PAGES

MISSING

Volume 30. Toronto, February 24, 1916. Contents of this issue on page 5.

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

STRESSES IN LATTICE BARS OF CHANNEL COLUMNS

DERIVATION OF THEORETICAL FORMULA THAT TAKES LENGTH INTO CONSIDERATION AND THEREFORE ALLOWS FOR STRESS CAUSED BY BENDING AND THAT ALSO AGREES CLOSELY WITH ACTUAL TEST RESULTS.

By **William Worth Pearse, C.E.,**
City Architect and Superintendent of Building, City of Toronto.

FORMULÆ for calculating stresses in lattice bars of columns have hitherto generally been considered empirical, but the writer believes that in the following will be found a theoretical formula which will meet any and all conditions, and which checks up with actual tests.

As a matter of history, it might be noted that on November 2nd, 1907, an article by the writer was published in Engineering Record, of New York, in which the writer evolved a formula for transverse shear which has since been adopted by several authorities, but which does not take into account the length of the column. In the following article the writer has evolved a formula which takes length of column and bending into account.

The formula published nine years ago was as follows:

$$R = \frac{232\,Ar}{n} \quad \text{[Equation a.]}$$

where A = area of column.
r = radius of gyration, axis parallel to back of channels.
n = distance from neutral axis to extreme fibre.

Equation a was derived from the New York law for columns, as follows:—

$$\frac{P}{A} = 15{,}200 - 58\frac{l}{r} \quad . \quad \text{[Equation b.]}$$

Now, if the American Railway Engineering Association's formula is used, which is

$$\frac{P}{A} = 16{,}000 - 70\frac{l}{r} \quad , \quad \text{[Equation c.]}$$

then $$R = \frac{280\,Ar}{n} \quad . \quad \text{[Equation d.]}$$

Equation d is the value for the transverse shear adopted by several authorities. It can easily be proven by direct proportion that Equation a and Equation d are similar, as follows:—

$$58 : 70 :: 232 : x$$

Therefore, $x = 280$.

It will be noticed that in Equations a and d the length does not appear.

Now, it is evident if we put $l = 0$ in Equations b and c that the quantity to be deducted due to bending drops out, and that nothing would be deducted due to the bending of the column, or in other words as the length of the column approaches zero, the stress to be deducted due to the bending also approaches zero, or there is a much greater stress in the column due to bending when the column is long. As it is only the stress caused by the bending of the column that causes any stress in the lattice bars, it is evident that the longer the column is, the greater must be the stress in the lattice bars.

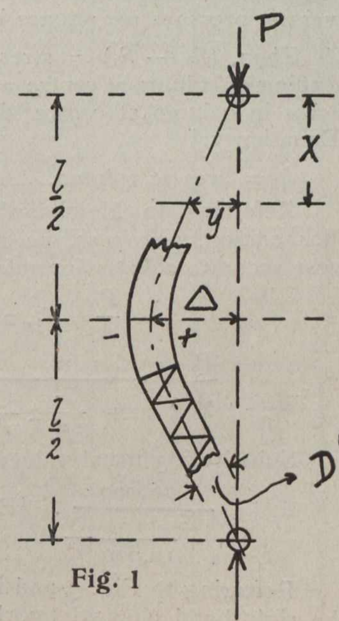
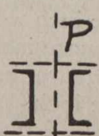


Fig. 1



By referring to Table No. 1, it will be noticed that the stresses for different lengths vary. Columns 9′ 0″ long have much less stress in the lattice bars than columns 20′ 0″, of the same cross-sections. (See Column 2 of Table No. 1.) It is, therefore, evident from the above that Equations a and c are incorrect except for one length of column, whatever that length may be.

For the same reason, the ratio given in Bulletin No. 44 of the University of Illinois, which was given as .0251 of the compression load, can only be correct for columns having a ratio of $\frac{l}{r} = 37.8$, or thereabouts. By referring again to Table 1, Cols. 11 and 12, it will be seen that for approximate ratios of $\frac{l}{r} = 37.8$, that the ratio .0251 compares very closely indeed with the result of the formula given hereafter.

Derivation of Formula.—Referring to Fig. 1, it has been assumed that column is hinged top and bottom, and that a load P is applied top and bottom.

If the column is very short the material will be crushed and there will be an even pressure over both channels, as shown by Fig. 2, and equal to S_0 per square inch.

Fig. 2.

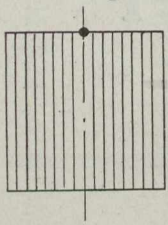
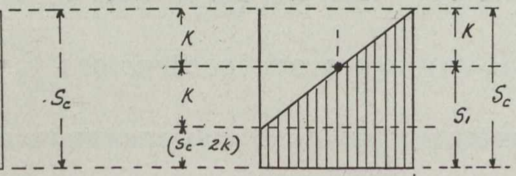


Fig. 3.



If the column is long, it will fail by bending and there will be tension on one side and compression on the other, or, by referring to Fig. 3, it will be seen that there is a difference of stress between the two channels equal to $2k$.

Or the total stress in channel marked C.R. would be $2k\frac{A}{2}$, due to bending.

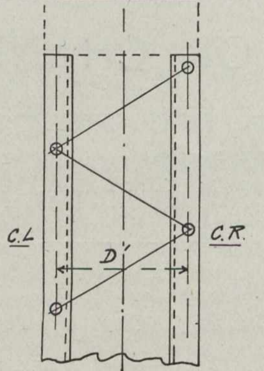


Fig. 4.

Let S_0 = 16,000 lbs. = allowable pressure per square inch when column is very short, and S_1 = allowable average pressure per square inch for long columns.

Then, $(S_0 - S_1)$ = stress per square inch due to bending of column at centre = k, and $(S_0 - S_1)A$ = total stress in column at centre due to bending of column. [Equation 1.]

A = area of column.

Referring to Merriman's Mechanics of Materials, 1894 edition, page 132, he gives what he considers the most accurate column formula for

$$\frac{P}{A} = S_1, \text{ namely,}$$

$$\frac{P}{A} = \frac{S_0}{1 + \frac{S_0}{m\pi^2 E}\frac{l^2}{r^2}} \quad \text{[Equation 2.]}$$

Substituting usual values in Equation 2,

$$S_1 = \frac{16{,}000}{1 + \frac{1}{12{,}000}\frac{l^2}{r^2}}. \quad \text{[Equation 3.]}$$

Referring to Fig. 3 and Fig. 4 it will be noticed that the right-hand channel (marked C.R.) has a stress per square inch = S_0, while channel marked C.L. has a stress per square inch = $S_0 - 2k$, making a difference in stress per square inch between the two channels of $2k$ per square inch.

But $k = (S_0 - S_1)$. [Equation 4.]

Therefore, $2k = 2(S_0 - S_1)$. [Equation 5.]

Then the total stress in channel (marked C.R.) due to bending is $= 2k\frac{A}{2} = 2(S_0 - S_1)\frac{A}{2}$. [Equation 6.]

Now referring to Fig. 1:—

When a long column is loaded it will bend as stated before, and the curve it will take will be a sinusoid whose equation is $y = \Delta \sin \pi \frac{x}{l}$. [Equation 7.] (Hinged ends only. If column is not hinged top and bottom, then the general equation for the flexure of the column will become $y = \Delta \sin n\pi x/l$. If one end is fixed and the other end is round, then $n = 2$. If both ends are fixed, then $n = 3$. The above equations would have to be used in place of Equation 7.)

(See Merriman's Mechanics of Materials, 1894 edition, page 115.)

Let M = bending moment at centre of column, then $M = P\Delta$.

Total stress in one channel due to

$$M = \frac{M}{D'}, \text{ and } \frac{M}{D'} = \frac{P\Delta}{D'}. \quad \text{[Equation 8.]}$$

But it was found in Equation 6 that the total stress in one channel was equal to $2(S_0 - S_1)\frac{A}{2}$.

$$\text{Therefore } \frac{P\Delta}{D'} = 2(S_0 - S_1)\frac{A}{2}. \quad \text{[Equation 9.]}$$

$$\text{Or, } \Delta = D'\frac{(S_0 - S_1)A}{P}. \quad \text{[Equation 10.]}$$

m = bending moment at any point x.

$= Py$. Substitute for y, (see Equation 7),

$$= P\Delta \sin \pi\frac{x}{l}. \quad \text{[Equation 11.]}$$

Substitute for Δ, (see Equation 10),

$$m = \frac{PD'(S_0 - S_1)A}{P} \sin \pi\frac{x}{l}.$$

$$\text{Or, } m = D'(S_0 - S_1)A \sin \pi\frac{x}{l}. \quad \text{[Equation 12.]}$$

Now, stress in channel at any point $x = \frac{m}{D'} = p$.

$$\text{Therefore, } \frac{m}{D'} = \frac{D'(S_0 - S_1)A}{D'} \sin \pi\frac{x}{l}.$$

$$\text{Therefore, } \frac{m}{D'} = (S_0 - S_1)A \sin \pi\frac{x}{l} = p. \quad \text{[Equation 13.]}$$

Referring to Fig. 5:—

The stress in end lattice bar $bc = p \sec \phi$.

Therefore, stress in end lattice bar

$$bc = (S_0 - S_1)A \sin \pi\frac{x}{l} \sec \phi. \quad \text{[Equation 14.]}$$

But there are two lattice bars; therefore,

$$bc = \frac{(S_0 - S_1)A \sin \pi\frac{x}{l} \sec \phi}{2}. \quad \text{[Equation 15.]}$$

But angle ϕ is usually 60° and the secant of 60° is 2; therefore, stress in each lattice bar

$$bc = (S_0 - S_1)A \sin \pi\frac{x}{l}. \quad \text{[Equation 16.]}$$

If Equation 16 is solved, it will give the stress in each end lattice bar when ϕ is 60°, and as the end bar

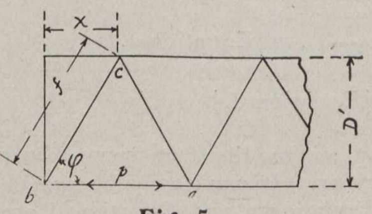


Fig. 5.

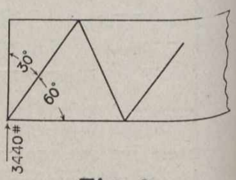


Fig. 6.

takes a maximum shear, all that it is necessary to do is to design the end bar and make the remainder of the bars the same size.

To find the stress in the lattice bars for any other angle than ϕ = 60°, use Equation 15, which is a general equation.

TABLE No. 1.—For Design of Lattice Bars of Columns.

(This is probably the first table ever published for this purpose that is worked out in such manner that a draftsman can use it for ready reference. A copy of this table, mounted on stiff cardboard and strung ready to hang, will be mailed free to any reader upon request to *The Canadian Engineer*.)

1	2	3	4	5	6	7	8	9	10	11	12	13.
L Length in feet.	Size of Channels.	A. area of Section sq. inches.	D. Distance C. to C. of rivets perpendicular to axis of column.	r.	L/r	x.	Sin. π x/L	S_1 Allowable stress per sq. inch on long columns lbs.	$S_c - S_1$ Stress per sq. inch due to bending of column.	Stress in each end lattice bar. lbs.	Stress in end lattice bar according to tests. lbs.	Size of Lattice bars.
9'-0"	2-6" ⊏ 8#	4.76	5¾"	2.34	46	3.32"	.096	13600	2400	1100		2¼" × 5/16"
"	2-7" ⊏ 9¾#	5.7	6¾"	2.72	40	3.9"	.113	14200	1800	1160	1170	"
"	2-8" ⊏ 11¼#	6.7	7½"	3.11	34	4.33"	.126	14600	1400	1180		"
"	2-9" ⊏ 13¼#	7.78	8¼"	3.45	31	4.76"	.139	14800	1200	1290		"
"	2-10" ⊏ 15#	8.92	9¼"	3.81	29	5.34"	.156	14950	1050	1450		"
"	2-12" ⊏ 20½#	12.06	11¼"	4.61	23	6.5"	.19	15350	650	1484		2¼" × 3/8"
"	2-15" ⊏ 33#	19.8	13¼"	5.6	19	7.65"	.221	15550	450	1870		2½" × 7/16"
12'-0"	2-6" ⊏ 8#	4.76	5¾"	2.34	61	3.32"	.073	12200	3800	1300		2¼" × 5/16"
"	2-7" ⊏ 9¾#	5.7	6¾"	2.72	53	3.9"	.086	12950	3050	1360		"
"	2-8" ⊏ 11¼#	6.7	7½"	3.11	46	4.33"	.096	13650	2350	1420		"
"	2-9" ⊏ 13¼#	7.78	8¼"	3.45	42	4.76"	.104	14000	2000	1600		"
"	2-10" ⊏ 15#	8.92	9¼"	3.81	38	5.34"	.116	14300	1700	1760	1848	"
"	2-12" ⊏ 20½#	12.06	11¼"	4.61	31	6.5"	.142	14800	1200	2030		2½" × 3/8"
"	2-15" ⊏ 33#	19.8	13¼"	5.6	25	7.65"	.165	15200	800	2600		2½" × 7/16"
15'-0"	2-6" ⊏ 8#	4.76	5¾"	2.34	77	3.32"	.058	10700	5300	1450		2¼" × 5/16"
"	2-7" ⊏ 9¾#	5.7	6¾"	2.72	66	3.9"	.07	11700	4300	1670		"
"	2-8" ⊏ 11¼#	6.7	7½"	3.11	58	4.33"	.076	12500	3500	1770		"
"	2-9" ⊏ 13¼#	7.78	8¼"	3.45	53	4.76"	.082	13000	3000	1930		"
"	2-10" ⊏ 15#	8.92	9¼"	3.81	46	5.34"	.093	13650	2350	1940		"
"	2-12" ⊏ 20½#	12.06	11¼"	4.61	39	6.5"	.113	14200	1800	2560	2480	2½" × 3/8"
"	2-15" ⊏ 33#	19.8	13¼"	5.6	32	7.65"	.133	14700	1300	3400		2½" × ½"
18'-0"	2-6" ⊏ 8#	4.76	5¾"	2.34	92	3.32"	.048	9350	6650	1510		2¼" × 5/16"
"	2-7" ⊏ 9¾#	5.7	6¾"	2.72	80	3.9"	.056	10700	5300	1700		"
"	2-8" ⊏ 11¼#	6.7	7½"	3.11	70	4.33"	.064	11380	4620	1940		"
"	2-9" ⊏ 13¼#	7.78	8¼"	3.45	63	4.76"	.068	12000	4000	2120		"
"	2-10" ⊏ 15#	8.92	9¼"	3.81	57	5.34"	.078	12600	3400	2340		"
"	2-12" ⊏ 20½#	12.06	11¼"	4.61	45	6.5"	.093	13650	2350	2680		2½" × 3/8"
"	2-15" ⊏ 33#	19.8	13¼"	5.6	39	7.65"	.11	14200	1800	3937	4077	2½" × ½"
20'-0"	2-10" ⊏ 15#	8.92	9¼"	3.81	63	5.34"	.07	11400	4600	2860		2½" × 3/8"
"	2-12" ⊏ 20½#	12.06	11¼"	4.61	53	6.5"	.084	12950	3050	3120		"
"	2-15" ⊏ 33#	19.8	13¼"	5.6	42.8	7.65"	.10	13900	2100	4060	3973	2½" × ½"

AUTHOR'S NOTE—Size and weights of channels referred to in Table 1 were taken from the Cambria Steel Company's handbook, as were also the distances back to back of the channels. The lattice bars for the smaller columns might be smaller, but it was assumed that 2¼" was the narrowest distance to take, due to punching and riveting, but different sizes may be substituted by designing the bars according to Equation 18. Sizes of lattice bars given in the last column of Table 1 were figured by Equation 18.

Each end lattice bar would have to be designed to act as a column having a length equal to f and a load equal to y.

Referring to Bulletin No. 44 of the University of Illinois, page 47, they give a formula for lattice bars as columns based on actual tests:—

$$\frac{P}{A} = 21,400 - 45\frac{l}{r}. \quad \text{[Equation 17.]}$$

Equation 17 gives the ultimate fibre stress per square inch; therefore, the safe load would be

$$\frac{P}{A} = 6,600 - 45\frac{l}{r}. \quad \text{[Equation 18.]}$$

Equation 18 is using a factor of safety of 3¼, which is about the same as is given in Equation 3.

From Equation 16, Table No. 1 was figured, which gives the stress in the end lattice bars for channel columns having lengths of 9′ 0″, 12′ 0″, 15′ 0″, 18′ 0″ and 20′ 0″. For intermediate lengths it would be safe to interpolate. For different areas, it will be directly proportional to the area, as will be seen by referring to Equation 16.

Application of Formula.—Now, to prove that Equation 16 is correct and agrees with experiments, one refers to Bulletin No. 44 of the University of Illinois, page 33, supplementary to Table 6, which gives in the last column of the table "Ratio of transverse shear to compression load = .0251."

This was the results of tests on "Column 1."

Referring to page 10 of the bulletin, a full description is given of Column 1, as follows:—

$A = 18.76$, $L = 21' \; 0''$, $\frac{l}{r} = 37.8$, angle of lattice bar with axis of column = 63° 30′.

It seems reasonable that all columns having a ratio of $\frac{l}{r} = 37.8$, or thereabouts, and having the lattice bars sloping approximately 63° 30′, should have a ratio of transverse shear to compression load = .0251. Referring to Table 1, on page 254, it will be noticed that for two channels 15″ at 33 lbs., 20′ 0″ long, the stress given in the end lattice bar is 4,060 lbs. $\frac{l}{r} = 42$, which is reasonably close enough to what is given in the tests to give approximately the same results; therefore, we get, for transverse shear, the following where $A = 19.8$ and the compressive load per square inch = 13,900 lbs.; and therefore transverse shear = 19.8 × 13,900 × 0.0251 = 6,880 lbs.

There are two lattice bars, therefore $\frac{6,880}{2} = 3,440$ lbs. transverse shear on each lattice bar. (See Fig. 6.)

The secant of 30° = 1.155, therefore 3,440 × 1.155 = 3,973 lbs. stress in end lattice bar, which is very nearly what is given in Table 1, which is 4,060 lbs.

Referring to Table 1 again, it will be noticed that for two channels 7″ at 9¾ lbs., 9′ 0″ long, that $\frac{l}{r} = 40$, $S_1 = 14,200$ lbs. and stress in end lattice bar is 1,160 lbs. $A = 5.7$ square inches.

Therefore, transverse shear = 5.7 × 14,200 × 0.0251 = 2,030 lbs.

Therefore, $\frac{2,030}{2} = 1,015$ lbs. transverse shear for each lattice bar.

Then, 1,015 × 1.155 = 1,170 lbs., which is within 10 lbs. of that given by the formula, which is 1,160 lbs.

Referring to Table 1, two channels 10″ at 15 lbs., 12′ 0″ long, $\frac{l}{r} = 38$, $S_1 = 14,300$ lbs. per square inch, $A = 8.92$ square inches, stress in lattice bar = 1,760 lbs.

Transverse shear = 8.92 × 14,300 × 0.0251 = 3,200 lbs. Therefore, $\frac{3,200}{2} = 1,600$ lbs. transverse shear for each lattice bar.

Then, 1,600 × 1.155 = 1,848 lbs. stress in lattice bar, which is within 88 lbs. of what is given in Table 1.

Referring to Table 1, two channels 12″ at 20½ lbs., 15′ 0″ long, $\frac{l}{r} = 39$, $S_1 = 14,200$ lbs. stress in lattice bar = 2,560 lbs., $A = 12.06$ square inches.

Transverse shear = 12.06 × 14,200 × 0.0251 = 4,300 lbs. Therefore, $\frac{4,300}{2} = 2,150$ lbs. transverse shear for each lattice bar.

Then, 2,150 × 1.155 = 2,480 lbs. stress in lattice bar, which is 80 lbs. less than what Table 1 gives.

Referring to Table 1, two channels 15″ at 33 lbs., 18′ 0″ long, $\frac{l}{r} = 39$, $S_1 = 14,200$ lbs., stress in lattice bar = 3,937 lbs., $A = 19.8$ square inches.

Transverse shear = 19.8 × 14,200 × 0.0251 = 7,060 lbs. Therefore, $\frac{7,060}{2} = 3,530$ lbs. transverse shear for each lattice bar.

Then, 3,530 × 1.155 = 4,077 lbs., stress in lattice bar, which is 140 lbs. more than what Table 1 gives.

NOTE—There are certain secondary stresses caused by inaccuracy in fabrication which cannot be covered by any formula that could be derived. This, no doubt, explains the slight difference between the results of the tests and the results obtained by use of the formula. One must take into account, also, the possible errors due to readings of the extensometers.

CANADIAN AND INTERNATIONAL GOOD ROADS CONGRESS.

As previously announced in these columns the third annual meeting of the above Congress will be held in Montreal at Sohmer Park, from March 6th to 10th, 1916.

A special effort is being made to get together influential members of all the societies interested in the Good Roads Movement, and as a result it is expected that the Congress will be made up of men from all branches of public life—Government officials, engineers and automobile owners being particularly in evidence.

The Eastern Canadian Passenger Association has agreed to grant reduced fares to all persons attending. Among the many papers to be discussed will be a paper on Road Laws, in which will be fully explained the legislation under which the provincial governments extend aid to municipalities for road improvements and the various statutes upon which municipal organization for road purposes is based. Also of equal importance will be a paper on traffic regulations. Other papers to be discussed will deal with subjects which come under the following heads: Road Foundations, Wearing Surface, Bridges and Culverts, Road Machinery, Road Maintenance and Materials of Road Building.

The officers of the Congress are: B. Michaud, president; O. Hezzlewood, vice-president; Geo. McNamee, secretary-treasurer; and A. H. Dandurand, W. A. McLean, Howard W. Pillow, J. Duchastel, J. A. Sanderson, members of committee.

The secretary's office is located in the new Birks Building, Montreal, P.Q.

LIMITATIONS OF RESULTS OF TESTS OF BITUMINOUS MATERIALS.

HAVE analyses of bituminous materials any real meaning to the municipal or highway engineer or road contractor? Are chemists' tests reliable; and when made on bituminous materials, are they anything but means of identification?

These questions are raised by a lecture on the limitations of the value of making tests on bituminous materials, which was given in the graduate course in highway engineering a couple of weeks ago at Columbia University by Chas. N. Forrest, of Maurer, N.J., who is chief chemist of the Barber Asphalt Paving Co.

Mr. Forrest says that the first application of bituminous materials for paving purposes was not likely preceded by laboratory tests of any kind, and that, at any rate, the earlier schemes for testing such substances did little, if anything, more than to identify the material under examination.

After a bituminous pavement was laid that was enough of a success to cause it to be conspicuous, Mr. Forrest says, the services of a chemist were employed to take the thing apart and determine of what it was made.

The function of all bituminous materials in a pavement is physical rather than chemical, as they are all chemically inert so far as concerns any influences to which they are subjected in normal service. An exception to this is the creosote oil used for impregnation of wood paving block, which must have certain chemical properties to perform its proper function. With the exception of creosote, however, Mr. Forrest claims that practically all of the tests now applied to bituminous materials, by those who are concerned in their application to roads, come within the classification of proximate analyses, and do not disclose the ultimate composition of the substances. He says they merely reveal certain of its characteristics, chiefly physical, when applied in very strict accordance with some prescribed method.

A great deal of time and thought has been given to the question of standardization of the methods employed in bituminous analyses. The standardization of methods for tests is of more importance, thinks Mr. Forrest, than the drawing of general specifications, as there can be no proper understanding of specifications until there is unanimity of opinion as to how the characteristics mentioned in them are to be determined. The following is an abstract of the portion of Mr. Forrest's lecture which deals with the difficulty in making, and the value or otherwise, of tests on bituminous paving materials:—

The standardization of the methods for performing tests of bituminous materials has not yet been satisfactorily accomplished, but is progressing slowly, and in the meantime a full description of the method which is to be employed should accompany all specifications, if confusion is to be avoided.

That there is considerable divergence of opinion as to the most suitable method for performing many of the tests, and a still greater divergence upon the results obtained, is appreciated by all who have been concerned in either the manufacture, sale or purchase of bituminous materials for any length of time.

Specific Gravity.—There is not much room for honest disagreement upon the subject of specific gravity, yet in view of the fact that that characteristic varies with temperature and such viscous substances as many of those involved are, are prone to entangle air and moisture, there has been more or less controversy over this simple matter. As this characteristic of bituminous materials frequently plays an important part in the computation of quantity delivered, and slight errors in the laboratory determination of specific gravity multiply into very considerable differences between what is shipped at one point and received at another, it is worthy of careful consideration.

The temperature of bituminous materials affects practically all of the physical tests to which they are subjected, and too much care cannot be exercised to insure the specific temperature specified, being the actual condition of the material under examination and not merely that of the surrounding air or water which may envelop it at the time. This class of material absorbs and radiates heat slowly and the period of time stated in a method, through which a sample is to remain in water, or the procedure to be followed in heating or cooling it, must necessarily be based upon considerable experience in such matters and must also be religiously followed if accuracy is important.

While there may not be much room for honest disagreement upon the subject of specific gravity, there is no limit to either the room for or the degree of disagreement in regard to practically all of the other tests to which bituminous materials are submitted.

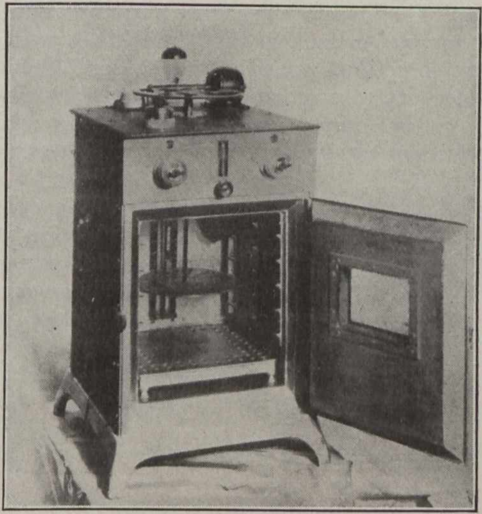


Fig. 1.—Improved Freas Oven for Loss on Heating Test of Bitumens.

Flash Point.—In addition to the dozens of miscellaneous independent methods used for the determination of the flash or fire point, or both, there are as many as at least eight more or less standard methods for the same purpose which may be described under the name of the apparatus used for the purpose. The eight standard methods are as follows: Tagliabue, open and closed cup; New York State, closed cup; Cleveland, open cup; Abel, closed cup; Abel-Pensky, closed cup; Pensky-Martin, closed cup; Bureau of Mines, closed cup.

No open-cup method will yield results capable of duplication in the hands of different operators, and the value of any results so obtained is questionable. The results obtained under unlike conditions, either as to type or cup, or its manipulation, are not comparable. The closed cup tests can be checked to a single degree.

Penetration.—At the present time there are several different instruments (Bowen Penetration Machine, Dow Machine, N.Y.T.L. Penetrometer, Abraham's Consistometer) and methods for the determination of the consistency or penetration of bituminous materials, although but one of each is in general use. As is well known, the principle of this test is to determine the depth to which a standard needle under a definite load will penetrate at a stated temperature and in a stated period of time. There are several variables or opportunities therefor in this test and these must be taken care of at the outset. The consistency of bituminous materials is an adjustable characteristic and, without consideration of any other feature, may be regulated in terms of the apparatus referred to, to any degree desired, but as to what is a proper penetration for a given material or a stated purpose, depends entirely upon experience with both that material and purpose and where the purpose is located.

The penetration of different classes of bituminous materials is not always a correct indication of their relative consistency due to the fact that very adhesive substances retard the progress of the needle, by clinging to its sides, while more oily and harder substances may encourage its progress. The diameter and depth of the vessel in which the substance under examination is tested, and whether its surface is covered with water or exposed to the air, may also influence the result.

Disagreement in the results of this test by different operators is more frequently due to temperature variations in the sample than any other cause, although a dull needle, too small sample, or lack of the "knack" of manipulating the test are sometimes contributory causes. Some experience is necessary to perform the test satisfactorily. After all conditions are correct, it is conceded that a difference of four points is satisfactory agreement between different operators.

Melting Point.—The number of different methods which have been proposed for the determination of the so-called melting point of bituminous materials probably exceeds that of flash point methods. Those with which the author is familiar are as follows: Cube on mercury; Mabery; Kramer & Sarnow and modifications; ball and ring and modifications; cube in water; cube in air; coated bulb and modifications; Wendringer; New York Testing Laboratory.

Nearly every laboratory has its own "pet" scheme for this test, and inasmuch as bitumens have no true melting point, because they are mixtures or combinations of many different hydrocarbons and other things, any one of the methods which have been proposed is about as good as any of the others in the hands of a single operator, but no two of them yield comparable results and no one of them in the hands of different operators will agree, unless every detail of the test is scrupulously adhered to.

Ductility.—While at least three different methods for the determination of ductility have been proposed, only one of them is in general use. The three methods referred to are the Dow, Cross and Abrahams, the first mentioned being the most popular. The Cross and Abrahams methods both employ cylindrical test specimens, while the Dow method involves the use of a briquette having a square cross-section at its narrowest part, and taking a flattened hour-glass form.

The results upon the same material as tested by these three methods are not comparable, but some recent co-operative work with the Dow method seems to indicate that results varying from 5 to 4 c.m. were obtained by six different operators upon the same material.

Loss on Heating.—The loss on heating test is one which has been the subject of considerable disagreement chiefly on account of the great variety of apparatus used for the purpose. It would seem to be a very simple matter to weigh out a definite amount of material and expose it in a suitable container to a stated temperature for a stated period of time, but the difficulty lies in the fact that the diameter and depth of the container influence the amount of loss, and the ovens in which the heating is done are of all sorts as regards temperature uniformity and air circulation. During the last couple of years a collection of boxes used by different analysts in making the volatilization test has been assembled. Seven dishes vary in diameter from 4.4 to 7.6 cm., and in height from 1.5 to 4.3 cm. Two have round corners and five have square corners.

Probably the two types of ovens which are in most general use are the New York Testing Laboratory gas-heated, cylindrical oven and the Freas electrically heated, rectangular oven. The former was adopted as standard for this test by the American Society for Testing Materials several years ago, but since that time the Freas and other electrically heated ovens have appeared and are now in very general use.

There is a discrepancy in results in the Freas oven which has been ascribed to the presence of convection currents set up inside the oven. The variation in loss from a number of samples of the same material in one test ranged from an average of 5.8% for position at the front of the oven to 10.4% for position at the back of the oven. The position of the samples in the oven is the chief factor in the cause of the variation. It is obvious that the temperature or the circulation inside this type of oven is not uniform, and that a thermometer in a fixed position will not indicate the true condition of affairs.

In order to circumvent the eccentricities of the oven, a revolving shelf has been devised and installed by Roy Fitch, of the U.S. Bureau of Standards, in the Freas oven in that laboratory. This modification is illustrated in Fig. 1. The shelf is made of a perforated disc of aluminum, and is hung midway in the oven from a vertical shaft which revolves in a fixed bearing in the top ventilator. The samples under test are arranged single file around the shelf and the whole outfit is revolved at the rate of 5 to 6 r.p.m. throughout the entire test. The power is a small 1/100 h.p. motor, geared directly to the shaft. Under these circumstances every sample in the oven is in the same position for the same length of time during test, and two sources of error appear to have been thus minimized, if not entirely removed. Concordant results are impossible if the amount of material, the diameter and depth of the box or dish, and the temperature and circulation of air are not exactly the same in every instance.

Hardening After Heating.—The penetration of the residue after the loss on heating test has been performed is, of course, subject to the same errors as surround that test at all times. It is also affected, however, by the depth of the material under observation, and if this test is to be performed a quantity sufficient to provide proper depth for the purpose should be taken in the beginning.

The maximum depth in millimeters of 20 and 50 grams respectively of a few of the bituminous materials used in road building, in boxes of different diameter, is as follows:—

Depth of Material in Heating Dishes of Different Diameter.

Diameter of dish.	2.5 inches.		2.25 inches.	
Amount of Material.	20 Grs.	50 Grs.	20 Grs.	50 Grs.
Depth of light flux.	8 m.m.	....	20 m.m.	50 m.m.
Depth of heavy flux.	6 m.m.	20 m.m.	9 m.m.	23 m.m.
Depth of 1.25 Sp. Gr. A.C., (50 Pen.)	5 m.m.	8 m.m.	6 m.m.	16 m.m.
Depth of 1.08 Sp. Gr. A.C., (50 Pen.)	6 m.m.	16 m.m.	7 m.m.	18 m.m.
Depth of 1.08 Sp. Gr. A.C., (140 Pen.)	6 m.m.	16 m.m.	7 m.m.	18 m.m.

As 20 grams of asphalt cement in a dish 2½ inches diameter is but 6 to 7 m.m. deep, or the equivalent of 60 to 70 penetration, it is obvious that such material cannot lose the amount permitted by many specifications in the heating test and still be of sufficient depth for the penetration test. The fact that the needle strikes and stops upon the bottom of the dish is not always appreciated and has led to controversy or unfavorable criticism in some instances.

There are a great variety of instruments available for indicating the viscosity of bituminous materials, and while no particular type has been officially adopted for testing road materials, the "Engler" is more generally used for that purpose than any other. In addition to the Engler, the Lawrence, Redwood, and Saybolt, are sometimes mentioned in specifications for road building materials.

None of these instruments speak the same language, but there is no reason for disagreement between different operators or laboratories with the same type instrument, if the standard directions for its operation are observed by both sides.

The relation of several of the more widely employed viscosimeters to each other has been worked out and published in the Proceedings of the American Society for Testing Materials.

Cementitiousness.—The direct determination of the cementitious properties of bitumen has been attempted by different investigators in a variety of ways, and a recent form of such test which is applicable to road surfacing oils is the Osborne test, devised by Clarence B. Osborne, chemist for the State Highway Department, California, and applied in the examination of the heavy oils or liquid asphalt used extensively in that State.

The Osborne apparatus is illustrated in Fig. 2. It consists of a horizontal hollow brass spindle 2 in. diameter by 3 in. long, through which water at 77° F. is circulated, a brass collar 2 in. long by 2.01 in. inside diameter, which fits loosely over the spindle, and a 3-kilo weight attached by a cord to an eye on the collar. The brass spindle and inside of the collar are coated with the oil under examination, and the latter is then slipped over the spindle. The cord holding the weight is wrapped about the collar and when the weight is released the time elapsed in seconds while the collar makes three revolutions is recorded. Results can be checked within a few seconds and the more cementitious materials interpose greater resistance to the movement of the collar than less cementitious ones of the same consistency. As this device is arranged at present, it is not available for testing and semi-solid bituminous cements or binders for macadam type of construction. A series of tests performed in the writer's laboratory upon a number of heavy oils of about the same consistency available in the east gave the following results:—

Heavy Oils.	Osborne Test.
1	770 seconds
2	600 "
3	250 "
4	175 "

The more solid bituminous materials are tested for adhesive properties by several experimenters by cementing two brass cylinders, or prisms, having an area of one square inch, together with as little of the hot bituminous material as will remain between the parallel faces of two such metal sections when a regulated amount of pressure is applied. After adjusting the temperature of the test piece so prepared, the cylinders are pulled apart in a suitable apparatus, such as a tensile machine for breaking briquettes of hydraulic cement. A large number of tests of the same material must be made to secure a fair average, and abnormally high and low results should be discarded. Variations amounting to several hundred pounds frequently occur.

A test of this character is employed by G. P. Homstreet, of the Hastings Paving Company, in the control of the manufacture of asphalt blocks, and also by Dr. Kleeberg, chemist, Bureau of Highways, Borough of Manhattan, but the specifications of municipalities for paving materials have not, so far, included such a requirement.

Brittleness.—A test for brittleness is not usually mentioned in connection with bituminous road building materials, but is in use by some investigators for special purposes. One type of such a test is performed at some specific temperature by resting a small prism of the bituminous material upon knife edges standing a definite distance apart, and striking it midway with a ball weight falling a prescribed distance. This test was probably devised in the asphalt laboratory of the District of Columbia.

Another type of test for brittleness is in use in the laboratory of the Highway Department, State of New York, and elsewhere, and is applied to semi-solid bituminous material of a considerable range of consistency. In carrying out the test, six or eight cylinders, 1.25 or 2.00 inches diameter and of equal height, are cast in a split mold and after they are adjusted to a standard temperature, usually 32° F., are removed from the mold and broken under a Page impact or similar machine. A large number of individual tests upon the same material is necessary to arrive at a fair average.

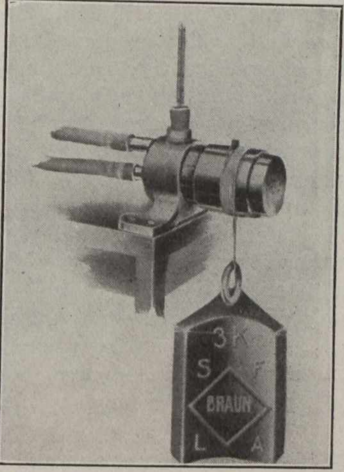


Fig. 2.—Osborne Test for Direct Determination of Cementitiousness.

Solubility.—Bituminous materials are tested in a variety of complete and partial solvents with certain objects in view. The universal solvent for bitumen is carbondisulphide, and bituminous materials and mixtures are therefore treated with that solvent for the purpose of ascertaining their bitumen contents. The bitumen contents of such materials is that portion which is so soluble. Bensole and chloroform are also complete solvents for bitumen, and are sometimes employed for that purpose, but carbondisulphide is in more general use and has wider approval. Carbontetrachloride does not always dissolve as much of a bituminous material as carbondisulphide.

Petroleum naphtha, acetone, and ethyl-ether are only partial solvents of bitumen. The former has been employed extensively in the examination of bituminous materials, but the test is subject to wide variation in the hands of even an experienced analyst, unless the temperature of the solvent, its gravity or limits of boiling point and general nature are collectively always the same.

The results of solubility tests of a given bitumen in 70° naphtha and 80° naphtha are not comparable, nor are the results the same in duplicate tests if one naphtha has been derived from a paraffine oil and the other from an asphaltic oil.

The solvent action of ethyl-ether upon a given bitumen is constant regardless of temperature and, as ethyl-ether is a definite chemical substance having a definite boiling point, the only precaution necessary in the use of that solvent to insure positive results is to employ pure ethyl-ether. (A common impurity is ethyl alcohol.) The same thing is also true of acetone or any other definite chemical substance. There are no limits to the possible variations in such tests if the solvents employed are impure or the tests are performed in a careless manner.

Conclusion.—It has been stated that "the ultimate utilization of tests for the purpose of selecting material for a given use makes it necessary that (1) the test limits adopted shall specifically define the material, and (2) that the material thus defined shall have previously proved satisfactory for that particular purpose."

Under the above circumstances, it is obvious that such tests as have just been discussed do not *per se* disclose the quality of a bituminous material for any specific purpose. The characteristics determined by such tests are usually common to all bituminous substances, good, bad and indifferent.

One will only differ from another in degree, and the extent of such differences, in view of the limitations of the tests now in use, will depend a great deal upon the experience and skill of the analyst making them. With very few exceptions, none of the tests are conclusive, nor the data as a result of their application even instructive, unless it represents a large number of observations upon the same material. Freak results are often encountered and such should be eliminated in computing the average result of any tests susceptible of producing freaks.

The drift of this subject during the past few years rather brings us abreast with the fact that a great deal of attention is being paid to the testing of an element which forms but a small part of an article of manufacture, *viz.*, the pavement in place and ready for work, which might perhaps be devoted, with the hope at least of more positive results, upon the finished article as a whole. The bituminous binder employed in road building is modified to such an enormous extent by the mineral aggregate with which it is associated that its suitability or its quality for any specific purpose cannot be estimated without consideration of the mineral aggregate, and the conditions of service which it is required to meet.

The amount of laboratory work required to ascertain whether a material does or does not comply with such specifications is small, and the question of mere compliance is much simpler and of less actual importance than that of quality.

Bituminous pavements which are put down in sheet form; *i.e.*, as a unit, do not lend themselves readily to testing as a whole or as a complete mixture, but it is obvious that a series of tests which could be applied to the finished article of manufacture, *viz.*, the whole mixture or the pavement in place, would be much more conclusive and satisfying from the point of view of the engineer who is responsible for the work, than the type of tests now in vogue, confined as they are to the raw materials as separate units, and give no direct information as to how congenial such raw materials will be after they are combined.

There is a definite understanding on the part of engineers as to the function of a bituminous pavement, and it would not be a difficult matter to forecast rather closely the probable punishment it will receive in service. A series of tests which could be applied to the finished pavement or to the complete mixture which is to form the pavement would be of infinitely more value to the engineer than any information developed by present-day procedure.

The manufacturer of a pavement must know what raw materials to bring together to produce the results demanded by the purchaser of his product, but at the present time the limitations of results of tests of bituminous materials for road building are such that after the results are obtained the purchaser of the finished article must still select the bituminous material for use therein by reputation for good service.

RIGHTS OF CONTRACTOR UPHELD.

At Montreal recently the Superior Court decided a suit which will be very interesting to engineers and contractors. According to the evidence, Geo. W. T. Nicholson, contractor, of Montreal, took a contract late in 1909 to build a power plant for the Canadian Light and Power Co. Under the terms of the contract the payments were to be made monthly on the engineer's certificate and final payment within 30 days after completion and acceptance of the work.

When the work was partly completed, an official of the company saw a chance to save money by inducing the contractor to consent to a change regarding the measurement of material. The official knew the contractor was hard-up for money and the men's pay was four days overdue. The company itself was behind with payment on the monthly estimate, then due. Knowing this, the official induced the contractor to sign a letter agreeing to a change in the method of measurement, threatening that otherwise the company would further withhold payment of the monthly estimate. The engineers of the company, when the letter was shown them, protested that such a change in the terms of payment was unfair to the contractor. It was also established to the court's satisfaction that by the terms of an agreement made between the company and its engineers at a later date, the engineers became mere servants of the company and not independent certifying engineers. Under instructions from the company the engineers refused to sign a final certificate on the completion of the work, and the contractor was thrown into bankruptcy.

The judge said in his decision: "The engineer was unable to preserve an attitude of judicial independence between the parties, and this released the contractor from all conditions in his contract with the company by which he had submitted to have his rights determined by the engineer." The facts in the case were established not only by the evidence of the plaintiff, but by the engineers themselves. Under these circumstances the court gave a sweeping decision in favor of the contractor, pointing out particularly that the agreement extorted from the contractor to consent to a change of measurement was an agreement obtained by "coercion, violence and fear and was therefore null and void."

A NON-CORROSIVE ALLOY.

A metal that will not corrode on exposure to moisture is very desirable for many purposes, such as for making faucets and other water fixtures, and fittings for yachts, and many alloys have been devised for the purpose, as no simple metal appears to meet the requirements satisfactorily. A new alloy that is claimed to be entirely non-corrosive has been recently patented by an American inventor, consisting of 82 parts of aluminum, by weight, 12 parts copper, 5 parts cadmium and one part silver mixed in a special manner. This alloy is said to be much lighter than copper or bronze, of good strength and to run well in casting.

CONSTRUCTION METHODS ON THE TORONTO AND HAMILTON HIGHWAY

By H. S. VAN SCOYOC, A.M.Can.Soc.C.E., A.M.Am.Soc.C.E.,
Chief Engineer, Toronto and Hamilton Highway Commission.

[Mr. Van Scoyoc's paper was fully illustrated by numerous lantern views and a motion picture film. In his introductory remarks he announced that 30 miles of the highway were graded, with practically all the culverts and bridges widened or replaced, and that approximately 17 miles of the concrete highway were open to traffic.—EDITOR.]

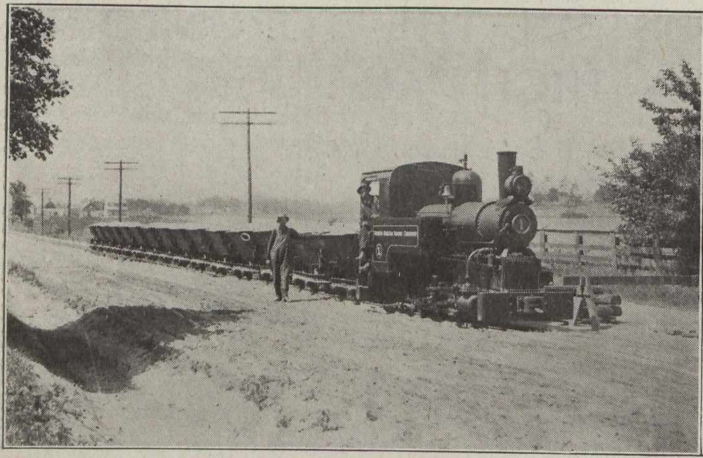
THE highway follows previously existing roadways with the exception of diversions at Bronte and Heeks Corners, a slight shifting of location on Water Street in Burlington, and a short stretch of new construction west of Maple Avenue in Burlington. The minimum width of graded roadway is 26 feet. This width has been increased on the highest fills. A minimum of 30 feet was graded in cuts. Culverts and bridges have a minimum clear width of 26 feet. In the towns and villages these widths have been increased to provide for one or two sidewalks, as was felt necessary. The smaller culverts in the heavier fills have been made of such a length that the slopes of the fills are carried out to the regular width, avoiding high end and wing walls. The structures have been designed for the loading specified in Class "C" bridges standard General Specifications for Concrete Highway Bridges, Ontario.

Completed Section.

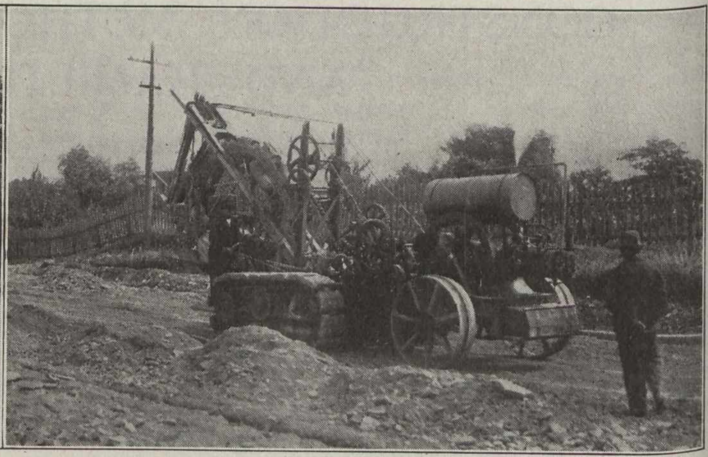
Concrete Culvert.

The problem may be considered as comprising (1) the handling of materials already on the road in the grading operations, and (2) the handling of materials from outside sources to the road; more particularly those required for the concrete paving. Modern highway building is largely a transportation problem. As illustrating this, more than 90% of the cost of the sand that went into the work under consideration represented handling and transportation charges.

In those sections where there were the remains of macadam roadways the first operation was to tear up the subgrade for at least the width of the concrete by means of a scarifier hauled by a gasoline tractor. In most cases the full depth of stone was loosened by one trip but occasionally more than one was necessary. No difficulty was experienced where bituminous macadam was encountered. The loose stone was moved to the side to increase the width of the subgrade, or to be utilized for shoulder construction, or backfilling by means of a grader, unless the cut was so heavy that the material had to be moved some distance. Pick plows or rooters drawn by horses were used to keep the material loose and the earth hauled by slushers, wheel scrapers or dump wagons, as the distance demanded. If a steam shovel had been near at hand it could have been used to good advantage on some of the Lorne Park hills, but the limited yardages in any one location did not seem to justify the purchase or rental of this kind of equipment. The slopes, both in cuts and in ditching, were hand-trimmed, which added considerably to the cost per cubic yard of excavation, but was necessary if the section was to be maintained. The slopes were made 1½ to 1. Practically all of the removing of sod was done by hand, although graders were used to some extent. Where possible, part of the ditching was done with slushers, but much of it was hand-work. About five miles of trenching was excavated by a trenching machine. While the limited quantity and the nature of much of the soil trenched did not present ideal conditions for low-cost work, a considerable saving was effected in the actual excavation and a much larger saving made indirectly by the reduction in the quantity of material required for backfilling. Practically all of the subgrade was rolled after the rough grading was completed and many of the fills were rolled while being made. The stakes to which the side forms were set were utilized for fine grading. In fact, much of the fine grading was done after the side forms were in place. The Commission's industrial railway track added somewhat to the difficulty of fine grading. This work cannot be too carefully done, for not only does an even subgrade greatly reduce the danger of cracks but it insures the proper thickness of concrete at all times



Industrial Railway.



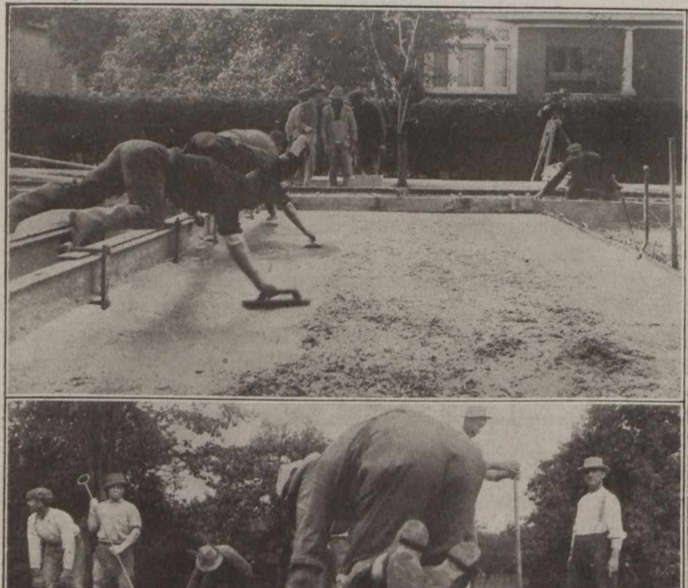
Buckeye Ditcher Used to Dig Ditch for Tile Drain Adjacent to Sidewalk.

and prevents unnecessary waste of concrete. In all cases the subgrade was carefully rolled just previous to the depositing of coarse and fine aggregate for the concrete.

Yards, Transportation Plant, Etc.—The original plan required three material yards at Port Credit, Oakville and Burlington respectively. Unforeseen difficulties and delays prevented the carrying out of this scheme, and yards were actually located at Waterdown, Oakville and Port Credit. An additional yard will likely be required for the work in York County. Existing sidings on the Hamilton Radial Railway at Port Nelson and on the Grand Trunk Railway at Gooderham Siding, near Clarkson's, were utilized. The sand and stone for the portion of the spur line east of the Grand Trunk Railway crossing was unloaded by hand at Burlington Junction and hauled by team. Practically all the sand and stone at Waterdown, Oakville and Port Credit were unloaded by locomotive cranes with clam-shell buckets and were hauled to the roadway by the locomotives and dump cars on the narrow-gauge track. The materials at Port Nelson were unloaded by hand and hauled by dinkey and dump cars. The materials at Gooderham Siding were unloaded by hand into dump cars, but the dump cars were hauled on the industrial railway by teams. Usually solid trains of sand or stone were hauled.

Where the concrete was 18 feet in width one dump of sand and two of stone met the requirements exactly. The track was first laid to the north of the centre line of the highway, one dump of sand and one of stone made; the track then shifted to the top of the stone pile and the second dump of stone made. As a rule, the cement was delivered after the track had been shifted to the top of the row of stone.

In addition to any economy that industrial railways may effect in actual transportation they are desirable be-



Finishing Pavement from Steel Bridge—Span, 50 ft.
Finishing Pavement from Bridge—Span, 18 ft.

Steel Forms and Form Set-up to Support Felt Expansion Joint.

cause they avoid any necessity for disturbing the subgrade after it has been prepared for the concrete.

For a limited period three mixers were supplied from the Oakville yard. Two locomotives were used and the outfits worked double shifts. The sand and stone were shovelled from the subgrade into wheelbarrows and dumped into the skip of the mixer.

Most of the water required was pumped from Lake Ontario and distributed through a two-inch pipe line.

Steel side forms have been used for practically all of the work so far except for the special work in Oakville. They have proven very satisfactory.

Proportioning has been done by wheelbarrow measurement, a wheelbarrow load having been established by measuring boxes. The concrete remained in the drum for at least 45 seconds and was deposited on the subgrade by means of a boom and bucket. Levelers with spades and hoes distributed the concrete. A strike-board resting on the side forms was used to secure the proper crown and two men working from a bridge finished the surface with wooden floats. The finishers also rounded off the edges of the roadway with edging tools and were responsible

Austin Mixers Working Side by Side on Main Street, Oakville. Roadway, 50 ft. Wide. Full Width of Pavement Carried Forward at Once.

for the workmanship at the joints. The joints were made of felt and were placed every 35 feet. The felt was held against a joint-board with pins until concrete had been placed on both sides of the joint. The board was then removed carefully so that the joint remained perpendicular, the felt extending above the surface of the concrete. A special tamper was used to consolidate the concrete. A divided float prevented one side of the joint from being left higher than the other. The fresh concrete was protected by means of tarpaulins just as soon as the floating was completed. On the following morning the tarpaulins were removed and an earth covering at least two inches in thickness applied. The earth was kept damp by frequent sprinkling for at least ten days. The road was not opened for traffic until the concrete was at least 21 days old. The joint material was cut off flush with the finished surface by means of a sharpened spade.

The earth covering provided part of the shoulder material, the remainder coming from the ditches.

(In concluding, Mr. Van Scoyoc observed that if no unforeseen difficulties arise construction work should be completed this summer.)

WATER DISINFECTION IN CANADA AND THE UNITED STATES.

GENERAL practice in the use of hypochlorite and liquid chlorine in the disinfection of water supplies is the subject of a paper presented recently at a meeting of the American Waterworks Association, by Mr. Francis F. Longley, of the firm of Hazen, Whipple and Fuller, New York City. The statistics contained therein are based upon solicited replies from 110 plants in Canada and the United States, aggregating over 2,000 million gallons per day.

The newer methods of sterilization, *viz.*, ozone and ultra-violet rays, are not dealt with, unfortunately, but Mr. Longley explains that the replies contained very little information in relation to them—not sufficient to warrant its inclusion with that of the hypochlorite and liquid chlorine methods.

According to the replies received, about 80% use, or have used, hypochlorite of lime, and the balance liquid chlorine. About 75% of the supplies regarding which information was received are river waters; about 20% are from lakes, and the small remainder are ground waters.

Of the total installations regarding which replies were received, the percentages installed each year have been as follows:

1909, 13%, representing a total of 100 mil. gals. per day
1910, 14%, representing a total of 450 mil. gals. per day
1911, 22%, representing a total of 320 mil. gals. per day
1912, 22%, representing a total of 710 mil. gals. per day
1913, 18%, representing a total of 70 mil. gals. per day
1914, 8%, representing a total of 265 mil. gals. per day

Some 37% of the cities replying use a disinfection without other treatment. The balance use it as an adjunct to some treatment, in most cases filtration. In 57% of those cases in which it is used as an adjunct to filtration, it is used as a final treatment. In 26% it is used after coagulation or sedimentation and before filtration. In the remaining 17% it is applied before coagulation and filtration.

The data at hand do not give any reasons for the application before coagulation. In general, an effective disinfection may be secured with a smaller quantity of hypochlorite if it is applied after rather than before filtration. It should be noted that the storage of chlorinated waters in coagulating basins and their passage through filters tend to lessen tastes or odors contributed by the treatment, and this fact may in some cases account for their use in this way. Beyond this there is nothing in the moderate amount of bacterial data secured in connection with this work that enables us to generalize upon the relative advantages of these different points of application.

The cost per million gallons for the equipment required for this treatment varies widely and does not seem to bear any very close relation to the capacity. The cost per million gallons as stated, varies all the way from $4 to $2,400. These variations are accounted for by the fact that designs for equipment of this sort vary widely. Some are the merest makeshifts, while others are elaborate. Some of the costs quoted include no building costs, while others include expensive structures. Taking the figures as they stand, as the data do not permit any further analysis, the total costs per million gallons are stated not to exceed $25 in 12% of the supplies, $50 in 30%, $100 in 42%, $250 in 67% and $500 in 87% of the supplies about which information is available.

The total cost per million gallons for the process also varies widely. By far the greater number of costs stated lie between 10 cents and 50 cents per million gallons, the average for these being about 25 cents.

The information at hand indicates that the commonest construction of tanks for hypochlorite is concrete. Some 67% of the replies stated that they had either concrete tanks or tanks of wood or iron relined with concrete. Something more than 20% are of wood without lining. The balance are either wood with lead lining, wood or iron with some protective or acid-resisting paint, or porcelain lining. The liquid chlorine is universally contained in special iron cylinders.

The piping seems in general to have been put together of the materials most easily available, without regard to corrosion. Fifty-six per cent. of the replies indicate the use of iron pipe, either block or galvanized, 15% use lead pipe and about an equal number use brass. A few use lead-lined iron pipe, cast iron pipe, hard rubber, rubber hose, bronze or copper pipe.

The same comments apply to the kind of valves and fittings commonly used. Sixty-six per cent. of these are of brass such as are usually found in stock. Some 14% state that bronze valves and fixures are used, but it is possible that some, if not most of these, upon further inquiry, might prove to be brass. A few use iron valves or fittings and a few have fixtures made of vulcanite, rubber composition, lead, copper, glass, etc.

The materials commonly used which seem to have shown the greatest resistance to the corrosive effects of hypochlorite are concrete tanks, lead pipe and rubber composition. Several of the answers indicate that copper, cast iron and lead-lined iron pipes are used without corrosion and a number indicate, too, that brass and galvanized iron are used without corrosion. The evidence as to these two last materials, however, is contradictory, as other answers indicate considerable corrosion with galvanized iron and brass. It seems likely that the quality of the material and some peculiar local conditions may, perhaps, be determining factors in the corrosive effect upon these two materials. The results show the unmistakable corrosive effect upon wrought iron and also upon wood.

Evidence has been found in the past of occasional large variations in the strength of commercial hypochlorite. In answer to an inquiry on this point, only 29% indicated that the strength of hypochlorite as purchased had been determined. That this is a point of considerable importance is indicated by the following figures:

The maximum percentage of available chlorine stated was 42%. Numerous others ran as high as 39 or 40%. The minimum stated was 15%, with several others less than 20%. The average strength was 33%. In two cases the maximum percentage strength noted is as large as 2½ times the minimum strength. These variations in quality in the commercial hypochlorite are significant, and it is obvious that the strength should be determined and a correction made in the application, if necessary, if the best results are to be secured.

The low cost and the ease of application of disinfection to water supplies have caused its introduction in a great many places where the records of mortality or morbidity from such diseases as typhoid, which can be used as indicators of the benefits derived, are already so low that no striking improvement can be expected therein. In a large percentage of the cases it seems clear that the application was as a precautionary measure. This fact makes it less easy than might be expected from the large number of cities and towns making use of disinfection to present statistics showing actual benefits resulting therefrom. Among the large number of communities from which information was obtained, about 75% failed to indicate that any improvement in typhoid or other health condition had resulted. In some cases where there has been an improvement it is difficult or impossible to discriminate between the effects of disinfection and of filtration. Mr. Longley summarizes a number of reports, however, to show the improvements that resulted in various places.

Judging from the lack of information in response to inquiries bearing upon the relation between the quantity of hypochlorite required and the color or turbidity in the water, it seems that a surprisingly small amount of attention is given in the various cities to following out this relationship. A knowledge of this relation is of some importance, as it influences the quantity of hypochlorite that is required for a given water, the quantity that may be applied without producing objectionable tastes and the economy of the treatment.

The reason for the lack of attention to this point seems to lie in the fact that the cost of the hypochlorite required for any water is trifling and it is not of great importance just what quantity is applied, so long as it is enough, on the one hand, to give good bacteriological results, and, on the other hand, not so much as to produce objectionable tastes and odors.

The doses that fulfil these two conditions do not always coincide. The character of some waters is such that the dose which can be applied without contributing objectionable tastes and odors is more than enough to produce the desired bacterial reduction. With such waters there is no difficulty in regulating the dose to give satisfactory results from every point of view. The character of other waters is such that the maximum dose which can be used without giving a taste is not enough to give the bacterial reduction required. This is the difficult condition to meet, and is found more frequently in raw waters than in filtered waters.

It is everywhere recognized that there are certain times when the hypochlorite treatment is less satisfactory than at others. This is shown principally in the appearance of tastes and odors that occasion complaint among consumers, or in a low and unsatisfactory removal of bacteria by the treatment. It occurs generally at a time when the turbidity or the color of the water increases greatly, or some other marked change, such as temperature, occurs in the condition of the untreated water.

Different waters vary a good deal in this respect, and but little information can be found which gives light upon the specific reasons for this variation and permits the formulation of general statements in regard to it.

An analysis of the figures at hand shows that in one place a maximum dose as great as 37 pounds per million gallons has not given rise to objectionable tastes or odors, and in numerous places 20 to 30 pounds has not been noticeable. The average amount stated for which no odor or taste was noticed was about 14 pounds per million gallons. The replies in which it was definitely stated that no tastes or odors were noticeable included about 40% of the total. Among the others there were general comments as to the occurrence of objectionable tastes or odors, indicating in the main that they are likely to occur with changes in the character of the water treated, especially at times of storm or freshet.

So far as is indicated by the somewhat incomplete data, the largest quantities of hypochlorite are used in those supplies in which the color or turbidity of the water are highest. Unfortunately, the information is not complete enough to enable any relationship to be established even in an approximate way between color, turbidity and quantity of disinfecting agents that may be used without objection.

COUNTRY ROADS.

By W. Muir Edwards,
Professor of Civil and Municipal Engineering,
University of Alberta.

In dealing with country roads it might be well to first point out that the use of material other than that found in the neighborhood is generally financially out of the question. Whether it be loam, sand or clay the local conditions must be dealt with and the road constructed of material at hand. In the second place, we should emphasize the fact that, although there are locations in which physical difficulties may be met which are hard to overcome, most country roads could be made quite satisfactory by a moderate expenditure of labor and oversight. Drainage, proper initial construction and continuous upkeep are the essential features.

In discussing road construction, too much importance cannot be attached to proper drainage. As we travel the country roads, possibly no feature is so noticeable as the almost uniform practice of repeatedly filling in bad spots which could be permanently cured by much less labor devoted to proper drainage. In road construction we deal with surface, side and subsoil drainage.

Surface drainage of the roadway is very important. The most destructive agent which the road has to contend with is water, if allowed to remain any length of time in its neighborhood. If pooled on the roadway the top surface is softened and under the action of the traffic the road is rutted. These ruts hold more water and if conditions are not speedily remedied the roadway goes from bad to worse until it is almost impassible. Just here attention might be called to the fact that the criterion of a good road is not the possibility of finally passing over it with a load, but rather that such a surface is maintained that the motive power, be it oxen, horses or motors, shall give a reasonable return on the capital it represents.

Surface drainage is accomplished by crowning the road. The slope from the centre to the sides should be varied to suit the material used. From one-half inch to one inch of fall per foot of road width measured from the centre will give satisfactory results. Too flat a crown tends to poor drainage, whilst too steep a side slope may rut the roadway and also will encourage undue traffic on the centre portion. This "tracking" of vehicles means increased wear at one spot and is a frequent source of destruction to the roadbed.

Having shed the water to the side of the roadway, it is equally important that arrangements be made for the satisfactory progress of this water in the roadside ditches. Although the slope of these ditches may be fairly flat, the water should flow to a definite outfall and so be carried away from the neighborhood of the roadway. It might seem quite unnecessary to emphasize such an obvious matter as an outlet for the side ditches but, strange to say, this feature is totally neglected in many pieces of roadwork. Due to the soakage of water from these blind ditches into the body of the roadbed, bad spots are developed which last long into dry-weather periods.

Subsoil drainage is often necessary where the road runs across low, wet land. If the surface of the subsoil water can be lowered, a firm foundation for the roadbed may be obtained. Drainage of this type is usually quite expensive and in many cases may be classed with bridges and other permanent provincial undertakings. Another type of subsoil drainage is that of the roadbed itself. Tile drains are placed on one or both sides of the roadway at a depth of 2½ to 3 feet below the surface. The moisture in the roadbed is drawn off, thus increasing its bearing power and lessening the effect of frost action. In the clay soils so prevalent in the Province of Alberta this type of work is of questionable utility. In sand roads it would be distinctly harmful, since a sand road is the one exception to the general rule regarding drainage. The retention of the moisture is the feature to be aimed at in the operation of such a road.

Initial construction and drainage are so closely connected that a discussion of one must include the other. Without, therefore, devoting any further space to the first two essentials in road building, we might consider the third, which applies more particularly to road operation. Upkeep should be given equal prominence with drainage in any roadway discussion. The filling-in rather than the drainage of bad spots has already been commented upon as the most noticeable feature of poor roadwork. This should really be qualified and possibly the premier place given to the practice of industriously grading a roadbed and then cheerily leaving it to look after itself. Earth roads especially need care if they are to remain in a satisfactory condition. This care may be of the simplest kind, consisting of the cleaning of roadside ditches and the dragging of the roadway. This latter operation consists of pulling over the road a drag which fills in the ruts, smooths out the ridges and recrowns the road by moving material from the side to the centre. The drag itself is extremely simple to construct. Any blacksmith shop or well equipped farmer's workshop could turn one out for not more than $15. The cost of the operation is also by no means excessive. Owing to the character of the spring and fall seasons in Alberta, and since no work is required during the winter, an average of $10 per mile per year should cover all that is necessary in dragging operations. This is equivalent to a charge of $3.75 per quarter-section for this part of road maintenance. Considering the saving to the farmers in actual cost and the convenience and comfort to be derived from good road connections with the nearest town and with the neighborhood generally, it might well be considered that it is inertia and lack of knowledge rather than the expense involved which prevents the practice. In dragging lies the secret of the proper maintenance of serviceable country roads.

The necessity for the proper placing and proportioning of culverts might very well be dealt with, but space permits only a reference to the matter.

Grading an earth road can be done for less than $150 per mile; maintenance, including dragging, might be placed at $15 per mile per year. It is quite possible that additional expenses may be found to be justified in surfacing country roads with a judicious mixture of sand and clay. The discussion of this might be left to be considered in dealing with more expensive types of roadwork justified in highway construction, and will be dealt with later.

The United States Senate has before it the Shackleford Bill, sent on by the House of Representatives, carrying an appropriation of $25,000,000 to aid the states in improving their public roads.

A convention of branch managers of the Trussed Concrete Steel Company was held on January 25th-28th, at Youngstown, Ohio. Representatives attended from all over Canada and the United States, and also from Japan, Hawaii, South America and Porto Rico. Among the papers and discussions were some on steel sash, reinforced concrete, shop practice, engineering practice, commercial value of engineering service, experiences with reinforced concrete, metal lath, concrete pavements, Kahn mesh reinforcement, history and growth of the company, etc.

HOW LONG WILL OUR TIMBER LAST?

By R. H. Campbell.

The question is frequently asked, "How long will the present supply of commercial timber last in Canada?" Estimates made have varied from 50 years to 300, depending on the basis of the estimate. As a matter of fact, Canada is not facing an immediate timber famine and the existing supply, if properly utilized, would last indefinitely.

The method of making these estimates shows their uselessness. If we assume that the present supply of material is 600,000,000,000 feet of saw timber and the annual consumption 5,000,000,000 feet, it is easy to see that the supply will be exhausted in 120 years, providing that the supply is not reduced except by regular lumbering, and that the annual consumption remains unchanged. These are the most important conditions, but the question also depends on changes in prices, extent of importation and exportation of lumber, use of substitutes and new uses of lumber itself.

It has been estimated that forest fires destroy more lumber annually than is cut and sawn by lumbermen. This is one of the most important variables in the equation. The annual production of sawn lumber increased up to 1912, then decreased in 1913 and in 1914 has increased again. It would be absurd to depend on this fluctuating factor in making calculations to cover the next century or more. If the increase in production of lumber were regular and equalled 200 million feet the supply would be exhausted in about 50 years, instead of 120 years. As prices of certain classes of lumber in Canada increase other cheaper woods are imported from the United States. The present war and the closing of the Baltic ports has created a demand for Canadian timber in Great Britain and France hitherto supplied by Russia and Sweden.

The use of metal and concrete in building construction, bridges, culverts, harbor works, etc., has reduced the demand for wood for these purposes, but has increased the demand for lumber for concrete forms, templets, foundry boxes, patterns and wood used in connection with mining and marketing metal products. The pulp industry which consumed an equivalent to one billion feet of lumber in Canada in 1914, is a new industry, using wood to an extent which could not have been foreseen 25 years ago. These various considerations demonstrate the futility of estimating the probable date at which our supply of lumber will have been exhausted. While we should not sit back complacently and say, "The supply is good for 300 years; let posterity look after itself," it is equally wrong to take the pessimistic attitude that we are facing an immediate wood famine.

The available statistics concerning forest products show the natural course of events. In January, 1900, the price of "white pine, good sidings" in Ottawa was from $33 to $38. The same material in 1914 was listed at $58 to $65. This is an increase of $26 per thousand in 14 years or about $2 a year. This is the best grade of white pine; the average price of white pine lumber of all grades in 1908 was $20.03. The average price in 1913 was $20.79, an increase of only 76 cents in five years or an average increase of 15 cents a year. In the last five years the average price of lumber has increased slightly compared to the increase in the value of the best grades. This means that there has been an increase in the production of the poorer grades of lumber. Logs are sawn to-day and used in making boxes, rough construction and other inferior uses that would have never been cut under the wasteful logging methods in vogue 20 years ago. This closer utilization, the use of inferior lumber for inferior uses, is a form of conservation that tends to postpone the final exhaustion of the lumber supply. It is through such forms of conservation as these that we can hope to postpone this exhaustion of supply indefinitely.

Forest fires destroy millions of dollars worth of standing timber annually; they can be prevented by proper precautionary measures. Wasteful logging methods are rapidly being superseded as the price of lumber increases. Closer utilization of all material is a form of economy. The use of substitutes wherever possible usually reduces the unnecessary consumption of wood. The use of inferior species or trees which have been considered as weeds, for purposes to which they can be adapted, reduces the consumption of more valuable materials. Finally the planting up of waste lands, burned-over or logged areas and all lands not fit for agriculture, paves the way to intensive forest management, when the forests of the country will yield an annual crop of wood equal to the demands of the country for all time.

Canada has a great national heritage of timber resources. The existing supply of commercial saw timber lies between five and seven hundred billion feet, board measure, and covers an area of approximately 170,000,000 acres, the greater part of which is land unfit for agriculture, but suitable for producing timber. There are over 150,000,000 acres of forest reserves in Canada, much of which does not carry timber of commercial value at present, but all of which is capable of producing valuable forest products.

In 1914, Canada's 2,843 active sawmills reported cutting 3,946,254,000 feet, board measure, of lumber valued at the mill at $15.30 a thousand feet. Spruce, white pine and Douglas fir together formed 72 per cent. of the total. Canada's lumber production consists chiefly of soft woods or the woods of coniferous trees, the hardwoods forming less than 7 per cent. of the total. (In the United States the hardwoods form over 20 per cent. of the lumber sawn.)

Canada produced in 1914, 2,196,884 cords of pulpwood, valued at $14,770,358. Lumber and pulpwood are our most valuable forest products, but the total, which includes firewood, ties, poles, posts, piles, fence material, wood for distribution, tanning material, cooperage stock, and many other miscellaneous products, is estimated at over $150,000,000.

RAILROAD EARNINGS.

The following is the weekly record of the transcontinental railroads' gross earnings for January:—

	1916.	1915.	
Canadian Pacific Railway			
January 7	$1,874,000	$1,316,000	+ $558,000
January 14	1,863,000	1,321,000	+ 542,000
January 21	1,910,000	1,391,000	+ 519,000
January 31	2,733,000	1,880,000	+ 853,000
Grand Trunk Railway			
January 7	$ 880,702	$ 753,522	+ $137,180
January 14	966,301	779,745	+ 186,556
January 21	980,914	795,830	+ 185,084
January 31	1,459,499	1,091,716	+ 367,783
Canadian Northern Railway			
January 7	$ 541,100	$ 315,700	+ $225,400
January 14	469,300	349,300	+ 120,000
January 21	504,000	322,600	+ 181,400
January 31	572,400	451,800	+ 120,600

The Canadian Pacific Railway statement of earnings and operating expenses for the month of December shows an increase in net earnings of $3,502,797, or 159 per cent., over the corresponding period a year ago, total net being $5,702,321. Gross earnings were $12,705,673; working expenses, $7,003,352. For six months ended December 31st figures are: Gross earnings, $66,470,164; working expenses, $36,845,977; net profits, $29,624,187. In December, 1914, net profits were $2,199,524, and for the six months ended December 31st, 1914, $19,673,576.

The Canadian Northern December statement shows the following figures:—

	1915.	1914.	Increase.
Gross earnings	$3,435,600	$1,809,600	$1,626,000
Expenses	2,233,500	1,376,400	857,100
Net earnings	1,202,100	433,200	768,900
Mileage in operation	8,270	6,886	1,384

COBALT ORE SHIPMENTS.

The following are the shipments of ore, in pounds, from Cobalt Station for the week ended February 4th, 1916:—

Dominion Reduction Company, 88,000; La Rose Mines, 87,027; McKinley-Darragh-Savage Mines, 170,126; Coniagas Mines, 168,423. Total, 513,423 pounds, or 256.7 tons.

New Liskeard—

Casey Cobalt Mine, 59,090 pounds.

The total shipments since January 1st, 1916, are now 2,888,662 pounds, or 1,444.3 tons.

VALUE OF ONTARIO'S NICKEL

By T. W. Gibson.

Nickel is the distinctive metal of Ontario. Its property of imparting great strength and toughness when alloyed with steel was first made known by James Riley, of Glasgow, in 1889, and advantage was almost immediately taken of this discovery in the manufacture of armor plate for battleships. Its success in this field soon led to its introduction into other departments of war equipment. Other metals there are, such as tungsten, vanadium and molybdenum, which form satisfactory alloys with steel, but all of them are rare, and more expensive than nickel. It would seem that no other element possesses all the qualifications for the manufacture of special steels, intended for military and naval use, in so high a degree as nickel. It is, therefore, not to be wondered at that from the very beginning of the present great war the abundant supplies of nickel in Ontario were regarded as of great, and indeed Imperial importance, since they conferred so marked an advantage on the arms of Britain and her Allies.

No doubt Germany had laid up stores of the metal in anticipation of the present conflict, but when these were exhausted there was little chance of replenishing her supply, since her native sources of nickel and those of Europe generally are few, and yield but scantily. Notwithstanding Germany's need for nickel, it may here be said that the fears expressed in some quarters that she might obtain supplies from Ontario during the war were, and are, entirely unfounded.

But while present conditions bring into prominence the usefulness of nickel for purposes of war, in normal times of peace its properties render it no less serviceable. Wherever strength and lightness are required in steel construction nickel is almost indispensable. It has come largely into use in the manufacture of automobiles, bicycles, marine boilers, propeller-shafts and other articles where a maximum of strength and a minimum of weight are desirable. A striking example of its use is in the new Quebec railway bridge across the St. Lawrence River. The old bridge was too heavy; that is to say, it would have been all right had it been possible to get it into place, but the completed structure succumbed to the strain imposed by its own weight. The admixture of nickel in the steel of the new bridge will at once add to its strength and, by reducing the weight of its parts, lessen the strain.

Nickel is very little susceptible to corrosion, and a mixture or alloy of nickel and copper, in practically the same proportions in which these substances occur in the ore, named monel metal, has been found very serviceable when called upon to resist such agencies as sulphuric or other acids, which quickly eat away ordinary iron or steel. Many other uses for nickel might be mentioned, such as for plating metallic objects, making Britannia metal or German silver, for coinage, etc.

There are two kinds of nickel ore found in Ontario: (1) the nickel-copper ores of the Sudbury district, which are essentially pyrrhotites, carrying chalcopyrite and pentlandite, and (2) the cobalt-nickel arsenides of the Cobalt region are described by A. P. Coleman as occurring in connection [sic — see text] these sources is of comparatively little importance commercially, though it may be mentioned in passing that the first refined nickel produced in Ontario came from the ores of Cobalt. Geologically, the ore bodies of the Sudbury region, whose chief value is in their silver. The second of nection with "a single great sheet of eruptive rock, roughly boat-shaped, with a blunt bow to the south-west and a square stern to the north-east." Only the upturned edges of the sheet are exposed, and on the outer edge of this sheet are found the ore masses, which are lenticular in character.

A considerable number of mines have been opened since the discoveries were made in 1883, and the ores, though of the same general character, vary somewhat in their metallic contents. The great Creighton mine of the Canadian Copper Company is one of the largest and richest of the mines. It carries about 2 per cent. of copper and 5 per cent. of nickel. The Crean Hill in 1907 averaged 4.84 per cent. of copper and 2.35 per cent. of nickel. No. 2, or Copper Cliff, produced more than a million tons of ore, containing 3.55 per cent. nickel and 3.3 per cent. of copper. The ore of the Evans mine ran about 3 per cent. nickel and 2.66 per cent. copper. Frood is an immense body of somewhat low-grade ore, running about 2.66 per cent. nickel and 1.39 per cent. of copper. The Stobie was also low-grade, and carried 2.13 per cent. nickel and 1.38 copper. The Murray, when worked, produced ore containing about 2.25 per cent. of nickel. Victoria, Blezard, Garson, Elsie, Gertrude, Levack, and numerous other deposits have all contributed to the output of the region. Whistle, Blue Lake and other deposits on the northern range have not yet begun production. Diamond drilling, during recent years, has greatly increased the known reserves of ore; this is true particularly of the Creighton, Frood, Murray and Levack mines, where many millions of tons of ore have been proven to exist.

The nickel-copper industry is expanding rapidly. The output of nickel in 1910 was 18,636 tons, and of copper 9,630 tons; in 1914, notwithstanding the outbreak of the war and the consequent disturbance of the industry, the product amounted to 22,750 tons of nickel and 14,448 tons of copper. For the first nine months of 1915 the yield was 24,054 tons of nickel and 14,057 tons of copper, and, if maintained at the same rate, the production for the full twelve months will be not less than 32,000 tons of nickel and 18,750 tons of copper. Even at the low valuation placed by the companies on the nickel and copper contents of the matte, the value of the nickel output of 1915 will be $6,400,000 and of the copper $2,600,000, or $9,000,000 in all. At the present price of the refined metals these figures would be increased to 20 or 25 millions and 7½ millions, respectively.

The processes employed in mining and treating the ores are well known. After being raised to the surface the ore is crushed and sorted, being afterwards roasted in heaps in the open air to expel the sulphur. It is then smelted in a blast furnace to a low-grade matte, which is immediately converted into a Bessemer matte carrying 75 or 80 per cent. of the metals, say, 50 per cent. nickel and 25 per cent. copper in the case of the Canadian Copper Company, and 40 per cent. each of nickel and copper in that of the Mond Nickel Company. The matte is subsequently exported to Constable Hook, N.J., and Clydach, Wales, respectively, for the final separation of the metals. The refining process employed by the Canadian Copper Company produces refined nickel and blister copper, which undergoes still further treatment before becoming pure metal. In the Mond Company's works the nickel carbonyl method gives pure nickel, while the copper is recovered as copper sulphate, which is in demand in the vine-growing countries of Europe as a safeguard against the phylloxera pest. The two companies mentioned are the only producers of ore, with the exception of the Alexo Company, which operates a comparatively small deposit in Dundonald township, on the Porcupine branch of the Timiskaming and Northern Ontario Railway. The significance of this ore body, which much resembles those of Sudbury, consists in its geographical position, being remote from the better-known deposits.

CANADIAN GOVERNMENT RAILWAY EXPENDITURES.

The Dominion government's expenditures on railways to the end of the last fiscal year was $648,075,427 and on canals $150,205,770. The revenues from railways and canals since Confederation were $222,183,757.

The annual report of the department of railways and canals shows the total expenditure on the National Transcontinental Railway for construction is $152,802,745.

The total expenditure on the Grand Trunk Pacific mountain section approved and certified up to the end of March, 1915, is given as $87,119,153, while $15,556,482 was spent on the prairie section up to the end of October, 1907, no further certificates having been issued for this section.

The total railway expenditure during the fiscal year to March 31st, 1915, was $42,747,532, including the outlay on the Quebec Bridge construction. This total includes $18,101,809 on the Intercolonial Railway, $1,168,757 on the Prince Edward Island Railway, and $10,071,479 on the National Transcontinental Railway.

The canal expenditure amounted to $7,314,131. The total outlay for the year on railways and canals was $50,063,988. The revenue derived from government railways and canals was $12,577,120, including $12,149,357 from railways and $427,763 from canals.

The operation of the Intercolonial Railway for the year resulted in a profit of $42,965 on total earnings of $11,444,873.

CONCRETE PIPE TUNNEL, N.T.R., QUEBEC.

By C. V. Johnson, A.M. Can. Soc. C.E.,
Chief Engineer to Joseph Gosselin, Engineering Contractors, Quebec.

THERE has been considerable discussion, at various times, as to the safety of erecting concrete structures in freezing weather. It seems to be generally recognized at the present time that there is little or no danger in pouring large masses of concrete in cold weather, such as is experienced in this country, provided proper precautions are taken to have the materials well heated and the work protected from the cold in so far as existing conditions will permit. On the other hand, many engineers and architects look with disapproval on the practice of pouring thin walls or slabs during the winter months, and probably with some reason, as more care must be taken, in order to ensure a good job, than is, perhaps, consistent with many contractors' ideas of allowable expenditure.

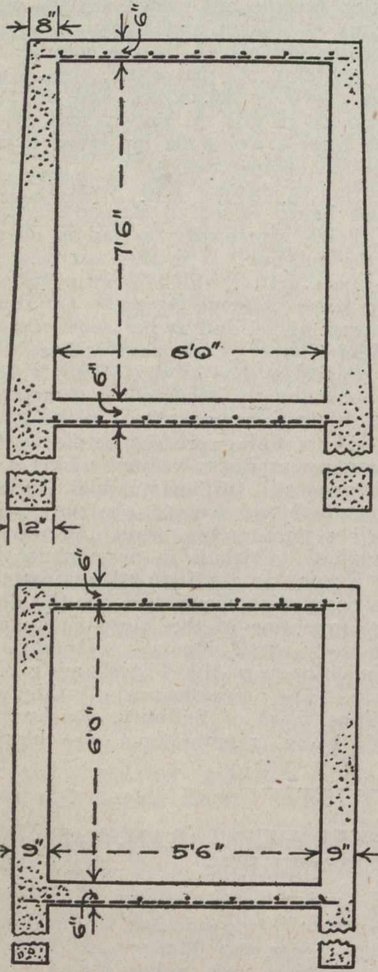


Fig. 1.
Typical Sections of Pipe Tunnel.

It is not, however, the intention of this article to enter into a discussion of this question, but merely to place before the profession an instance which tends to show that, with proper care, thin work may be carried on with equal safety to mass work.

The work in question is a concrete pipe tunnel, partly reinforced, which was constructed in the yard of the National Transcontinental Shops at Quebec. The concreting of this tunnel was commenced on the 20th February, 1915, and carried on almost continuously until the end of April, during which period the mercury dropped considerably below zero at various times. No concreting, however, was done at a lower temperature than 10 deg. above zero, although on one day, during the construction of the reinforced top, owing to a very sudden drop in temperature, the mercury had reached 5 deg. below zero before the concrete was 12 hours old. No ill effects developed from this as ample precaution was taken, by means of sacks and planks, to protect the finished work.

This tunnel, as shown by the accompanying sections (Fig. 1), is of thin construction throughout, the walls at no point exceeding 12 in. in thickness, and the floor and top being a 6-in. slab, reinforced with ½-in. square bars, placed 12 in., c. to c., both ways. The total length is approximately 850 feet, and the sections vary slightly according to the depth required.

The transportation of the concrete to the forms was accomplished by means of barrows, the longest haul being about 300 ft. Two ½-yd. Smith mixers were placed at the most convenient points, together with separate boilers to supply steam for heating the materials to be employed. In preparing the site for the reception of the sand and stone, a line of 1-in. steam piping with half a dozen branches of varying length and with open ends, was placed on the ground at each point where it was intended to pile the sand and stone and the materials dumped over these pipes. In this way it was only necessary to connect up the mains from the boilers, with the ends of pipe projecting from the piles, and turn on the steam, thus ensuring a continuous supply of well-heated sand and stone. A branch steam line was also run to the tank from which the water was supplied to the mixer and the water kept heated. Many authorities claim that it is unnecessary to heat the water if the sand and stone are also heated, but at any rate it accomplishes the purpose of doing away with the inconvenience of ice forming on the tanks and pails, and the small amount of extra steam required is of no consequence.

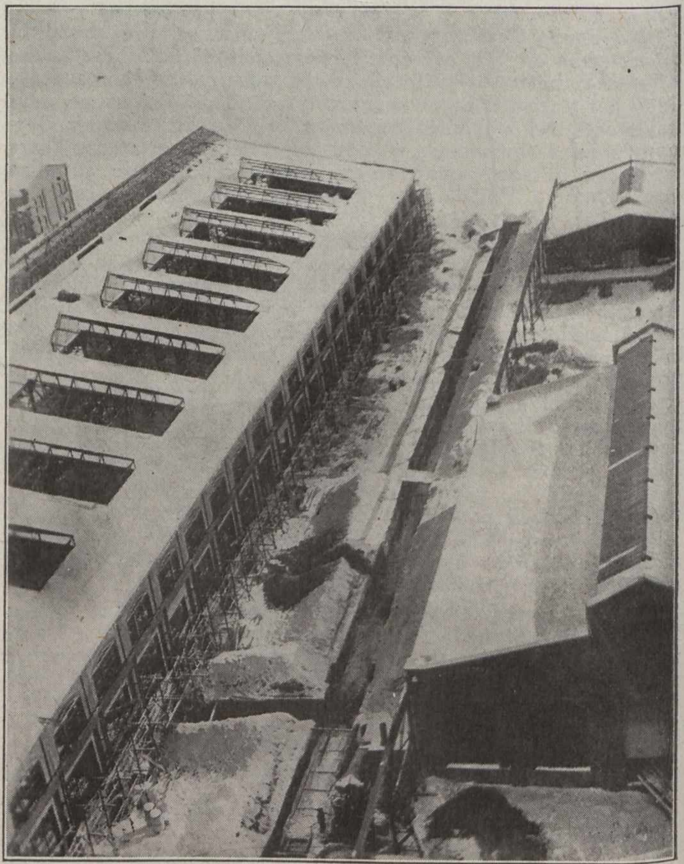


Fig. 2.—General View, Showing 550 ft. of Trench with Outside Form in Place—(Walls in Background are Ready for Pouring.)

Each night, on completion of a portion or section, of the top of the tunnel, care was taken to protect the finished work with a double layer one 1-in. boards and empty sacks, these being left in place for a period of 48 hours at least. The walls were protected by filling the space between the forms and the side of the trench with snow.

(Continued on page 294.)

Editorial

DESIGN OF LATTICE BARS.

The determination of a supposedly indeterminable formula naturally always awakens interest among engineers. Upon consulting the various authorities upon structural steel design, one finds that they all agree that the only formula obtainable for calculating stresses in lattice bars of channel columns are empirical and approximate. *The Canadian Engineer* has great pleasure in presenting this week an article by the city architect of Toronto, who gives a theoretical formula from which results are obtained that agree remarkably well with the few tests that have been made.

Mr. Pearse has decided, after years of work, that this formula is correct and practical. He has not only derived the formula, but he has also put it upon a working basis by compiling a table which will be of great convenience to structural detailers.

Mr. Pearse's name is not an unfamiliar one to steel men, as he has been the author of a number of valuable articles, including one published about two years ago on buckling in the webs of beams. In another article he derived the approximate formula for stresses in lattice bars which has been in most general use during the past nine years.

The new formula is based upon the idea that if the stress in the centre of the column be known, and if a curve be plotted that conforms to the shape that the column takes when bending, and if the centre ordinate be made equal to the stress at the centre of the column, then the stress at any other point in the column must be equal to the ordinate of the curve at the point taken.

It is proven that the curve will be sinusoid. A practical demonstration of this is to take a very thin piece of wood and press upon it at both ends. The strip will then take the form of a sinusoid. This method might be an easy way of plotting the curve after the centre ordinate is known.

It would seem that the formula derived by Mr. Pearse is a distinct advance in the theory of structural engineering, and unless disproven in some way, which is unlikely, it will undoubtedly be used hereafter in the design of all built-up columns.

ICE CONDITIONS IN HUDSON BAY AND STRAIT.

According to the report of F. Anderson, officer in charge of the Hudson Bay survey, the entrance to Hudson Strait is blocked more or less from the last week in November to the first week in January, due to the Arctic current carrying great masses of field ice and icebergs along the east shore of Baffin Land, across the entrance to the strait. The *Acadia* was held up off Cape Chidley from July 19th to 30th by ice packs. On the 31st a gale from the northwest opened out the pack and improved conditions. It would have been possible for the ship to proceed through the strait and enter Hudson Bay at this stage without any more difficulty or damage than would result from remaining in this locality, but as considerable work was to be done in the vicinity of the Button Islands, the ship remained.

In attempting to make the Buttons, it was found that the passage to the anchorage was completely cut off by ice and the ship was caught in heavy tide rips and hemmed in; thus it was clearly demonstrated that ships trying to make the strait should give the Buttons a wide berth.

On the north side of the entrance, however, about Resolution Island, the tidal currents were found just as strong, but the ice appeared to be much lighter.

After doing some survey work on the north side of the entrance, a course was laid for the Button Islands, which were reached with little difficulty. Considerable exploration work was done in the strait and the ship proceeded to Port Nelson, which was reached September 13th. After making surveys in the bay, the ship cleared Port Nelson on October 8th. On the 14th she was held up by an ice pack which, however, opened out next morning when the tide changed. Although the *Acadia* was able to get through this ice without injury, it would have been quite difficult for an ordinary freighter to have done so.

It will be seen from the above abstract of Mr. Anderson's report that he has not made any derogatory statements as to the navigability of the strait, such as he is alleged to have made by certain prejudiced persons who have abstracted isolated paragraphs from his report which are at variance with his deliberately expressed opinion in a previous supplement issued before leaving on his last trip to Hudson Bay. Mr. Anderson then stated that "the period during which properly constructed vessels could enter Hudson Strait with comparative safety may be taken from July 15th to November 15th, with a slight extension at either end, according to the season," which statement was made from observations based on his years of experience and not on this one trip. It is hardly likely Mr. Anderson would allow the difficulties of one season to change his deliberately expressed opinion.

LETTER TO THE EDITOR.

Oil Tar Creosotes.

Sir,—I have noted with interest the editorial comment in your issue of December 30th, 1915, with reference to oil tar and coal tar creosotes. Apart from the discussion of the relative value of these products for various uses in the preservative treatment of wood, the following information regarding methods of analysis and distinguishing tests may be of interest to engineers, inspectors and chemists who are responsible for the interpretation and enforcement of specifications covering the purchase of creosote or creosoted material.

There are certain fairly constant differences in the composition of these products which serve as a basis for distinction by means of chemical and physical tests as indicated below. Typical coal tar creosote is composed almost entirely of the aromatic series, including a proportion of tar acids—phenols and cresols. Typical water gas tar, which is the most important of commercial oil tars, contains a proportion of undecomposed paraffin oils and is lacking in tar acids.

Fractional distillation of coal tar creosote and water gas tar oil may give very similar results, but it is generally possible to identify the origin of such oils by a closer examination of the composition and physical properties of the various fractions so obtained. Differences in specific gravity and refractive index are the most reliable of the distinguishing physical characteristics. Fractions distilled from coal tar creosote have higher specific gravity than fractions of water gas tar oil distilled between the same temperature limits, and similarly the indices of refraction of the former are higher than those of the latter fractions. The melting point of the higher boiling fractions—those distilled above 320° C.—is also of value as a means of distinguishing between the two products. Oil tar fractions distilled above 320° C. are liquid at 60° C. while corresponding coal tar fractions are rarely liquid at this temperature. Other characteristic physical properties which may serve as a supplement to the more definite tests noted above are the odor and color of the oil fractions. Water gas tar has a particularly disagreeable characteristic odor which can generally be recognized.

The detection of paraffin oils by sulphonation test is probably the most conclusive chemical test for the distinction between coal tar and oil tar products. Hydrocarbons of the aromatic series are converted into soluble sulphonic acids by treatment with concentrated sulphuric acid, and the undissolved residue—paraffin oils—determined by separation. This test is usually made on the fraction distilling between 305° C. and 320° C. A positive result, *i.e.*, a residue of undissolved oils, indicates oil tar origin. The determination of tar acids by hot alkaline extraction is also of value in identifying a creosote sample. Deficiency in compounds of these series indicates that the oil is an oil tar product. However, this test is, perhaps, not so conclusive as the sulphonation test.

The distinguishing tests above described apply to typical commercial oils, but it should be remembered that low coking temperatures, as in certain types of bituminous gas producers or where bituminous coal is used as a blast furnace fuel, yield tars from which creosotes may be distilled which will be very similar to water gas tar oil. Coal tars of this class are, however, of very limited production in America. It must also be noted that the certain detection of oil tar in mixture with coal tar creosote is not always possible, and in cases where the results of foregoing tests suggest the presence of oil tar products, it may be necessary to investigate the history of the sample for conclusive information.

Detailed methods for the laboratory examination of commercial creosotes are outlined in "Preservation of Structural Timber," H. F. Weiss (McGraw-Hill Book Co.), or in publications of the United States Forest Service as noted below. Complete laboratory examination includes determination of specific gravity of the whole sample, fractional distillation, determination of specific gravities and refractive indices of the fractions distilling between 235° C. and 305° C., sulphonation test of fraction obtained between 305° C. and 320° C., and determination of tar acids and water.

In the following quotations, all temperatures refer to Centigrade scale.

***Specific gravity of the whole oil.**—The perfectly liquefied oil is poured into a hydrometer cylinder, and, at a temperature of 60°, the specific gravity is read with hydrometer standardized against water at 60°.

***Fractional distillation.**—The Hempel distilling flask of resistance glass is employed. The empty flask is tared, 250 grams of melted, well-shaken oil introduced, the platinum-wire plug and the glass beads put in place, and a second weight taken. The thermometer is then inserted in the flask, so that the first emergent reading is 200°. The flask is supported on an asbestos board with a slightly irregular opening of very nearly the largest diameter of the flask. A condensing tube is employed and the fractions are collected in tared flasks. The distillation is run at the rate of 1 drop per second, and fractions collected between the following temperatures: Up to 170°, 170°-205°, 205°-225°, 225°-235°, 235°-245°, 245°-255°, 255°-285°, 285°-295°, 295°-305°, 305°-320°, and if feasible 320°-360°.

The character of the fractions and their weights are recorded and the results plotted as a curve, in which the ordinates are percentages by weight and the abscissae temperatures. When the distillation has reached the 225° point, an asbestos-board box should be placed around the distilling flask, to cover the bulb, but leave the Hempel column exposed. Drafts upon the distilling apparatus must be avoided.

***Index of Refraction.**—The indices of refraction of the different fractions between 235° and 305° are determined at 60° in a refractometer with light compensation. The results are plotted with temperatures as abscissae and indices of refraction as ordinates.

***Specific Gravity.**—The specific gravities of the fractions between 235° and 305° are determined by means of specific-gravity bottles. These bottles are filled at 60° and the weights referred to water at the same temperature. The results are plotted as a curve, in which the ordinates are specific gravities at 60°, and the abscissae temperatures.

***Tar Acids.**—Fifty cubic centimeters of the creosote under analysis are measured at 60° into a small distilling flask by a pipette. The oil is distilled as completely as possible without breaking the distilling bulb, and the distillate is caught in a short-stemmed, 100 cubic centimeter separating funnel. At the end of the distillation 25 cubic centimeters of boiling hot 15 per cent. sodium hydroxide is added to the distillate and the mixture thoroughly shaken. The alkaline extract is then drawn off into a 100 cubic centimeter shaking cylinder and 25 cubic centimeters more of hot sodium hydroxide added. After extracting with this second portion for five minutes, with frequent shaking, the solutions are allowed to separate and the alkaline extract added to the first portion in the cylinder. A third extraction is made with 15 cubic centimeters of alkali. The total alkaline extract is cooled, acidified with sulphuric acid, thoroughly shaken, brought to 60°, and the volume of supernatant oil read off.

***Water.**—After weighing the first two fractions of a fractional distillation they are united in a small separatory funnel, and any water which is present is separated from the oil and its amount accurately determined. If particular accuracy is required in the estimation of the water it may be done by the Marcusson xylol distillation method.

†Sulphonation Test.—Ten cubic centimeters of the fraction of creosote to be tested are measured into a Babcock milk bottle. To this is added 40 cubic centimeters of 37 times normal acid, 10 cubic centimeters at a time. The bottle with its contents is shaken for two minutes after each addition of 10 cubic centimeters of acid. After all the acid has been added the bottle is kept at a constant temperature of from 98° to 100° C. for one hour, during which time it is shaken vigorously every 10 minutes. At the end of an hour the bottle is removed, cooled, and filled to the top of the graduation with ordinary sulphuric acid, and then whirled for five minutes in a Babcock separator. The unsulphonated residue is then read off from the graduations. The reading multiplied by 2 gives per cent. by volume directly. (Each graduation equals one two-hundredths of a cubic centimeter.)

---

*United States Forest Service Circular 112, "The Analysjs and Grading of Creosote," A. L. Dean and Ernest Bateman. Also reproduced in United States Forest Service Circular 206, "Commercial Creosotes," Carlile P. Winslow; and in "Preservation of Structural Timber," H. F. Weiss (McGraw Hill Book Co.)

†United States Forest Service Circular 191, "Modification of the Sulphonation Test for Creosote," E. Bateman. Also reproduced in "Preservation of Structural Timber," H. F. Weiss.

JOHN S. BATES, CHEM.E., PH.D.,
Superintendent, Forest Products Laboratories of Canada,
Forestry Branch, Dept. of the Interior, Canada.

Montreal, February 9th, 1916.

The Engineer's Library

Any book reviewed in these columns may be obtained through the Book Department of The Canadian Engineer, 62 Church Street, Toronto.

CONTENTS.

BOOK REVIEWS.

Mechanical Technology. By Prof. G. F. Charnock, M.I.C.E., M.I.M.E. Published by Constable & Company, London. 635 pages; 503 illustrations; 6x9 ins.; cloth. Price, $2.00, (Reviewed by A. J. MacDougall, mechanical engineer, Toronto Power Co.)

This book deals principally with the mechanical processes in refining and preparing metals for use in the arts. The chemical and thermochemical changes, however, are not taken up. The book is divided into three parts: the production and properties of materials of construction, the processes depending on fusion, and the processes depending on ductility.

The beginning of the first part is given up to the physical properties of materials—tenacity, elasticity, hardness, toughness, malleability and ductility.

There is an error at the beginning of this chapter. The statement is made on page 4 that water has the greatest specific heat of any known substance. The specific heat of liquid hydrogen is six times and of gaseous hydrogen 3.4 times that of water.

In Chapter 3 there is described the smelting of iron from its ores in blast furnaces. The accessories are given the hot blast stoves, blowing engines, hoisting skips and air gas mains. The properties of pig iron are stated in Chapter 4. Then follow in order, with plans and illustrations, to Chapter 10, the production of wrought iron, classification of steel, the manufacture of steel by the crucible, the Bessemer, the open-hearth, and the electro-thermic processes.

The author then takes up in a scientific manner a subject in which there have been great advances in the last few years—alloys and the heat treatment of steel. Credit is given to the late Sir W. C. Roberts Austen for the discovery of physical changes in formation of alloys at various temperatures and the practical heat treatments developed therefrom. Non-ferrous metals and the methods of refining are briefly described in Chapter 13. The metals described are copper, tin, zinc, lead, aluminum, antimony and nickel. Their alloys are given in Chapters 14, 15 and 16. In Chapters 17 and 18 are given the properties and uses of timber and building stones. These chapters describe timbers and building stones in use in Great Britain and therefore lack in value for Canadian conditions.

The author describes in Chapter 19 oils and lubricants, their properties and specifications for various uses. He has neglected to give any statement about the effect of an emulsifying oil and a test of the oil for emulsification.

Leather, rubber and cotton and their use as belting with methods of manufacture are given in Chapter 20.

Part II., comprising Chapters 21 to 30, takes up the moulding of fused metals. Starting with advice as to design and form of patterns to avoid defects in castings, the author proceeds to describe methods of moulding and then gives advice as to the foundry and its equipment, devotes a chapter to steel casting, and finishes this part of the book with defects in castings and machine moulding.

In Part III., Chapter 30 to the end of the book, there are taken up forging and working metals, ductile, plastic, and malleable, at ordinary or high temperatures. After describing the tools and machines required in forge and smithy the author gives in Chapter 30 a classification of operations in forging, and illustrates with examples, and then devotes a chapter to each to describe manufacturing processes, utilizing the ductility of metals. The processes are drop forging, wire drawing, flanging, coining, the rolling mill, and the manufacture of tubes.

All the machines and processes in this book are well described, and the book is valuable to the foundry man and to the smith, to those who have to do with fused or forged metals. But the book might be even more valuable. One would like to know the following about a machine to make any product: the general design of the machine, the process to make the product, the cost of the machine, the power, and the labor required to operate the machine. The cost, power, and labor are neglected in this book and the book lacks in value to that extent.

American Sewerage Practice, Vol. 3—Disposal of Sewage. By Leonard Metcalf and Harrison P. Eddy. Published by McGraw-Hill Book Co., New York City. First edition, 1915. 851 pages; 230 illustrations; 205 tables; 6x9 ins.; cloth. Price, $6.00.

This is the third and final volume of an exhaustive treatment of the subject of sewerage practice. Reviews of the previously published volumes, 1 and 2, relating respectively to the design and construction of sewers, have already appeared in these pages. As in the previous instances, the book under consideration is non-technical in nature, but deals in a comprehensive way with sewage and the changes which it undergoes when subjected to different conditions. The book is undoubtedly intended primarily for engineers connected with the design and operation of sewage disposal plants, but it will be found of great value by civil engineering students, sewerage boards, public health officers and corporation lawyers.

The first six chapters have to do with sewage itself. The progressive steps in sewage treatment are reviewed in Chap. 1. Significance of chemical analyses is considered in Chap. 2; bacteria and their relation to the problem of sewage disposal, Chap. 3; microscopic organisms, Chap. 4; composition of sewage, Chap. 5; theories of sewage disposal and treatment, Chap. 6.

The remaining fourteen chapters deal with subjects of particular interest to designing engineers and operators of disposal plants, an idea of the scope of this portion of the work being obtained from the chapter headings which are as follows: Sewage Disposal by Dilution; Grit Chambers; Racks, Cages and Screens; Sedimentation, Straining and Aeration; Tanks for Sludge Digestion; Chemical Precipitation; Sludge; Contact Beds; Trickling Filters; Intermittent Sand Filtration; Irrigation and the Agricultural Utilization of Sewage and Sludge; Automatic Apparatus for Dosing; Disinfection of Sewage and Sewage Effluents; and Disposal of Residential and Institutional Sewage.

Although the title confines the scope of the book to sewerage practice on this side of the Atlantic, the authors have provided a great deal of useful and important information from European engineers as well. The book is quite up-to-date in its information. In fact, the authors lay claim to extensive revision and rewriting with this aim in view. The duty of the engineer with respect to sewage and sewerage work is clearly indicated to involve the careful safeguarding of public health. Wise limits of expenditure are advised, this being accomplished most effectually by insisting that each undertaking shall be considered upon its own conditions and that the trained specialist in this branch of engineering shall be the judge of the significance and applicability of experience gained with sewage disposal works elsewhere. The danger of failure resulting from copying plans is pointed out.

In addition to finding the book to be one of great practical value for the subject matter contained therein, the reader will note its completeness in the matter of the selection and arrangement of illustrations. These comprise views of works and of apparatus. The line drawings of plant arrangements, etc., conform, as do the other physical features of the work, with those in the previous volumes. Taken altogether, the engineer will not readily find a more complete compendium of information regarding sewerage practice in America than the three volumes which the above authors have presented.

PUBLICATIONS RECEIVED.

Heat Transmission Through Boiler Tubes.—Technical paper No. 114, U.S. Bureau of Mines; 35 pages.

Ontario Bureau of Mines.—Twenty-fourth annual report, containing 74 pages of information on the Porcupine gold area. Illustrated and containing maps.

Tide Tables for Nelson, Hudson Bay.—An 8-page pamphlet containing tidal data for Hudson Strait and James Bay. Issued by the Tidal and Current Survey, Department of Local Service, Ottawa.

University of Illinois.—Bulletin No. 83 of the engineering experiment station, dealing with magnetic and and other properties of iron-silicon alloys melted in vacuo. Seventy pages, illustrated. Price, 35 cents.

Shot Firing in Coal Mines by Electricity Controlled from Outside.—Technical paper No. 108, issued by the U.S. Bureau of Mines; giving a description of systems in use and suggesting certain improvements; 36 pages.

Mine Ventilation Stoppings.—Bulletin No. 99 U.S. Bureau of Mines. A 30-page illustrated pamphlet very completely describing the types of mine stoppings in use in Illinois, giving costs of erecting and maintaining.

Water Power Branch.—Annual report, Part 8, 1914, of the superintendent of water powers. Three hundred pages, profusely illustrated, and with numerous maps inset. Published by the Department of the Interior, Ottawa.

Copper Deposits in Quebec.—A 290-page illustrated report of the Department of Colonization, Mines and Fisheries, Quebec, prepared by J. A. Bancroft and relating to the copper deposits in the eastern townships of the province.

Motors.—A paper on the single-phase, squirrel-cage motor with large starting-torque and phase compensation. By W. A. Fynn, Consulting Engineer, Wagner Electric Manufacturing Co. Reprinted from the proceedings of the A.I.E.E.

Hazards in Handling Gasoline.—Technical paper prepared by Geo. A. Burrell, of U.S. Department of Mines, outlining relation of properties of gasoline and vapor to inflammability and presenting directions for extinguishing burning fluids.

Gasoline Mine Locomotives.—Bulletin No. 74, U.S. Bureau of Mines. A pamphlet describing the use of gasoline locomotives in mines and methods of diluting the noxious gases, from the standpoint of safety and health. Eighty-three pages, illustrated.

Production of Metals in Canada, 1914.—Advanced chapter of annual report on mineral production of Canada, 1914, issued by Mines Branch, Department of Mines. Relates to 1914 production of copper, gold, lead, nickel, silver, zinc and other metals.

Mexpet Record.—A 16-page illustrated publication describing the oil fields of the company in Mexico and the various uses to which the oil may be put. Also containing a diagram showing the comparative costs of coal and fuel oil. Published by the Mexican Petroleum Corporation, 52 Broadway, New York.

Discovery of Phosphate of Lime in the Rocky Mountains.—A 36-page illustrated Commission of Conservation report, prepared by Frank D. Adams, D.S.C., and W. J. Dick, M.S.C., relating to the geology of these phosphate deposits and illustrated by maps, diagrams and microphotographs.

Petroleum and Its Products.—Bulletin No. 9 of the Kansas City Testing Laboratory. A 20-page pamphlet summarizing the production and uses of petroleum, and containing tables and other useful information for both the refiner and consumer. Issued by the Kansas City Testing Laboratory, 1013 Grand Avenue, Kansas City, Missouri. Price, 25 cents.

CATALOGUES RECEIVED.

Johns-Manville Products.—An 80-page illustrated catalogue describing the varied products of this company. The H. W. Johns-Manville Co., Limited, Toronto.

Bosch & Lomb Optical Instruments.—This is an interesting catalogue of 36 pages, describing various optical applications for the microscopic examination and testing of materials.

The Cement-Gun on the Elephant Butte Dam.—Reprint of article by E. H. Baldwin, assistant chief of construction in U.S. Reclammation Service, Denver, Col., on waterproofing the upstream face of the Elephant Butte Dam, New Mexico, by use of the Cement-Gun. Issued gratuitously by The Cement-Gun Co., Inc., 30 Church Street, New York.

Tiffin Flushers.—This is a twelve-page pamphlet containing illustrated descriptions of the Tiffin flushers, showing their new models of 1,000, 1,200, 1,400 and 1,500 gallons capacity. It gives specifications of the flushers and also some data concerning the sprinkler portion of them and should be of great interest to all those who have to do with the maintenance of roads and pavements.

COAST TO COAST

Winnipeg, Man.—A commission to inquire into drainage questions has been practically promised by the provincial government.

Kingston, Ont.—The Utilities Commission has offered to supply the Street Railway Company with power for ten years at 1.2 cents a kw. hour.

Vancouver, B.C.—It is expected that the new Kettle Valley route over the Hope Mountains will be ready for traffic when the C.P.R. puts the summer schedule into effect on June 1st.

New Westminster, B.C.—The Canadian Northern Railway has recently acquired that section of the old main line of the Great Northern Railway between Fraser River bridge and Port Kells.

Victoria, B.C.—Alluding to certain criticisms of the purchase of the Sooke watershed, Mr. Rust maintains that the city will derive sufficient revenue from the sale of the timber to more than cover the cost.

Toronto, Ont.—At the annual convention of the Ontario Hydro-Electric Railways Association a resolution was passed calling upon the government to restrict exportation of power to the United States.

Galt, Ont.—The new Lake Erie and Northern Electric Railway has commenced operating its line from Galt to Brantford. The Port Dover line is complete except for the overhead construction, which is under way.

Montreal, Que.—The Bell Telephone Company last week successfully opened the Montreal-to-Vancouver telephone line. This line is said to be the longest ear-to-ear circuit in the world, extending for 4,227 miles.

Toronto, Ont.—The Toronto, Barrie and Orillia Railway has applied to the government to be allowed to proceed with the construction of its proposed line. The company has already spent $55,000 on preliminary work.

Calgary, Alta.—City Engineer Craig is in favor of waiting results of the activated sludge experiments before building a new sewage disposal system, which as at present proposed, would cost in the neighborhood of $400,000.

Winnipeg, Man. — According to Superintendent Phillips, over $19,000,000 has been expended in bringing the electric railway system up to its present standard. The number of passengers carried during the last three years averages 50,000,000.

Ottawa, Ont.—Hon. J. D. Hazen estimates that it will cost probably $9,000,000 more to give the St. Lawrence ship channel a width of a thousand feet and a depth at low tide of 35 ft. from Montreal to Quebec. He states that the work will take five years.

Windsor, Ont.—At a meeting of representatives of the five border municipalities here it was decided to form the Essex Utilities Commission to construct and mantain sewer, water, light and power systems at Windsor, Walkerville, Sandwich, Ford and Ojibway.

Berlin, Ont.—At a conference of municipal representatives Sir Adam Beck outlined a scheme for a hydro-radial line from Elmira through Berlin to Galt and thence to Hamilton and St. Catharines, with branch lines running to Guelph, Hespeler and Puslinch Lake.

Limoilou, Que.—Work has started on the construction of the cattle market for the Quebec Abattoir Co. at Limoilou. Work will be done by day labor under the superintendence of Jos. Gosselin, General Contractor. Estimated cost, $35,000. H. Laberge, Architect.

Toronto, Ont.—The Toronto Suburban Railway has asked the York County Council for an extension of franchise to enable the company to connect the present Dundas line with the Georgetown branch at a point near the present terminus of the Dundas line at Lambton.

Calgary, Alta.—Superintendent Breen, of the waterworks department, informed the city commissioners that the matter of water services freezing up was becoming very serious. The cost of thawing out services during this winter will likely be in the neighborhood of $50,000.

Loretteville, Que.—The grading of the St. Charles and Huron River Railway, a branch of the C.N.R., from Loretteville to Stoneham, Province of Quebec, has now been completed. Track will be laid in the spring and the road opened for traffic on June 15th. Jos. Gosselin, General Contractor for grading. C. A. Newton, Resident Engineer.

St. Catharines, Ont.—The Niagara, St. Catharines and Toronto Railway have asked parliament to extend the time allotted for finishing its railway from Fort Erie to Niagara-on-the-Lake; from St. Catharines to Hamilton and Toronto, and from Port Colborne to Fort Erie, but is partly to allow the Niagara, St. Catharines and Toronto Railway time to purchase the Michigan Central line from Fort Erie to Niagara-on-the-Lake.

St. Catharines, Ont.—Although the construction of Sections 1 and 2 on the Welland Ship Canal are behind on the schedule for their completion in the spring of 1917, Chief Engineer Weller states that now construction work is in full swing they are gaining on their schedule and will be ready for opening as intended. He states, however, that it is practically impossible for Section No. 3 to be completed before the spring of 1918, owing to the large amount of concrete to be placed. He recommends that contracts be let for Sections 4 and 8 as soon as possible.

Edmonton, Alta.—During 1915 three hundred and twenty-six miles of new railway were constructed in the province. With the exception of 22 miles built by the C.P.R., the entire mileage was constructed with the aid of government guarantees. The new mileage is credited to the various lines, as follows: Canadian Pacific Railway, 22 miles; Canadian Northern Railway, 59 miles; E., D. & B.C., 97 miles; A. & G. W., 100 miles; Central Canada Railway, 48 miles.

Hamilton, Ont.—There will shortly be a mass meeting of representatives of local municipalities to discuss the hydro radial schemes. There is talk of a branch line from the main radial between Toronto and London with a junction at Port Credit. There is a likelihood of efforts being made to purchase the electric line between Hamilton and Oakville of the Dominion Power and Transmission Co. From Hamilton the radial will proceed to St. Catharines and thence to the Niagara River. It is also planned to build a line from Hamilton to Guelph.

Berlin, Ont.—To a large gathering of municipal representatives Sir Adam Beck recently outlined a proposition whereby existing branches of the G.T.R. and C.P.R. may be used to better advantage and serve as feeders for the main lines in this section of the province. Whereas it will be impossible to construct hydro-radial branch lines parallel to branches already in operation of steam railways, it will be possible to have these branches electrified and to secure running rights over them. Sir Adam instanced the G.T.R. branch from Berlin to Galt and from Berlin to Elmira as well adapted for such use.

Winnipeg, Man.—Concerning the disturbance which has arisen as a result of charges made by Mr. M. T. Cantell against the engineers of the Greater Winnipeg Water District, it is interesting to note that the Manitoba Branch of the Canadian Society of Civil Engineers adopted the following resolution at its recent meeting: "Whereas certain articles have appeared in the Winnipeg public press from time to time criticizing the engineers of the Greater Winnipeg Water District, resolved that it be recorded that the Manitoba Branch of the Canadian Society of Civil Engineers regrets that such criticism has been made, and repudiates any responsibility for the same, and that further, the secretary be instructed to so inform the various newspapers of Winnipeg."

Toronto, Ont.—It was announced by Premier Hearst last week that the provincial government, having before it the general details of the proposed Niagara development of the Hydro-Electric Power Commission, will submit legislation authorizing such development. It is estimated that within the next few years the Commission will require an additional 100,000 h.p. If the expenditure is favorably considered by the government, the Commission will probably proceed with the installation of several large units, probably 50,000 h.p. each, and by the time these are in operation another set of similar capacity will likely be necessary. The engineers of the Commission have in view the ultimate development of 600,000 h.p. at the site proposed. This large development will probably comprise two plants of equal size, each of which will consist of about six units of the extraordinarily large capacity mentioned above.

PERSONAL.

J. H. MEAD has been appointed president of the Spanish River Pulp and Paper Co.

W. G. TRETHEWEY has been appointed resident engineer of West Dome Consolidated.

A. J. CARROLL has been appointed district manager of Eugene F. Phillips Electrical Works, Limited, with office in Montreal.

E. W. DuVAL, until recently superintendent of Saskatoon District, C.P.R., is at present acting general superintendent of Saskatchewan Division.

W. E. CORMAN is at present superintendent for the Excelsior Electric Co., Toronto, on the manufacture of tools and machinery for munitions, having temporarily left the employ of C. H. and P. H. Mitchell.

W. R. SMITH, general manager of the E.D. and B.C. Railway, recently addressed the members of the Board of Trade in Edmonton on "The Development of our Northern Hinterland and What it Means to Edmonton."

Lieut.-Col. WILLIAM H. DAVIS. of the firm of Davis and Lubin, Vancouver, and formerly city engineer of Berlin, Ont., and later of Prince Rupert, B.C., who is in command of the 2nd Pioneer Battalion, which has been in England several months, is seriously ill in the hospital as a result of a fall from his horse. Col. Davis is a member of the Canadian Society of Civil Engineers and a graduate of R.M.C., Kingston.

F. C. GAMBLE, Chief Engineer of Railways for the British Columbia Government, and Past-President of the Canadian Society of Civil Engineers, was entertained by the Edmonton Branch of the Society at a dinner given in his honor in the Macdonald Hotel on the 9th instant. Mr. Gamble has been in the city during the past few days enroute to Victoria, B.C., from Montreal, where he has been attending the Annual Meeting of the Society. About twenty members of the Society resident in Edmonton were present at the dinner.

OBITUARY.

E. B. JONES, at one time city engineer of Chatham, Ont., and an authority on hydraulic and electrical engineering, died recently at Erie, Pa.

CONCRETE PIPE TUNNEL, N.T.R., QUEBEC.

(Continued from page 288.)

In the spring, when the forms were removed, the structure was found to be in first-class condition, and to date no defects whatever have appeared, though the tunnel underwent a rather severe test during the course of the past summer by having work trains run over it at various points.

The concrete specified and made in this work was a 1:2:4 mixture throughout. A small amount of displacers were used, though these were necessarily limited in quantity and of small volume, owing to the small space between the forms. During the construction of that part of the tunnel not reinforced a small amount of salt was also used, though only on exceptionally cold days. The amount of crushed stone, from ¾ in. to 1½ in., used was 0.8 cu. yd. for each cu. yd. of finished concrete. The cement amounted to 1.2 bbls. per cu. yd. of finished concrete. Lumber for forms figured to 60 ft. B.M. to the cu. yd. concrete.

The accompanying illustration, from a photo taken by Mr. H. E. Balfour, assistant engineer in charge of construction for the N.T.R., gives a general view of about 550 feet of the trench with the outside form in place. At the extreme lower end the inner form is also in place and ready for pouring the walls. The photograph was taken from the top of a 200-foot chimney.

The contractor for this work was Joseph Gosselin, of Quebec and Levis, General Contractor for the N.T.R. Shops.

COMING MEETINGS.

AMERICAN ROAD BUILDERS' ASSOCIATION.—Thirteenth Annual Convention to be held at Pittsburgh, Pa., February 28th to March 3rd. E. L. Powers secretary, 150 Nassau Street, New York, N.Y.

CANADIAN MINING INSTITUTE.—Eighteenth annual meeting to be held at the Chateau Laurier, Ottawa, March 1, 2 and 3. Secretary, H. Mortimer-Lamb, Ritz-Carlton Hotel, Montreal.

THIRD CANADIAN AND INTERNATIONAL GOOD ROADS CONGRESS AND EXHIBITION to be held at Sohmer Park, Montreal, March 6, 7, 8, 9 and 10, 1916. General Secretary, Geo. A. McNamee, New Birks Building, Montreal.

At the annual meeting of the Kingston Branch of the Canadian Society of Civil Engineers it was decided to discontinue the meetings of the branch for the present, owing to the fact that so many members are on active service. The chairman of the branch, Major Wilgar, is O.C. 8th Field Co., Can. Engineers, and Mayor Gill, the secretary, O.C. the Queen's Battery in England.