PAGES

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will be the most economical pipe for a particular loss of head. The new interpretation of formulas (1) and (2) (and all other formulas of the same nature) is therefore the general interpretation, and these formulas as an expression of Adams' Rule become a special case.

The economical size of a penstock or pipe may now be determined in a manner analogous to that suggested for pipes of constant diameter throughout. If, for instance, the percentage return on the original investment shall be a specified amount, we may proceed as follows:—

For each of several assumed values for b determine the pipe and calculate or approximate the percentage return p. With b as abscissa and p as ordinate a curve may be drawn. From this curve that value for b may be obtained for which the percentage return is the specified amount.

Illustrative Problem

A hydro-electric plant is to be designed so that the gross percentage return on original investment shall be a specified amount. The pipe is to be riveted steel. Besides the data given in the figure, let $q=50$ cu. ft. per sec.

$S=10{,}000$ lbs. per sq. in.
$t'=\frac{1}{4}$ in. as a minimum value
$c=\$.05$
$i=\$.12$

Since the pipe is homogeneous, the pipe of least annual cost is also the pipe of least amount of metal. We may if we choose, let $c=i=$unity (or we may let $\frac{b}{ci}$ be the constant) and design for minimum amount of metal. The final results will not be affected. We will design therefore for least annual cost.

As a first trial let $b=50$.

To eliminate the unknown coefficient of friction, f, use formulas (5) and (6). From (6)

$$d_1=0.1356\sqrt[6.25]{\frac{b\ q^3}{t'\ ci}}=4.35\text{ ft.}$$

Run this section (low head) down to $h_1=220$ ft.

Divide the rest of the pipe line into three sections as indicated in figure. From (5)

$$d_2=0.1423\sqrt[7.25]{\frac{b\ q^3S}{ci\ h_2}}=3.70\text{ ft.}$$

$d_3=3.50$ ft.
$d_4=3.35$ ft.

For the pipe thus determined, the total investment may be calculated, and the total annual income approximated. If the percentage return is the amount specified, the problem is

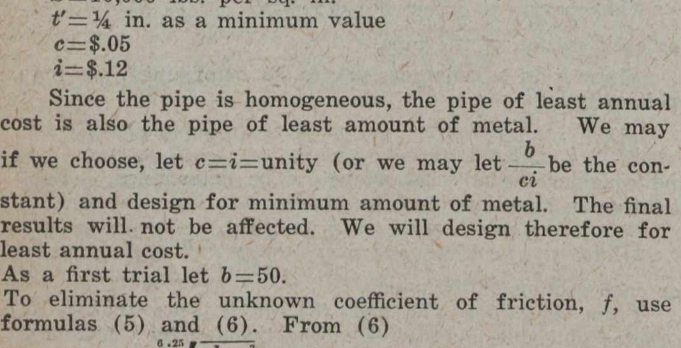

FIG. 2

solved. If not, another trial value for b should be shown. In fact several trial values for b may be successively chosen and a curve drawn with b as abscissa and p, the percentage return, as ordinate. From this curve the proper value for b can be found.

With the diameters of the four sections as determined above, the total loss of head in the pipe line is found to be $h'=49$ ft. The above pipe then for $h'=49$ ft., and for the particular mode of division assumed, is the most economical pipe that can be constructed.

It may be of interest to add the following: If the above pipe of four sections had been designed for a constant diameter throughout but variable thickness of shell, this pipe for $h'=49$ ft., would require 3.5% more metal. If the part AB, the part under high head and consisting of three sections, had been designed for a constant diameter throughout but variable thickness of shell, only 0.8% additional metal would be required. It seems advisable therefore to make the part AB have the same diameter throughout but to change the thickness of shell several times.

If the pipe had been considerably larger, the last statement would not hold. In such a case the saving in the amount of metal required if the pipe under high head is designed for several sections of different diameters and thickness of shell over that required if these sections are designed for the same diameter but different thicknesses of shell may be appreciable. In many cases, however, this saving is not enough to justify the expense of reducers.

The question therefore arises: What is the formula for a pipe or part of a pipe that shall consist of a certain number of sections all of the same diameter but different thicknesses of shell? This question can be readily answered. Referring to Fig. 1, assume that the three sections shall have the same diameter but different thicknesses of shell. Then [see equations (11), (9), (10), and (15)]

$$L=Ad^2\,(h_1\,l_1+h_2\,l_2+h_3\,l_3)+\frac{bq\,C}{8.8\,d^5}\,(l_1+l_2+l_3)$$

This must be a minimum. That is,

$$\frac{d\,L}{d\,(d)}=2Ad\,(h_1\,l_1+h_2\,l_2+h_3\,l_3)-\frac{5\,bq\,C}{8.8\,d^6}\,(l_1+l_2+l_3)=0.$$

Now let

$$(18)\quad h_c=\frac{h_1\,l_1+h_2\,l_2+h_3\,l_3}{l_1+l_2+l_3}$$

and solve for d, and we obtain, for high head,

$$(19)\quad d=0.2153\sqrt[7]{\frac{fbq^3S}{cih_c}}$$

as the required diameter of a pipe (or part of a pipe) that shall have the same diameter throughout but shall consist of a given number of sections of different thicknesses of shell. Formula (19) is the same as formula (1) except that h of (1) must be replaced by h_c as defined by (18). So far as the writer knows, formula (19) is here given for the first time.

Suppose that the part AB of the problem given above shall consist of three sections as shown and that these sections shall have the same diameters but different thicknesses of shell. From (18),

$$h_c=\frac{(3{,}000\times 480)+(3{,}000\times 720)+(8{,}000\times 1{,}000)}{3{,}000+3{,}000+8{,}000}=828\text{ ft.}$$

Formula (1) or (5) may now be used if h is taken as 828 ft., and the resulting value for d will be the economical diameter of the part AB consisting of three sections of the same diameter but of different thicknesses of shell.

The Corrugated Bar Co., Inc., of New York, announces that it has taken over the entire assets and liabilities of the Corrugated Bar Co., a Missouri corporation, and is continuing the business of the latter company, which is in process of dissolution. This means the retirement by purchase of the Garrison interests, which held the majority of the stock of the Missouri corporation from its inception, in 1891, until the recent reorganization. The control now passes to A. L. Johnson, who has been connected with the company since 1895, and who is now its president.

An information service is being organized by the Associated General Contractors of America, who have established a general office at 111 West Washington St., Chicago, Ill. It is planned to have the manager of the service keep in touch with all the technical and trade papers, and to issue a special bulletin to contractors at least once a month, calling their attention to the best articles on all topics which will be of interest to them. This bulletin will be sent to all of the chief general contractors and construction engineers in the United States, whether members of the association or not, in the hope of stimulating the interest of all general contractors in problems of mutual interest and also in the work of the association.

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Convenient Method of Calculating Trash Racks

Table and Formulae by Means of Which Designers Can Readily Determine Lengths of Panels Between Supports for Various Spacings and Sizes of Bars—Structural Details and General Suggestions Regarding the Design of Racks

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IN calculating trash racks, we should assume that they may become completely clogged and will therefore be subject to the full hydrostatic pressure due to the head of water.

As this is the worst possible case that can occur, the structure will be safe if the stress in the bars for this condition is within the elastic limit of the material used, and we can therefore use a stress as high as 30,000 lbs. in our calculations. However, for the basis of these calculations we will assume a stress of 25,000 lbs. with full hydrostatic pressure imposed.

The pressure at any point will be directly proportional to its depth below the surface; i.e., the load on any bar will be represented by a triangle with the point or apex at the surface of the water.

For any given pitch or spacing of bars, then, the free span, or distance between supports for rack bars, is determined from the resisting moment of the bar used.

Using the notation given in Fig. No. 1, the length between the different supports can be determined as follows:—

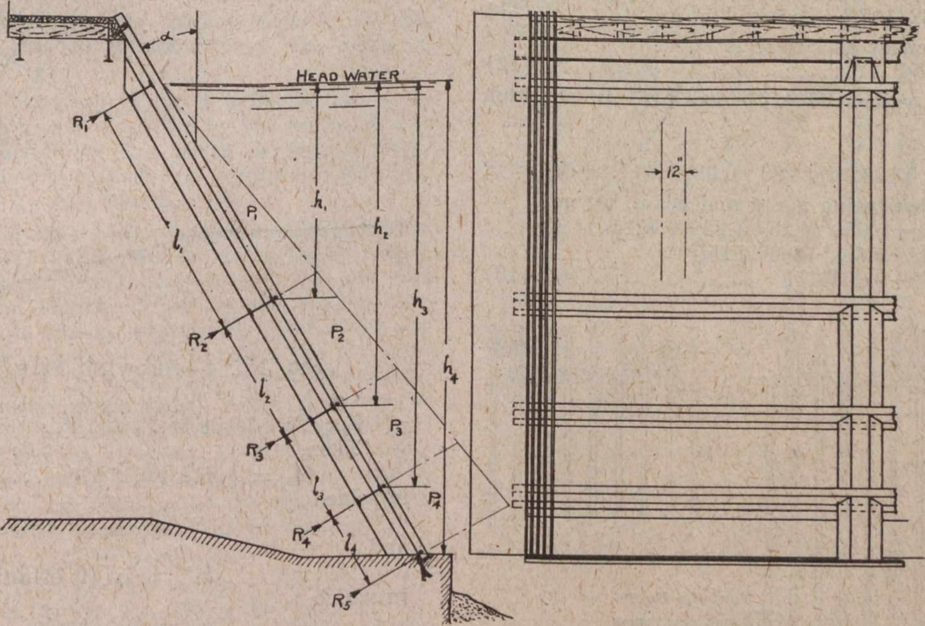


FIG. NO. 1—DIAGRAM INDICATING NOTATIONS IN FORMULAE

We will call these distances panel lengths and indicate them by l_1, l_2, l_3, l_4, etc., all in inches.

The loads P_1, P_2, etc., are for a width equal to the pitch of the bars. For the first panel, or l_1, the moment due to the load can be represented by

$$M_1 = 0.128 P_1 l_1 \quad \ldots\ldots (1)$$

where P_1 = total pressure on one bar;

l_1 = distance between supports in inches, considering ends free.

The resisting moment of the bar is

$$M_{r1} = \tfrac{1}{6} bd^2 \times 25{,}000 \quad \ldots\ldots (2)$$

Where b = thickness of bar in inches;

d = depth of bar in inches; and the dangerous section will be at a distance

$$x = 0.5774 l_1 \quad \ldots\ldots (3)$$

from top support. The spacing bolts should be spaced to avoid this section, so as not to weaken the bar. The load

$$P_1 = 0.434 l_1 p h_1 / (12 \times 2).$$

Therefore,

$$P_1 = 0.0181 l_1^2 p \cos\alpha$$

where p = spacing of bars; $h = l_1 \cos\alpha$; and $\cos\alpha = \cos$ 30 degs., generally 0.866.

By substituting for $\cos\alpha$,

$$P_1 = 0.0157\, l_1^2\, p \quad \ldots\ldots (4)$$

Substituting equation (4) in equation (1), we get

$$M_1 = 0.128 \times 0.0157\, l_1^3\, p = 0.00201\, l_1^3\, p \quad \ldots\ldots (5)$$

Equating (2) and (5), we get

$$0.00201\, l_1^3\, p = 25{,}000\, bd^2/6 = 4{,}170\, bd^2 \quad \ldots\ldots (6)$$

Now by assuming values at will for p, b and d, we have a cubic equation in l_1. By solving for l_1 we have the maximum allowable distance between supports for panel length No. 1. To carry the problem through we will assume a spacing of bars $p = 1\tfrac{1}{4}$ ins., centre to centre, and a bar ¼ in. by 2½ ins.

Substituting these values in equation (6), we get

$$0.00201 l_1^3 \times 1.25 = 4{,}170 \times 0.25 \times 2.5^2 \quad \ldots\ldots (7)$$

Therefore,

$$l_1^3 = (4{,}170 \times 0.25 \times 2.5^2) \div (0.00201 \times 1.25) = 2{,}590{,}000 \quad \ldots (8)$$

Consequently,

$$l_1 = (2{,}590{,}000)^{1/3} = 135.5 \text{ ins.}$$

The perpendicular distance, or head, $h_1 = l_1 \cos\alpha = 135.5 \times 0.866 = 117.4$ ins.

Second Panel

Theoretically the second panel, or l_2, should be calculated as a continuous beam if the bars do not end at the lower support of the second panel, but, as frequently is the case, the total length of rack is divided into several panels and would therefore not be continuous, so we will again assume free ends. This assumption will in some cases give us a shorter length for l, but the discrepancy will be on the side of safety.

The load on the second panel will be represented by a trapezoid of which the shorter leg will be the same as the base of the upper triangle (for panel l) and the lower leg will be increased by the increment due to additional head. This loading can be subdivided into two loads, one a parallelogram with height equal to the short leg of the trapezoid, and the other a triangle similar to that on first panel.

Let these loads be P_2 and P_2'. The moment will then be the sum of the two moments produced by these loads. Theoretically this is not correct because the maximum moment produced by each load does not occur at the same point. The maximum moment due to load P_2 occurs at the middle, while that due to load P_2' occurs $0.5774 l_2$ from the upper support, or $0.0774 l_2$ from the middle. Therefore the moment at the middle for load P_2' will be somewhat less, and the sum of the moments at the middle will be somewhat less, than that given in equation (9). For simplicity, however, we will assume the bending moment to be the sum of the two moments, as the difference is but small and the error gives us a safer result.

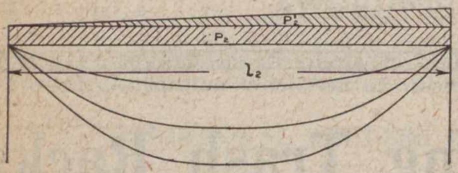


FIG. NO. 2—LOADING ON NO. 2 PANEL

$$M_2 = \tfrac{1}{8} P_2 l_2 + 0.128 P_2' l_2 \qquad (9)$$

in which

$$P_2 = 0.434 h_1 l_2 p/12,$$

and

$$P_2' = \tfrac{1}{2}[(0.434 h_1/12) + (0.434 h_2/12)] l_2 p$$

in which $h_2 = h_1 + l_2 \cos\alpha = 117.4 + l_2 \cos\alpha$.

Substituting the values of h_1 and h_2, we get

$$P_2 = \tfrac{1}{12} \times 0.434 \times 117.4 l_2 p = 4.25 l_2 p \qquad (10)$$

$$P_2' = [(\tfrac{1}{12} \times 0.434 \times 117.4) + (\tfrac{1}{12} \times 0.434)(117.4 + l_2 \cos\alpha)] \tfrac{1}{2} l_2 p$$
$$= [4.25 + 0.0362(117.4 + l_2 \cos\alpha)] \tfrac{1}{2} l_2 p \qquad (11)$$

The resisting moment as before is

$$M_{r2} = 4{,}170 bd^2 \qquad (12)$$

Substituting the values of (10) and (11) in equation (9), we get

$$M_2 = (\tfrac{1}{8} \times 4.25 l_2^2 p) + (\tfrac{1}{2} \times 0.128 l_2^2 p)[4.25 + 0.0362(117.4 + l_2 \cos\alpha)]$$

Reducing and substituting for p and $\cos\alpha$, we get

$$M_2 = 0.664 l_2^2 + 0.08 l_2^2 (4.25 + 4.25 + 0.0314 l_2)$$
$$= 0.664 l_2^2 + 0.68 l_2^2 + 0.002515 l_2^3$$
$$= 1.344 l_2^2 + 0.002515 l_2^3 \qquad (13)$$

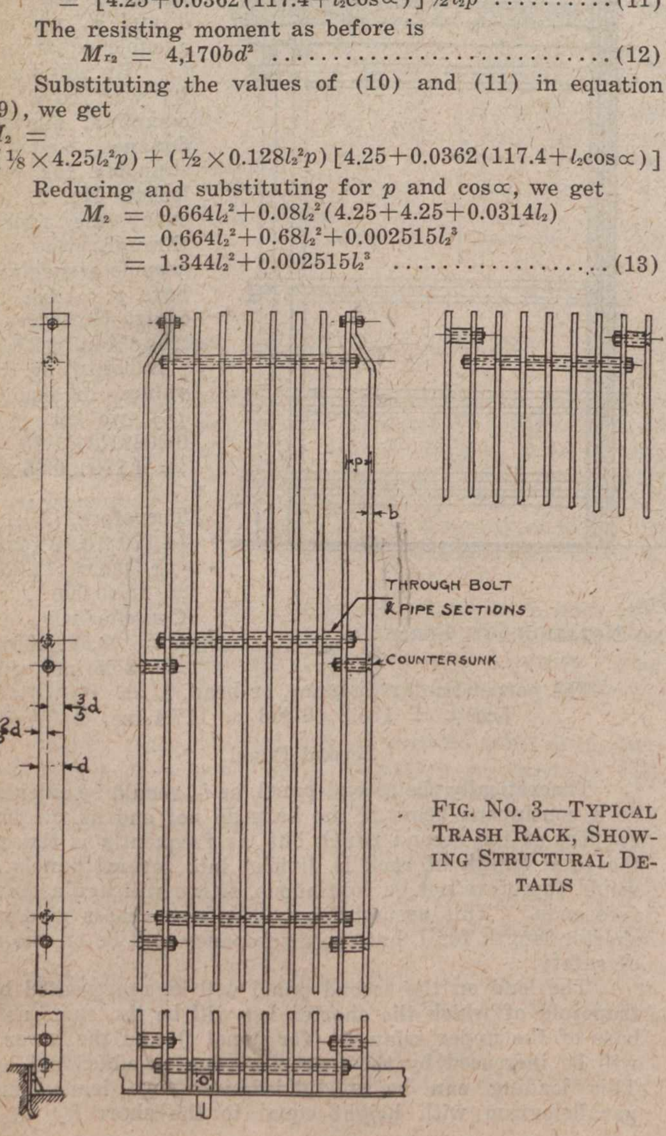


FIG. NO. 3—TYPICAL TRASH RACK, SHOWING STRUCTURAL DETAILS

Equating (12) and (13), we get

$$1.344 l_2^2 + 0.002515 l_2^3 = 4{,}170 bd^2 = 6{,}660 \qquad (13a)$$

Solving for l_2 by trial, we get

$$l_2 = 67 \text{ ins.}$$

and

$$h_2 = h_1 + l_2 \cos\alpha$$
$$= 117.4 + (67 \times 0.866)$$
$$\doteq 174 \text{ ins.}$$

Third Panel

The load on the third panel, or l_3, will be represented by a trapezoid, as in the second panel, with the short leg equal to the long leg of the trapezoid on second panel, and the long leg increased by the increment due to the additional head. This loading can likewise be divided into two loads, as in the case of the second panel.

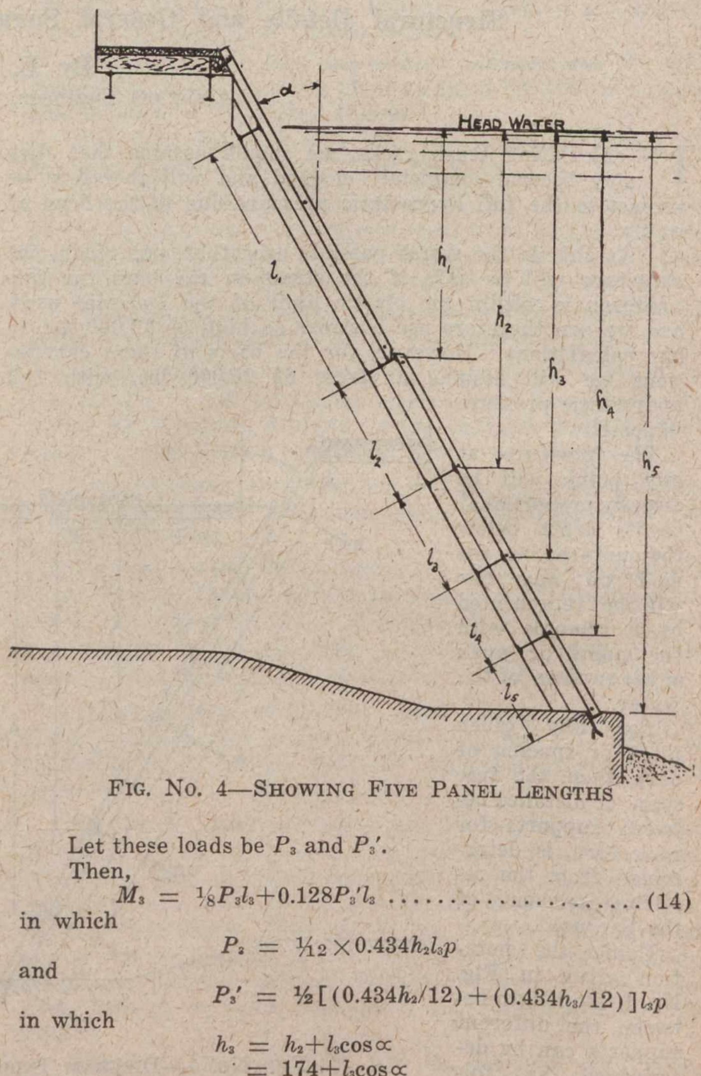


FIG. NO. 4—SHOWING FIVE PANEL LENGTHS

Let these loads be P_3 and P_3'.

Then,

$$M_3 = \tfrac{1}{8} P_3 l_3 + 0.128 P_3' l_3 \qquad (14)$$

in which

$$P_3 = \tfrac{1}{12} \times 0.434 h_2 l_3 p$$

and

$$P_3' = \tfrac{1}{2}[(0.434 h_2/12) + (0.434 h_3/12)] l_3 p$$

in which

$$h_3 = h_2 + l_3 \cos\alpha$$
$$= 174 + l_3 \cos\alpha$$

Substituting values for h_2 and h_3, we get

$$P_3 = \tfrac{1}{12} \times 0.434 \times 174 l_3 p = 6.3 l_3 p \qquad (15)$$

$$P_3' = [(\tfrac{1}{12} \times 0.434 \times 174) + (\tfrac{1}{12} \times 0.434)(174 + l_3 \cos\alpha)] \tfrac{1}{2} l_3 p$$
$$= [6.3 + 0.0362(174 + l_3 \cos\alpha)] \tfrac{1}{2} l_3 p \qquad (16)$$

The resisting moment, as before, is

$$M_{r3} = 4{,}170 bd^2 \qquad (17)$$

Substituting values of (15) and (16) in equation (14), we get

$$M_3 = (\tfrac{1}{8} \times 6.3 l_3^2 p) + (\tfrac{1}{2} \times 0.128 l_3^2 p)(6.3 + 6.3 + 0.0314 l_3)$$

Reducing and substituting for p, we get

$$M_3 = 0.985 l_3^2 + 1.01 l_3^2 + 0.002515 l_3^3$$
$$= 1.995 l_3^2 + 0.002515 l_3^3 \qquad (18)$$

Equating (17) and (18), we get

$$1.995 l_3^2 + 0.00252 l_3^3 = 4{,}170 bd^2 \doteq 6{,}660.$$

Solving for l_3 by trial, we get

$$l_3 = 56 \text{ ins.}$$

and

$$h_3 = h_2 + l_3 \cos\alpha$$
$$= 174 + (56 \times 0.866) = 288 \text{ ins.}$$

Fourth Panel

The load on the fourth panel, l_4, is similar to that on the second and third panels. Let these loads be P_4 and P_4'. Then

$$M_4 = \tfrac{1}{8}P_4l_4 + 0.128P_4'l_4 \quad \ldots\ldots (19)$$

in which

$$P_4 = \tfrac{1}{12} \times 0.434h_3l_4p$$

and

$$P_4' = \tfrac{1}{2}[(0.434h_3/12) + (0.434h_4/12)]l_4p$$

in which $h_4 = h_3 + l_4\cos\alpha = 228 + l_4\cos\alpha$.

Substituting the values of h_3 and h_4, we get

$$P_4 = \tfrac{1}{12} \times 0.434 \times 228l_4p = 8.23l_4p \quad \ldots\ldots (20)$$

$$P_4' = \tfrac{1}{2}[(\tfrac{1}{12} \times 0.434 \times 228) + (\tfrac{1}{12} \times 0.434)(228 + l_4\cos\alpha)]l_4p$$

$$= \tfrac{1}{2}[8.23 + 0.0362(228 + l_4\cos\alpha)]l_4p \quad \ldots\ldots (21)$$

The resisting moment, as before, is

$$M_{r4} = 4{,}170bd^2 \quad \ldots\ldots (22)$$

Substituting values of (20) and (21) in equation (19), we get

$$M_4 = (\tfrac{1}{8} \times 8.23l_4^2p) + (\tfrac{1}{2} \times 0.128l_4^2p)(8.23 + 8.23 + 0.0314l_4)$$

Reducing and substituting for p, we get

$$M_4 = 1.29l_4^2 + 1.317l_4^2 + 0.00252l_4^3$$

$$= 2.607l_4^2 + 0.00252l_4^3 \quad \ldots\ldots (23)$$

Equating (22) and (23), we get

$$2.607l_4^2 + 0.00252l_4^3 = 4{,}170bd^2 = 6{,}660.$$

Solving for l_4 by trial, we get

$$l_4 = 49 \text{ ins.}$$

and

$$h_4 = h_3 + l_4\cos\alpha$$

$$= 228 + (49 \times 0.866) = 270.5 \text{ ins.}$$

In this way the length of panels between supports can be determined for any spacing of bars and any size bar. The accompaning Table No. 1, gives these lengths for bars ¼ in. by 2 ins. to ¼ in. by 4 ins. and spacing of 1¼ ins. to 3 ins. inclusive.

If it be desired to use a bar thicker than ¼ in., the length of first panel can be obtained from the table as follows:—

Cube the length, l, corresponding to a bar of the same height, d, and spacing p, and multiply by the width of bar to be used. Then divide by the width of bar in table (¼ in.). Extract the cube root of this result, and this will be the desired length, l_1. See equation (8).

By examining equation (13a), it will be seen that the second term of the left hand member is of small value, and the first term is the controlling factor, and we can therefore say that the length varies as the square root and not as the cube root, with no appreciable error. We can therefore say that the length of all panels after the first vary as the square root of the resisting moment of the bar. As this moment is directly proportional to the thickness of the bar, the values of l_2, l_3, etc., can likewise be taken from the table by squaring the length given in table for a bar of the same height and spacing, and multiplying this result by the desired thickness, and dividing by the thickness used in the table (¼ in.), then extracting the square root and using the values of l_2, l_3, etc., so obtained.

For example, say it is desired to use a bar ⅜ in. by 3½ ins. instead of ¼ in. by 3½ ins., and a spacing of 2 ins. Then l_1 from table = 147 ins. Let l_1' = the desired length for ⅜ in. by 3½ ins. bar. Then

$$l_1' = (l_1^3 \times 0.375/0.25)^{1/3}$$

$$= l_1(0.375/0.25)^{1/3}$$

$$= 147 \times 1.145 = 168 \text{ ins.}$$

Let l_2' = second panel length. From table, l_2 = 69 ins. Therefore

$$l_2' = (l_2^2 0.375/0.25)^{1/2}$$

$$= l_2(0.375/0.25)^{1/2}$$

$$= 69 \times 1.225 = 84.5 \text{ ins.}$$

Let l_3' = third panel length. From table, l_3 = 57.5 ins. Therefore

$$l_3' = (l_3^2 \times 0.375/0.25)^{1/2}$$

$$= l_3(0.375/0.25)^{1/2}$$

$$= 57.5 \times 1.225 = 70 \text{ ins.}$$

Let l_4' = fourth panel length. From table, l_4 = 51.5 ins. Therefore

$$l_4' = (l_4^2 \times 0.375/0.25)^{1/2}$$

$$= l_4(0.375/0.25)^{1/2}$$

$$= 51.5 \times 1.225 = 63 \text{ ins.}$$

Of course this is only true when the angle of the rack bar is 30 degs. from the perpendicular. For any other angle, the panel lengths should be determined from the foregoing equations by substituting the proper value for $\cos\alpha$.

The values here given in Table 1 will be safe for the worst conditions imaginable, because the stress used is inside the elastic limit of steel. If the designer wishes to use a different stress, he need only multiply l_1, from the table, by the cube root of the quotient, stress (S) divided by 25,000; that is, multiply l_1, from the table, by $(S/25{,}000)^{1/3}$ for the first panel length, and by $(S/25{,}000)^{1/2}$ for l_2, l_3, etc.

TABLE 1

Back Bar (Inches)	Resisting Moment*	Spacing of Bars (Inches)	l_1	l_2	l_3	l_4	h_1	h_2	h_3	h_4
¼x2	4,170	1¼	118	58	48	42	102	152.5	194	230
¼x2½	6,660	1¼	135.5	67	56	49	117.4	174	228	270
¼x3	9,350	1¼	155	77	64	56	134	201	256	304
¼x3½	12,750	1¼	172	86	71	62	149	247	308	361
¼x4	16,650	1¼	188	94	78	68	163	245	312	371
¼x2	4,170	1½	111.5	55	45	39.5	96.5	144	183	217
¼x2½	6,660	1½	130	65	54	47	113	169	216	257
¼x3	9,350	1½	146	73	60.5	53	127	190	242	288
¼x3½	12,750	1½	161.5	81	67	59	140	210	268	319
¼x4	16,650	1½	176.5	88	73	64	153	229	292	347
¼x2	4,170	1¾	106	52	43	37	92	137	174	206
¼x2½	6,660	1¾	123	61	51	45	107	160	204	243
¼x3	9,350	1¾	138.5	69	57.5	50	120	180	230	273
¼x3½	12,750	1¾	153.5	76	63.5	55	133	199	254	301
¼x4	16,650	1¾	168	83	69	60	145.5	217	277	329
¼x2	4,170	2	103	48	40	36	89	131	166	197
¼x2½	6,660	2	118	56	47	43	102	150	191	228
¼x3	9,350	2	133	62.5	52	47	115	169	214	255
¼x3½	12,750	2	147	69	57.5	51.5	127	187	237	282
¼x4	16,650	2	160	75	62.5	56	139	204	258	306
¼x2	4,170	2¼	97.5	46	39	35	84	124	158	188
¼x2½	6,660	2¼	114	54	46	41	99	146	186	221
¼x3	9,350	2¼	127	60	51	46	111	163	207	247
¼x3½	12,750	2¼	141	66.5	56	50	122	179	227	270
¼x4	16,650	2¼	154.5	73	62	55	134	197	250	297
¼x2	4,170	2½	94	44.5	38	34	81.5	120	153	182
¼x2½	6,660	2½	110	52	44	39	95.5	140.5	178.5	212
¼x3	9,350	2½	123	58	49.5	44	106.5	156.5	199.5	237
¼x3½	12,750	2½	136	64.5	55	49	118	174	221.5	264
¼x4	16,650	2½	149	70.5	60	53.5	129	190	242	288
¼x2	4,170	2¾	91	43	37	33	79	116	148	177
¼x2½	6,660	2¾	106	50	43	38	92	135	172	205
¼x3	9,350	2¾	119	56	48	43	103	151.5	193	230
¼x3½	12,750	2¾	133	63	54	48	115	169.5	216	257
¼x4	16,650	2¾	144	68	58.5	52	125	184	234.5	279
¼x2	4,170	3	88.5	42	36	32	76.5	113	144	172
¼x2½	6,660	3	104	49.5	42.5	38	90	133	170	203
¼x3	9,350	3	116	55	47	42	100.5	148	188.5	225
¼x3½	12,750	3	128.5	61	52	46	111	164	209	249
¼x4	16,650	3	140	66.5	57	50	121	178.5	228	271

$*M = \tfrac{1}{6} \times bd^2 \times 25{,}000.$

Construction of Panels

The bars are usually held together by through bolts, with sections of wrought-iron pipe of proper length strung between the bars, as shown in Fig. 3. The through bolt is placed back of the centre line of the bar so that the cleaning rake will not catch so readily.

The nuts on the bolts should not project outside the panel but should be guarded by a bar which is riveted at both ends. If this is done, the rack panels can be easily withdrawn and replaced.

The lower end of the rack bars can rest in an angle iron embedded in the concrete, and the upper end should be anchored by means of a hook engaging the spacing bars.

Supporting Structure

There are various methods for supporting the bars, depending on the construction of the adjacent building. If dividing walls can be placed at frequent intervals so as not to make too great a spacing, then I-beams can be embedded in these to support the racks. Such an arrangement is shown in Figs. 1 and 3, where the walls stop behind the rack bars, so as not to obstruct the flow through the racks. The beams can then be determined from the conditions for uniform loading, and in Table 2 is given the loading per foot of length of beam. Where the spacing is too great for an economical beam, a steel truss can be placed midway between the walls.

TABLE 2—LOADS PER FOOT WIDTH OF RACKS

Bar (Inches)	P_1	P_2+P_2'	P_3+P_3'	P_4+P_4'	R_1	R_2	R_3	R_4	R_5
¼x2	2,610	3,210	3,610	3,860	870	3,250	3,395	3,730	2,045
¼x2½	3,450	4,230	4,890	5,285	1,150	5,290	4,535	5,075	2,800
¼x3	4,500	5,575	6,350	6,800	1,500	5,620	5,950	6,550	3,610
¼x3½	5,550	7,390	8,540	9,000	1,850	7,170	7,930	8,755	4,775
¼x4	6,650	8,250	9,400	10,100	2,217	8,308	8,785	10,740	5,350
¼x2	2,330	2,870	3,190	3,430	775	2,905	3,020	3,300	1,820
¼x2½	3,180	3,980	4,510	4,820	1,060	3,990	4,230	4,655	2,555
¼x3	4,010	5,020	5,650	6,100	1,335	5,025	5,310	5,870	3,230
¼x3½	4,900	6,140	6,950	7,510	1,633	6,147	6,520	7,415	3,985
¼x4	5,860	7,300	8,250	8,860	1,953	7,337	7,740	8,550	4,690
¼x2	2,110	2,580	2,900	3,050	703	2,620	2,627	2,975	1,615
¼x2½	2,860	3,535	4,030	4,360	953	3,567	3,770	4,185	2,310
¼x3	3,610	4,490	5,110	5,450	1,203	4,517	4,780	4,270	2,890
¼x3½	4,425	5,480	6,230	6,620	1,475	5,525	5,835	6,410	3,510
¼x4	5,300	6,350	7,400	8,010	1,767	6,518	6,835	7,690	4,250
¼x2	1,990	2,290	2,580	2,840	663	2,402	2,425	2,705	1,505
¼x2½	2,610	3,125	3,480	3,910	870	3,210	3,290	3,680	2,075
¼x3	3,320	3,850	4,320	4,775	1,107	4,023	4,070	4,530	2,535
¼x3½	4,050	4,700	5,290	5,800	1,350	4,910	4,970	5,535	3,075
¼x4	4,820	5,590	6,250	6,850	1,607	5,838	5,895	6,535	3,635
¼x2	1,775	2,080	2,390	2,625	592	2,160	2,228	2,500	1,390
¼x2½	2,450	2,870	3,320	3,620	817	2,983	3,080	3,460	1,920
¼x3	3,060	3,570	4,100	4,540	1,020	3,720	3,815	4,305	2,410
¼x3½	3,730	4,340	4,930	5,390	1,243	4,527	4,615	5,145	2,860
¼x4	4,500	5,240	6,000	6,520	1,500	5,460	5,585	6,245	3,460
¼x2	1,660	1,950	2,250	2,475	553	2,022	2,090	2,355	1,320
¼x2½	2,275	2,660	3,040	3,310	758	3,767	2,840	3,165	1,755
¼x3	2,840	3,310	3,825	4,170	947	3,448	3,350	3,985	2,215
¼x3½	3,480	4,085	4,710	5,170	1,160	4,240	4,375	4,930	2,740
¼x4	4,170	4,875	5,630	6,150	1,390	5,070	5,225	5,880	3,260
¼x2	1,560	1,820	2,120	2,330	520	1,895	1,965	2,220	1,235
¼x2½	2,110	2,460	2,870	3,110	703	2,562	2,650	2,985	1,650
¼x3	2,660	3,095	3,590	3,950	887	3,228	3,325	3,760	2,095
¼x3½	3,320	3,880	4,520	4,925	1,106	4,039	4,175	4,710	2,615
¼x4	3,900	4,550	5,310	5,800	1,300	4,740	4,900	5,550	3,070
¼x2	1,465	1,730	2,010	2,200	488	1,790	1,862	2,100	1,165
¼x2½	2,030	2,400	2,790	3,080	677	2,483	2,580	2,935	1,625
¼x3	2,550	2,970	3,430	2,860	850	3,095	3,185	3,165	1,515
¼x3½	3,070	3,640	4,210	4,550	1,023	3,070	3,905	4,320	2,410
¼x4	3,680	4,325	4,790	5,400	1,227	3,680	4,545	5,080	2,860

$R_1 = P_1/3$. $R_2 = 0.66P_1+0.47(P_2+P_2')$.

$R_3 = 0.53(P_2+P_2')+0.47(P_3+P_3')$.

$R_4 = 0.53(P_3+P_3')+0.47(P_4+P_4')$.

$R_5 = 0.53(P_4+P_4')$.

If the walls cannot be extended, then steel trusses will have to be built at intervals throughout the whole length of trash racks, and the beams supported on these.

In General

The effective area of the racks should be somewhat larger than the canal into which they lead, so as not to cause too great a loss in head.

The effective area will be the space between the bars multiplied by the perpendicular height. Allowance must also be made for obstruction by supporting beams and trusses.

The number of bars to make one panel is fixed by the the allowable weight and means for handling same when removing for cleaning, etc. Space the through bolts so that they come on a supporting beam and the bar will not be weakened.

Tenders will be received by the secretary of the Board of Control of Ottawa, Ont., until Tuesday, July 29th, for the supply of the following quantities of water meters: Fifty ⅝-in., twenty-five ¾-in., twenty-five 1-in., ten 1¼-in., fifteen 1½-in., seventy 2-in., thirty 3-in., ten 4-in., twelve 6-in. and four 8-in.

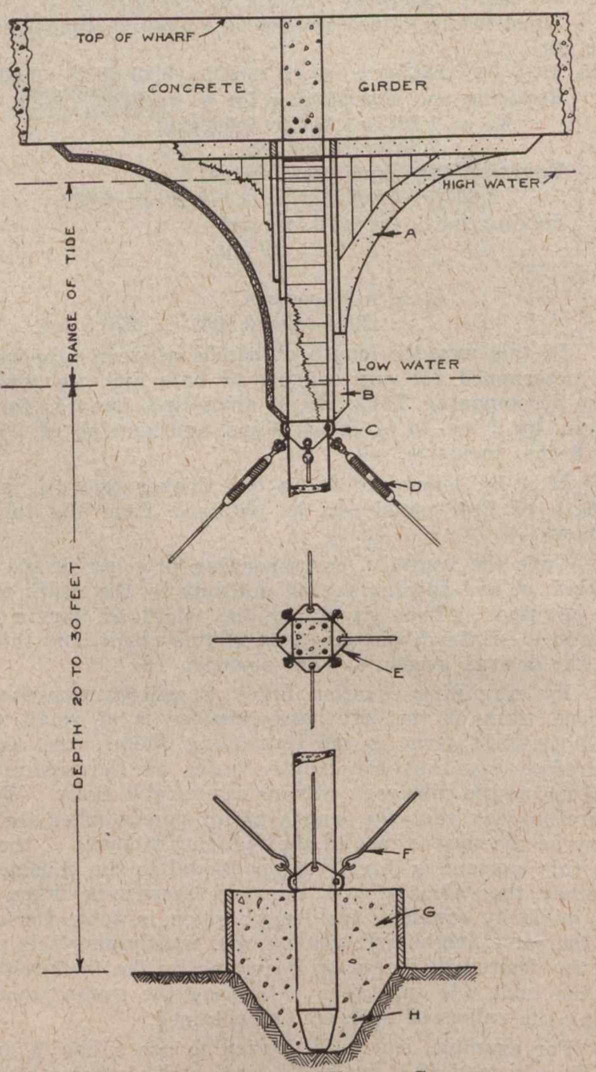
SUGGESTED STANDARD CONCRETE WHARF

By C. R. Coutlee
Department of Public Works, Ottawa, Ont.

THE accompanying drawing is an endeavor to create standard practice with regard to wharf construction in fresh and salt water, and any criticisms of the type shown will be appreciated.

With rock bottom, or with rock only slightly covered with earth, it seems possible to secure the bottom of pile as shown.

The matter of diagonal bracing has been given much thought by many engineers. Steel seems to have a life of 25 years or more if kept always below water level in fresh or sea water. Reinforced concrete also appears to be permanent when always immersed.



TYPICAL CONCRETE PILE WHARF CONSTRUCTION

A—Concrete deposited into and protected by grooved and tongued, creosoted forms, lined with Muntz metal, that remain as part of structure; B—Step-out to ensure that steel reinforcing rods are well covered from salt air; C—Adjustable steel band; D—Steel tie-rod to foot of next pile, with turnbuckle for adjustment; E—Detail of adjustable steel band placed after concrete pile is driven, to which tie-rods are attached; F—Steel tie-rod to top of next pile; G—Concrete deposited in wooden form by pipe from surface, or in bags; H—Rock blasted out to insert foot of concrete pile.

Above low tide, concrete is affected by clinging ice and by salt air. To protect it, grooved and tongued, creosoted covering is suggested. To prevent oil affecting the concrete, the creosoted covering should be lined with sheet copper or Muntz metal or else painted.

If the steel band to which diagonals are attached tends to slip upwards, it is suggested that a canvas bag partially filled with cement be slipped down the pile to rest upon and seat around the steel.

CANADA'S FUEL PROBLEM — SOME NATIONAL AND INTERNATIONAL ASPECTS*

By Arthur V. White
Consulting Engineer, Commission of Conservation

So much has been said, drawn from seemingly authoritative sources, respecting the "unbounded extent of the natural resources of Canada," that it is little wonder the popular view is entertained that Canada's resources are practically unlimited, and perpetual prosperity only waits upon their fuller development. For Canadians, however, to hold and be governed by such a view is to live in a "fool's paradise."

Little more than a decade ago, a large majority of the people of the United States believed that the natural resources of their country were unbounded, and that there was hardly any limit to material progress based upon their development. Even in that country, however, there were many who did not share these views, and through their efforts special investigation was made respecting the actual conditions of the natural resources of the nation.

Natural Resources are Exhaustible

No country possesses, within its own borders, more varied and extensive resources than the United States, yet it is now recognized that many of these are within measureable distance of exhaustion. This fact was so clearly demonstrated that prompt action by the trustees of the nation became imperative. So far as one can judge, natural resources from the 49th parallel to the Gulf of Mexico are better situated, geographically, and must always be more desirable than those from the 49th parallel to the Arctic ocean; thus, by reason of situation, Canada's usable natural resources are, in variety and extent, less than those of the United States.

Those who have observed the rapid disappearance of many of the natural resources of Canada and the present alarming rates at which some are being consumed, realize that the situation, as a whole, is one of great gravity. Consequently, true conservation in Canada is as great, if not a greater necessity than in the United States.

Must Use and Conserve

It is true that some resources, such as minerals—perhaps more especially coal, oil, and gas—if used, must in time, necessarily become exhausted. On the other hand, such resources as the soil, plant growth, waterways and ground waters, may be conserved and transmitted to posterity unimpaired, or at least unabused, just as a good husbandman passes on his farm in an improved condition to that in which he received it. The policies advocated by the Commission of Conservation of Canada have aimed at passing on to succeeding generations in an improved condition the heritage of the natural resources of this country.

By intelligent and thrifty use, the natural resources of Canada may beneficently serve the needs of a large population. If, however, Canadians become really dependent upon necessary commodities supplied them by other countries, they must be prepared to accept the circumstances in which they may suddenly find themselves if the supply of such commodities is cut off. Such circumstances will be aggravated by any abuse of our assets.

Coal Scarcity and Coercion

There is, apart from food, raiment and shelter, perhaps no single commodity which has been found so necessary as fuel—chiefly coal—for the maintenance of life and for the carrying on of commerce and transportation. Recently the public interest has been keenly aroused respecting the nation's fuel supply and increasing dependence upon hydro-electric energy. War conditions have driven home to Canadians as never before the tremendous gravity of their position with respect to fuel.

*From the General Electric Review.

Countries like Norway and Sweden, Denmark, Holland and Switzerland—countries, indeed, which were neutral—were practically dependent upon the warring nations for coal, and found themselves seriously curtailed in obtaining this commodity. They were forced to recognize the momentous fact that the countries which possess coal are able, absolutely, to dictate the terms upon which coal will be supplied to others.

Dependent Upon United States

Now, a very large portion of Canada—and for this one may hold in mind much of the populated territory extending, say, from Quebec to Winnipeg—has become increasingly dependent for its fuel supply upon the coal fields of the United States, and absolutely dependent upon that country for its annual supply of some 4,500,000 tons of anthracite.

In addition to the use of imported anthracite for heating and domestic purposes, large quantities of bituminous coal—some 10,000,000 to 14,000,000 tons—are also imported annually from the United States, largely for power purposes.

The known anthracite fields of the United States are within measurable distance of exhaustion. Doubtless, in the not distant future, the United States will feel compelled so to conserve this valuable commodity that the exportation of it may be largely restricted, if not entirely cut off. There are available many examples, arising out of the great European war conditions, where the United States has found it necessary to place stringent embargoes upon natural and manufactured products.

Now, if Canada is to be in a position to command special consideration under possible restricted trade conditions, she must realize the value of her own resources and have them strictly under national control in order that she may be enabled to deal on a basis of *quid pro quo*. When the commodities of commerce are exchanged there must, of course, be a substantial basis for barter. When Germany demanded gold from Switzerland, she offered to exchange coal. Suppose that the United States, in the conduct of her commerce, concluded that it was in the general interest of her citizens only to *barter* coal for certain commodities which she specially required, what desirable commodities has Canada to barter?

Nothing is further from the thought of the writer than to suggest that it is or that it would become the arbitrary desire of the United States to deprive Canada of the coal which at present is so necessary to life in Canada. It is important, however, to take cognizance of the fact that a nation, pressed by the demands of its own people, may be compelled, under certain conditions, to deprive other nations—in part at least—of even the necessaries of life until the needs of its own citizens are met. No country can be expected to send out of its confines that which is essential to the very existence of its own people.

It is not the policy of Canada to embargo her exports. She must, however, conserve against the day of her own need such resources as are available for barter. It certainly is sound policy to insure that commodities of national importance should not be exported without an adequate *quid pro quo*.

Some portions of the United States are as badly in need of coal from Canada as portions of Canada are in need of coal from the United States. Between these two great countries there is an exchange of many natural and manufactured products, and the problems which from time to time arise in connection with such interchange can be satisfactorily solved and the whole situation reduced to a good working basis.

Canada's Water-Power Heritage

Other than the products of her agricultural lands, mines, and forests, there are certain resources in Canada of unique and special value. Canada has an especially rich heritage in her water-powers, including her equity in international waters. To a large extent these water powers are still under the control of the people. This control is being zealously guarded so that as the country develops and sites come into the sphere of active economic importance they may be developed and used in the general public interest. Men far-sighted in the fields of industry and finance have foreseen the extent to which present and future generations will become increasingly dependent on power, whether it be steam or hydro-electric.

Any estimate for the water powers of Canada must be presented and considered with a due appreciation of its limitations. Table I. representatively sets forth the water-power situation in Canada. By no means may all the water powers be economically developed.

TABLE I.—WATER POWERS OF CANADA
(Tentative Schedule)

Province	Total Estimated 24-hour Low-water Horse Power	Developed Horse Power (a)
Prince Edward Island	3,000	500
Nova Scotia	150,000 (b)	30,000
New Brunswick	300,000 (b)	15,000
Quebec	6,000,000	900,000
Ontario	6,000,000	1,000,000
Manitoba	2,700,000	83,000
Saskatchewan	250,000	5,000
Alberta	450,000	33,000
British Columbia	3,000,000	300,000
Yukon	100,000 (c)	13,000
North West Territories (d)	....	......
Total for Canada	18,953,000	2,379,500

(a) This column presents aggregates of installed capacities.
(b) Special investigation now in progress.
(c) A rough estimate made for inclusion in this summary, probably low.
(d) No reliable data available.

Canada has been aggressive in the development and utilization of her water-powers, and no large communities are better supplied with hydro-electric power and light than are places like Montreal, Ottawa, Toronto, Hamilton, Winnipeg, Calgary, Vancouver and Victoria.

The most striking example of hydro-electric energy being developed and distributed on a large scale in order to afford a supply of cheap power and light for communities is found in the work of the Hydro-Electric Power Commission of Ontario.*

This Commission, co-operatively with over 200 Ontario municipalities, has upwards of 3,000 miles of transmission line, and serves over 120,000 customers. In fact, nearly half the population of Ontario is supplied with electricity through the agency of the Commission. The capital investment of the province in connection with these undertakings approximates $55,000,000, in addition to which the various municipalities co-operating with the commission have made an investment of some $20,000,000 in connection with their local distribution and operating systems. This extensive use of electrical energy results in the annual saving of several millions of tons of coal.

Niagara River Power Development

At Niagara Falls, great power development has already taken place. There the capacity of the large power plants in Canada may be stated as in Table II.

Allotted Water all Taken

The total diversion for both countries of 56,000 cubic feet of water per second from the Niagara River as provided by the Boundary Waters' Treaty has now been fully allotted, and before long will all be in actual use by plants on both sides of the river. Suggestions are continually being made to have the treaty revised, so as to permit of greater diversion. One recent proposal is that under a new treaty each country shall be permitted to divert 60,000 cubic feet of water per second, which corresponds to approximately 1,800,000 electrical horse-power, assuming 30 h.p. to be developed per cubic foot of water.

An Exporter of Electricity

About 125,000 h.p. of Niagara hydro-electric power is exported to the United States. Canada is exporting electrical energy from New Brunswick to the state of Maine, from Quebec to New York, from Ontario to New York and to Minnesota, and from British Columbia to Washington. The United States is importing from Canada about 200,000 h.p. years of electrical energy.* Many factors, of course, enter into the determination of the equivalent of this electrical power in terms of anthracite. Speaking in round figures, and taking cognizance of some of these special factors, the electrical power now imported by the United States would be the equivalent of not less than 3,000,000 tons of coal—and doubtless is a quantity substantially greater, even 6,000,000 tons or possibly more, the determination of the equivalent being dependent upon what in any set of circumstances are found to be the governing factors.† It will thus be perceived that, on a power basis, the coal equivalent of the electric energy exported to the United States approximates the quantity of anthracite imported by Canada from the United States.

TABLE II.—NIAGARA POWER PLANTS IN CANADA

Plant	Rated Capacity of Present Installation. Horse Power	Approximate Maximum Generating Capacity. Horse Power
Canadian Niagara Power Co.	112,500	100,000 (a)
Ontario Power Co. (controlled by the Hydro-Electric Power Commission of Ontario)	159,000	162,000 (b)
Electrical Development Co.	135,800	125,000 (c)
Ontario Power Co.'s new pipeline (installed by Hydro-Electric Power Commission), completed 1919	32,000	32,000 (d)
Present total development	439,300	419,000
Chippawa plant under construction by Hydro-Electric Power Commission of Ontario, ultimate development	300,000	300,000 (e)
Total development now provided for	739,000	719,000

(a) At times has generated about 103,000 h.p.
(b) At times has generated about 163,000 h.p.
(c) At times has generated 146,000 h.p., but it is claimed that the water used to generate this amount exceeds the quantity legally usable to generate the 125,000 h.p. specified in the contract.
(d) This pipeline has a nominal capacity to supply water for 50,000 h.p., but the balance of water in excess of that required for the two new 15,000 kv-a. generators is used to increase the efficiency of operation of the older portion of the plant.
(e) To operate under a head of 305 feet and to utilize the descent of the Lower River.

This electrical energy is, of course, much more profitably employed for power than for heating purposes. In this connection it may briefly be commented, with respect to the restricted possibilities of electric heating, that for years past the author has been emphasizing the comparatively limited use which can be made of electric energy as a wholesale substitute for coal for heating—including the heating of buildings. The sooner it is realized that hydro-electric

*A brief but comprehensive historical survey of the evolution of the Hydro-Electric Power Commission of Ontario, by Arthur V. White, is given in the Commission of Conservation's report, "Water-Powers of Canada," Ottawa, pp. 35-56. For a valuable resume of activities of the Commission, consult, "Electric Power Generation in Ontario on Systems of Hydro-Electric Power Commission," by Arthur H. Hull, in "Proceedings of American Institute of Electrical Engineers," January 1st, 1919; also published in "The Canadian Engineer," issues of December 12th and 19th, 1918.

*For discussion of various aspects of problems respecting the exportation and use of electrical energy, consult the following articles by Arthur V. White: "Exportation of Electricity," which appeared in the "University Magazine," October, 1910, pages 460, et seq. Consult, also "Toronto World," March 18th, 1912; also "Exportation of Electricity—An International Problem; Relation of a Possible Coal Embargo by United States to a Curtailment or Stoppage of Canada's Electric Power," in "The Monetary Times Annual" of January 5th, 1917, pages 21 et seq; also "Coal Problem of Canada Demands National Action—A Solution of a Vital National and International Question" in "The Monetary Times Annual," January 4th, 1918, pages 25 et seq; also consult, "Barter Power for U. S. Coal," in "The Globe," Toronto, November 27th, 1917; and "Monetary Times," Toronto, January 18th, page 9, and February 22nd, 1918, page 26.

†Consult the Hydro-Electric Power Commission of Ontario Report on the "Rate of Coal Consumption in Various Electric Generating Stations and Industrial Establishments in Canada and the United States," by A. S. L. Barnes, Toronto, 1918.

energy can never as a heating agent be an adequate substitute for coal for the citizens of Canada, the sooner will action be concentrated upon sources from which real relief may be derived—there is no use entertaining hope towards a source from which no sufficient relief can come. At the annual meeting of the Commission of Conservation, in November, 1917, the author stated that: "The extent to which electric energy will be available for heating has been much overrated and, realizing the underlying physical limitations one cannot be enthusiastic respecting the extent to which it may be utilized." This statement being made at a time of serious hardship due to power and fuel shortage, attracted widespread attention.*

St. Lawrence River Water-Powers

Outside of the Niagara district the greatest amount of water-power of immediate economic importance is found along the St. Lawrence River. On a conservative basis, the low-water power of the international portion of the St. Lawrence River may be estimated at about 800,000 h.p., of which Canada is entitled to one half, or 400,000 h.p. The correspondingly estimated low-water power on the portion of the river which lies wholly within Canada, is about 1,400,000 h.p., thus making an estimated total for Canada of 1,800,000 low-water continuous h.p. Assuming the diversity load-factor of the present Niagara system of the Hydro-Electric Power Commission of Ontario, Canada's 1,800,000 h.p. on the St. Lawrence would take care of a power demand of some 2,400,000 h.p. The St. Lawrence River power sites are detailed in Table III.†

Coal Resources of Canada

Now, we have seen how great are the water-power resources of Canada, and these, it may be observed, are largely spread over the areas which have no natural coal resources. These areas now importing coal will no doubt be increasingly supplied from the Canadian mines. Considering the country as a whole, Canada in respect of quantity, quality, and accessibility for mining purposes, possesses coal deposits which compare favorably with those of the greatest coal mining countries of the world. Canada, as we have seen, can never depend upon her water powers as a sole source for heat. Consequently, the alternative open to her, and it is this to which special attention is directed, is to develop, and that as rapidly as possible, both her own fuel and power resources, and by co-ordination of transportation and other cognate agencies to provide for the distribution of fuel to all communities in the Dominion. In some respects it is more important to move coal and have it adequately stored and distributed throughout Canada than it is to move the grain out of the country.

TABLE III.—WATER-POWER ON THE ST. LAWRENCE RIVER
(Tentative Schedule) (a)

Site	Head Available	Estimated Low-water 24-hr. h.p.	Average Estimated 24-hr. Low-water h.p.
Morrisburg-Rapide Plat	11-15	170,000-230,000	200,000
Long Sault rapid	30-40	500,000-650,000	575,000
Coteau rapid	15-17	230,000-260,000	250,000
Cedars rapid (b)	30-32	490,000-525,000	500,000
Split Rock and Cascades rapids	14-18	220,000-280,000	250,000
Lachine rapid	20-30	300,000-450,000	375,000
Total	....	1,910,000-2,395,000	2,150,000

(a) In this table, to have the estimates fairly representative of the possible quantities which might be expected under representative low-water flow conditions, some allowances have been made for efficiency and other factors.

(b) Under development for about one-third of the low-water flow of the river. Consideration would be given to the possibility of combining the Coteau, Cedars, Split Rock and Cascades; also of increasing the Lachine power.

*For several years past attention has been drawn by Mr. White to the relatively limited use that can efficiently be made of electrical energy as a heating agent. On February 11th, 1918, when addressing the important Fuel Conference held by municipalities in Galt (see "Galt Reporter," Februry 12th, 1918), Mr. White again emphasized his contention that, as a general proposition, electrical energy is more serviceably employed for strictly power purposes, while fuel, such as coal, oil, etc., is more profitably employed for heating. At this meeting he set forth the underlying principles governing in this matter. See "Monetary Times," March 1st, 1918, page 18. Consult, also, "Annual Reports of Commission of Conservation," Ottawa; and article by Mr. White, "Electricity will not Replace Coal," in "Industrial Canada," Toronto, April, 1918.

†From "Power Possibilities on the St. Lawrence River," by Arthur V. White, Ottawa, 1918. See, also, by same author, "Long Sault Rapids, St. Lawrence River, an Enquiry Into the Constitutional and Other Aspects of the Project to Develop Power Therefrom," Commission of Conservation, 384 pp. Ottawa, 1913.

TABLE IV.—ESTIMATED COAL RESOURCES OF CANADA (a)

Province	Area of Coal Lands Square Miles	Semi-Anthracite Million Tons	Bituminous Million Tons	Sub-Bituminous Million Tons	Lignite Million Tons
Nova Scotia	521		10,691		
N.B.	121		166		
Ontario ...	10				27.5
Manitoba	48				176
Sask.	13,406				65,793
Alberta ...	81,878	845.9	217,918(b)	932,053	29,095
B.C.	6,045		77,923(b)		5,715.5(c)
Yukon	2,840		275(b)		5,159 (c)
N.W.T. ..	300				5,280 (c)
Arctic Is. ..	6,000		6,600		
Total	111,169	845.9	313,573	932,053	111,246

(a) Consult "Coal Fields and Coal Resources of Canada," by Dr. D. B. Dowling, Geological Survey of Canada; also "Coal Situation in Canada," by W. J. Dick, in "Transactions of the Canadian Mining Institute," 1916.
(b) Includes some anthracite coal.
(c) Includes some sub-bituminous coal.

The coal fields of Canada may conveniently be divided into four main divisions:—

1. The bituminous coal fields of Nova Scotia and New Brunswick.
2. The lignites of Manitoba and Saskatchewan, and the lignites, sub-bituminous and anthracite coal fields of Alberta and the Eastern Rocky Mountain region.
3. The semi-anthracite and bituminous fields of Vancouver Island, Queen Charlotte Island, and the interior of British Columbia, and the lignites of Yukon.
4. The low-grade bituminous coal and lignites of the Arctic-Mackenzie basin.

The coal areas and estimated quantities for the different provinces are shown in Table IV. There should, of course, for practical consideration, be a substantial reduction made in these quantities, due to waste in mining operations.

Coal Production and Distribution

Canada annually produces 15,000,000 tons of coal. Her coal and coke production in 1916, 1917 and 1918 are given in Table V. Canada is making special efforts to increase the production of, and areas served by, her coal mines. This is evident from the figures in the table for the province of Alberta, the mines of which, in 1918, increased their production by over 1,200,000 tons. The falling off in production from the Nova Scotia mines is more apparent than real. It is believed that but for the fact that the British Admiralty required, for war purposes, vessels which ordinarily would have been used for transporting coal from the Nova Scotia mines, considerably larger amounts of this coal would have been marketed in territory west of Montreal. No doubt increased quantities of coal will be shipped westward into central Canada through the 14-ft. navigation afforded from the sea to the Great Lakes by the present canal system of Canada.

As a result of the efforts of the Fuel Administration in Canada, there have been assembled considerable data not before available relating to the Canadian coal trade. Some of these data have now been incorporated in a valuable report on the coal trade of Canada. Table VI. from this report summarizes the facts respecting the output, importation and consumption of coal in Canada.*

*Consult "Report of the Coal Trade of Canada for the Year Ended March 31st, 1918," issued by the Internal Trade Division, Dominion Bureau of Statistics, 8vo., xiv., 59 pp., Ottawa, 1919.

Canada is making serious effort towards the development on a large scale of her lignite and peat resources; also, towards the increased utilization of her coal fields in the east and in the west. The sum of $400,000 has been made available to the Honorary Advisory Council for Scientific and Industrial Research of the Dominion government for the erection of a carbonized lignite briquetting plant of 30,000 tons of briquettes per annum. Of this sum, $200,000 was voted

TABLE V.—COAL PRODUCTION AND DISTRIBUTION IN CANADA

Coal Production in Canada (a)

Province	1916 Short Tons	1917 Short Tons	1918 (b) Short Tons
Nova Scotia	6,912,140	6,327,091	5,852,802
New Brunswick	143,540	189,095	267,746
Saskatchewan	281,300	355,445	345,310
Alberta	4,559,054	4,736,368	5,941,864
British Columbia	2,584,061	2,433,888	2,568,591
Yukon	3,300	4,872	2,900
Total	14,483,395	14,046,759	14,979,213

Distribution of Coal Produced (c)

Sold for consumption in Canada	10,701,530	10,469,468	11,210,628
Sold for export to U.S.A	1,451,075	1,301,881	1,351,179
Sold for export elsewhere	284,513	301,060	317,135
Total sales	12,437,118	12,072,409	12,878,942
Used by producers in making coke, steel, brick, etc.	804,814	690,573	682,304
Used by producers for colliery operations and by workmen ..	1,241,463	1,283,777	1,417,967
Total used by producers	2,046,277	1,974,350	2,100,271

(a) Consult "The Production of Coal and Coke in Canada," by John McLeish, B.A., Chief of the Division of Mineral Resources and Statistics, Department of Mines, Ottawa.
(b) Preliminary figures, subject to minor modification.
(c) This is merely a record of distribution by the companies operating the collieries. The figures "Used by producers making coke, steel, brick, etc.," do not represent the total amounts of coal used even in making coke by coke-oven operators.

by the Dominion government and $100,000 each by the provinces of Manitoba and Saskatchewan. Work incident to the construction of the plant is under way. The estimated cost of the briquettes per ton at the mine, including all fixed charges amounting to 20 per cent. on the capital, is $7.*

Peat Resources of Canada

Respecting the peat bogs of Canada, Dr. Eugene Haanel, director of mines, Canada, has strongly urged the necessity of developing our peat resources, and at a recent annual meeting of the Commission of Conservation of Canada, he gave an able, forceful and serious address upon this subject which the people of Canada cannot too carefully consider. Dr. Haanel affirmed the commercial and economic practicability of peat production. Many persons who have had their interest and hope aroused in the prospects of commercial peat, feel that sufficient time has already been available for "experimenting" with peat. They feel that if essential conditions respecting the acquirement of bogs are rightly provided for, and the employment of the best processes of manufacture and handling, costs, etc., are known, the peat industry should by this time have become commercialized the same as other profitable industries. Throughout Canada there have already been discovered areas of peat bog estimated to aggregate 37,000 square miles. According to a broad estimate by Dr. Haanel, and assuming an average depth of bog of six feet, this area corresponds to over 28,000,000,000 tons of peat, having a fuel value equivalent to over 16,000,000,000 tons of good coal. Manitoba, Ontario, Quebec and New Brunswick have peat bog areas aggregating 12,000 square miles.*

The province of Ontario has recently created a Peat Commission, which, it is stated, has two experimental plants in process of construction.

Petroleum Resources in Canada

Canada is known to possess great areas of rich petroleum-bearing shales and sands. Although considerable work has been performed in such areas—as in New Brunswick—nevertheless, the industry cannot really be said to be commercialized. Having in mind the success of the oil shale industry in Scotland, there appears little doubt but the corresponding industry in New Brunswick, Nova Scotia and elsewhere, will ere long become extensive.

TABLE VI.—COAL OUTPUT, IMPORTATION AND CONSUMPTION OF COAL IN CANADA

West of Head of Great Lakes:	1915	1916	1917
Output B.C.	2,208,289	2,783,849	2,676,760
Output Alta., anthracite	125,732	140,544	118,717
Output Alta., bituminous	1,626,237	2,335,259	2,206,868
Output Alta., lignite ..	1,682,922	2,172,801	2,537,829
Output Sask., lignite ..	243,125	294,264	360,623
Imported from U.S.A., anthracite	298,895	533,846	514,688
Imported from U.S.A., bituminous	1,423,882	2,550,352	2,825,702
Total tonnage made available	7,609,082	10,810,915	11,241,187
Exported	864,160	1,105,718	1,029,532
Net consumption ...	6,744,922	9,705,197	10,211,655
East of Head of Great Lakes:			
Output Nova Scotia ...	7,513,739	6,911,995	6,345,335
Output New Brunswick	126,923	143,658	189,668
Imported from U.S.A., anthracite	3,773,135	4,040,368	4,805,000
Imported from U.S.A., bituminous	7,622,449	10,739,478	14,394,122
Total tonnage made available	19,036,246	21,835,499	25,734,125
Exported	902,383	1,029,641	703,824
Net consumption ..	18,133,863	20,805,858	25,030,501
Total consumption in Canada	24,878,785	30,511,055	35,242,156

According to all indications, the year 1919 will see the greatest prospecting propaganda for oil that has occurred in Canada. Many interests—Canadian, British and United States—are arranging for prospecting parties with modern equipment and oil experts to prospect, especially in Alberta and British Columbia.

Respecting the possibility that petroleum will be discovered, particlarly in the Viking area and the Peace and Athabaska valleys, "the situation may be summed up as very promising," states Mr. James White in his recent monograph on the "Fuels of Western Canada."†

He states further:—

"A small quantity of dark oil obtained in one of the wells in the Viking gas field is an encouraging indication, and oil has also been found in the Pelican Rapids gas well. Seepages of oil have been found near Waterton Lake, in

*Consult "The Briquetting of Lignites," by R. A. Ross, Report No. 1, Honorary Advisory Council for Scientific and Industrial Research, Ottawa, 1918. Consult, also, "Carbonizing and Briquetting of Lignites," by W. J. Dick, Commission of Conservation, Ottawa, 1917; also by same author, "Canada's Own Coal and the Fuel Problem," in "Industrial Canada," April, 1918; also "Fuels of Western Canada and Their Efficient Utilization" (revised edition), by James White, Commission of Conservation, Ottawa, 1918.

*Consult "Peat as a Source of Fuel," by Eugene Haanel, Director Mines Branch, Ottawa, 1918.
†See note under Lignites, "Supra."

(Continued on page 151)

POINTS REQUIRING SPECIAL OBSERVATION AND INVESTIGATION IN BRIDGE INSPECTION*

By Herbert C. Keith

THE old proverb that a chain is no stronger than its weakest link seems sometimes to be contradicted by a bridge truss, which may be stronger than its weakest member appears to be, as judged by the ordinary methods. Professor Vose used to say that there are many bridges that are kept from falling "only by the grace of God and the force of habit." There are certainly many which depend upon some means of transmission of loads to the abutments that no self-respecting engineer would rely upon in designing, though recognizing and taking advantage of it sometimes in a critical investigation of an existing bridge. For instance, a rapidly moving electric car may skate safely across a short span or a single panel which would be unsafe for the same car even to stand on. Another example is found in the fact that a bridge may be safe for a car electrically driven when it would be unsafe for a steam locomotive of the same weight, on account of the difference in the mode of transmission of the power to the driving wheels, rotary in the one case and reciprocal in the other. These are cases which show a reduction of strain on stringers often greater than would be the increase of strain due to the sudden application of a load. Track rails (and jack stringers when used) add materially to the carrying power of stringers of short spans, especially if the rails are heavy. Guard rails and even guard timbers and the stiffness of the car itself give some help; also the continuity of the stringers of a truss bridge when the stringers are framed into the floorbeams and riveted to them. The stiffness of truss chords may make the strength decidedly greater than would be determined by considering each intersection as if it were a joint with a fractionless pin, instead of a continuous riveted box girder, as may be the case.

Rivets and Pins

A very marked instance of greater strength than is assumed in the ordinary methods of calculation is the case of rivets and pins. A large factor (indeed probably the main factor) in the real strength of a riveted joint is the friction of the members upon each other under the pressure of the gripping of the rivet. W. J. Watson, in a paper presented to the American Society of Civil Engineers in 1906, assigns to this friction a value of 14,000 lbs. per sq. in. of cross section of rivet for one plane of contact (or when acting in single shear) and 18,000 lbs. per sq. in. for two planes of contact (or in double shear). The present author would hesitate to give definite mathematical value to this friction, since probably no two rivets exert the same pressure. But it is axiomatic that this friction is great only while the rivet is tight; as soon as the rivet becomes loose it is an entirely different story. This value of a riveted joint is so great and so evident that account of it is taken in the author's modifications of the specifications of the Massachusetts Public Service Commission. In calculating pins it is customary to assume that the pressure of each member upon the pin is concentrated at the centre line of its bearing surface, whereas the fact is that, before a pin would fail by bending, the pressure of each member would become concentrated at that edge of the member which would give the minimum bending moment. This makes the real bending moment on most pins only a small fraction of that obtained by using the ordinary assumptions. An examination made by sawing through the line of flange rivets of an iron floorbeam removed nearly 30 years ago showed the rivets in exceptionally good condition, though by the accepted method of calculation they had been subject to 80,000 lbs. per sq. in. in shear and 130,000 lbs. per sq. in. in bending. In the same bridge, pins which were figured to have a moment of 300,000 lbs. per sq. in. bending, were found to show no slightest sign of overstrain.

*From a paper presented before the Brooklyn Engineers' Club.

Another matter, the importance of which is often greatly overestimated, is the secondary stresses due to large gusset plates at joints of riveted trusses. In most cases where youthful engineers speak with awe of the "terrible secondary stresses," they overlook the added value given to the members by stiffening them through the length of these gussets, thereby reducing the unsupported length of the members, and also giving them "fixed ends." This remark should not be understood to give approval to eccentric connections, for these should always be avoided if practicable, and the eccentricity reduced to a minimum when it cannot be altogether avoided; it is simply intended to call attention to a side of the question which is sometimes overlooked. If one were to judge by the school of specialists on the "secondary stress" bugaboo, pin-connected trusses would be the ideal construction for all bridges, long or short; whereas the greater rigidity or stiffness of riveted trusses makes them far more durable, especially for moderate and short spans; while plate girders, for a similar reason, are still better for lengths for which their use is practicable.

Reduction of Vibration

The importance of rigidity and reduction of vibration, not only in prolonging the life of a bridge but also in increasing its strength when new, can hardly be overestimated. Its advantage in increasing the confidence of the public is also real and important. Time was when some engineers delighted in pointing out the "spidery" structures of their designing, with pride that they could perform such marvels. The cost, or amount of material used in such cases may have exceeded what would have sufficed for a structure that would appear, and really be, much more substantial.

Effect of Track Position

The capacity of a bridge for track loads is far more affected by the position of the track than is generally appreciated. It is frequently found that a track which, according to the plans, should be centered with the bridge is considerably off centre. As an illustration of the effect of this "eccentricity," take the case of stringers 5 ft. on centres, and the centre of the track 1 in. to one side of the centre of stringers; this causes a strain on the nearer stringer 3⅓ per cent. greater than if the track were on centre. The eccentricity of a track is likely to change from time to time, especially on a curve and particularly near its ends. Because of possible changes in the eccentricity, it is the practice of the author, in making up the figures for moment and shear, for inspection reports, to make them first as if the track were on centre and to make a separate item for the excess due to eccentricity of more than about ½ in.

Shear Due to Sidewalks

An overhanging sidewalk, similarly, adds more than its weight and that of its load to the strain in the nearer truss. Reduction of moments in floorbeams by such overhanging sidewalks is disregarded in the author's calculations, on account of the possible temporary removal of the sidewalk. But the increase in shear due to such sidewalk is given its due importance.

Roadway and Sidewalk Loads

Sometimes engineers are known to argue that no impact allowance need be made with roadway and sidewalk loads, though it seems strange that anyone should hold this opinion. The specified 100 lbs. per square foot is no doubt sufficient to provide for as large a crowd on a sidewalk as can move with such speed and harmony as to exert the additional force ordinarily included in the term "impact," unless the gathered crowd is expected to "cheer with its feet." But even for sidewalk loads there is a possibility of a greater weight than the sum of the specified weight and the specified impact. Prof. L. J. Johnson, in experiments made in 1904, obtained a weight of 181 lbs. per square foot. In reporting the experiments to the Boston Society of Civil Engineers, Prof. Johnson says: "Though 181 lbs. per square foot must be conceded to be an extreme, it is believed that something very close to that figure is reached, over the whole drawbridge on the way from Soldiers' Field to Harvard Square after one of the great football games"; and he adds: "The conclusion seems irresistible that loads of 180 lbs. per square foot may actually occur in exceptional cases; that 160 lbs. must frequently occur; that 140 lbs. must be common on station platforms, in corridors and in many other places frequented by throngs of people." In the present day of rapid giant automobile trucks, the case for roadway loads is different. One such motor truck for which data are available has a weight of 17 tons on an over all area of 140 sq. ft., or 243 lbs. per square foot, when carrying no more load than its rated capacity. As there is no inspector at the junction points of highways, it is altogether probable that the overload on such trucks is not kept down to the 10 per cent. common with freight cars, and the actual load may be expected to run up sometimes to 300 lbs. per square foot of the space occupied when the truck is at rest. (Trucks with much greater weights per square foot than this are operated in this city, but they are reported as never used on bridges.) Of course, the whole roadway of a bridge would not be covered with such trucks in close contact both longitudinally and transversely; and if they were so placed, they would not be able to operate at speed. But such loads covering a third of the roadway area would be quite possible and might run at moderate speed. That the specified allowance for impact is none too large for such loads, any observing man will admit after seeing and hearing such trucks run across a bridge with a plank floor, or one on which even small pebbles are found.

Errors of Erection

If errors in erection have been found, so that members are transposed or misplaced on the pins, or if a test with the hammer indicates uneven distribution of stress between the pairs or sets of tension members intended to work together, due attention must be given to these facts in determining the capacity of the bridge.

Composite Stringers

Composite stringers, as two or more timbers or beams of different depth, or flitched beams with timber between I-beams or channels, present two possible conditions to the investigator. If the component parts are constrained to equal deflection, the load is considered as distributed in the way which would cause such equal deflection, in which case the capacity of the combination is less than the sum of capacities of the components. If unequal deflections may take place, the distribution of the load is determined by the theory of least work, or so as to produce equal unit stresses in the extreme fibers, if of similar material, or proper relative stresses if of unlike material.

Safety of Derailed Cars

Any type of construction which makes no provision for the safety of a derailed car is very undesirable. One such which seems to be popular is a flitched beam with the rail spiked directly to the timber stringer, which is bolted between two I-beams or channels, with no floor between the stringers at all adequate to support a car if it leaves the rail. Another similar construction is a double stringer of I-beams or channels with spiking pieces between, which rest on horizontal separators of short pieces of channel riveted to the beams. Fortunately, many bridges with such stringers have heavy plank floors laid on top of the stringers, so providing for the safe passage of a derailed car if it does not get too far away from the track stringers. A danger in many highway bridges is that a car may leave the rails and the support provided for it and get on to that part of the bridge where the stringers were designed for lighter loads; perhaps also nearer the centre of floorbeams competent to carry a car only near one end.

Investigation of Compression Members

Compression members should sometimes be investigated on three different bases, each with its proper length and radius of gyration:—

(a) In the plane of the truss.

(b) In the plane of the members, perpendicular to the plane of the truss.

(c) In a plane normal to the least radius of gyration of the member or of one of its components.

In case (a) the effective length may be taken as the distance between centres of connections (or sometimes less) instead of the distance between the theoretical panel points.

Pony trusses without proper side support for the top chords call for careful consideration as to what should be taken as the unsupported length of such chords. No general rule for such cases can be laid down, but each must be considered on its own merits, according to the specific conditions.

Riveted Connections

The value of a rivet whose grip is more than four diameters is decreased about 1 per cent. for each 1/16 in. of this excess. Attention may here be called to the fact that the diameter of a rivet which fills the hole is 1/16 in. greater than its diameter before driving.

Rivets in reamed holes, if equally well driven, are worth much more than in punched holes for several reasons:—

(a) Because in the reamed hole the rivet upsets more readily to completely fill the hole;

(b) Because it has its full section for its full length without a possibility of offset or shoulder;

(c) Because, on account of both facts just mentioned, the rivet also exerts greater pressure on the parts riveted together, increasing the friction between the surfaces in contact;

(d) Because whatever burr is formed in reaming the hole adds to the friction between the parts.

The rivets of top flanges of deck girders and stringers, especially in very old bridges, are sometimes found to be insufficient for local loadings.

In riveted connections the spacing is often so close as to leave insufficient metal between to develop the rivets. If this is found to be the case the value of the net section is used, rather than the rivet value, in determining the value of the detail. The same trouble is often found near the ends of a girder, where the desire to save 1/16 in. in the thickness of the web leads the careless or ignorant designer to crowd the rivets unduly. This reduction of thickness of web is in other ways not always real economy, as it may necessitate additional stiffeners costing more than is saved in the web.

Floorbeams

End floorbeams of swing bridges or of fixed spans adjacent to such bridges are often found to be lighter than the intermediate floorbeams, through a mistaken notion that the loads for these floorbeams are only half as great. As a matter of fact, the actual live load is usually much larger (often double or even more), and even the dead load is sometimes greater than on the intermediate floorbeams, for the overhang of the floor gives not only an extra loaded length, but also a leverage which makes the force acting on the floorbeam greater than the weight of the load itself. In addition to the direct loads, the extra impact due to the open space between the fixed and movable spans adds greatly to the effect of the live load, which is still further increased by a possible difference in level of the floors of the two spans.

Pedestals and Rockers

Often pedestals for truss bridges, and sometimes rockers for long plate girders, are found to be too short to provide fully for longitudinal thrust or webs are too thin to support their loads and resist transverse shocks without stiffening diaphragms. In a similar way pin plates on compression members of pin trusses, or joint gussets of riveted trusses, are frequently found to be too thin to give a radius of gyration for the unsupported length of jaws comparable to the radius of gyration of the member as a whole for the whole length of the member.

Loop Hangers

Loop hangers for floorbeams are frequently found to be deficient in the details. Loop hangers of liberal size may bear upon clip angles which have insufficient strength, either in themselves or by stiffeners bearing upon them, to prevent bending up from the weight which they have to carry. Sometimes insufficient rivets are used in connecting such clip angles to the floorbeams. Even when a loop hanger passes down through or around both flanges of a floorbeam and takes bearing on the bottom flange angles, if there is no tie plate or only a thin loose washer plate, these angles and washers are very often found to be insufficient.

Decay of Timber Stringers

The reduction of the strength of timber stringers due to decay is not always appreciated. That the unit stresses generally allowed for timber leave a larger factor of safety above the elastic limit than is commonly left in the case of steel members is realized. This is wise, because wood exposed as is usual on bridges, deteriorates more rapidly than steel or iron which receives reasonable care. But, regardless of the reduction of strength of individual fibers which, though not so far gone as to be called rotten, are approaching that stage, a slight loss of section in the top or bottom of a stringer reduces the strength for resistance to bending altogether out of proportion to the amount of section lost. In a timber beam 12 in. deep a loss of 1 in. in depth reduces the section 8 per cent. and the strength 16 per cent.; 2 ins. in depth reduces the section 17 per cent. and the strength 30 per cent.; 3 ins. in depth reduces the section 25 per cent. and the strength 44 per cent.; 4 ins. in depth reduces the section 33 per cent. and the strength 55 per cent.

If the decay is uneven the loss of strength is even more striking. A 12-in. stringer having full depth at one side and reduced at the other side 2 ins. has its section reduced 8 per cent. and the strength reduced 28 per cent.; 4 ins. has its section reduced 17 per cent. and the strength reduced 46 per cent.; 6 ins. has its section reduced 25 per cent. and the strength reduced 58 per cent.; 8 ins. has its section reduced 33 per cent. and the strength reduced 66 per cent.

Sound timber, notched for pipes or other obstructions, would be reduced by these ratios; but in considering decayed timber it must be remembered that there is not a sharp dividing line between sound and rotten wood. Hence it is not wise to increase the allowed unit stress in timber for the consideration of existing structures above the amounts given in the specifications, particularly as decay in timber is wont to proceed rapidly when once started. Oak, chestnut, ash, and to a less degree, spruce timber, may lose a great part of their original strength while still showing little change in their appearance.

Corrosion and Bolt Holes

Corrosion and bolt holes in flanges of rolled steel beams reduce the strength far more than is generally realized. Of course the fact is known when thought of, but it is too commonly overlooked. The following figures illustrate these cases:—

If a 12-in.-31½-in. I-beam used as a stringer has 1 hole ⅞ in. in diameter in one flange, the strength is reduced 12¼ per cent.; 1 hole ⅞ in. in diameter in each flange, the strength is reduced 14¼ per cent.; 2 holes ⅞ in. in diameter in one flange, the strength is reduced 24½ per cent.; 2 holes ⅞ in. in diameter in each flange, the strength is reduced 28½ per cent.; ⅛ in. thickness rusted from one flange, the strength is reduced 15¼ per cent.; ⅛ in. thickness rusted from each flange, the strength is reduced 19 per cent.

If a 12-in.-20½-in.-lb. channel used as a stringer has 1 hole ⅞ in. in diameter in one flange, the strength is reduced 17¾ per cent.; 1 hole ⅞ in. in diameter in each flange, the strength is reduced 21½ per cent.; ⅛ in. thickness rusted from one flange, the strength is reduced 15 per cent.; ⅛ in. thickness rusted from each flange, the strength is reduced 18¾ per cent.

Spacing of Ties

Ties should be spaced not more than 8 ins. apart in the clear (6 ins. is better), or a derailed car wheel will drop so low between the ties as to cause too great pounding. They should be notched not less than ¾ in. for the stringers and attached to them by hook-bolts or some suitable substitute at every third tie. There should be not less than 6 ins. thickness of timber above the dapping. For wide spacing of girders or stringers, or when one rail is elevated while the stringers are at the same level, deeper ties may be required.

Guard Rails

Inside guard rails are a very important adjunct to a bridge carrying a track, to prevent the wandering of a derailed car; such guard rails should be fully spliced or their efficiency will be greatly reduced. Care should be taken that bolts are so placed that neither heads nor nuts can be sheared off by a derailed car. Some engineers do not realize that outside guard timbers do not answer the same purpose; and the requirements of at least one Railroad Commission until recently called for lining angles on these timbers, apparently with this misunderstanding. A brief consideration of this subject will show the fallacy of this view; if a wheel is retarded by rubbing against the inside rail, it will tend to turn the axle a little, directing the car toward its normal location; but the retarding of a wheel by rubbing on the outside guard timber will swing it further out of line and away from its proper place. This change of direction, too, will throw it against the guard more nearly at right angles, thus making it more likely to climb the guard and leap into whatever disaster is lurking beyond.

Though the outside guard timbers are not qualified for guiding a derailed car, they do have a very important office. Without them or some substitute, the ties would be likely to become bunched; the guard timbers also help to distribute the load and reduce the danger that the ties will tip up under a derailed wheel when stringers are too closely spaced. Guard timbers should always be notched over the ties and should be bolted to at least every fourth tie. Splices should have a horizontal lap joint.

PUBLICATIONS RECEIVED

IRVING SUBWAY.—Pocket-size catalogue (No. 2-A), issued by the Irving Iron Works Co., Long Island City, New York, illustrating and describing the "Irving Subway," a fireproof, ventilating flooring for power houses, industrial plants, etc.

PUBLIC WORKS REPORT.—Report of the Minister of Public Works for the Province of Ontario for the twelve months ended October 31st, 1918; 100 pages and paper cover; 6½ by 9½ ins. Contains the reports of A. J. Halford, Engineer of Public Works; C. H. Fullerton, Superintendent of Colonization Roads; and F. R. Heakes, Provincial Architect.

EMPIRE MUNICIPAL DIRECTORY AND YEAR-BOOK.—Published by the Sanitary Publishing Co., Ltd., 8 Breams Bldgs., London, E.C., England. This directory is in its 37th year of publication. It consists of lists of local authorities and officials in the United Kingdom and all of the British dominions and colonies; 272 pages and cover, 7 by 9½ ins., cloth bound; price, $1.50 postpaid to Canada.

CERTAIN LINES IN ONTARIO AND QUEBEC.—By F. B. Reid, supervisor of levelling, Geodetic Survey of Canada. Published as Publication No. 4 of the Geodetic Survey. This pamphlet describes bench marks from Montreal to Hull, P.Q.; St. Martin Junction to Three Rivers, P.Q.; Grenville, P.Q., to Prescott, Ont.; Ivanhoe to Toronto, Ont.; Bethany to Port Hope, Ont.; Myrtle to Whitby, Ont.; North Toronto to Mimico, Ont. It also includes an index and map showing all work previously published.

THE JEFFREY CARRIER.—Cloth-bound book, 96 pages and cover, 6 by 9¼ ins., distributed gratuitously by the Jeffrey Manufacturing Co., Montreal, P.Q., and Columbus, Ohio; published in three colors on coated paper, profusely illustrated. This booklet describes the pivoted bucket conveyer and is published as catalogue No. 210. It is so full of useful data concerning carriers, has so many illustrations of various installations, and is so well printed and substantially bound, that it will prove a desirable addition to the engineer's library.

ECONOMICAL SIZE OF PIPE FOR GIVEN LOSS OF HEAD*

By Prof. E. W. Rettger
Cornell University

THE most economical size of penstock is a matter of the greatest importance when the penstock is a long pipe under high head. In such a case the first cost of the penstock is apt to be the largest part of the total first cost of the plant and it is therefore very important that the most economical size of the penstock be determined.

Before the most economical size of penstock can be determined, it is necessary to know what principal of economy is to be used. This principal may be different for different plants. For instance, it may be required to determine the size of the pipe so that the total net annual income shall be a maximum, or so that the percentage return on the original investment shall be a maximum. In other cases it may be required to determine the pipe so that the percentage return on the original investment shall be a specified amount. This may be the case when the amount of water available is limited and when it is imperative to produce as much power as possible, consistent with a fair rate of return on the original investment. Thus, the economic design of a penstock may come up in a variety of forms.

When the penstock is to consist of a pipe of constant diameter throughout, the problem, so far as the penstock is concerned, is comparatively simple. Assume, for instance, that the net annual income shall be a maximum. A simple and direct method of procedure in determining the economical size of pipe of constant diameter throughout, under the given principle of economy, is as follows:—

Calculate or approximate the total net annual income for each of several assumed diameters. With the diameters as abscissae and the total net annual income as ordinates, a curve may be plotted. From this curve, the diameter can be found for which the total net annual income will be a maximum.

In the case of high heads, however, it is often found economical to make the pipe consist of two or more sections of different diameters. Such a pipe would approximate the shape of a funnel with the smallest diameter where the head is the highest. In other cases it is found economical to make the upper part—the part under the low head—consist of concrete or staves and the remainder of steel. The determination of the economical pipe now reduces to the determination of the diameters of the several sections and the problem may not be an easy one. The method of procedure suggested for the case of a pipe of constant diameter throughout, is no longer applicable. While considerable latitude is left to the designer, it is nevertheless important to be able to determine what the theoretically economical diameters of the several sections are.

In 1907, A. L. Adams proposed a principle for the design of a penstock that seemed to him self-evident. This principle may be stated as follows:—

That pipe is most economically designed for which the interest and depreciation on first cost of the pipe plus the annual value of the power lost due to friction in the pipe is a minimum.

This principle of economy seems simple and logical and it is referred to in nearly every discussion on the economical size of penstock. Frequently, formulas for the economical diameter are derived from it. For the case of riveted steel, Professor D. W. Mead (Mead's Water Power Engineering, 2d edition, page 546) derives two formulas:—

$$(1) \quad d=0.2153 \sqrt[7]{\frac{fbq^3S}{cih}} \text{ for high head}$$

and

$$(2) \quad d=0.2195 \sqrt[6]{\frac{fbq^3}{t'ci}} \text{ for low head}$$

where h is the head on the point under consideration; f is the coefficient of friction defined in equation (3) which follows; S is the allowable unit stress in shell in pounds per square inch corrected for rivet holes and water hammer; c is the cost of the metal per pound; i is the rate of interest and depreciation on first cost of pipe; b is the annual value of a horsepower at the wheel; and q is the discharge in cubic feet per second.

When the required theoretical thickness of the shell is more than the minimum allowable thickness, the pipe is considered to be designed for high head and formula (1) applies. When the theoretical thickness of the shell becomes less than the minimum allowable thickness, formula (2) applies, which was derived on the asumption that the thickness of the shell shall be the minimum allowable thickness, t'.

From formula (1) it is seen that the theoretically economical diameter of a pipe under high head decreases as the head h, increases; and from (2) it is seen that the economical diameter for a pipe under low head is independent of h.

In deriving formulas (1) and (2) the friction head was assumed to be given by

$$(3) \quad h'=\frac{fl}{d}\cdot\frac{v^2}{2g}.$$

Now f is unknown to start with since it depends upon the diameter of the pipe which is not yet determined. In practice, a value of f is first assumed, and the diameters of the pipe are determined by means of the above formulas. If the average value of f for the pipe so determined differs appreciably from that assumed, a revised value for f is taken.

If the friction head for riveted steel pipes is assumed to be given by the formula

$$(4) \quad h=0.00050 \frac{v^2 l}{d^{1.25}};$$

the resulting formulas become:

$$(5) \quad d=0.1423 \sqrt[7.25]{\frac{bq^3S}{cih}} \text{ for high head;}$$

and

$$(6) \quad d=0.1356 \sqrt[6.25]{\frac{bq^3}{t'ci}} \text{ for low head.}$$

Formulas (5) and (6) do not contain the unknown coefficient f. So far as the writer knows, formulas (5) and (6) are here given for the first time.

If the value of b, the value of a hydraulic horsepower at the wheel, is given, Adams' principle and the resulting formulas will solve the problem. Unfortunately the proper value for b is not always known. As already stated the principle of economy to be used in the design of a penstock may be one of several, and Adams' principle may be difficult to apply. Engineers of experience declare that this principle is not always applicable. These considerations urged the writer to see if a method of attack analogous to that suggested for a pipe of constant diameter throughout could be used, and as a result he has arrived at certain conclusions that may be of interest to students of hydraulics.

If for an assumed total loss of head h', the most economical pipe could be found, the following method would be applicable: For each of several assumed values for the total loss of head, h', in the pipe, determine the economical pipe, and if, the total percentage return, p, is to be a specified amount, calculate or approximate the *percentage return* for each assumed value of h'. A curve can then be drawn with h' as the abscissa and p as the ordinate. From this curve the value of h' can be obtained so that the percentage return shall be the desired amount. Now with h' determined, the most economical pipe can be found.

If the pipe is homogeneous—made entirely of riveted steel for instance—the pipe of least annual cost will be the pipe of least first cost, or of least amount of metal. If the pipe is not homogeneous, such as when the upper part is of staves and the lower part of steel, it is no longer a question of least amount of metal but rather one of least first cost or least annual cost. As shown later, the expression that will determine the diameter of the pipe for least annual cost will also determine the pipe for least first cost or least amount of metal (pipe homogeneous) if one or two of the

*From the "Cornell Civil Engineer."

constants involved are made equal to unity. It will be convenient therefore, to consider the case of least annual cost. The problem may be stated as follows:—

Given a pipe of fixed length, l, and under a given head, h, with a given discharge, q, it is required to find the size of the pipe so that for a given or assumed total loss of head, h′, in the pipe the annual cost of the pipe will be a minimum.

The problem as thus stated is of considerable interest. In the "Engineering Record" of December 20th, 1913, page 682, E. R. Bowen describes the inverted Jawbone Syphon of the Los Angeles aqueduct. This inverted syphon was to be designed to contain the least amount of metal subject to the condition that the loss of head due to friction in the syphon should be 26 feet. The solution as given by Mr. Bowen is a graphical one requiring a great deal of labor. This same problem could have been solved in a much simpler way.

The annual cost of the pipe is the interest and depreciation on first cost and this will be represented by I. The The problem then is to find the size of the pipe so that I will be minimum, subject to the condition that the total loss of head in the pipe shall equal h'.

In practice, the pipe is made to consist of two or more sections, each section of constant diameter and thickness of shell. The greater number of sections, the more nearly will this pipe approach the theoretically most economical pipe, one in which the diameter decreases as the head increases.

For the sake of convenience we will assume that the pipe is to consist of three sections as shown in Figure I.

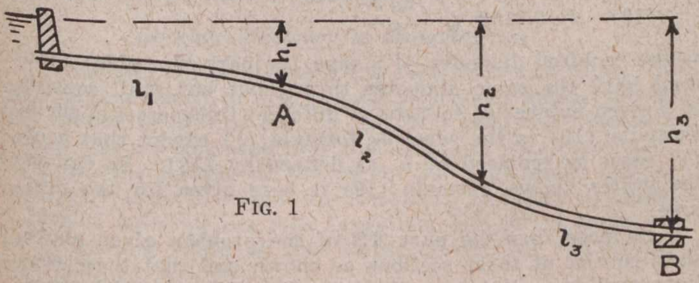


FIG. 1

Let l_1, h_1, d_1; l_2, h_2, d_2 and l_3, h_3, d_3 be the lengths, heads and diameters of the respective sections.

Evidently, the location of the points of division a and b will effect the economy. It can be shown that the location of the most economical points of division depends upon the profile. These points, perhaps, can best be found by trial. For our purpose it is necessary to assume that the points of division are given. Consequently h_1 and l_1, h_2 and l_2, h_3 and l_3 are assumed as given or determinate.

The interest and depreciation on first cost of a section is proportional to the amount of metal in that section. Using a well known principle of hydraulics, the amount of metal in that section under high head is found to be proportional to $d_r^2 h_r l_r$. The subscript r is used to indicate that it applies to a section and not to the pipe as a whole. The annual cost (interest and depreciation) of this section may therefore be represented by the equation

(7) $I_r = A d_r^2 h_r l_r$;

where A is a constant. Moreover, the friction head for this section may be expressed by (see eq. 3)

$$h'_r = \frac{f l_r}{d_r} \cdot \frac{v_r^2}{2g}$$

or, if v is eliminated by means of the relation $F_r v_r = \frac{1}{4} \pi d_r^2 v_r = q$, by

(8) $h'_r = \dfrac{C l_r}{d_r^5}$;

where C is a constant. The problem then requires us to find d_1, d_2, and d_3 so that

(9) $I = I_1 + I_2 + I_3 = A \; (d_1^2 h_1 l_1 + d_2^2 h_2 l_2 + d_3^2 h_3 l_3)$

will be a minimum subject to the condition that

(10) $h' = h'_1 + h'_2 + h'_3 = C\left(\dfrac{l_1}{d_1^5} + \dfrac{l_2}{d_2^5} + \dfrac{l_3}{d_3^5}\right)$

shall have a specified value. If, now λ is a constant, the expression,

(11) $L = I + \lambda h'$,

will be a minimum when I is a minimum. Since h' shall have a definite value, it may be considered a constant. Substituting the values of I and h' as given by equations (9) and (10) and rearranging, equation (11) becomes

(12) $L = (I_1 + \lambda h'_1) + (I_2 + \lambda h'_2) + (I_3 + \lambda h'_3) = L_1 + L_2 + L_3$

For an assumed mode of division of the pipe into sections, h_r and l_r are given for each section and therefore must be considered as constants. Consequently L_1 contains d_1 as the first variable. Similarly, L_2 contains d_2 as a second variable and L_3 contains d_3 as the third variable. L_1, L_2, and L_3 contain no variable in common and they are therefore independent functions. From this it follows that if their sum must be a minimum, each separately must be a minimum. That is, we must have separately

(13) $\dfrac{d L_1}{d (d_1)} = 0 \quad \dfrac{d L_2}{d (d_2)} = 0$ and $\dfrac{d L_3}{d (d_3)} = 0$.

Or in general [see eq. (11)],

(14) $\dfrac{d L_r}{d (d_r)} = \dfrac{d I_r}{d (d_r)} + \lambda \dfrac{d h'_r}{d (d_r)} = 0$

for each section of the pipe.

Since λ is a constant, yet to be determined, we may arbitrarily let

(15) $\lambda = \dfrac{b \; q}{8.8}$

and consider b the constant yet to be determined. Substituting in equation (14), we obtain

(16) $\dfrac{d L_r}{d (d_r)} = \dfrac{d I_r}{d (d_r)} + \dfrac{b \; q}{8.8} \cdot \dfrac{d h'_r}{d (d_r)} = 0$

for each section of the pipe.

From equations (7) and (8), it is seen that l_r is a factor of equation (16). Dividing through by l_r and performing the differentiation indicated, the resulting equation becomes identical with that derived by Prof. Mead (Water Power Engineering, page 546). Formula (1) therefore, gives us the required diameter for any section under high head and formula (2) for low head. The value of h to be used in formula (1) when applied to any section should be of course the highest head that section is under.

In the present interpretation of formulas (1) and (2), b is not to be considered as the value of a hydraulic horsepower at the wheel, but as a constant or parameter such that the total loss of head in the pipe shall be h'. Although a constant, b is not arbitrary, but its value must be determined. This can be done in the following way: For riveted steel pipes, the diameters as determined by formulas (1) and (2) must satisfy the equation [see equation (10)]

(17) $h' = C \left[\dfrac{l_1}{d_1^5} + \dfrac{l_2}{d_2^5} + \dfrac{l_3}{d_3^5} + \; . \; . \; . \right]$

If, therefore, the values of d_1, d_2 and d_3 as given by formulas (1) and (2) be substituted in equation (17), the resulting equation will contain b as the only unknown, and therefore b is determined. If, for instance, the first section is under low head and the other two under high head, d_1 is given by formula (2) and d_2 and d_3 by formula (1).

Instead of determining b algebraically as was suggested above, a value for b may be assumed and the diameters determined by means of the formulas. A few trials will suffice to determine b so that the total loss of head in the pipe line will be h'.

Since for a given mode of division of the pipe line into sections, h' is determined as soon as a value for b is assumed, the formulas (1) and (2) may be given a new interpretation. According to this interpretation b may be taken as a parameter such that for every assumed value for b, the resulting pipe line will, for the resulting total loss of head in the pipe, be the pipe of least annual cost (or least first cost or least amount of metal). This interpretation, so far as the writer knows, is here given for the first time.

In special cases b may be taken as the value of a hydraulic horsepower at the wheel. The new interpretation, however, still holds since the pipe as thus determined

CANADA'S FUEL PROBLEM — SOME NATIONAL AND INTERNATIONAL ASPECTS

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south-western Alberta, and in the Flathead valley in south-eastern British Columbia.

"In northern Alberta there are enormous tar seepages which evidence an upwelling of petroleum unequalled elsewhere in the world. Along the Athabaska River they extend from Pelican Rapids to Fort McKay, a distance of over 100 miles. The known occurrences indicate that there is in sight at least 6½ cubic miles of bitumen, and the petroleum from which it was derived must have been many times greater. While this enormous amount of petroleum has escaped, there must be untapped reservoirs in the Devonian limestones, whence it was derived. Similar seepages occur near the Peace and Mackenzie Rivers.

"Near Peace River Landing, oil has been found in two wells, 900 and 1,100 ft. deep, respectively. The first well is reported to have yielded three to four barrels per day, when oil was struck in the upper portion of the tar sands and to have had a maximum production of about nine barrels. Drilling, however, was continued through the tar sands, which are about 80 ft. in thickness at this point, and a heavy flow of water and gas was struck immediately below the sands.

"The second well is in the tar sands and is reported to be yielding about 25 barrels per day."

There is marked evidence that Canadians are alive to the important possibilities of the petroleum industry, and the results of the efforts to be made in 1919 are looked forward to with the greatest interest.

Seeking Efficiency in Consumption

Canadians are recognizing the fact that it is fairly incumbent upon them to apply every permanent means within their power to utilize coal in the best and most efficient manner. It is recognized that coal shortage may recur, and therefore, the lessons of the recent shortage must not be forgotten. It is true that the lessons of the coal shortage of 1902-03 were all too soon forgotten, but surely those of the distressing times of the winter of 1917-18 will prove more lasting.

We must not forget the "heatless days"; the times when gasoline could not be used; the denial of fuel for certain luxuries, as use on private yachts; the curtailment of fuel for the manufacture of such apparatus as musical instruments, talking machines, etc.; the allotment to florists for greenhouse purposes of only 50 per cent. of the fuel they were accustomed to receive; the compelled use in certain districts of wood for fuel; the restrictions upon the use of natural gas; the prohibited use in many cases of anthracite and the substitution therefor of bituminous coal; the daylight saving legislation on both sides of the Atlantic; the cutting down of illuminated advertising; and the enforced "lightless nights." These and many other facts must be held in mind as indicating how wide-spread and absolutely necessary have been the efforts for economy with respect to fuel. In the period of reconstruction, and afterwards, the demand for fuel will doubtless be such that many of the restrictions placed upon its use during the war period will in one form and another find permanent expression.

Obtaining Greater Efficiency

In Canada, as in the United States, it is expected that coal consumers will endeavour to effect economies by the systematic employment of every reasonable means which modern progress can devise. Some of such means may suggestively be enumerated as follows:—

In the use of coal generally, great economies may be effected by subjecting the raw bituminous and lignite coals to such by-product and other manufacturing processes as will save the valuable by-products and at the same time produce from inferior grades a satisfactory and clean-burning fuel; by a proper co-ordination of the uses of electricity and coal according to their respective spheres of greatest efficiency; and by a greater utilization of gas. Those interested in the coal-gas-producing industries are looking forward to the greatly increased use of gas and the recovery of by-products, including the coke.* Manufacturers of stoves and heating apparatus are giving serious attention to the production of apparatus more suitable for satisfactorily burning the softer coals.

In the production of power, savings may be effected by taking advantage of the greater efficiency of the modern steam turbine and of large hydraulic units, and by the interconnection, especially over large areas, of various electric plants—whether steam-electric or hydro-electric, or combinations of both—with the object of securing the greatest efficiency in the supply of power and light to districts respectively served.

Effecting Savings of Fuel

By co-ordinated efforts by communities, savings may be effected by staggering the hours of closing of factories, by the adoption of the skip-stop system for street railways, by daylight-saving legislation, by the enactment and enforcement of wise laws, designed to eliminate the wastes resulting from the smoke nuisance.

In manufacturing establishments, savings will be effected by the more efficient use of light and power, by the elimination of uneconomical plants and processes, by the installation of means to use more economical fuel for direct heating, by the substitution wherever possible of hydro-electric for steam-developed power, and by standardization.

By the electrification of steam railways, especially if operated by hydro-developed power, enormous savings in fuel consumption may be made by the reduction of the amount of coal to be hauled, by the saving of energy resulting from the regeneration of electricity by improved methods of braking, by the reduction of the number of buildings and divisional points due to the greater radius of action of electric locomotives, and where fuel-power is employed, by its economical production in large, modern, generating stations. Canada is looking ahead to great development in the near future in the electrification of steam railways. The Ontario government and municipalities already have this problem in hand.

In all such efforts to attain the efficiency possible by intelligent saving and co-ordination, Canada may be relied upon not to fall short of her privileges. Recognizing that the days of the widespread use of anthracite are numbered, her bituminous coals and lignites will be subjected to by-product and other manufacturing processes with the object of producing a satisfactory and clean-burning fuel. Canada does not desire to ignore the march of progress in these fuel problems, nor will she be backward in effecting economies for the prevention of needless fuel and power wastes.

Canada Must Bestir Herself

Now, in conclusion, it must be recognized that anthracite as a fuel is a luxury. Within the last twenty-five years many farmers and citizens, especially in outlying communities where formerly only wood was used, now use anthracite. It became easier and more convenient for the farmer to haul his coal from the railroad siding than to go into the bush and chop his year's supply of wood.

A great portion of this Dominion, like the farmer, has become dependent upon others for coal.

Canada, even though she may regret being deprived of the luxury of clean-burning anthracite or the easily-delivered bituminous coal, must, nevertheless, arouse herself and bestow the necessary intelligent labor upon her own fuel resources in order to make them available for her national needs.

There is no necessity for Canada, with her vast resources of fuel and water power, to go cold or to have her industries throttled by reason of power shortage; but Canada may have a sore trial in both these respects unless every possible effort is speedily made to deal with the fuel and power situation in a comprehensive manner.

Once a broad national policy has been determined, financial and other assistance should be promptly rendered to

*Consult "Possibilities Ahead of the Gas Industry as Revealed by a Digest of Reports from Various Sources," by G. W. Allen in "Proceedings of the 11th Annual Meeting of the Canadian Gas Association," 1918.

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PRINCIPAL CONTENTS

CENTRAL HEALTH LABORATORY REQUIRED

DR. C. J. HASTINGS, medical officer of health for the city of Toronto, is reported in a Toronto daily paper as having stated that practically every city is still experimenting with methods of sewage disposal, and that none have yet been able to solve the problem satisfactorily.

"We will be just as well to sit tight and watch experiments in other cities," says Dr Hastings, "as spend money for experiments here. All the so-called better methods are still in the experimental stage."

Dr. Hastings' policy of "sitting tight" and letting others experiment, is hardly the policy that one would expect from a progressive city like Toronto, and it is not likely the policy that the Works Department of that city will take.

Nevertheless, the attitude assumed by Dr. Hastings is not quite so selfish as might appear at first glance. It is undoubtedly founded upon one kind of logic. Milwaukee and other cities have spent many thousands of dollars upon experiments, and Dr. Hastings probably feels that these cities have gone much further in their experiments than Toronto could hope to go for a considerable period, and, as those cities are still spending money for this work, more or less freely, he naturally questions the necessity of Toronto's duplicating the work when he feels that it is already in good hands and is being capably carried out elsewhere.

But is this policy of waiting for "the other fellow" to solve one's problems, the best to pursue? Why should one city spend money in conducting experiments that are of general benefit to all cities? Milwaukee, having spent a certain amount of money in sewage disposal experiments, might very properly say: "We have done our share. Let's stop spending money, and let Toronto, Montreal or some other city finish the work." Then the work would be left to that city which had the most progressive, generous and far-sighted governing officials.

Dr. Hastings' remarks are another reminder that there should be some central bureau, or laboratory, fully equipped with funds and staff for conducting experiments in public sanitation. All problems of general application could then be referred to that bureau and properly taken care of, leaving only purely local problems to be solved by the individual municipalities. Now that the new Department of Health at Ottawa has an official and capable head in Dr. John A. Amyot as deputy minister, it is to be hoped that problems of this kind can be centralized under the direction of that department.

AN IMPROVED COST-PLUS CONTRACT

SEVERAL different forms of percentage contracts have been devised during the past few years in the United States, but a Canadian, J. A. Beatty, of the firm of Morrow & Beatty, Ltd., general contractors, Peterborough, Ont., has inaugurated a form of contract which appears superior in many respects to any other of its kind that has yet been suggested.

The Beatty plan, if it may so be called, has been tried out on a half-million dollar contract for the Southern Canada Power Co., and has resulted, says Mr. Beatty, most satisfactorily, both to the owners and their consulting engineers, and to Mr. Beatty's firm, who were the contractors.

Mr. Beatty's scheme is to charge (tentatively) a fixed fee of 20% on the estimated cost of the work and then, at the end of the job, to pay back to the owners 10% of the total cost of the work, whatever it may be. For instance, if a job were to be estimated by the contractors at a probable cost of $500,000, Mr. Beatty would charge a fixed fee of $100,000. When the job was finally completed, if it were found that the total cost amounted to $550,000, Mr. Beatty would pay the owners $55,000, leaving his firm a profit of $45,000. If the job had only cost, say, $475,000, he would pay the owners $47,500, leaving a profit for his firm amounting to $52,500.

At first glance this does not seem far different from a fixed fee with a bonus and penalty clause. Financially, it is practically no different, but it has two advantages, one of which, especially, is worthy of serious consideration.

First, it is a simpler and more clean-cut way of expressing the contractor's responsibility, and is less likely to result in disagreements or law suits. The owner knows that after he has paid or pledged himself to the fixed fee, whatever the cost of the work may be, he only has to pay 90% of it and the contractor pays 10%. In a simple arrangement of this kind, there is no room for unpleasant misunderstandings as to responsibility for cost having exceeded a certain figure. If the cost of the work be $1,000 or $1,000,000, the contractor pays 10%.

The second and more important advantage of the Beatty plan, the advantage that will appeal to every contractor, is its effect upon the contractor's staff.

Every man on the job knows right from the very beginning that his firm must pay ten cents of every dollar that is spent. When the contractor is not penalized until after the cost has reached a certain figure, the staff is likely to be less careful at the very beginning of the work, perhaps feeling certain that the work will not exceed the estimated cost, and that there is no need for stringent economy or for devising unique methods of saving every possible dollar; and not until the estimated cost has been reached, or nearly reached, and the work is seen to be far from completed, does the real situation impress itself upon the staff; then, when it is too late to prevent a penalty, every effort is made to finish up the job as economically as possible.

Mr. Beatty's plan prevents any laxity right from the start. The contractor and the staff know that they must pay one dollar out of the very first ten dollar bill that is spent on the work, and this direct liability is an excellent incentive to the contractor himself and to his staff to use all possible brains and energy in carrying out the work in the most ingenious manner from the very first shovelful of excavation.

Engineers, and also contractors, differ in their opinions whether the lump-sum, or unit-price, contract is or is not preferable to the percentage contract. Many articles have been written upon both sides of the subject. But if the percentage contract is to be widely adopted (and it has grown a great deal in popularity during the last few years), we venture to predict that the Beatty plan will be tried by many firms, and that the contractors will find it a very satisfactory form of contract.

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enable sane and businesslike development of Canada's lignite, peat and other fuel resources for the benefit of the nation, to be carried out by competent technical officials entrusted with this great and honorable responsibility. As we have already noted the work has been commenced.

Officials of the government of Canada, such as those in the Geological Survey, Department of Mines, the Commission of Conservation, and other organizations, have knowledge of existing conditions and of practical means by which much of the stress may be relieved. To carry out these measures of relief and to place Canada in a reasonably independent position with respect to fuel will take time; but there is no doubt that if matters are dealt with in a broad statesmanlike manner, and the necessary encouragement of financial and other assistance is given to those who are competent, Canada will, at a minimum of effort and expense, be relieved of a menace with respect to her coal supply which threatens not only her economic life, but the well-being of a large proportion of her citizens.

EXHIBITORS AT WATER WORKS CONVENTION

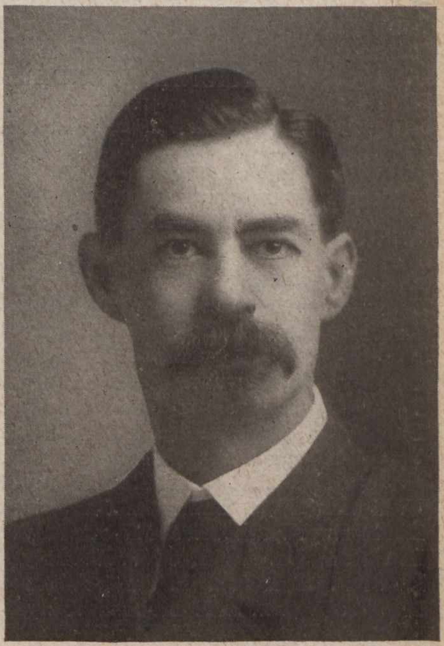
In the June 19th issue of *The Canadian Engineer* there was published a list of the firms that exhibited at the American Water Works convention, June 9th to 12th, Buffalo, N.Y. It is very much regretted that several names were omitted accidentally from this list. In order to make the record of the meeting complete, it should be stated that in addition to the firms mentioned on page 550 of the June 19th issue, the following firms also had space: National Water Main Cleaning Co., New York City; Joseph Dixon Crucible Co., Jersey City, N.J.; United States Cast Iron Pipe and Foundry Co., Burlington, N.J.; Irving Iron Works Co., Long Island City, N.Y.; Badger Meter Manufacturing Co., Milwaukee, Wis.; McNutt Meter Box Co, Brazil, Ind.; Glauber Brass Manufacturing Co., Cleveland, O.; Richardson Phenix Co., Milwaukee, Wis.; and the Gaunt Co., Knoxville, Tenn.

The damage caused by a recent cloudburst along the line of the Canadian National Railways, between Port Arthur and Winnipeg, was of greater extent than indicated by early reports. Four to ten inches of rain fell during forty-eight consecutive hours. Several miles of roadbed, eight bridges and thirteen culverts were washed away. During the time necessary for repairs to be completed, C.N.R. trains ran on the C.P.R. tracks.

City Architect Pearse, of Toronto, says that the first draft of the revised building by-law is in the hands of the city solicitor. As soon as the latter official is through with it, the first draft of the by-law will be printed. Mr. Pearse says that in the revision of the by-law, three points have been kept in mind, in the following order of importance: First, safety of the public; second, fire protection; third, economy of design. Mr Pearse advocates the establishment in Canada of one or more laboratories for testing Canadian materials.

PERSONALS

Lt.-Col. (Dr.) John A. Amyot, C.M.G., of Toronto, has been appointed Deputy Minister of the Department of Health that was recently created by the Dominion Government. Dr. Amyot will go to Ottawa next week and will commence his new duties at once. Prior to going overseas in May, 1915, Dr. Amyot was professor of hygiene at the University of Toronto and director of the laboratory of the Ontario Board of Health. He went overseas with the No. 4 Canadian General Hospital of the University of Toronto. Upon his arrival in England, owing to his extensive experience in sanitation and public health work he was sent to France to take command of the sanitary section of the First Canadian Division. A few months later he was placed in charge of the sanitary organization of the Canadian corps. In September, 1916, his services were requested by the commanding officer of the Second British Army, of which he was appointed assistant director of medical services, in charge of sanitation. Dr. Amyot then had charge of all sanitary work extending from the North Sea to Ypres and Armentieres. He was mentioned in despatches in December, 1917, and was awarded the C.M.G. the following New Year's Day. During the last period of his overseas service, he was consultant on sanitation work to the commanders of the Canadian forces in England. He returned to Canada early last month and is at present enjoying a well-earned vacation. Dr. Amyot was born about 1869 in St. Agathe, P.Q., and was educated at St. Michael's College and at the University of Toronto, from which latter institution he graduated in 1891 with the degree of Bachelor of Medicine.



Captain Dawson, recently assistant engineer, Halifax Ocean Terminals, is now practising in Montreal as a consulting engineer.

Ex-Senator C. D. Clark, of Evanston, Wyoming, U.S.A., has been appointed a member of the International Joint Commission, succeeding the late James Tawney, of Minnesota. The appointment was made this week by President Woodrow Wilson.

Major T. E. Ryder, D.S.O., M.C., has been appointed general manager of the Rudel-Belnap Machinery Co., Ltd., Montreal. Major Ryder recently returned home in command of the 7th Canadian Siege Battery after having been overseas for four years.

Lieut. J. E. Pringle, formerly of the Queen Victoria's Own Sappers and Miners, Indian Army (Royal Engineers), has been appointed to a position on the engineering staff of the Hydro-Electric Power Commission of Ontario. Lieut. Pringle will be engaged in location work in connection with the "hydro-radials" between Niagara Falls and Toronto.

In an interview with the "Toronto World," Dr. C. J. Hastings, medical officer of health for the city of Toronto, states that if the water of Lake Ontario were not treated, it would not be safe for the people of Toronto to drink it.

CONSTRUCTION NEWS SECTION

Readers will confer a great favor by sending in news items from time to time. We are particularly eager to get notes regarding engineering work in hand or proposed, contracts awarded, changes in staffs, etc.

ADDITIONAL TENDERS PENDING

Not Including Those Reported in This Issue

Further information may be had from the issues of *The Canadian Engineer*, to which reference is made.

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Aurora, Ont., pavement	July 18.	July 10.	136
Aurora, Ont., sewers	July 18.	July 10.	46
Belleville, Ont., sewers	July 18.	July 10.	46
Berthier, Que., wharf	July 24.	July 10.	52
Cornwall, Ont., wharf	July 22.	July 10.	52
Donnacona, Que., mill	July 20.	July 10.	50
Fort Qu'Appelle, Sask., boilers, etc.	July 31.	July 10.	48
Half Moon Bay, B.C., wharf	July 23.	July 10.	52
Kindersley, Sask., five culverts	July 21.	July 10.	136
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L'Assomption, Que., bridge	July 18.	July 10.	136
Montreal, Que., coal crusher	July 23.	June 19.	50
Montreal, Que., coal drying equipment	July 23.	June 26.	52
North Arm, B.C., dredging	July 30.	July 10.	52
North Bay, Ont., pavements	July 18.	July 3.	118
Ottawa, Ont., highway	July 18.	July 3.	118
Owen Sound, Ont., pavements	July 18.	July 3.	118
Pickering, Ont., highway	July 21.	July 3.	52
Port Essington, B.C., float and approach	July 31.	July 10.	52
St. Anne de Beaupre, Que., wharf	July 23.	July 10.	52
Toronto, Ont., bridge	July 21.	June 26.	48
Toronto, Ont., fire escapes	July 15.	July 3.	50
Toronto, Ont., pipe	July 21.	July 10.	48
Welland, Ont., pavement	July 21.	July 10.	45
Weyburn, Sask., heating, etc.	July 26.	July 10.	48
Whitby, Ont., bridge	July 21.	July 10.	45
Winnipeg, Man., culverts	July 18.	July 10.	50
York Township, Ont., water mains	July 19.	June 26.	52

BRIDGES, ROADS AND STREETS

Barrie, Ont.—The town council proposes to issue debentures to the amount of $10,000 for construction of cement sidewalks, crossings and improvements to roads.

Belleville, Ont.—Debentures will be issued to the amount of $6,635.06 for granolithic sidewalks and $32,871.06 for street pavements. Wilfred Holmes, city clerk.

Calgary, Alta.—The C.P.R. is reinforcing the concrete retaining wall on the Eighth St. W. and First St. E. subways in order to make them waterproof. Excavation is now being carried on along the retaining wall in order to put in th waterproof protection.

Cedardale, Ont.—Tenders will be received by Bowman and Connor, engineers, 31 Queen St. W., Toronto, until noon, July 19th, for the construction of a 73 ft. steel bridge with concrete abutments, or of a concrete arch truss bridge on the base line between Oshawa and Cedardale.

Chatham, Ont.—Tenders will soon be called for paving the River Rd. in Dover Tp. Plans and specifications are with W. C. McGeorge, chairman and engineer of the Roads Commission. There will be no curbing but merely a straight country road with three-foot gravel shoulders.

Cobden, Ont.—The county council has decided to take over the Cobden village road as a county highway. Reeve, W. J. Connelly.

Cobourg, Ont.—The part of the Kingston road, between Port Hope and Grafton, recently taken over by the provincial department of highways will be improved. In addition to grading, widening and draining, the department is putting in reinforced concrete bridges. Tenders have been awarded for 24-foot bridges on the road west from Cobourg, at Gage's Creek, and at Pontiac stock farm on the road east of the town, and at "Sidbrook," just outside the town limits. It has been recommended that the road running from the Home for the Aged to the corner of King and William Sts., be taken over by the department, and property be purchased to straighten the road near the corner of William St. and the Kingston road west of the town, which has a dangerous curve.

Compton, Que.—Contracts for gravelling Sherbrook-Norton road have been awarded to Francis Laroche, Coaticooke, Que.; F. E. Lovell, Coaticooke, Que.; R. E. Willard, Islandbrooke, Que., and L. D. Cairnie, Lennoxville, Que.

Cornwall, Ont.—Work is progressing favorably on the Ottawa-Prescott provincial highway in the neighborhood of Kemptville.

Daly, Man.—Contract for two reinforced concrete bridges and one culvert has been awarded by the municipal council to E. Fulcher, Brandon, Man.

Dundas, Ont.—The town council has awarded contract for 30-inch segment block to Toronto Potteries for $10,175.

Esquimalt, B.C.—Palmer Bros., Vancouver, have been awarded contract by department of public works for grading and paving Island Highway, 2¼ miles. Tender price, approximately $75,000.

Fenelon Falls, Ont.—At a meeting of the Victoria County Good Roads Board, a resolution was carried recommending the construction of a county road of asphaltic concrete, from Leddy Corners to the swamp. The construction is subject to the approval of the highways department.

Halifax, N.S.—The Canadian Bituminous Paving Co., Ltd., Toronto, has been awarded contract for all paving work advertised, with the exception of portions of three streets. The contract for bituminous macadam has been awarded to the Barrett Co., Halifax.

Halton County, Ont.—Contract for the middle road, of stone construction, a distance of 3¾ miles, and for the Milton road, 2¼ miles of waterbound macadam, have both been awarded. Work is expected to commence next week. Halton county intends expending about $130,000 on construction and maintenance this year. The county owns four stone-crushing plants; two of them only are working, one near Milton and the other near Nelson village, each having a capacity of about 100 yards of stone per day.

Hespeler, Ont.—The town council contemplates construction of cement sidewalks on George St. and Adam St. Mayor, L. E. Weaver.

Kingston, Ont.—The department of public works has awarded contract for placing of stone rip-rap along south walls of Lasalle highway, to John F. Sowards, Kingston.

Lindsay, Ont.—The Good Roads Board of the Victoria County Council has decided to construct one mile of permanent pavement in the township of Mariposa. Estimated cost between $20,000 and $27,000.