldom if ever worth while to attempt to hold such a movement of earth in place by piles or retaining walls. The only sure treatment is the thorough cutting off of the water before it enters the sliding mass. French drains with suitable laterals are generally better than tile drains, the usefulness of which may be destroyed by a slight movement in the slide. The drainage must be ample, as regards the sizes and lengths of the drains and the sufficiency of the outlets. This is sometimes a very expensive treatment, but if well done a permanent cure is generally effected.

The Ontario Government has secured an option upon timber rights in a large section of the limits of the Pembroke Lumber Company in and immediately adjoining the Algonquin National Park. The limit taken over, and by order-in-Council brought within the park, is chiefly valuable to the province from the fact that it contains a splendid stand of young pine. The price to be paid by the Government is $185,000.

Repairing a Locomotive with Portland Cement.—The Chesapeake and Ohio Railroad Company have successfully used Portland cement for the temporary repair of a fissure, 3-in. long, in the steam chest of a locomotive engine. Cement was employed because the part affected was inaccessible for the customary treatment. It is stated that after having been in service for eight months, the locomotive was sent to the shops for general overhauling, when the cement lining was found to be so perfect that it was left in place.

The conference of the International Waterways Commission just concluded at Washington, D.C., has resulted in the decision of the commission, first, to employ leading sanitary engineers to study the problem of the pollution of boundary waterways, then to give them a hearing, which will be in New York about the middle of May. After that hearings will be held in the various cities and towns affected, Buffalo and Detroit, as the two largest, being the first to be visited by the commission. The commission will meet again at Sault Ste. Marie on May 4th to investigate the water power project which American and Canadian concerns desire to build at the point, and which will affect the level of Lake Superior.

Sir Robert Perks, the English contractor, has received a contract from the Russian Government to build what will be practically a new harbor at Vladivostock. The port has deep water and other natural advantages, but so far little has been done for its improvement by the government of the Czar. Some time ago the Russian Government undertook to double-track the great Trans-Siberian Railway from the Pacific to St. Petersburg, and that work being now near completion, attention is turned to the proposed terminals which will cost millions of roubles. The contract which Sir Robert is soon to enter upon will comprise accommodation for both war vessels and merchant shipping and the contractor has several years to complete the work.

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FUNDS FOR HIGHER TECHNICAL EDUCATION.

The Royal Commission, appointed in 1910 to enquire into the needs and present equipment of the Dominion of Canada with respect to industrial training and technical education, has recently submitted a voluminous report in which many findings are presented and recommendations made. Its investigations into the systems of education in this and other countries have disclosed many shortcomings as well as some commendable features.

In the matter, for instance, of technical education of university or college grade, although a complete study of the organization of institutions and causes of instruction was not entered into, a study of the effects of the higher forms of technical education upon progress in industry and trade brought out one outstanding fact.

In France, Germany, Switzerland and the United States, the power and influence of technical education of the highest types appeared to be greater than in the United Kingdom or in Canada. In England, moreover, the opinion most frequently heard—and it was earnestly urged—was to the effect that hereafter the industries must somehow secure the services of more men of the highest scientific attainments with thorough technical training, or her manufacturers and merchants will not be able to hold their own against foreign competition.

The faculties of applied science of colleges and universities in Canada have the reputation of preparing engineers for professional work in a thorough and satisfactory manner. From what was learned abroad by the commission, the opinion appears to prevail that students in technical colleges, at some time before they graduate, should have obtained experience with materials, tools, machines and products for the purpose of giving them a clear understanding of principles and a correct knowledge of the conditions of production and construction which prevail in shops and factories. It is not important that they should have enough practice to develop either skill or speed as workmen in manipulative labor.

Technical education for the preparation of technical engineers, and other persons being trained for professional work of a grade and rank similar to theirs, would be improved, states the commission, by further extensions in the direction indicated by the practice in Germany, where industry and trade require, precisely like the German army, a number of intellectually highly trained officers, who are recruited almost exclusively from the technical colleges. These colleges educate the leaders of industry and also the state and municipal officials who are entrusted with the execution of technical problems.

The universities and colleges in Canada are providing technical courses to meet the demands from an increasing number of students. The rapid growth and development of the country, and the further application of science and scientific methods to all forms of production, construction, conservation and administration, will call for still larger numbers of graduates. In consequences the universities and colleges are sure to require increased financial support. The commission expresses itself to be of the opinion that this should be provided from some source without causing the fees required from students to be so high as to exclude suitable young persons who may seek the highest grade of technical instruction.

The report, as a whole, is well seasoned with admonitions that the higher educational centres of Canada are not yet at such a stage of excellence and proficiency that the country can sit back and entertain thoughts of retrenchment of financial support. The advice which the commission imparts in this respect is most timely, as the severity of lack of funds is making itself keenly felt in some of our institutions upon which we are placing a great deal of dependence for a continuation of Canadian enterprise and awakening. When, after a world-wide survey of industrial and educational conditions, Canada is advised by its Royal Commission that an increase of financial support is necessary for the proper education which its national problems demand, there is only one thing to do.

CANADIAN ROAD CONGRESS.

Canada's first Good Roads Congress will be held in the "Arena" at Montreal, May 18th to 23rd, and it is expected that it will be attended by several hundred delegates from all parts of the Dominion, and by many from the United States, all of them enthusiastically interested in the international awakening to the necessity for the betterment of urban and interurban streets and highways.

Geo. A. McNamee, secretary of the Automobile Club of Canada, has been appointed secretary-treasurer of the congress, and has associated with him the following men: Former Alderman U. H. Dandurand, of Montreal, is chairman of the congress; H. W. Pillow, president of the Automobile Club of Canada, and Oliver Hezzlewood, president of the Canadian Automobile Federation, are among the active workers.

Hon. Chas. Tessier, Minister of Good Roads for the Province of Quebec, elected to this position during the last week in March, has given the congress his official sanction. Endorsations have been received from W. A. McLean, president of the American Road Builders' Association; W. J. Kerr, president of the Canadian Highways Association, of Vancouver, and F. R. Robinson, chairman of the Saskatchewan Highway Commission, of Regina.

The congress will be opened at 3 p.m., May 18th, by the Honorable Lieutenant-Governor of the Province of Quebec, Sir Francois Langelier, assisted by Sir John M. Gibson, the Lieutenant-Governor of the Province of Ontario. Official representatives will be present from the French, British, United States and Canadian governments, and addresses will be given by more than two score men of prominence.

Over $60,000,000 is available in appropriations in Canada for expenditure for good roads during the current year. The congress delegates will debate, as one of their most important problems, the best and wisest method for outlaying this huge sum. Thirty-three millions is the amount which will be spent under provincial supervision, and the other twenty-seven millions will be spent by cities, towns and townships. This estimate, made by Geo. A. McNamee a few weeks ago, is said to be a conservative one, and has since been augmented by Ontario's appropriation.

EDITORIAL COMMENT.

Work on the Welland Canal has made remarkable progress during the past month. Sections I., II., and III. are being operated upon while Section IV.-A will be commenced immediately. This sub-section was awarded last week to Maguire and Cameron, St. Catharines, Ont. It comprises the construction of a diversion weir and of culverts at several points between the present and the old canal, after which a portion of the old canal will be filled in and the space between it and the present canal used as a dumping ground.

THE ENGINEER AND THE PUBLIC.

THE following remarks are extracted from several recent addresses of Walter J. Francis, C.E., of Montreal—one to the Ottawa branch and another to the Calgary branch of the Canadian Society of Civil Engineers, on the 2nd and 9th inst., respectively:—

It is, perhaps, easier to say what an engineer is not than to say what he is. The expression engineer is most difficult to define. Turning to a dictionary it will be found that an engineer is one who practises engineering, or that he is one who schemes or contrives. One of the most eminent jurists of the United States struggled with this problem for twenty minutes—to come to the conclusion that the engineer is a good fellow. To define engineering is about as difficult as to define engineer. It may be presumed that the logical dictionary method would be to say that engineering is the art practised by an engineer. The Institution of Civil Engineers of Great Britain refers to "the art of directing the great sources of power in nature for the use and convenience of man." The Canadian Society of Civil Engineers refers to "the profession of a civil engineer whereby the great sources of power in nature are converted, adapted and applied for the use and convenience of man." Is it any wonder that the public does not understand what we are when we have so much difficulty resulting in trying to say what we are. It would appear that Professor Swain has devised a definition which is, at least, comprehensive. He calls engineering the application of the laws of nature, the principles of mechanics and the materials of construction, to the business of the world.

The classes of engineers were placed by Mr. Dunn, the President of the American Institute of Electrical Engineers, in Boston a couple of years ago, as numbering 27. Later, some individual of a statistical turn of mind isolated 110 distinct species of engineer. Since then four others have been discovered, which gives a factor of safety of two as compared with the famous "57 Varieties."

Much of our difficulty doubtless arises from the peculiar combination of the two words, civil and engineer, which occurred long before the present state of engineering art, at a time when it seemed desirable to separate those who were engaged by the Government in purely military works from the presumably less important number who made their living without attaching themselves to the Ship of State. This word civil has been a great source of haziness for a long time. Doubtless it will disappear in the not-distant future. The great engineering organization already recognizes distinctions even amongst the military engineers.

The word engineer is very much abused. There has been noted with much pleasure the persistent care with which one of the vice-Presidents of the Society always refers to his numerous locomotive drivers as enginerunners or enginemen, either of which terms is very definite and easily comprehended. It is a fortunate thing that the man who drives a street car is satisfied to style himself a motorman, that the driver of an automobile prefers to be known as a chauffeur, and that the aviator does not wish to be called an aeroplane engineer. If the man who runs an engine must be called an engineer, what would you call a man who runs a wheelbarrow?

One of the safest standards for judging what an engineer should be may be taken from the requirements of the highest grade of membership in the three great engineering Societies of English-speaking engineers, the Institution of Civil Engineers of Great Britain, the American Society of Civil Engineers and the Canadian Society of Civil Engineers. All of these recog nize four principal qualifications, namely, age, education, occupation and professional experience. For full membership the Institution requires one to be at least 33 years of age, the other two have a minimum age limit of 30. All three require a liberal education, while the Institution and the Canadian Society of Civil Engineers consider university graduation a great benefit and the equivalent of several years' experience. Regarding occupation, the requirement is that the candidate must be in active practice and have been engaged in engineering work for 10, 12 or 15 years. The professional experience demanded is ability to design and direct engineering works and having had at least five years of responsible charge of important work, the Institution requiring also that the candidate shall have attained a considerable degree of eminence in the profession. Comment on these requirements would seem to be superfluous. It is practically impossible for a person to attain the requisite experience before reaching the age of 30. Education never made an engineer, but it has made many a good foundation. Occupation and professional experience are essential features. All of the Societies make provisions for young men to enter their ranks and to have advantages while climbing upwards to the highest grade.

Is the Engineer a Professional Man?—The question naturally arises, "What is a professional man?" and we instinctively think of the lawyers, the doctors and the clergymen.

One of the distinguishing features of their profession is a representative governing body. The distinguishing feature of each professional body is its code of ethics. The distinguishing feature of professional men is that their remuneration is independent of the result of their labors. A professional man would then seem to be one who is engaged in mental labor, associated with a recognized governing body directed by a code of ethics and receiving recompense without reference to profits resulting from his work. Judged by this standard alone, the engineer as a whole cannot be classed as a professional man, because many of our greatest engineers are engaged in some form of business, such as contracting, bridge-building, shipbuilding or manufacturing, whereby their remuneration depends on the success or failure of undertakings. In medicine, for instance, if a doctor were to exploit one of his prescriptions for the sake of deriving profit therefrom, he would no longer be considered a member of the profession, notwithstanding the fact that he may still have the same high moral character, the same medical skill and the same interest in the alleviation of suffering. Because he is deriving a profit from the sale of his medicine he is considered to be in business.

It will be interesting to digress for a moment in passing to refer to the positions that the three professions, law, medicine and theology, have attained in the mind of the public. They have, of course, all been at it for centuries. The Inns of Court go back so far that it is difficult to arrive at the true history of the organizations of legal men. The doctors co-operated so long ago that the commencement of their organization seems to be lost track of. The preachers have had very close corporations from the beginning of history. These three professions are examples of the strongest possible kind of close corporation. It is impossible for a man to practice in any one of them without the full consent of the governing body. Indeed, to attempt to practice in some of these fields would be to commit an offence against the law of the land. The strength of the professions of law and medicine in this sense is due in a great measure to two important factors, one, the education of the young men entering the profession, and the other the part played by the older members of the profession as representatives in Parliament. As an example of the influence of the medical profession on the education of the coming generations of doctors, two years ago the Carnegie Foundation sent out too representatives, who paid a visit to, and studied the course given in, all the medical colleges of America. These representatives reported to the Foundation. Since that time 39 medical colleges have closed their doors and every other medical curriculum has been altered.

In theology the lines of denominations are so firmly fixed that the most absolute of all close corporations exist, corporations that have practically absolute control of the most far-reaching of all civil contracts, namely, the marriage contracts. These points are mentioned merely to show the result of the efforts of time and organization.

The position attained by the older professions cannot be attained by engineers in a short time. Law, medicine and theology are as old as the hills. Engineering is a modern art. By the very definition of Professor Swain it will be seen that it was impossible for man to have an art of engineering until he understood the laws of nature and the principles of mechanics. What he knows of these things he has not known long, and probably he knows them still imperfectly.

The above-mentioned engineering societies must be considered as technical societies and not professional societies. The statement that there is only one professional society of civil engineers in America may sound rather novel and improper to many. About three years ago there was formed in New York City the organization known as the American Institute of Consulting Engineers. Since that time similar bodies have been instituted on the Continent, and quite recently in England. The distinguishing characteristics are that the minimum age for admission is 35 years, and that a candidate for membership must be of good personal character and high professional reputation. The qualifications required are higher than those of any of the other engineering societies, and it is expressly forbidden for any member to engage in contracting.

This organization has a very rigid code of ethics, as well as a schedule of fees.

The Relation of Engineers to Each Other.—The code of ethics of the Canadian Society of Civil Engineers may be taken as a reasonable guide for conduct towards a fellow-engineer. It does not require anything more than the respect accorded by doctors to other doctors or lawyers to other lawyers.

The Relation of the Engineer to the Public.—The public seems too prone to consider the engineer a sort of glorified plumber, and we immediately come to the anomalous situation that that same public, while hesitating to attempt to wipe a joint on a lead pipe, would rush in and express the most decisive opinions on larger questions, believing that they know all about the laws of nature and the principles of mechanics.

The daily press is not blameless in its comparative appreciation of engineers. It is frequently observed that four lines or so are given to the reference of some important engineering gathering, while a whole column of the same issue is devoted to a popular story about "a veteran engineer." One reads the column only to find that it refers to the man who operates the throttle-valve on the engine of a river-boat. Such a man is not by any means immune from praise and noteworthiness. It is evident, however, that there is a lack of distinction between those persons represented by the creators of the engine and those represented by a man who operates it.

It is the common public practice for corporations, municipalities, and even individuals, to invite competitive bids for engineering services. Permit an analogy to be made with medical men. Suppose a person were afflicted with a tumor. Then let him send out invitations, far and wide, to surgeons to ascertain their prices, when they can do the work, complete specifications for the operation, and the photograph of the applicant. Having chosen the two lowest bidders, one of whom happens to be the handsomest of the bunch, perhaps, the tumerous individual proceeds to work the two competitors against each other, with the result that the homelier-looking one underbids the pretty one by $3.60 and gets the job.

Then, the native engineers are very apt to be forgotten by the press. Not long ago one of the foremost newspapers of Canada had an article stating that as American engineers had failed in a certain Canadian proposition it had been necessary to call English engineers.

One is apt to think at times that the unfortunate failures in engineering are unduly advertised. For each one failure, there are thousands of successes in engineering. In this regard the engineer as compared with the lawyer, the preacher and the doctor is severely handicapped. In the case of the lawyers on opposite sides in a suit, one of them must necessarily lose. The preachers deal in futures, and nobody has as yet been known to return to tell us about their mistakes. The doctor buries his.

It cannot be denied that the engineer has not yet reached in public and parliamentary life the eminence of the doctor and the lawyer. Give him time, wait until he gets a little older, and it will be found that the engineer will be just as successful in the legislative halls of the country as he has been in the great outside world.

The fact that the remuneration of engineers is steadily increasing shows in a tangible way that the appreciation of the public is growing.

What the Engineer is to Expect of the Public.—The engineer has a right to expect from the public the same consideration as accorded to doctors and lawyers.

The engineer should frown upon competitive prices for engineering services. The stand recently taken by the Institution of Civil Engineers in a letter written last month is a very firm one. It is as follows:—

"The Council have had their attention drawn for some time past to a practice which exists among local authorities, of inviting by advertisement engineers to submit in competition with others their terms for preparing plans and proposals for certain engineering schemes, accompanied then or perhaps at a later stage by estimates of the cost of the works proposed.

"In the opinion of the Council such a proceeding is very undesirable in the best interests of the public authorities themselves and is derogatory to the engineering profession. The Council desire to express emphatically that repugnance with which they regard the practice in question. They have every confidence that the members of the Institution will support them by declining to respond in any way to such advertisements as those alluded to.

"The Council have informed the Local Government Board of their action in making this communication to the Institution."

The engineer has a right to expect the medical and the other professions to refrain from entering the field of the engineer. I doubt if an engineer ever lived who would have the temerity to suggest the course whereby a surgeon should accomplish a certain result.

The engineer has a right to expect his country to prefer him before the engineers of other countries. Where unusual skill or highly specialized advice is necessary, it matters not where it be obtained, but having obtained the advice if necessary, the native engineer should be in a better position to deal with the problem as a whole than the men from outside. Canadian engineers can do the engineering of Canada. The work of Canadian engineers stands before the world as a monument to the ability and integrity of Canadian engineers.

How is the Engineer to Reach the Public?—The question of publicity by an engineer is a somewhat delicate one. Proper and improper methods of soliciting work have recently been the subject of carefully studied discussion, and the consensus of opinion seems to be that dignified and proper publicity by such means as professional cards and the way in which doctors and lawyers obtain their practice is the best course. It is generally conceded that a competent and dignified engineer will not solicit work. He does not need to.

The best way of all to reach the public is by education along broad lines in showing the public what the engineer has done. Too many of us are nothing more than animated slide-rules. Too many of us are narrow-minded. Too many of us think we are so busy that we have no time to take the interest of the true citizen in public affairs. Remember that in life there is more than dollars. Next to the agriculturist, the engineer is the greatest producer in the world. The transportation problems and the questions of communication are all in the domain of the engineer. It is for the engineer to design the conveyance for use on land, on and under water and in the air. The influence of the engineer on the arts and sciences should also be spread abroad. The greatest advance in architecture since the ancient orders was the introduction of steel skeletons and reinforced concrete by the engineer. The great advances in surgery result from the engineers' inventions in instruments, as well as electrical and other devices.

How is the Profession to be Elevated?—The profession is to be elevated by the thorough education of the young man entering it, such education being followed by careful training and long, hard experience.

The profession is to be elevated by the dignity of every engineer and by the perfection of his work.

The profession is to be elevated by co-operation with fellow-engineers and by association with the Canadian Society of Civil Engineers.

GARBAGE INCINERATION.

Incineration is the most efficient, sanitary, and, if properly managed, economical way of disposing of garbage in cities and large towns. Mere dumping in a huge midden is not disposal in the true sense of the word. It is simply an attempt to segregate a nuisance. Burial of rubbish requires a large area of ground and a long haul. It may be suitable for small towns that cannot afford an incineration plant, but it is out of the question for larger centres. Dumping into sea-water should never be permitted except by cities on the coast, and only then provided the tides are favorable and the waste material will not be washed back on the shore. Reduction of garbage in "digesters" to remove grease is practised in many United States cities, but the capital required and the operating expenses are high. Moreover, such reduction plants are liable to give rise to foul odors, and many kinds of rubbish, such as bottles, tin cans, broken furniture, cast-off clothing, etc., cannot be disposed of in this manner.

THE TRANSPORTATION PROBLEM IN CANADA, AND MONTREAL HARBOR.

THE following abstracts are from a paper read on April 7th, 1914, at a meeting of the Institution of Civil Engineers of Great Britain. The speaker was Fred. W. Cowie, B.A.Sc., M.Inst.C.E.

The population of the Dominion of Canada is about 8,000,000, and the foreign trade per capita is $125.

The population of Montreal, including the connecting municipalities, is about 600,000, and the foreign trade of Montreal per inhabitant is over $600. As a comparison, England (United Kingdom) has a foreign trade per capita of $125, Germany $67, and the United States $41.

The total land area of Canada is 3,600,000 square miles, so that the density of population is less than two per square mile, as compared, for instance, with thirty-one per square mile in the United States.

It has been stated by trade experts that the difference between the average price received by the producer of Western Canada and the price paid by the consumer of the food products is 33 per cent. For wheat for which the consumer pays $1 the farmer therefore receives 67 cents; 33 cents are paid for transportation and handling, and to the selling organizations. It is equally vital, therefore, to the producers in Western Canada and to the consumers in Great Britain, that this latter percentage should be reduced to the lowest possible figure, so that the farmer may receive the full due for his toil, and the cost of living in Great Britain may not be unduly enhanced.

Another consideration which is of vital interest to Canada is the absolute necessity of collecting by her own people the transportation and selling tolls.

As an illustration, it may be stated that, although in Montreal harbor 60,000,000 bushels of grain were handled in 1913, nearly 100,000,000 bushels of Canadian grain were shipped in the same year through Buffalo in the United States.

The cost of transportation per bushel, from the average point of divergence to the United Kingdom, may be stated, for the various stages, as approximately 18 cents.

For every bushel of grain shipped through Buffalo there is therefore a loss to Canadian transportation and selling organizations of about 18 cents, or for 100,000,000 bushels $18,000,000.

Transportation in Canada.—Even with these striking illustrations it is not easy to fully appreciate what is known in Canada as the "problem of transportation." A comprehensive view of the Dominion and the North Atlantic to Europe is shown in the paper by an original map drawn to scale (Mercator's Projection), showing Canada and the northern half of the United States, with the trade routes to Europe. The main routes are naturally "east and west," and the vast area tributary to the River St. Lawrence is geographically shown.

The "north and south" routes through the United States are principally by rail or by the Erie Canal from Buffalo to American Atlantic ports. The Erie Canal was created by the United States to offset the advantages of the St. Lawrence route. The magnificent railway systems between New York and Buffalo are the most powerful rivals of the "all Canadian" routes.

The opening-up of the vast productive areas of Western Canada, where it has been found that with one-tenth of the cultivable land under crop, 200,000,000 bushels of wheat, and double that quantity of other grains, may be grown, has established, within the last few years, entirely new transportation conditions.

With the tremendous tide of emigration from both Europe and the United States to the new provinces, this production will necessarily increase greatly, and the "problem" is, how to provide the required transportation facilities.

A table of transportation routes from the Canadian West to the United Kingdom is given. This interesting table is worthy of study, as not only present routes are shown but important projected and commenced lines of trade are indicated.

Great efforts are being put forth by the Canadian government and the transportation and other corporations to improve facilities, so as to cheapen and render available Canadian routes; but at the same time similar and extraordinary efforts are being made to improve Buffalo harbor, the Erie Canal, the rail routes, and the harbors of Boston and New York.

In the opinion of the author, who advances striking illustrations and argument, with equal effort, the advantages for future transportation should lie with the St. Lawrence route.

Montreal's Position on the Line of Route.—From the West to Montreal.—The transportation routes in Canada almost all lead to Montreal.

Up to the present the only real rival to the Montreal-St. Lawrence route is the United States route via Buffalo and New York. The western trunk lines of the United States have been improving their "north and south" connections so as to tap the three great western provinces of Canada. These railways provide excellent services to Duluth and Chicago.

A further diversion is made to the United States route at Port Arthur and Fort William. From this twin port at the head of the Great Lakes, the cheapest commercial navigation in the world enables grain and other products to be shipped to Buffalo. Between Buffalo and New York there are several splendid railway systems and the Erie Canal. The new Erie Canal, a modern barge-canal through the state of New York, giving a draught of 12 feet, will soon be completed at a cost, including harbors and damages, which is expected to reach $150,000,000.

The New York and Boston port authorities are at the same time making every effort to improve their harbors, and to provide such attractive facilities as will capture at least a large share of this growing Canadian trade.

By the Canadian routes everything goes by rail direct from the west to Port Arthur. From the twin cities, Port Arthur and Fort William, there are, with modifications, two distinct routes, namely, the "All-Water" route, direct to Montreal, and the "Lake and Rail" route, through Georgian Bay to Montreal.

By the "All-Water" route to Montreal, a distance of about 1,400 miles, vessels are limited by the present Welland and St. Lawrence canals to a draught of 14 feet, or 2,500 tons. An excellent type of vessel has been developed for this service, and the trip from Montreal to Port Arthur and back is made in 14 days.

By the "Lake and Rail" route vessels of 10,000 tons ply between Port Arthur and ports on the Georgian Bay. The Canadian railway companies have established magnificent elevators at Port Arthur and Fort William, and also at several Georgian Bay ports, so that loading and discharging may be carried on with unsurpassed facilities. From the Georgian Bay ports splendid railways are being built to Montreal and existing lines are being improved.

Montreal.—At Montreal harbor the St. Lawrence Canal system and all the great Canadian transcontinental lines centralize. The great Canadian railways—the Canadian Pacific, the Grand Trunk, the Grand Trunk Pacific and the Canadian Northern—are all feverishly improving their terminals at Port Arthur and Fort William, at Georgian Bay ports, and at Montreal.

The Canadian government has commenced the construction of the new Welland Ship-Canal between Lakes Ontario and Erie. This canal, with 800-foot locks and with a possible ultimate draught of 30 to 35 feet, will accommodate the large lake carriers so as to continue to Kingston or Prescott without breaking bulk. This will add greatly to the shipping in Montreal, and will, it is confidently expected, hold the greater part of the Canadian trade to the St. Lawrence route.

Montreal, however, under existing conditions of traffic and accommodation, is almost at the limit of its capacity. With double the present traffic assured within the next few years, it will require a great deal more and better harbor accommodation to meet the demands upon it.

Montreal to the Sea.—With the possible exception of the development of Glasgow there is no more romantic episode in the annals of harbor engineering than the making of Montreal an ocean port. Largely by the faith and energy of Scotch Canadians, following the successful improvements on the Clyde, the River St. Lawrence between Montreal and the sea has been deepened from less than 10 feet to its present depth of 30 feet at the low stages of the river level. During the early summer months the depth is greater, and reaches as much as 38 feet. The minimum width is 450 feet.

Although the author is not now connected with the staff of the River St. Lawrence Ship-Channel, he was continuously engaged upon that great work for twenty-two years, commencing as an assistant and being in charge as superintending engineer for ten years up to 1909. For many years this work has been looked upon as being one of the great successful public works of Canada, and under the Hon. J. D. Hazen, Minister of Marine, the work is now in charge of Mr. V. W. Forneret, B A.Sc., superintending engineer, who for many years was the author's chief assistant.

The work is all carried on departmentally. The plant is owned by the government, and for its own special work is probably the most complete dredging plant and excavating machinery for submarine rock which is in existence at the present time.

At the present time, with magnificent range lights for each course, with a splendid system of gas buoys and a telephone signal service, navigation is considered very easy and safe by night as well as by day.

The deepening of the channel from 30 to 35 feet at extreme low water was commenced two years ago, and about one-fifth of the work to tidal water is already completed.

The natural fall in the river level between Montreal and Quebec, a distance of 160 English miles, is 29 feet. The maximum discharge of the river during the season of navigation is about 600,000 cubic feet per second, while at the lowest stages of water the minimum is slightly less than 200,000 cubic feet per second.

With the present average slope and velocity of current and average cross-section, the low-water river level and discharge are balanced, with an average current of about 3 miles per hour. This being theoretically correct, it may be considered assured, that if the water supply of the St. Lawrence remains unchanged and the natural cross-section of the river is not enlarged, the present river levels will be constant.

The permanence of the ship-channel and the St. Lawrence route would therefore appear to be well assured.

From Montreal via the St. Lawrence to the open sea the distance is nearly 1,000 miles, and, besides the attraction to passengers of 3 days' sailing in smooth water with beautiful scenery, the strong commercial consideration for water freights into the interior is the incentive to keep pace with increasing trade on the North Atlantic. During the season of seven months the commerce passing through Montreal is nearly 40 per cent. of the total commerce of Canada, and this percentage is increasing.

In 30 years only two ships have been totally lost between Quebec and Montreal, and the occasional groundings, which are well advertised, are not frequent. None of the accidents whatever in recent years has been due in any measure to the ship-channel.

Montreal Harbor.—The First Improvements.—In 1830 the first Harbor Commission was appointed under the authority of the Governor of the Province of Canada, for the purpose of carrying into effect "An Act to provide for the improvement and enlargement of the harbor of Montreal."

In their first annual report the commissioners recorded that they confidently anticipated that the wharves undertaken would be, when completed, superior to any works of the kind in the province, and would enable the City of Montreal to be advantageously contrasted with any other in North America for beauty, solidity, and convenience of approach by water.

This was the first attempt made to improve the harbor of Montreal by a commission. The commissioners had the same faith in the future of the harbor, and courage in undertaking works, which has characterized the administration from 1830 to the present time. The present harbor of Montreal justifies the modest boast of the commissioners of 80 years ago.

Scheme of Harbor Extensions of 1910.—In 1910, the author prepared for the harbor commissioners a comprehensive scheme of improvements, according to which it was proposed to develop the valuable water front and shores of the river, owned exclusively by the Dominion government and held in trust by the harbor commissioners, so as to result in the following revenue-producing features: (*a*) Sites for industries, by making land and improving connections with inaccessible properties; (*b*) the extension, enlargement and improvement of railway termini, giving equal facilities to all Canadian lines for connecting with harbor and industrial points; (*c*) facilities for encouraging and developing industries along the valuable water front.

According to the Board of Consultive Engineers, the items approved were estimated to cost $17,000,000, and this work is now in progress.

This winter condition is a surprise to those who are accustomed to ports open all the year round, but as the Great Lakes and their navigation, amounting to 75,000,000 tons annually, and their great ports are also all closed at the same time, and by the same cause, Montreal harbor does not suffer unduly. The shipping of the St. Lawrence in the autumn is at once transferred to the excellent Canadian ports of Halifax and St. John, and commerce is carried on all the winter as usual with only the disadvantage of the extra rail haulage.

A very full description is given of the physical features of the River St. Lawrence and Montreal harbor.

Construction conditions and types of construction are described and illustrated. They show that although the cost of labor is very high in Canada, this is counterbalanced to a large extent by the use of machinery.

The original "make shifts" for harbor construction are now being followed by modern design. The use of timber and concrete, and the designs to overcome the danger and damage from frost action, are described fully.

Floating Dock, Shipbuilding and Repairing Yard.—For many years the harbor commissioners of Montreal, urged on by the shipping and business interests, have endeavored at various times to solve the problem of the establishment of a dry dock in Montreal harbor.

Negotiations in 1909 with a shipbuilding firm and the final incorporation of The Canadian Vickers, Limited, solved the problem. The harbor commissioners agreed to furnish the site, situated on harbor property, in such a position that nothing would be done to hamper future extension of the harbor. The commissioners undertook to dredge the deep basin and to furnish a site of 30 acres of made land. The rental from the land and the increase in harbor traffic is expected to pay the harbor commissioners the interest on the outlay.

As a result, Montreal harbor has now a floating dock capable of docking the largest vessel trading to the St. Lawrence, at practically no burden on the harbor finances, and there are being established naval construction works capable, in a year or two, of building, in Canada, any vessel from a Dreadnought to a full-sized merchant ship.

This dock was constructed complete at Barrow-in-Furness, and towed across the Atlantic by two powerful tugs, reaching Montreal on 18th November, 1912. The length of the dock over platform is 600 feet, the width over all 135 feet, and the lifting capacity 25,000 tons. On the 18th November, 1912, H.R.H. the Duke of Connaught, Governor-General of Canada, formerly dedicated the new floating dock to the service of commerce and shipping.

The Storage and Handling of Grain.—As grain shipments in Montreal harbor constitute about one-fifth of the total annual freight handled, and as every effort is being made to meet competition so that the greater part of the Canadian grain exported shall be shipped through Canadian ports, special attention is given in this paper to the facilities for the storage and handling of grain.

It is acknowledged that the Montreal equipment is the latest and most successful, as compared with the facilities for the storage and handling of grain at any of the great ocean ports of the world.

As the most characteristic unit of this plant has just been completed, the author, who has had to do not only with designing but also with operating, gives a detailed description of the grain-handling trade, as well as of the design and construction of the plant in Montreal harbor. There is probably no lesson in port-management to be learned that will better illustrate how failure may be turned into success by arranging varied operations under one management and yet so centralized as to cover every requirement of a special trade without disturbing other departments of port business.

Elevator No. 1 was constructed in 1904. It was of the latest design and was placed in the most valuable site on the harbor. It could receive grain by railway wagons or by lake vessels at the rate of 16,000 bushels (400 tons) per hour. Ocean steamships, by moving to the elevator berth, could be loaded at double that rate. The ocean vessels, however, declined to move to the grain berth to receive grain. It involved tug service, pilotage, etc., and interrupted other operations of loading and unloading, and they desired to ship grain at certain and convenient periods of unloading and loading. Tramp vessels were satisfied, but the proportion of tramps was small. In 1907 the working of this elevator devolved upon the author. The capital cost then amounted to about $1,000,000, the interest account to over $25,000, the operating and maintenance charges to an equal sum. The total revenue for 1907 was about $8,000, and the loss was over $40,000.

The system can store 3,600,000 bushels of grain, can receive about 800,000 bushels (20,000 tons) per day, and can deliver an equal quantity to any of fifteen ocean steamships at their regular berths, and to nine vessels at one time. With it, and with a fleet of six floating elevators for direct transfer, the harbor commissioners received, stored and delivered in 1913 nearly 44,000,000 bushels. The capital expenditure had now reached $4,500,000, but during this season, the first covering the operation of the complete installation, the system paid interest, maintenance, operation and depreciation.

This very complete and costly installation is the result of competition. Its purpose is to keep the trade in Canadian channels, and reduce the cost of transportation. While the Canadian Government and the harbor commissioners of Montreal are encouraging and cheapening transportation, there are those who, rightly or wrongly, are of opinion that improvements for the storage and handling of grain in the ports of the United Kingdom are not advancing in equal measure, so as to result in lower cost to the consumer and better encouragement to the producer. The importation of grain is one of the largest items of the shipping at several of the ports of the United Kingdom. The facilities for the economical handling of grain, and the cheap forwarding of it to the manufacturing mills are, however, far behind the modern successful American and Canadian practice, and even of the growing competitive North Sea ports. There is also a decided lack of such storage facilities as would guarantee food supply, and at the same time regulate shipments and, consequently, prices. In several of the magnificent new dock schemes, where such methods could be installed to apparent advantage, these features, which have been so successful in reducing costs in Canada, are apparently overlooked, although it is felt that, for so extensive a trade, they should receive exceptional attention. Otherwise further encouragement will be given to the United States millers to manufacture Canadian wheat, and ship the flour in convenient packages direct to the bakers, resulting in loss not only to Canadian transportation systems but also to British manufacturers, and further curtailment of the home food supply, to which public attention has been drawn.

The questions of storage and ventilation, and also the cost of modern elevators are dealt with, and the remarkable reduction in insurance rates in modern elevators is referred to.

The floating pneumatic elevator, discharging on to conveyer-belts in culverts leading to a central storage elevator, should be practicable at most of the new British docks. Construction work, labor, machinery, and power being cheaper than in Canada, the tariff charges, allowing for profit, should not be higher than in Montreal for a similar operation. The cost of insurance on grain in modern elevators is exceedingly low; the rate on grain in the Montreal harbors elevators is 20 cents per annum per $100, as compared with $3.20 per $100 in wooden elevators. With such storage facilities owners could store in large quantities and hold for favorable markets, and the economic results on even a portion of the total imports into the United Kingdom, amounting to about 500,000,000 bushels per annum, would pay in a year for probably one such installation.

Cost of Elevators.—The cost of modern elevators has ranged from 40 cents to $1 per bushel of capacity, so that a million-bushel house costs from $400,000 to $1,000,000. The harbor commissioners' system, with a storage capacity of 5,000,000 bushels, and with its extensive conveyer system providing galleries to nineteen berths, will cost about $5,000,000, or $1 per bushel. Elevators of similar type and working capacity can be built without the conveyer facilities for about 60 to 70 cents per bushel.

A detailed description of the construction of the latest elevator is given in an appendix.

Of importance to engineers and architects and builders is a section of the paper on Vibration Tests of Reinforced Concrete.

Considering the experiments as a whole, it would appear that the effect of the vibration was to increase the tensile and crushing strengths of the concrete, rather than to reduce them. This is probably due to the fact that the vibration had the effect of compacting the concrete, filling the voids more completely, and driving out any air bubbles.

General Organization.—The banks and river-bed making up the area included in the limits of Montreal harbor are owned by the Federal Government of Canada, represented by the Minister of the Department of Marine and Fisheries. Within the limits of the harbor is included the two banks and the bed of the River St. Lawrence for a distance of about 17 miles. The area of land, improved and unimproved, is approximately 350 acres.

By statute the administration and control of this property are entrusted to the harbor commissioners of Montreal, a corporate body having exclusive powers by Act of Parliament for the improvement and management of the harbor, subject to approval by Order-in-Council. Except for police and fire jurisdiction the harbor is quite separate from and independent of the city. The commissioners build and maintain all roads on their territory, do the electric lighting, and have absolute control of traffic.

From absolutely unimproved shores in 1830, the harbor has been developed until now the value of the land, without including the extensive improvements, is much in excess of the bonded debt of about $20,000,000.

The present harbor commissioners are: Mr. W. G. Ross, president; Mr. Farquhar Robertson and Lieut.-Col. A. E. Labelle; Mr. David Seath is the secretary.

Ocean Tonnage.—The number of sea-going vessels which arrived during 1913 was 820, with a total net tonnage of 4,690,535 tons. An equal number of vessels with the same net tonnage departed.

COPPER-BEARING STEEL SHEETS.

B. and S. H. Thompson and Co., Limited, Montreal, announce that they are prepared to supply samples and descriptive booklets of Keystone copper-bearing steel sheets. These sheets were placed on the Canadian market last year, and it is claimed by their makers that they have greater durability than ordinary steel sheets and that they are therefore particularly adaptable for use in the manufacture of all exposed sheet metal work.

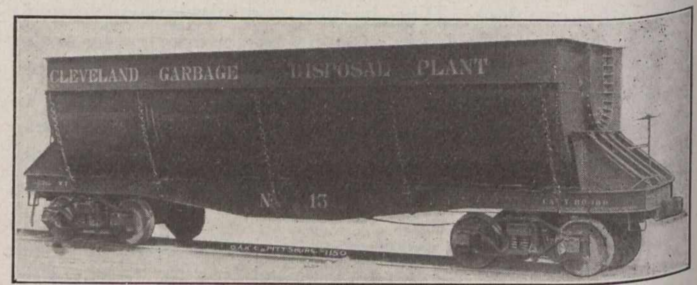
A NEW PATENTED GARBAGE CAR.

As cities increase in size, the disposal of garbage becomes of more and more importance and in connection with garbage disposal, the following points must be considered.

(1) The garbage disposal plant must be located so that it will not be a nuisance to surrounding property. This means that it will often be located some distance from the centre of the city, and too far out to haul the garbage to the plant by horse and wagon.

(2) The receptacles in which it is conveyed must be water-tight to avoid leakage of the material and consequent nuisance on account of the odor.

(3) The receptacles must be constructed so that they can discharge their contents with minimum labor and cost.



For cities located on the sea-coast, the material is generally loaded into barges from the garbage wagons; but for the interior city, this method is not possible, and the garbage disposal plants are usually located some distance out from the city and on a railroad.

A switch is then obtained as near the centre of the city as possible, and the garbage wagons go to this point and dump their loads in large capacity cars which are hauled to the garbage destruction plant. The type of car which has proven most satisfactory for this purpose is shown in the cut. It consists of a large tank with semi-circular bottom and capacity of 1,200 to 1,800 cu. ft. The tank rests on rockers at the ends and at intermediate points on rollers so that it can be dumped and righted with the expenditure of very little power. These cars are built to conform to standard M.C.B. requirements in every respect, and are accepted for transit on their own wheels by any railroad. Large quantities of these cars have been supplied to Cleveland, Columbus, Toledo, St. Louis, and a number of other cities by the Orenstein-Arthur Koppel Company, of Koppel, Pa., who control and have patented the design.

DISCUSSION OF TRANSIT FACILITIES.

An interesting topic and one of great economic importance at the forthcoming International Conference on City Planning, in Toronto, will be the improvement of rapid transit facilities in our growing cities. A paper on "Provision for Future Rapid Transit: Subway, Elevated or Open Cut and their Influence on the City Plan" will be delivered by J. V. Davies, Consulting Engineer, Brooklyn Rapid Transit Company, and will be followed by another paper on "Rapid Transit and the Auto Bus," by John A. McCollum, Assistant Engineer, Board of Estimate and Apportionment, New York City.

An estimate of the water extensions necessary for this season at Fredericton shows a total cost of work that will be about $8,000; while the estimate furnished on sewer extensions approximates a cost of $10,420.

ENGINEERS' LIBRARY

Any book reviewed in these columns may be obtained through the Book Department of The Canadian Engineer.

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BOOK REVIEWS.

Gear Cutting in Theory and Practice.—By Jas. G. Horner, A.M.I.Mech.E., published by Emmott & Co., Limited, Manchester and London, as one of their "Mechanical World Series;" 391 x xii. pp.; 367 illustrations; size 6 x 9 in.; cloth; price $2 net.

This is a very useful book for the mechanical engineer and shop man. It is practically devoid of technical formulae, the author endeavoring to incorporate the later developments of the art in a reasonably comprehensive manner rather than to enter into a necessarily long theory of design of gear teeth. The association of practice with principles has evidently been his aim throughout and in this he has for the most part succeeded. His illustrations are many and are well chosen, and his writing is of a readily understandable nature.

The book comprises 18 chapters in four sections, the first of which covers the principles of design; the second, methods of gear cutting; the third, machines, including cutters, plainers, milling machines, etc. Section 4, deals with materials, manufacture and strength of gears. An appendix consists of very useful tables for mechanical engineering.

There are several instances where the author does not make himself clear. In one or two cases his terminology is undoubtedly at variance with that which is almost universally accepted. These slips are unimportant, however, and are not misleading to the man familiar with the machinery of gears or the principles of their design. To counteract them he will find a great deal of very useful information with which to supplement his previous knowledge by the later developments in engineering practice.

Roads and Pavements.—By Ira O. Baker, C.E., M.Am.Soc.-C.E., Professor of Civil Engineering, University of Illinois. Published by John Wiley and Sons, New York, Canadian Selling Agents, Renouf Publishing Company, Montreal; 698 pp.; 171 illustrations; size 6 x 9 in.; cloth; price $5.

The second edition of Dr. Baker's treatise on Roads and Pavements is an enlargement upon the previous edition, but the incorporation into it of an additional chapter of over 40 pages on the subject of automobile roads and concrete pavements, and by the bringing up-to-date of the original edition, which will be remembered as having been accepted 10 years ago as an excellent treatise on this subject. In the new edition the concise but comprehensive style of the author is evident throughout. Part 1, deals with country roads, their location, economics of various kinds. It comprises seven chapters. Part 2, contains 14 chapters on street pavements covering economics, design, drainage, foundation, more important kinds and the comparison of them. A chapter is also devoted to sidewalks. In the newly added chapter mentioned above appears a summary of the modern and changed practices which the advent of the motor vehicle has necessitated. It discusses effect of automobiles upon roads; method of suppressing dust; methods of forming a protective covering; construction of bituminous macadam roads and of concrete roads. In the latter various specifications have been summarized. The whole chapter is well condensed and orderly, and adds materially to the value of the book.

Poor's Manual of Railroads for 1914.—Published by Poor's Railroad Manual Company, 535 Pearl Street, New York; 2,052 pp. of text; size 7 x 9 in. This is the 47th annual number of Poor's Standard Manual. It is devoted entirely to steam railroad securities, and is published separately, Poor's Manuals of Public Utilities and of Industrials respectively to be published at a later date.

The special feature this year is the information part given in the manual showing whether or not interest on railroad bonds is payable without deduction for the United States income tax. It contains other new features, including about 500 new comparative and analytical tables, all contributed to assist the investor in forming an opinion of the value of railroad securities. It is needless to say that this manual is the most reliable and carefully compiled work of its kind on the subject of American roads.

Industrial Training and Technical Education. Part 4, of the report of the Royal Commission on Industrial Training and Technical Education, Jas. W. Robertson, Chairman, 770 pp.; 6 x 9 in.; cloth.

This part of the report deals with the inquiry in Canada. The provinces are taken separately. An outline of the educational system of each, provisions for technical instruction, a summary of testimony as to industrial workers, steel, iron and coal, agriculture and agricultural education are divisions typical of the classification of the inquiry.

Canadian Patent Law and Practice.—By Harold Fisher, B.A., LL.B., and Russel S. Smart, B.A., M.E., with an appendix on Canadian Patent Office Practice, by W. J. Lynch, I.S.O.; published by Canada Law Book Company, Limited, Toronto; 478-xxxii. pp.; 6 in. x 9 in., half leather binding; price, $7.50.

There are many ways in which this book will be found of distinct value by not only patent attorneys and solicitors, but by engineers who have frequent occasion to investigate patent claims or regulations respecting them.

The work is divided into 20 chapters, some of them condensed to essentials only, while others go into considerable detail such, for instance, as the sections devoted to infringement, and practice in infringement cases.

The whole question of patent law seems to have been very thoroughly investigated, and although written primarily for the patent lawyer, engineers and manufacturers who are interested in inventions should acquaint themselves of Canadian practice as considered in this book.

An important feature is an appendix by W. J. Lynch, Chief of the Canadian Patent Office, who discusses in detail Canadian Patent Office Practice. The volume also contains copies of standard forms for petitions, specifications, assignments, disclaimers, etc.

The Gyroscope.—By F. J. B. Cordeiro, published by Spon and Chamberlain, New York; 104 pp., illustrated; 5½ x 8½ in.; cloth; price, $1.50.

(Reviewed by A. S. L. Barnes, Hydro-Electric Power Commission of Ontario).

This book is divided into two parts,—"Theory" and "Applications."

The author has a way of making positive statements which arouse in the reader a desire to refute them if possible, and several of them are certainly open to argument. For example, when we are told that the word "torque" is engineering "slang" for "couple," it seems time to raise a protest since the two words are not inter-changeable, the former being the cause and the latter the effect.

Again, it is argued that rotation from right to left should be taken as the positive, or +, direction instead of, as is more usual, the reverse or "clockwise" direction; the reason given being that "in the Northern Hemisphere . . . . practically all the motions of nature are to the left—cyclones, heavenly bodies, etc." This question of direction, however, surely depends on the location of the observer; for example, in looking down on the solar system, from an astronomer's point of view, that is, from outside, while considering the North Pole as the top, the author's statement is true, but we are not all astronomers, and it is at least probable that man's universal predilection for what we call right-handed rotation has been due to the fact the apparent direction of rotation of the "heavenly bodies" is in that sense, so that, instead of our clocks and our screws having been made right-handed "by accident," it is much more likely to be traceable to man having had an example of "right-handed" rotation before his eyes throughout the whole period of his existence on this planet—the accident, if there be one, is due to the Creator having arranged, not only the directions of rotations as they are, but also to his having allowed "the greatest population and the highest civilization" to exist on the Northern Hemisphere—had astronomy had its birth in the Southern Hemisphere Mr. Cordeiro would have argued in the opposite sense to what he does now, as then his viewpoint would have been changed and he would have declared that the motions of the heavenly bodies were from left to right.

A considerable portion of the theoretical part of the book is not of direct interest to engineers, as it is devoted to problems of an astronomical nature; in the earlier pages there are, however, several interesting cases of gyroscopic motion treated mathematically which could be readily applied to many engineering problems. In the second part of the book, the writer points out that a train in rounding a curve has two forces tending to de-rail it, the centrifugal action, which is guarded against by raising the outer rail, and also the gyroscopic action of the rapidly revolving, heavy masses of the wheels, which, as is well-known, tends to prevent their being turned out of the plane of rotation. It is asserted that engineers neglect this latter point; if so, they should consider it at once, as the force thus exerted on a long train running at a high speed must be very far from negligible.

Aviation comes in for some remarks, and here it is stated that two motions and two propellers revolving in opposite directions would have the effect of neutralizing the gyroscopic action which is present when only one motion is employed. Makers of aeroplanes might well look into this point as tending to greater flying efficiency.

Following this are descriptions of several practical applications of the gyroscope, such as the Brennan Mono-rail car and the Gyro-compass, etc., which have been described in the technical journals.

Although some little criticism is here given, the book is really interesting, and to anyone dealing with any bodies in which rotational motion plays a part, whether he be an engineer, an astronomer, meteorologist, a designer of guns and projectiles, or even a "sky pilot," in the latest accepted meaning of this term, there are points which, especially if he have a liking for mathematics, will take his attention.

Egyptian Irrigation.—By Sir W. Willcocks, K.C.M.G., F.R.G.S., and J. I. Craig, M.A. (Edin.), B.A. (Cantab.), F.R.S.E., F.R.Met.S., with an introduction by Sir Handbury Brown, K.C.M.G. Published by E. and F. N. Spon, Limited, London, and Spon and Chamberlain, New York. Third edition in 2 volumes; 884 pages, 81 plates and 188 illustrations; cloth. Price, $10.50 net.

To engineers having to do with irrigation, reclamation work and water storage, Egyptian Irrigation presents a very valuable compilation of statistics and details covering the extensive development of the Nile region. The Aswan dam and the Delta Assint, Zifta and Esna barrages, to which Egypt is indebted for its transformation, are known throughout the world for the engineering skill, which their construction has entailed. That "the Egyptian question was the Irrigation question," has been for years a well-known saying, as the influence of irrigation pervades Egyptian economics, politics, social life, agriculture, legislation and even religion.

The work includes the fullest information obtainable of the Nile and its tributaries; together with minute presentations of the problems and their solution, covering some of the most interesting hydraulic questions ever encountered.

Sir William Willcocks, whose engineering work in Egypt dates from 1883, was the author of the first two editions of this treatise. The first was published in 1889, just about the time, according to Milner's "England in Egypt" he, while on an exploration trip for the Minister of Public Works, into Upper Egypt, had occasion to join, and take part in, a Mohammedan thanksgiving service in a mosque at Tahta. Later, as Director-General of Reservoirs, he drew up the designs and estimates of the Aswan dam and Assint barrage. Subsequently he prepared the Cairo drainage project. From 1908 to 1911 he acted as consulting engineer to the Turkish Government and prepared projects for irrigating 3,000,000 acres, and controlling the Euphrates and Tigris. (In connection with this work he is at present in America at the Savannah drainage convention as announced in last week's issue of *The Canadian Engineer*.

His collaborator, Mr. J. I. Craig, has spent 12 years in Egyptian engineering. He is now Controller of Statistics for the Egyptian Government, and is a distinguished mathematician and meteorologist.

Since the publication of the second edition of Egyptian Irrigation in 1899, all the above-mentioned regulating works, and others both in Upper and Lower Egypt, have been constructed, and have been attended or followed by notable results. This new edition completely covers the entire development. It necessarily contains a vast body of facts and figures. Reference to these, however, is facilitated by a system of triple indexing.

Volume I. deals in general with the geology, meteorology, hydrology of the Nile region; the Nile in detail; Basin Irrigation (2 chapters), and Perennial Irrigation (2 chapters). Volume II., has the following chapters: Drainage and land reclamation; the Nile in flood; Engineering details; Barrages; Water storage and flood protection; the Aswan dam; Agricultural; Administrative and legal. Appendices deal with Evaporation; Strength of Egyptian stones and mortars; Salt in various lakes; Discharge diagrams, etc.

The book is not the presentation of the views of one or two men. It contains the opinions of many experts, some of them in direct opposition to those of the author's. As an example, one chapter contains quotations from 10 different experts.

The volumes are well printed and strongly bound. Tables and illustrations are exceptional in their comprehensiveness and clearness. The metric system has been used throughout.

Outlines of Railway Economics.—By Douglas Knoop, M.A., Lecturer on Economics, University of Sheffield. Published by MacMillan and Company, Limited, London, New York and Toronto; 274 pp., 5 x 7 in.; cloth; price, $1.50.

This volume is based for the most part upon a study of the railway industry in Great Britain, although it contains frequent references to railways of other countries, particularly Canada and the United States. Its contents are carefully classified into 21 chapters, each dealing with an important and distinct phase of the application of economic study to railways. Some of these, characterizing the book, are as follows: Application of the law of increasing (and decreasing) returns to railways; Determination of prices under both competitive and monopoly conditions; Fixing of rates and fares, and State regulation thereof; State ownership and management of railways, etc.

In his introductory chapter the author presents the following special reasons for the study of the railway industry:

(1) Railways are of enormous importance in society; on the one hand, transportation has some share, great or small, in the production of all commodities, so that practically all producers and consumers are directly interested in the price of railway services. On the other hand, railways have a great influence on the distribution of population, and are consequently a matter of much social concern.

(2) The railway industry affords illustrations of some of the most interesting problems of price determination; the principle of differential charging can be seen at work in other industries, but nowhere is it so fully acted upon as in the case of railways.

(3) The railway industry, partly owing to its tendency to be monopolistic in character, has been marked out for special attention by the State throughout the world; governments either exercise considerable supervision over railways or actually own them.

Suspension Bridges.—By. Prof. Wm. H. Burr, 1913, published by Messrs. John Wiley and Sons, New York. Canadian Selling Agents, Renouf Publishing Company, Limited, Montreal. 414 pages, 67 text figures and 6 plates. Size, 6 x 9 in., cloth. Price, $4.50 net. Reviewed by David A. Molitor, C.E.

The book comprises eleven chapters and two appendices, devoted to the following subjects:—

Chapter I. deals with an approximate theory of the stiffening truss and the properties of the cable, employing a notation which is not uniform with the other chapters.

Chapter II. treats the statically determinate suspension cable with a three-hinged stiffening truss.

Chapters III. and IV. take up the statically indeterminate suspension cable with continuous and non-continuous straight stiffening trusses, considering the special cases of suspenders absent or present in side spans, using Menabrea's "method of least work." Pages 57 to 122 are practically a translation of pages 5 to 17, of chapter 12, vol. II., part IV., "Der Brückenban," by Prof. J. Melan, in Handbuch der Injenieurwissenschaften. More probably this was taken from the translation given in a "Report on Maximum Span Practicable for Suspension Bridges," 1894, by Major Raymond, Capt. Bixby, and Capt. Edw. Burr. The remainder of chapter IV. is elaborated from the same sources, and pages 175 to 211 are devoted to problems pertaining to the Manhattan Bridge, designed by Mr. Moiseieff.

Chapter V. gives the analysis of the straight stiffening truss, according to the method of deflections, and uses two illustrations applied to the Manhattan Bridge.

Chapter VI. concludes the subject of suspension bridges in the discussion of temperature stresses with applications to the Manhattan Bridge.

Chapter VII. deals with arch ribs by graphics applied to the cases with fixed and hinged ends, with one problem of each class.

Chapter VIII. treats of the arched rib for fixed and hinged ends, by Menabrea's "method of least work," giving an example of the fixed arch. This chapter clearly illustrates the circuitous process of the method of least work when compared with the elegance of the influence line method, according to Mohr, Müller-Breslau, Mehrtens, etc.

Chapter IX. briefly discusses the three-hinged arch rib.

Chapter X. devotes 7 pages to the spandrel braced arch.

Chapter XI. deals with cantilevers by analytical methods. This covers 28 pages of information usually given in standard works, without any numerical applications.

Appendix I. on limiting spans and depths of stiffening trusses, gives conclusions arrived at by Prof. Steinman in 1913.

Appendix II. devotes about 7 pages to formulae for reinforced concrete beams employing a notation radically different from the standard and thus rendering the formulae quite useless until the reader has memorized a notation covering 1½ pages.

As stated in the opening sentence of the Preface, "This book has been written primarily to meet the author's needs in the class room, where the chief requisite is the clear elucidation of general principles in connection with their bearing upon engineering work. The satisfactory accomplishment of such a task is none too easy in the treatment of the more simple statically determinate trusses or other structures, but it is excessively difficult when some statically indeterminate structures are under consideration."

To one familiar with the subject matter treated, it is quite apparent that the author has not achieved his principal aims, "the clear elucidation of general principles," and "to give each main structure a general treatment so as to make one demonstration cover all desired or useful special cases."

The general principles governing all structures involving redundancy have remained entirely out of consideration, and yet these are essential to a clear understanding of any modern methods of analysis, and cover all the general and special cases treated, both of suspension and arch bridges.

No criterion is given by which to judge the nature of any particular structure, that is, to decide definitely upon the number and character of redundant conditions involved. Yet this question alone determines the nature and difficulty of the stress analysis; and depending upon the choice of the redundant conditions, the problem becomes difficult or relatively simple, though the general laws and methods remain the same.

The first important step then would be to classify structures according to their degree of redundancy, and then to apply the general method of analysis for statically indeterminate structures. Without these preliminary steps, the solution in its special form loses its comprehensiveness and the reader fails to grasp the broad principles underlying the analysis.

To elucidate this point more clearly, the general process may be briefly sketched as follows: For any number of redundant conditions, X_a, X_b, X_c, etc., any function of the structure, as a moment M, shear Q or stress S may be expressed by general equations, thus:—

$$\left.\begin{aligned} M &= M_o - M_a X_a - M_b X_b - M_c X_c, \text{ etc.} \\ Q &= Q_o - Q_a X_a - Q_b X_b - Q_c X_c, \text{ etc.} \\ S &= S_o - S_a X_a - S_b X_b - S_c X_c, \text{ etc.} \end{aligned}\right\} \ldots\ldots(1)$$

These are applicable to the principal frame, derived from the given structure by removing as many members or external supports X, as may be necessary to convert the given structure into a statically determinate one. The quantities with zero subscripts are, therefore, found as for a beam or truss without redundancy, while the X's, which may be moments, stresses, or reactions, represent the unknown redundant conditions. These X's depend upon the elasticity properties of the material and cannot be evaluated by the methods of statics, while all other subscript bearing quantities can be readily found by statics applied to the principal frame.

For every structure there exist as many elasticity condition equations as there are redundant conditions, thus making the problem solvable after evaluating the X's by one of the following methods.

I.—Elasticity condition equations in terms of certain determinable stresses according to Prof. Mohr's work equations, where $l/EF = \rho$, as follows:—

$$\left.\begin{aligned} \delta_a &= \Sigma S_a S_o \rho - X_a \Sigma S_a^2 \rho - X_b \Sigma S_a S_b \rho - X_c \Sigma S_a S_c \rho + \Sigma S_a \textit{ etl.} \\ \delta_b &= \Sigma S_b S_o \rho - X_a \Sigma S_b S_a \rho - X_b \Sigma S_b^2 \rho - X_c \Sigma S_b S_c \rho + \Sigma S_b \textit{ etl.} \\ \delta_c &= \Sigma S_c S_o \rho - X_a \Sigma S_c S_a \rho - X_b \Sigma S_c S_b \rho - X_c \Sigma S_c^2 \rho + \Sigma S_c \textit{ etl.} \end{aligned}\right\} .(2)$$

II.—Elasticity condition equations in terms of certain determinable deflections according to Prof. Maxwell, thus:—

$$\left.\begin{aligned} \delta_a &= \Sigma P_m \delta_{ma} - X_a \delta_{aa} - X_b \delta_{ab} - X_c \delta_{ac} + \delta_{at.} \\ \delta_b &= \Sigma P_m \delta_{mb} - X_a \delta_{ba} - X_b \delta_{bb} - X_c \delta_{bc} + \delta_{bt.} \\ \delta_c &= \Sigma P_m \delta_{mc} - X_a \delta_{ca} - X_b \delta_{cb} - X_c \delta_{cc} + \delta_{ct.} \end{aligned}\right\} ..(3)$$

There will always be as many such equations of the form (2) or (3) as there are redundant conditions X.

Owing to the innumerable values of the variable X's required to solve any case for moving loads, the only practicable solution for statically indeterminate structures, even those of the first degree, is by the method of influence lines as first given by Prof. Mohr. The solution is reduced to its simplest possible form by a judicious choice of the redundant conditions as proposed by Prof. Müller-Breslau, by which certain terms of equations (2) or (3) are reduced to zero, thus saving the laborious solution of simultaneous equations.

However, it is not the writer's purpose to do more than to show the broader aspect of this subject which the author has tacitly passed over, and which is of the utmost value in rendering the subject intelligible.

The complexity of the suspension problem in a general treatise is not so much in the solution of the individual case, as in the innumerable variety of possible and feasible cases which exist. Thus any form of truss, arch or cantilever can be combined with a suspension cable, an eye-bar chain or a braced chain.

The author deals with only three general combinations of cables with straight stiffening trusses; 1, girder, with centre hinge; 2, simple girder on two supports; 3, continuous girders. These comprise merely the ordinary types in use. Prof. Müller-Breslau in his Graphische Statik, treats 17 cases without exhausting the subject.

Little or nothing is said regarding the stresses in the individual members of the stiffening trusses, or of braced arches, except for the two-hinged braced spandrel arch. Yet this is quite an important part of the subject and constitutes the real problem after the redundant conditions are solved.

The questions of economic shape and critical sections of an arch rib are not answered, yet a knowledge of these matters is most essential in procuring practical designs with a minimum af labor. It is the writer's experience also, that the "Method of least work" more properly deserves the name "Method of most labor."

The illustrative problems given are not sufficiently comprehensive to serve as complete examples, leaving a great deal to be supplied by the reader in planning actual computations.

While influence lines are employed to a limited extent, far greater use should have been made of these in the analysis of stresses. For the structures treated are precisely those which should be treated by influence lines in preference to any other method.

The style of the book is of uniform excellence with the Wiley publications, though the full-page plates are poorly drawn.

No bibliography is given, and with very few exceptions, only the names of those offering direct assistance to the author are mentioned.

It is rather difficult to understand why students should devote much time to the study of suspension bridges when there is so much fundamental work crowded out by the already overfilled curriculum. On the other hand, the few engineers who may accidentally have to deal with this subject, will do well to consult those authors who have dealt more exhaustively with statically indeterminate structures in general, and suspension bridges in particular.

PUBLICATIONS RECEIVED.

Temiskaming and Northern Ontario Railway Commission.—12th annual report, for the year ending October 31st, 1913.

Electric Switches for Use in Gaseous Mines.—By H. H. Clark and R. W. Crocker, United States Bureau of Mines, Bulletin No. 68, 38 pp., illustrated. A study of methods for preventing switching flashes from igniting gases surrounding the switch.

Specifications for Open-Hearth Steel Girder and High Tee-Rails, as adopted by the American Railway Engineering Association, and by the American Society of Testing Materials. Issued in pamphlet form by Robt. W. Hunt and Co., Limited, McGill Building, Montreal.

Illinois Water Supply Association.—Proceedings of the 6th meeting of this Association, held at the University of Illinois, March 9th to 11th, 1914, containing reports of committees, papers, discussions and general society affairs. 240 pp., illustrated, 6 x 9 in.; cloth.

Sampling and Examination of Mine Gases and Natural Gas.—By George A. Burrell and Frank Seibert, issued as bulletin No. 42, of the United States Bureau of Mines, 116 pp., illustrated. It takes up the collection and analysis of samples and gives a full description of the apparatus and methods used in the various operations.

Tests on Concrete in Sea Water—Progress report of an investigation made by the Aberthaw Construction Co., and H. L. Sherman, Boston, at the United States Navy Yard, Charlestown, Mass., to determine the effect, both mechanical and chemical, of the action of sea water and varying temperatures upon concrete piers of varying composition. Specimens made and immersed early in 1909 were recently examined. A 36 pp., illustrated booklet discloses the observations made.

Preparation of Metallic Cobalt by Reduction of the Oxide.—By H. T. Kalmus, B.Sc., B.H.D., published by the Mines Branch, Department of Mines, Canada, and covering research on cobalt and cobalt alloys conducted at Queen's University, Kingston, 36 pp., illustrated, describing preparatory treatment, methods and apparatus, and reduction with carbon, carbon monoxide, hydrogen and aluminium at various temperatures. The bulletin forms Part 1 of a series of 6 on the study of cobalt.

Trent Watershed Survey.—By C. D. Howe and J. H. White, with an introductory discussion by B. E. Fernow, Dean, Faculty of Forestry, University of Toronto. Published by the Committee on Forests, Commission of Conservation, Canada. 156 pp., illustrated, size 6 x 9 in.; cloth.

This is a report on the conditions in the Trent Watershed and recommendations for their improvement. It outlines the procedure of the survey, its results, etc. One section of the book is devoted to physiographic and forests conditions, including drainage, topography, geology, soils, etc., and a discussion of the financial losses due to forest fires. Another section is devoted to the mechanical and industrial conditions covering farming, lumbering, tourist traffic and social conditions. The book is accompanied by five appendices.

Conservation of Coal in Canada.—By W. J. Dick, M.Sc., Mining Engineer, published by the Committee on Minerals, Commission of Conservation, Canada. 212 pp., 6 x 9 in., illustrated with photographs, maps and diagrams; cloth.

In his report Mr. Dick reviews a full investigation of the coal situation in Canada. Its dependence on the United States for its supply of anthracite coal is one of many points strongly brought out. The development of electric power in the lignite fields of Western Canada is recommended. The manufacture of coal briquettes in other countries is described in detail and the methods adopted to conditions in Canada are indicated. Comparisons are made between the beehive ovens and the by-product ovens for the coking of coal and the economies effected by the latter over the former are clearly presented. Descriptions are given of the principal coal mines in Canada.

The book will be found of great value, not only to those directly engaged in coal mining, but to all who are interested in the economic development of a country.

Good Roads Year Book, 1914.—J. E. Pennybacker, editor, published by the American Highway Association, Washington, D.C., 500 pp., illustrated, 6 x 9 in.; cloth; price $1.

The 1914 Good Roads Year Book is very comprehensive in its collection of data for road men of the United States. It is issued annually by the Association as part of its campaign throughout the country for an adequate system of improved highways. A considerable portion of the volume is devoted to state aid and local road legislation, digests of various road, automobile and convict laws, etc. It contains a complete list of patents issued in 1913 pertaining to roads; a list of bulletins, circulars and documents published in the interests of road builders; a reference list of papers, addresses and magazine articles published in 1913 on the subject of roads. It 'synopsizes' the academic courses in highway engineering of the various universities and colleges, and catalogues the various road associations. The work in different states and the progress of road improvement are featured, while a chapter deals with the important events in the road movement during 1913.

CATALOGUES RECEIVED.

Welding and Cutting Plants.—A 16 pp. catalogue of equipment for acetylene welding issued by Waterhouse Welding Co., Boston, Mass.

Air Compressors.—A 48 pp. leaflet issued by the Canadian Ingersoll Land Co., Montreal, outlining some advantages in their Class "N" compressors.

Aneroids.—A small catalogue circulated by the Topley Co., Ottawa, descriptive of watch and pocket aneroid barometers of "Tycos" make.

Ironclad-Exide Battery.—A sketch of the development of this type of battery in a 24 pp. booklet issued by the Canadian General Electric Co., Toronto.

Cranes for Wharves and Docks.—A pamphlet illustrating typical uses of Demag Cranes, issued by the Deutsche Maschinenfabrik A-G Duisburg, Germany.

Duntley Electric Tools.—An 8 pp. bulletin of Chicago Pneumatic Tool Co., describing portable drills, grinders, spike drivers, etc., for street and interurban railway use.

Mining Tools.—Bulletins Nos. 152-3 and 4 of the Chicago Pneumatic Tool Co., Limited, illustrating their drills, sinkers and stopers, together with the accessories for each.

Railway Motor Gears and Pinions.—20 pages descriptive of forged, solid and split cast-steel gears, pinions, etc. Circulated by the Canadian General Electric Co., Toronto.

Aston Fans.—A 24 pp. illustrated catalogue issued by Veritys, Limited, London, E.C., dealing with the Aston range of ceiling, desk, bracket, ship, railway and saloon fans and blowers.

Small Direct Current Generators.—Bulletin No. A-4188, descriptive of type CVC small, belted, direct current generators; illustrated, 12 pp., issued by Canadian General Electric Company, Toronto.

Montezuma Asphalt.—A beautifully illustrated booklet of 56 pages, issued by the Warner-Quinlan Asphalt Co., New York, describing the qualities and illustrating many streets and roads upon which Montezuma asphalt has been used.

"Steele" Buildings.—A bulletin issued by the William Steele and Sons Co., engineers and contractors, Philadelphia, illustrating a large group of industrial buildings in the design and construction of which that company has had to do.

Chain-Blocks.—A 4 pp. pamphlet illustrating and describing the Morris travelling spur gear chain-block of different types showing saving of headroom due to special design, issued by the Herbert Morris Crane and Hoist Company, Toronto.

Pneumatic Appliances.—An 80 pp. catalogue of air compressors, air hoists, air cranes, pneumatic and hydro-pneumatic elevators, trolleys and trolley systems, and sand blasts fully illustrated, issued by the Curtis Pneumatic Machinery Co., St. Louis, U.S.A., as catalogued No. 62.

Dudbridge Gas Engines.—These types of variable admission gas engines and of gas producing plants are described in a 28 pp. illustrated catalogue issued by Dudbridge Iron Works, Limited, Stroud, England. It shows diagrammatically the construction of the various types and parts, and contains tables of dimensions of capacities, speeds, weights, etc.

NEWS OF THE ENGINEERING SOCIETIES

Brief items relating to the activities of associations for men in engineering and closely allied practice.
THE CANADIAN ENGINEER publishes, on page 90, a directory of such societies and their chief officials.

OTTAWA BRANCH, CAN. SOC. C.E.

The closing meeting for the year of the Ottawa branch of the Canadian Society of Civil Engineers was held on Thursday evening, April 23rd.

Mr. C. A. Magrath, C.E., Member of the International Joint Commission and Chairman of the Ontario Highways Commission, gave a short address on "The Engineer and His Profession."

BRITISH COLUMBIA ASSOCIATION OF LAND SURVEYORS.

The British Columbia Association of Land Surveyors has announced the following successful candidates as a result of recent preliminary examinations; G. V. Atkins, R. R. Browne, F. H. Blunt, C. Carswell, G. C. Dunsford, C. N. Dean, G. A. Earle, E. D. Fort, A. B. Fraser, G. F. Heaney, A. D. C. Herne, L. Held, J. L. L. Johnston, W. M. Myers, J. A. McCulloch, J. D. Slaven, F. W. Stevens, N. T. Townsend, R. P. Thomson, and R. S. Wood.

"SUBAQUEOUS TUNNELLING."

This was the subject of a paper read on the evening of April 23rd by Paul Seurot, C.E., chief engineer of Jacobs and Davies, Montreal, at a general meeting of the Canadian Society of Civil Engineers.

COMING MEETINGS.

AMERICAN WATERWORKS ASSOCIATION.—Thirty-fourth Annual Meeting to be held in Philadelphia, Pa., May 11-15, 1914. Secretary, J. M. Diven, 47 State Street, Troy, N.Y.

AMERICAN HIGHWAYS ASSOCIATION.—Fourth American Road Congress to be held in Atlanta, Ga., November 9-13, 1914. J. E. Pennybacker, Secretary, Colorado Building, Washington, D.C.

AMERICAN PEAT SOCIETY.—Eighth Annual Meeting will be held in Duluth, Minn., on August 20, 21 and 22, 1914. Secretary-Treasurer, Julius Bordollo, 17 Battery Place, New York, N.Y.

AMERICAN SOCIETY FOR TESTING MATERIALS.—Seventeenth Annual Meeting to be held in Atlantic City, N.J., June 30 to July 4, 1914. Edgar Marburg, Secretary-Treasurer, University of Pennsylvania, Philadelphia, Pa.

UNION OF CANADIAN MUNICIPALITIES.—Annual Convention to be held in Sherbrooke, Que., August 3rd, 4th and 5th, 1914. Hon. Secretary, W. D. Lighthall, Westmount, Que. Assistant-Secretary, G. S. Wilson, 402 Coristine Building, Montreal.

CANADIAN AND INTERNATIONAL GOOD ROADS CONGRESS.—To be held in Montreal, May 18th to 23rd, 1914. Mr. G. A. McNamee, 909 New Birks Building, Montreal, General Secretary.

INTERNATIONAL CONFERENCE ON CITY PLANNING to be held in Toronto, May 25-6-7, 1914, in charge of the Commission of Conservation. Secretary, James White, Ottawa.

CANADIAN FORESTRY ASSOCIATION.—Annual Convention to be held in Halifax, N.S., September 1st to 4th, 1914. Secretary, James Lawler, Journal Building, Ottawa.

ROYAL ARCHITECTURAL INSTITUTE OF CANADA.—Seventh Annual Meeting to be held at Quebec, September 21st and 22nd, 1914. Hon. Secretary, Alcide Chaussé, 5 Beaver Hall Square, Montreal.

CONVENTION OF THE AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—To be held in Boston, Mass., on October 6th, 7th, 8th and 9th, 1914. C. C. Brown, Indianapolis, Ind., Secretary.

PERSONALS.

J. A. SKERTCHLY, an English mining engineer, is visiting British Columbia to report on gold properties.

GEO. W. CRAIG, City Engineer of Calgary, recently delivered a very interesting and attractive lecture on city planning in that city.

W. S. HARVEY has discontinued his connection with the city of Lethbridge as its acting city engineer, owing to its having adopted commission control of civic affairs. Mr. Harvey is at present in Eastern Canada.

J. W. EVANS, of Belleville, has recently been appointed city engineer of that place, to fill a vacancy of over a year's standing. Mr. Evans, who is president of the Tivani Steel Company, of Belleville, was previously associated with the Bay of Quinte Railway as engineer.

FREDERICK W. COWIE, chief engineer of the Montreal Harbor Board, was recently awarded the Telford gold medal by the Institution of Civil Engineers of Great Britain for his paper, entitled "Transportation Problems in Canada and the Montreal Harbor," read on April 7th. His paper appears in extract form in another part of this issue.

G. N. GUEST, A.M.I. Mech. E., M.I.H.V.E., director of Hollings and Guest, Limited, of Birmingham, England, engineers and manufacturers of hydraulic presses, pumps, accumulators, etc., will visit Canada at the end of May. Mr. Guest will tour the country thoroughly, visiting all the principal towns and cities.

F. A. YERBURY, M.I. Mech. E., manager of the Heaps Engineering Company, Limited, Vancouver, B.C., has resigned and expects to return to England about the end of May. Mr. Yerbury has been in Canada for a number of years. He was formerly manager of the Canadian Boving Company, and while with that firm he introduced the Diesel engine into Canada. Mr. Yerbury will devote his time to inspection work throughout Europe for Canadian and American firms, also reporting on European machinery, methods and progress.

OBITUARY.

As the result of the capsizing of a small boat in the Fraser river, near Lytton, B.C., Messrs. E. T. Shaw, R. M. Horton and H. Burniston, three engineers on Canadian Northern Railway construction, were drowned last week. Mr. Shaw was a son of Mr. H. S. Shaw, of Ottawa, and was division engineer of that section.

The death is announced at Burlington, Ont., of Mr. William White, whose connection with engineering as a contractor is known to many. Mr. White carried out a number of contracts for the Government, among them being the timber works at Sault Ste. Marie new locks, and the C.P.R. trestles on the north shore of Red Sucker Cove. He built piers at Port Colborne and many other places, also many bridges throughout Ontario.

The death occurred on April 19th of Alfred Noble, C.E., a very prominent member of the engineering profession in New York. His career was a most interesting one, and typical of that of many great men of the profession who rank as nation-builders. Among his many activities in engineering work were the following: From 1868 to 1870 he was assistant engineer on river and harbor work on the Great Lakes. From 1870 to 1872 he was in charge of improvements on St. Mary's Falls canal and St. Mary's river. During this time the first great masonry lock at the Sault, then by far the largest canal lock in the world, was built. On completion of this work he became resident engineer on the construction of an important bridge at Shreveport, La., over the Red River. From 1883 to 1886 he was general assistant engineer, Northern Pacific R.R. From 1886 to 1887 he was resident engineer on the construction of the Washington bridge over the Harlem River; at that time the largest arch bridge in existence. From 1887 to 1894 he was resident engineer on the construction of several bridges over the Mississippi at Memphis and Alton, over the Missouri at Bellfonton and Leavenworth, over the Ohio at Cairo. He was appointed a member of the Nicaragua Canal Board, which visited Central America and examined the route of the Nicaragua Canal, and also the Panama Canal.

In 1899 he became a member of the Isthmian Canal Commission, which was charged with the selection of the best canal route across the isthmus, and it has been substantially on the route selected by this Commission that the Panama Canal has been constructed.

In 1905 he was appointed a member of the International Board of Enginers to recommend whether the Panama Canal should be constructed as a sea-level or a lock canal. This Board consisted of thirteen members, of whom five were nominated by foreign countries. Mr. Noble was one of the minority of five Americans who recommended the adoption of the lock-level plan. Their views were adopted by the Government and the Canal has been built in accordance with their recommendations.

In March, 1907, he was one of the three to visit the Panama Canal to investigate the conditions regarding the foundations of some of the principal structures. Mr. Noble was continuously identified with the Canal project and deserves much credit for the solution of its engineering problems.

In July, 1897, he was appointed a member of the United States Board of Engineers on Deep Waterways, which made surveys and estimates of cost for a ship canal from the Great Lakes to deep water in the Hudson River. In November, 1901, the city of Galveston, Texas, appointed Alfred Noble, along with Henry C. Ripley and General Robert, as a Board of Engineers to devise a plan for protecting the city and suburbs from future inundation. From 1902 to 1909 Mr. Noble was chief engineer of the East River Division of the New York extension of the Pennsylvania R.R., and was in entire charge. Since 1909 he engaged in general practice as a consulting engineer. Probably the most important work dealt with was in relation to the dry docks built for the United States Government near Honolulu. He was also for a time consulting engineer to the Quebec Bridge Board, to the Board of Water Supply, New York City, and to the Public Service Commission of the State of New York.

He has been Past President of the Western Society of Engineers, American Society of Civil Enginers, and American Institute of Consulting Engineers, and an Honorary Member of the Institution of Civil Engineers of Great Britain.

Coast to Coast

Regina, Sask.—A considerable reduction in power rates will probably go into force in Regina within the near future, the civic utilities committee having decided to grant various concessions in the interests of the power user.

Toronto, Ont.—It is reported that an agreement has been effected between the G.T.R. and C.P.R. companies in connection with plans for the Toronto Union Station. These will be submitted to the Dominion Railway Board about May 15. The matter of the viaduct construction has not been finally decided, and will be given later consideration. The cost of the Union Station is estimated at between $12,000,000 and $15,000,000, and that of the viaduct at $3,000,000.

Ottawa, Ont.—The Railway Commission has considered the proposition of the building of the proposed "All Red Line Railway" with a total projected length of 3,270 miles, and has cut it down to a line of but 1,000 miles in length to run from Cape St. Charles on the Labrador coast, to the city of Quebec. The name of the railway was changed to "The Labrador, Quebec and Southern Railway," and the capital stock was reduced from one hundred millions to ten millions. The line, as now authorized, will run west from Cape St. Charles to the Peribonka River, 600 miles; then through the valley of the Peribonka River to a point on Lake St. John, 200 miles further, and then on to the city of Quebec.

Montreal, Que.—The Montreal board of control for the present fiscal year has voted sums amounting to $2,789,907 for public works which have been recommended by Chief Engineer Janin. Of this amount $1,500,722 is to be expended on pavements, $915,545 on sewers and $373,640 on waterworks. The sewer allowance is divided as follows: $31,345 for the East division, $639,500 for the West division, and $244,700 for the North division. The amount for paving is divided as follows: $387,410 for the North division, $621,254 for the West division, and $492,057 for the East division, and the appropriation for the waterworks department is to be used as follows: main pipe $125,000, new services in all sections of the city $65,000, hydrants $27,000, meters $30,000, pipes to relieve strain on present pipes $86,175, and $40,465 for the cost of installing pipes.

Winnipeg, Man.—The season's programme of railway construction in Manitoba, Alberta and Saskatchewan has been definitely decided. The C.P.R. will proceed with the grading which is being done on the 15-mile extension of the Moose Jaw south-west branch beyond Expanse, and will also lay steel upon the same. Also grading will be done on a further 25-mile extension of the line proceeding from Sterling East, though steel may not be laid this year. The C.P.R. will also proceed with grading operations as follows: 72 miles on the Monitor-Kerr Robert line, 25 miles Suffield south westerly, 87 miles on the line running west of Weyburn, 25 miles on a line running north westerly from Coronation, and 126 miles on the line from Bassano easterly. The G.T.P. operations will be largely confined to the branch into Prince Albert from Young, Sask., and the track laying on the Brandon branch in Manitoba. The main line in British Columbia will be completed. On the C.N.R., construction work will be done on the Peace River line from Onoway on the main line north-westerly; also on a line on the north side of the Saskatchewan River extending from Oliver to meet the branch running west from North Battleford. Work will be in progress on the Calgary-Lethbridge branch, on the Elrose to Alsack branch on the Gravelbourg-Swift Current line, on the extension of the Thunder Hill branch, and on the branch from Wroxton to Yorkton.

ORDERS OF THE RAILWAY COMMISSIONERS OF CANADA

Each week on this page may be found summaries of orders passed by the Board of Railway Commissioners, to date. This will facilitate ready reference and easy filing. Copies of these orders may be secured from *The Canadian Engineer* for small fee.

21632—April 11—Approving location C.N.O.R. station grounds at Lac a Travers, mileage 140.8 from Ottawa, Division "E," Twp. White, Dist. Nipissing, Ontario.

21633—April 11—Approving, subject to terms of consent of Twp. of Verulam, location of platform and shelter of C.P.R. (Lindsay, Bobcaygeon and Pontypool Ry.) at mileage 36.0, Bobcaygeon Sub. Div., in Lot 13, Con. 7, Tp. of Verulam, Co. Victoria, Ont.

21634—April 14—Reporting to Governor-in-Council for sanction By-law No. 13, approving "General Train and Interlocking Rules," for observance by officers and employees of Dominion Atlantic Railway Company, in operation of its railway.

21635—April 14—Authorizing C.L.O. and W. Ry. (C.P.R.) to take, without consent of owner, certain lands in town of Oshawa, for purpose of affording access to diversion of Albert Street, said town.

21636—April 14—Authorizing C.P.R. to use bridge No. 18.7 on St. Gabriel Subdivision, Eastern Division.

21637—April 14—Authorizing C.P.R. to operate over bridge No. 11.3, Standbridge Subdivision, Eastern Division, Que.

21638—April 15—Approving location Pacific and Hudson Bay Ry. from Bella Coola Harbor to Hagensborg, B.C., mileage 0 to 10, Coast Dist.

21639—April 14—Authorizing Lake Erie and Northern Ry. to construct bridge over Western Counties Canal, station 3.00, at Brantford, Ontario.

21640—April 8—Authorizing T.H. & B. Ry. to take certain lands situate in Twp. Pelham, Co. Welland, Ont., for purpose of providing two or more team tracks upon such lands.

21641—April 15—Authorizing C.N.R. to cross and divert public highway on S.W. ¼ Sec. 19-10-30, W. P. M., mileage 76, Kipling Subdivision.

21642—April 14—Authorizing C.N.R., at its own expense, to construct and maintain a highway crossing over its railway on Second St. North, in S.E. ¼ Sec. 1-47-6, W. 3 M., Townsite of Leask, Sask.

21643—April 14—Directing that, within 60 days from date of this Order, G.T.R. install stop blocks on sidings on its line at east side of Cherry Street, Toronto, Ontario.

21644—April 9—Authorizing, subject to terms contained in paragraphs 1 and 2, Bylaw No. 9 of Town of Goderich, G.T.R., to construct siding into premises of American Road Machine Co. of Canada, Limited.

21645—April 14—Authorizing G.T.R. to use and operate bridge No. 257, mileage 25.25, 13th Dist. in Town of Milton, Ont.

21646—April 14—Amending Order No. 19646, dated May 16th, 1913, by striking out all words after word "Caution," in fifth line of operative part of Order, and substituting therefor following, namely: "All trains must come to a full stop at that semaphore and then proceed to the home semaphore and there be governed by the rules governing the operation of interlocked signals."

21647—April 16—Approving revised location G.T.P. Branch Lines Co., Battleford Branch, through N.W. ¼ Sec. 4.43-16, W. 3 M., Sask.

21648—April 15—Approving revised location G.T.P. Branch Lines Co.'s station at Coalspur, mileage 35.8, Alberta Coal Branch, in Sec. 33-48-21, W. 5 M., Alberta.

21649—April 16—Amending Order No. 21537, dated March 23rd, 1914, by striking out figures and letters "19th" in fifth and second lines of description of bridges, under heading "District," and substituting therefor figures and letters "20th."

21650—April 15—Authorizing C.N.O.R. to construct bridge over Raimbault Creek, Parish St. Laurent, Co. Jacques Cartier, Que., mileage 48 from Hawkesbury; and rescinding Order No. 19657, dated June 21st, 1913.

21651—April 15—Approving location C.N.R. extension of Swift Current Line through Tp. 15-10 and 12, west 3rd, Meridian, Sask., mileage 124.96 to 142.53.

21652—April 17—Authorizing C.P.R. to construct spurs for F. A. Fish, from a point on easterly limit of right-of-way Main Line, mileage 26.62, Orangeville Subdivision, Ont. Div. in Lot 14, Con. 3, west of Hurontatio St., Township of Caledon, Co. Peel, Ont.

21653—April 17—Directing that, within 30 days from date of this Order, G.T.P. Ry. re-appoint station agent at Zelma, Sask.

21654—April 18—Authorizing C.P.R. to construct road diversion in Sec. 22-36-11, W. 4 M., Alta., and construct, by means of grade crossings, tracks of Swift Current Northwesterly Branch line across eleven (11) highways, mileage 0.0 to 13.0 of said Branch Line.

21655—April 16—Authorizing, subject to terms of resolution, Esquimalt and Nanaimo Ry. to construct siding to property of B. C. Pottery Co., at Esquimalt, B.C.

21656—April 16—Relieving G.T.R. from providing further protection as crossing of St. Patrick St., village of Port Dover, Ontario.

21657—April 17—Granting leave to Hamilton Cataract Power, Light and Traction Co., Limited, to erect, maintain and place 2,400-volt overhead distribution circuit over G.T.R. branch line at Ferguson Ave., north of Barton St., Hamilton, Ont.

21658—April 15—Approving and authorizing, subject to condition that company keep its employees off sides of cars on freight shed side, clearances as shown on plan of an overhead platform runway to serve tracks of T.H. & B. Ry. on north side of Forest Ave., Freight House, city of Hamilton, Ont.

21659—April 18—Authorizing C.N.O.R. to construct across Castle Crescent Road in Lots 36 and 37, Con. 3, F. B., Tp. York, Co. York, Ont., by means of structure carrying highway over railway.

21660—April 17—Authorizing C.N.R. to cross and divert two (2) highways on Maryfield Branch, Sask., namely,—South Road Allowance between Secs. 7 and 8-26, W. 2 M.; and Highway between Secs. 19-5-27, W. 2 M., and Sec. 24-5-28, W. 2 M.

21661—April 16—Authorizing Montreal and Atlantic Ry. Co., to construct siding for Bedford Manufacturing Co., Bedford, Que., from point on westerly limit of right-of-way, mileage 11.16, Stanbridge Subdivision, thence southwesterly across Lots Cadastral Nos. 1315, 1314, 1313, 1310, 1304, 1302 and 1303, Rge. 7, Tp. Stanbridge, Co. Missisquoi, Quebec.

21662—April 16—Authorizing Western Canada Power Co., Limited, to construct spur from point on main line, running through Langley Indian Reserve No. 2, crossing a highway in the Mission Dist. Mun., to connect with trestle in the Stave River, B.C.

21663—April 15—Authorizing Montreal and Atlantic Ry. to construct spur for B. R. Stevens, town of Bedford, Que.

21664—April 17—Authorizing C.P.R. to construct, at grade, tracks of wye at mileage 230.0 on Weyburn-Stirling Branch, across road allowance between Secs. 8 and 17, Tp. 8, Rge. 18, W. 3 M., Sask.

21665—April 17—Authorizing C.P.R. to construct alterations and extensions to tracks at Hardisty St., Fort William, Ont.