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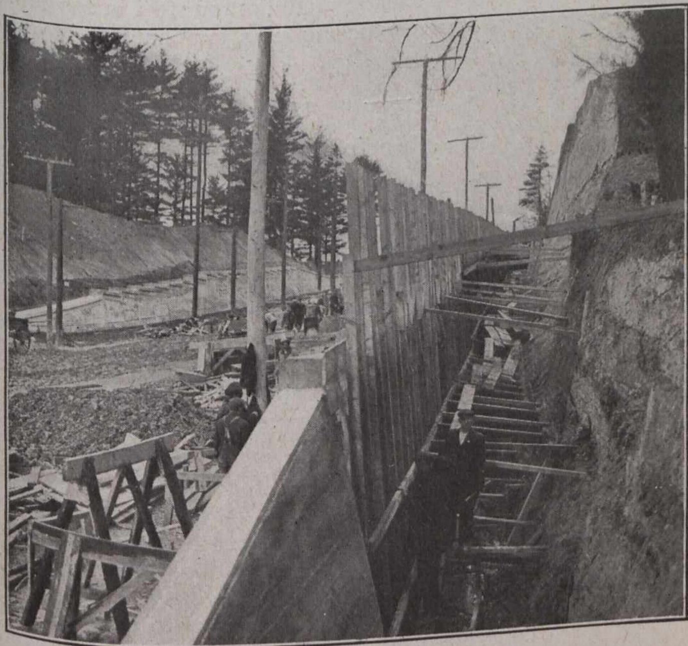
RETAINING WALLS ON BATHURST STREET HILL, TORONTO

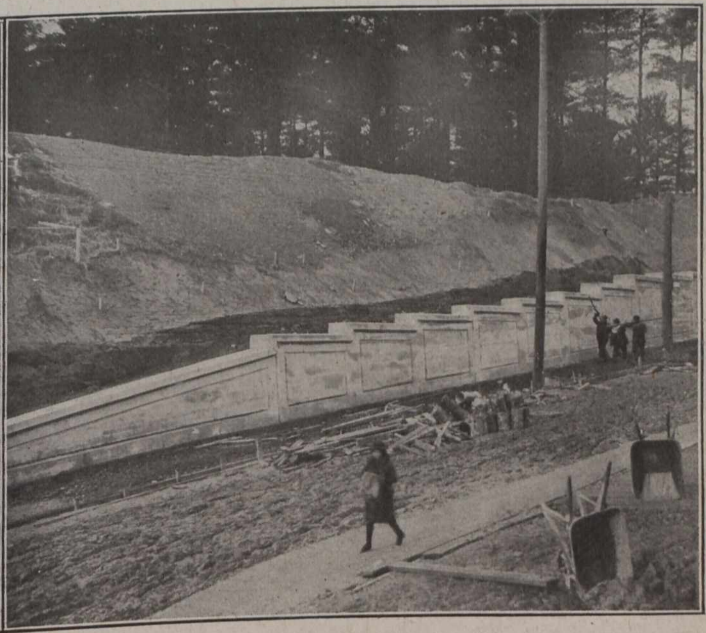
A DISCUSSION ON THE DESIGN AND CONSTRUCTION OF THESE RETAINING WALLS WHICH WERE BUILT TO IMPROVE THE ROAD AND PROVIDE BETTER ACCESS TO THE RAPIDLY GROWING NORTHWEST SECTION OF THE CITY.

By **S. G. TALMAN, A.M.Can.Soc.C.E., A.M.I.E. (South Africa).**
Roadways Section, City of Toronto.

It is at once apparent from a glance at the sketch map of the city of Toronto, as shown in Fig. 1, that a good road connecting up the newer sections of the city north of the Hill, which runs along the old northern boundary, is an absolute necessity for the proper de-



East Wall—Reinforced Concrete Section.



West Wall—Concrete Gravity Section.

velopment of this district. It will also be seen that the centre of population of the city is rapidly approaching the vicinity of the intersection of Bathurst and College Streets, although perhaps the latter is not so evident to the person who is unacquainted with the city and the spreading out of its boundaries to take in the fast-growing suburbs. Before the city improved this roadway the Bathurst Street hill was a thing to be avoided on account of its steepness, although a ramp from Davenport Road on the east made matters easier for horse-drawn vehicles. The old road—that is, Bathurst Street proper—was of corduroy and the only drainage provided was in gutters on the side. As the material was of hard clay this did not matter much, and it took quite a severe rainfall to cause any damage. The ramp, which was of macadam, led from the top of the hill at Bathurst Street and had a maximum grade of 14.2 per cent. in dropping down to the elevation of Davenport Road, which is the road running along the foot of the hill. Such conditions, however, could not last long if the future development of the district was to be taken into account. It was necessary to go to Yonge Street, which was 1¼ miles east, in order to find a good road for taking up heavy loads, so that the improvement of Bathurst Street hill was obviously the duty of the city to the district.

Work was commenced in March of 1914, the grading giving relief work to the local unemployed. Approximately 17,200 yards were handled, the spoil being used for fill at the foot of the hill. The maximum cut on the hill, exclusive of the old works, was 11.5 feet, and the maximum fill on the Davenport intersection was 7 feet.

Reinforced concrete walls were designed for the east side and plain gravity walls for the west. A more satisfactory treatment of the west side would have been by terracing, plans for which were prepared by the city but failed to receive the sanction of the property owners interested.

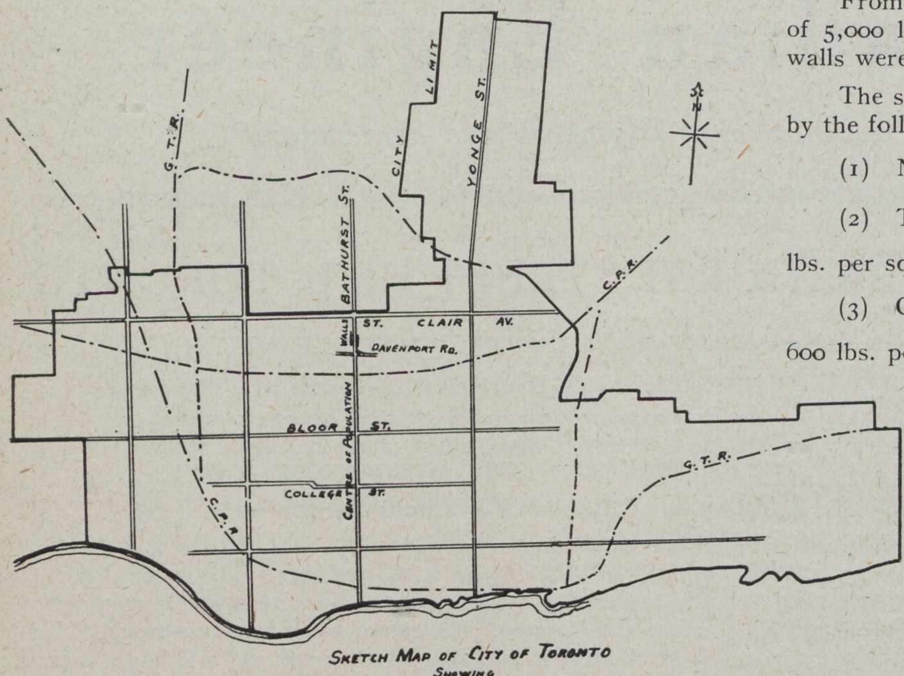


Fig. 1.—Map of City of Toronto.

From tests on the site an allowable bearing pressure of 5,000 lbs. per square foot was decided upon and the walls were designed to fulfil this requirement.

The stresses in the steel and concrete were calculated by the following formulæ:—

(1) Neutral axis $= [\sqrt{(r^2m^2 + 2rm)} - rm]\ d.$

(2) Tension in steel $= \dfrac{B}{r\,b\,d^2\,(1 - \frac{1}{3}k)} = 16{,}000$ lbs. per sq. in.

(3) Compression in concrete $= \dfrac{2B}{k\,b\,d^2\,(1 - \frac{1}{3}k)} = 600$ lbs. per sq. in.

Where

b = breadth of the beam in inches.
d = effective depth of the beam in inches.
n = distance of the neutral axis from the compressed edge of the beam in inches.
$k = \dfrac{n}{d}$.
$A_c = bd$ square inches.
A_t = area of tensile reinforcement in square inches.
$r = \dfrac{A_t}{bd}$.
E_s = elastic modulus for steel in tension.
E_c = elastic modulus for concrete in compression.
$m = \dfrac{E_s}{E_c} = 15$.
B = bending moment in inch-pounds.

The notation being that approved by the Concrete Institute (England).

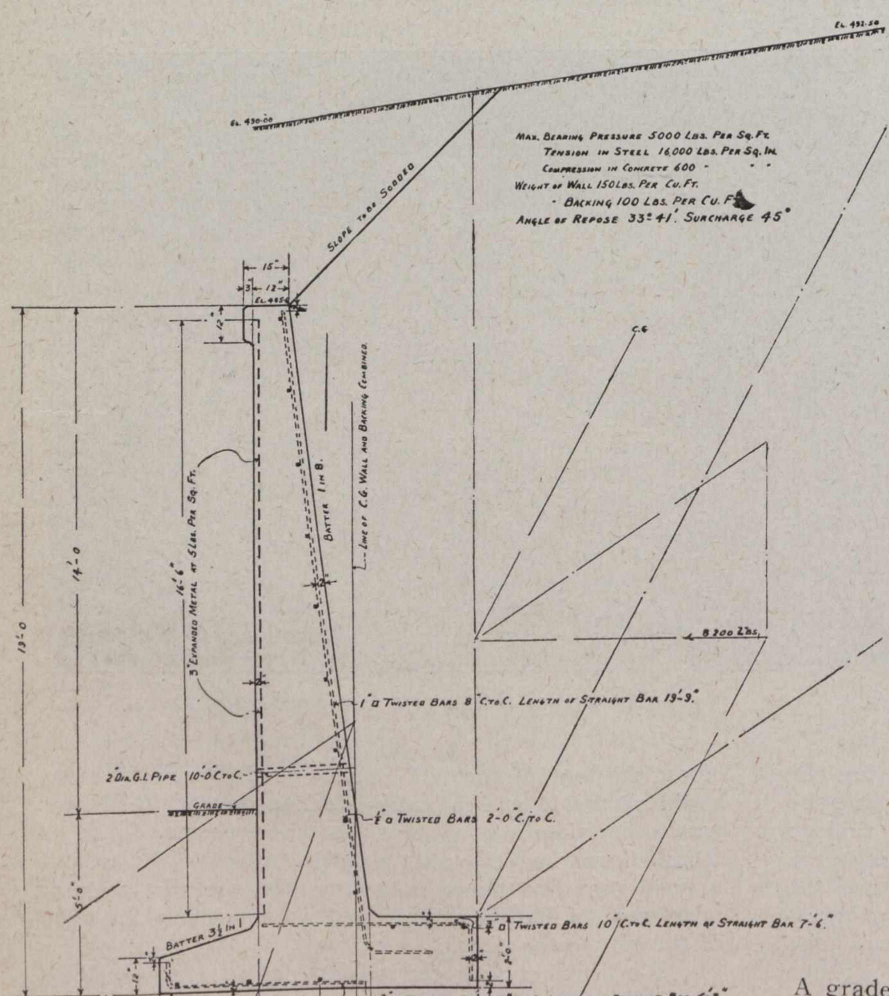


Fig. 2.—Detail of Reinforced Concrete Section of Wall.

A detail of the wall at its highest part is shown in Fig. 2. The longitudinal reinforcing is ½-inch square twisted bars spaced 2 ft. 0 in. centre to centre. The face of the wall has 3-inch expanded metal @ 5 lbs. per square foot, which gives practically the same area as ½-inch bars would have done, and is, in the writer's opinion, a far more satisfactory distribution of the steel for that part of the wall.

The trunk is reinforced with 1-inch square twisted bars at 8 ins. centre to centre, the heel has ¾-inch square twisted bars at 10 ins. centre to centre, and the toe has ¾-inch square twisted bars at 12 ins. centre to centre. The concrete used was a 1:2:4 mix, fairly wet, the aggregate being ¾-inch limestone with a specific gravity of 3.07.

The mixers were placed so as to allow the concrete to gravitate to the forms.

The construction offered no special features excepting in the vicinity of station 3 + 50 (Fig. 3), where a water-bearing stratum was struck, necessitating the use of a certain amount of timber sheet piling and special drainage, a general idea of which is given in Figs. 3 and 4. A grade was formed on the heel of the walls with well-puddled clay and three 3-inch diameter tile drains were laid on boards resting on the clay. At intervals a puddled clay cut-off wall was inserted in the line of tiles to prevent scouring action.

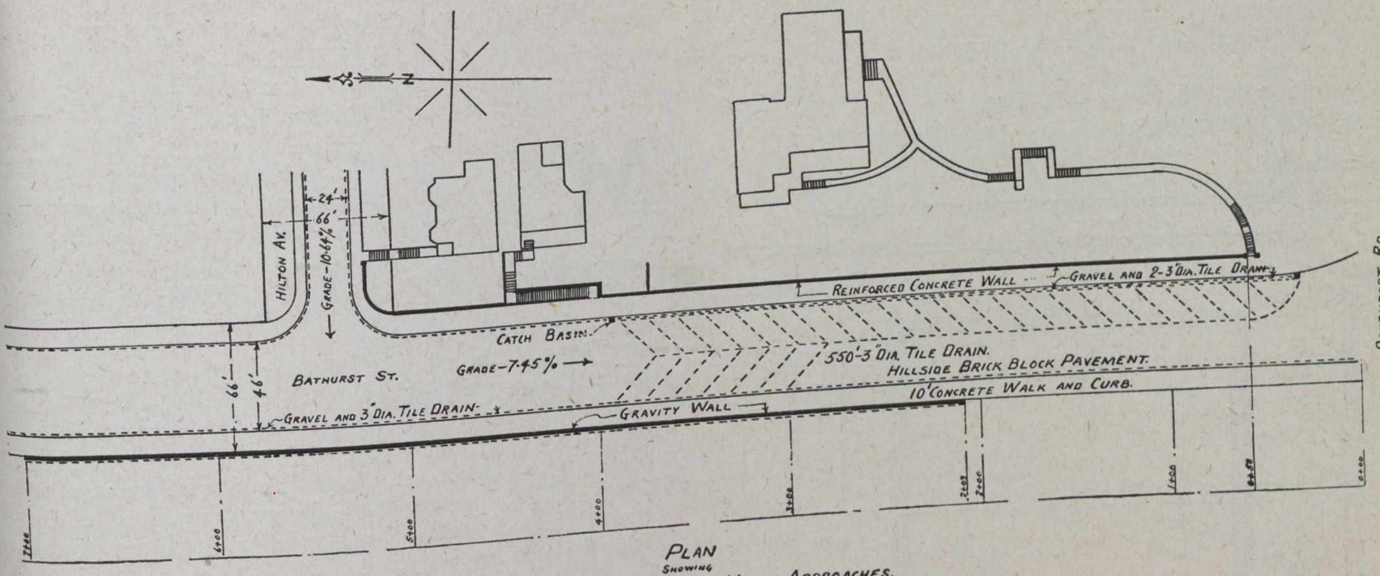


Fig. 3.—Sketch Plan Showing Location of Walls on Bathurst Street.

In such a wall the question of expansion and contraction is a very important one. In order to take care of this, expansion joints (shown in detail in Fig. 5) were placed at intervals of 40 feet in both the reinforced concrete wall and the gravity wall. The back of the gravity wall was given a considerable batter at the top and in order to prevent the action of frost on it, the wall was given a coat of hot asphalt.

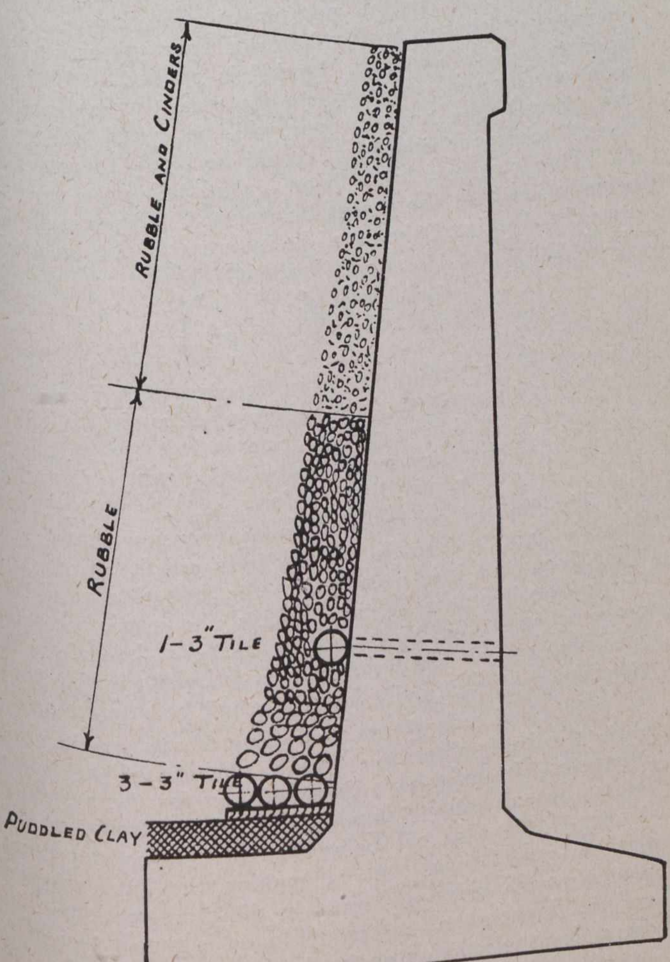


Fig. 4.—Section Showing Drainage System.

As the wall is on a street which not only carries big traffic but is in a fine residential section it was necessary to make its appearance pleasing to the eye. To do this, a scheme of panelling was carried out, the panels being moulded in the face of the wall. A general idea of their construction can be gathered from Fig. 6. These, in conjunction with the coping and the changes in elevation of the top of the wall, help to relieve the usual inartistic appearance of concrete construction.

The pavement on this section is hillside brick block on 6 inches of concrete, and was opened to through traffic by Mayor Church on September 25th, 1915.

It is worthy of note that the wall has withstood several severe rainfalls during its construction. The worst of these occurred last spring when the banks were still unsodded. In this case a surcharge of several feet over

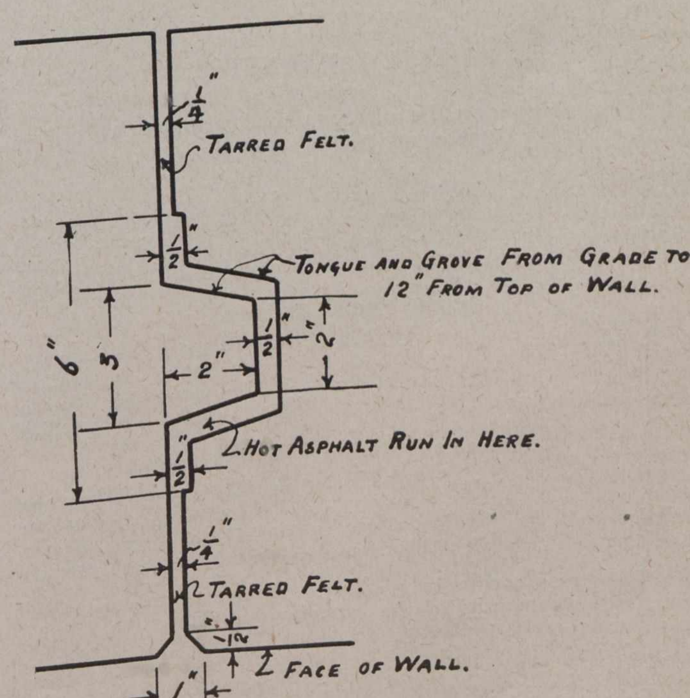


Fig. 5.—Detail of Expansion Joint in Wall.

the top of the wall was held up. This surcharge of sand had been washed down against some of the form work from the slopes above and, of course, was heavily laden with water.

A few details, such as railings along the top, some sodding on the slopes, etc., remain to be completed.

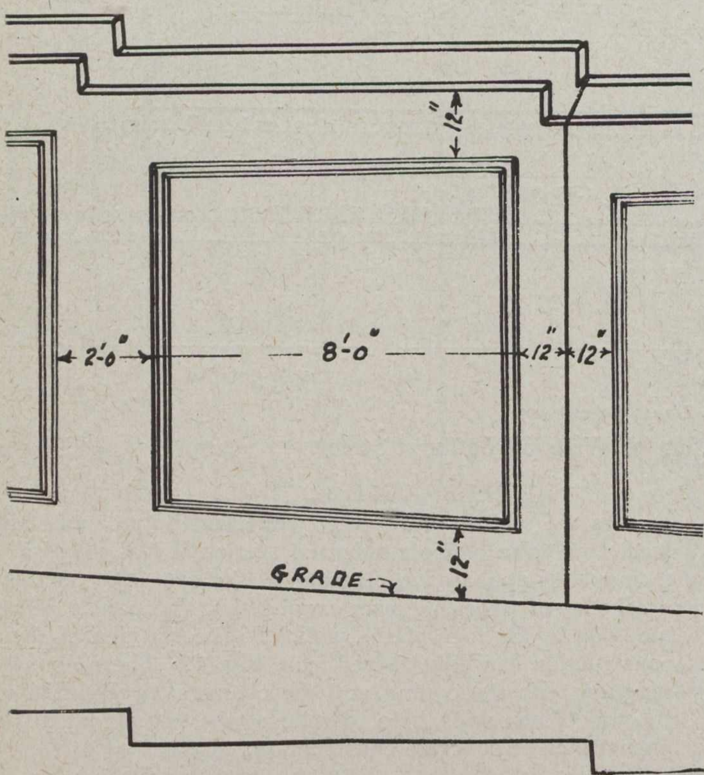


Fig. 6.—Detail of Panelling of Wall, also Showing Location of Expansion Joint.

The cost of the work will be approximately $260,000, and in view of the important bearing the street will have on the future of the city of Toronto the taxpayers' money could hardly have been better invested.

RAILWAY EARNINGS.

The following are the weekly railroad earnings for April:—

Canadian Pacific Railway.

	1916.	1915.	
April 7	$2,482,000	$1,766,000	+ $716,000
April 14	2,577,000	1,701,000	+ 876,000
April 21	2,343,000	1,623,000	+ 720,000
Aprii 30	3,166,000	2,074,000	+ 1,092,000

Grand Trunk Railway.

April 7	$1,155,486	$1,008,320	+ $147,166
April 14	1,024,505	864,658	+ 159,847
April 21	1,059,661	869,772	+ 189,889
April 30	1,445,853	1,263,028	+ 182,825

Canadian Northern Railway.

April 7	$ 677,000	$ 457,000	+ $220,000
April 14	668,900	463,700	+ 205,200
April 21	634,000	442,300	+ 192,000
April 30	844,100	585,900	+ 258,200

The gross earnings for three transcontinental roads for the first four months of the calendar year show the following gains:—

Month:		
January	$14,724,216	+ $3,966,033
February	14,667,915	+ 3,237,879
March	17,344,243	+ 3,731,539
April	18,077,805	+ 4,959,127

DESIGN OF MASONRY AND CONCRETE ARCHES.*

By R. J. Williams, BS.C. (Eng.).

MOST masonry and concrete arches which have been erected in this country appear to fulfil the primary condition of strength and stability which every structure must satisfy. It is a rare occurrence for an arch to collapse, and this, perhaps, accounts for the fact that the theory of the arch is not better understood.

It is, however, doubtful if many existing arches have been designed with due regard to economy, and the cost may probably be much decreased, as explained in Table I., by a proper method of design. In view of the great number of bridges which will have to be rebuilt in different countries on the termination of the war, when money will be scarce, the design of arches ought to receive more attention from practical engineers than has hitherto been the case.

It is not proposed in this article to deal with the subject from the mathematical point of view, though most of the results have been obtained by mathematical calculations. Mathematicians too often leave problems at the stage when they begin to be of interest to the engineer, with the result that their investigations have not been of such service as they might otherwise have been. It has been considered preferable to give sufficient particulars to draw the necessary diagrams, so that the reader may verify the accuracy of the results obtained, and thus form an opinion as to the merits of the designs.

For reasons which will be stated later, the arches have been designed without backing or filling, and the effect of the horizontal pressure of the gravel on the extrados of the arch ring has not been taken into consideration. As the term "arch" is applied to both the arch proper and the complete structure (which includes the gravel), the arch proper will be called the "arch ring," wherever confusion would be likely to arise.

The stresses have been calculated on the usual assumption that the stress curve on a cross-section is a straight line, and the maximum stress is obtained from the formula:—

$$f = \frac{Q}{t}\left(1 + \frac{6s}{t}\right)$$

where f = maximum stress in lb. per square foot.
Q = normal thrust on a close section in lb.
t = thickness of arch ring in feet.
s = distance between the line of pressure and the centre line, in feet.

The line of pressure, to avoid tension in the arch ring, is supposed to lie entirely between the two middle third lines, but it is certain that the arch ring would not fail in tension at a section unless the maximum compressive stress on that section exceeds the safe compressive stress. The results of experiments on blocks of concrete asymmetrically loaded would be interesting.

The chief difficulty in the design of the arch is, probably, the determination of the position of the line of pressure. It must be a link polygon for the system of loads, but an infinite number of such polygons may be drawn by varying the polar distance, which represents the horizontal thrust, or by making the link polygons pass through different points in the cross-section at the crown. Hence the system of loads is not sufficient to determine the position of the line of pressure. If the arch

*"Surveyor," London, England.

ring is hinged at the crown and springings, the problem is considerably simplified, but, for varying loads, the introduction of hinges would have the effect of weakening the arch.

It is necessary, therefore, to make certain assumptions and to experiment on models of arches designed according to those assumptions, in order to see how far they are justifiable. It appears that, whatever assumptions are adopted, the arch, called the "Ideal arch," is much stronger than a circular or semi-elliptic arch of the same dimensions.

First Assumption.—The true line of pressure is that link polygon for the system of loads which deviates the least from the centre line of the arch ring. Arguments in favor of this assumption are wanting, and consequently the lines of pressure are not shown in the diagrams, but the stresses, if calculated, would be found to be only slightly in excess of those obtained according to the third assumption.

Second Assumption.—It is assumed that no arch ring is stable for symmetrical loading unless the link polygon, which touches the extrados middle third at the

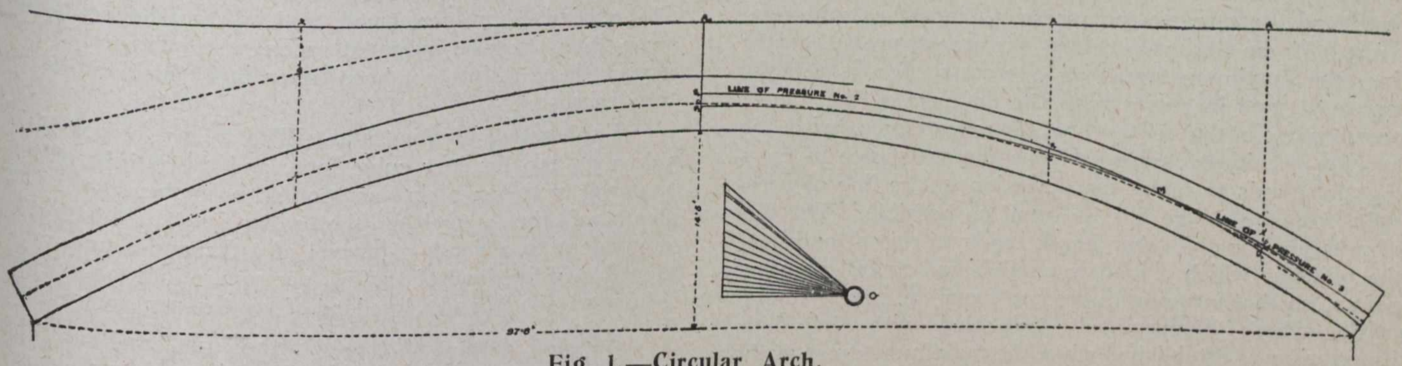


Fig. 1.—Circular Arch.

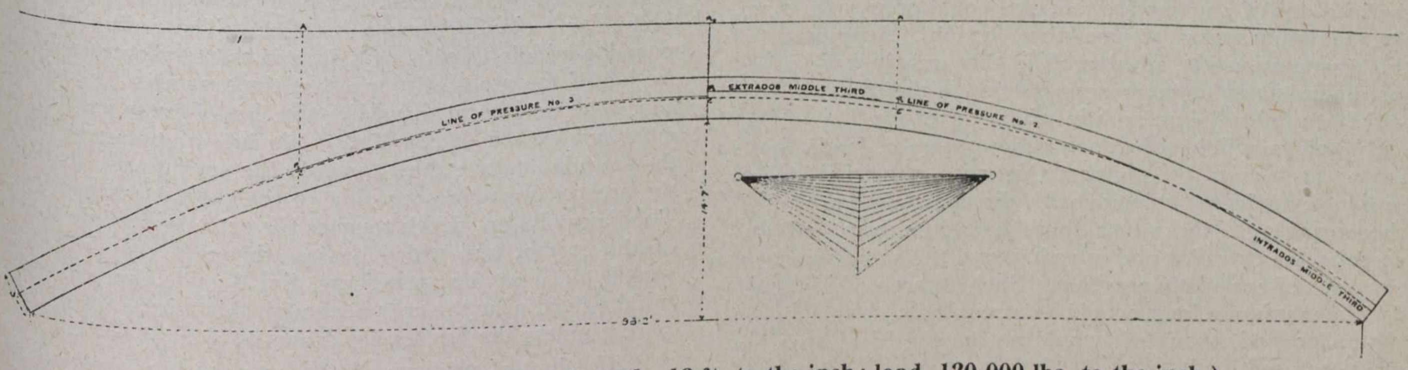


Fig. 2.—Ideal Arch. (Scales: Length, 12 ft. to the inch; load, 120,000 lbs. to the inch.)

Table I.—Illustrating the Advantages of the Ideal Arch Over the Circular Arch.

	Ideal Arch.	Circular Arch.
Span of centre line	100 ft.	100 ft.
Rise of centre line	15 ft.	15 ft.
Depth of gravel at crown	4 ft.	4 ft.
Span of intrados	98.2 ft.	97.8 ft.
Rise of intrados	14.7 ft.	14.6 ft.
Thickness of arch ring	3 ft.	4 ft.
Maximum compressive stress		
(a) Second assumption	76,300 lb.	The critical line of pressure cannot be drawn.
(b) Third assumption	40,500 lb.	40,500 lb.
Width of arch	20 ft.	20 ft.
Total quantity of gravel	17,720 cub. ft.	18,250 cub. ft.
Total quantity of material in arch ring	6,390 cub. ft.	8,450 cub. ft.
Total weight of arch	2,971,000 lb. or 1,322 tons.	3,360,000 lb. or 1,500 tons.
Appearance	Pleasing, owing to gradually varying curvature.	Uniform curvature contrary to laws of beauty.

Some writers define the "Ideal arch" as the arch in which the centre line of the arch ring is the actual line of pressure for the given load. This evidently assumes that the centre line, if it is a link polygon for the system of loads, is the true line of pressure. Generalizing this, the first assumption may be stated as follows:—

crown, lies entirely between the two middle third lines between the crown and springings. In order that this condition should be satisfied, the horizontal thrust must not exceed the product of the radius of curvature of the extrados middle third at the crown and the total load on a section of the arch, 1 ft. wide, of which the cross-section at the crown is the central line. If H denotes the horizontal thrust, ρ the radius of curvature, g_o and t the depths of the gravel and arch ring at the crown, and w_l, w_g, w_a the respective weights of the live load, gravel, and material of the arch ring, then H must not exceed $\rho\ (w_l + g_o,\ w_g + t w_a)$. If such a line can be drawn it is evident that, by reducing the horizontal thrust, the line can be made either to touch the intrados middle third at or towards the springings, or to pass through the same middle third at the springings, and the line would then be the critical line or pressure.

Though the first signs of collapse in arches have appeared at points suggested by the critical line of pressure, it does not necessarily follow that the true line of pressure tended to approach that line of pressure previous to internal collapse. The apparent cause of failure is often different from the real cause, and the line of pressure may have taken up the position indicated by the critical line of pressure as a consequence of internal failure. Failure of the backing or insufficient depth of gravel at the crown would tend to concentrate the load at the crown to a greater extent than at other sections during the passage of a live load.

This assumption is usually considered as the criterion of stability, but some arches, which have been standing for years without showing any signs of collapsing, do not satisfy the test.

Third Assumption.—The author is inclined to think that the true line of pressure follows the line of least resistance, which is the link polygon which gives the least stresses in the arch ring.

The assumption underlying this assumption is, that for comparatively low stresses, the resistance of concrete and masonry to compression increases with the stress. If the line of pressure deviates from the centre line, the maximum stress on a cross-section is thereby increased, and increases with the distance of the line of pressure from the centre line, in accordance with the formula previously given. Hence the resistance to compression tends to make the deviation of the line of pressure from the centre line as small as possible. The line of pressure, on the other hand, tends to rise at and near the point at which a load is applied and to fall at other points, so that it tends to deviate from the centre line at points where it previously coincided with that line. Equilibrium is established when the maximum stress at the extrados of one section is equal to the maximum stress at the intrados of another section, and equal or greater than the maximum stress at any other section. According to this assumption the Ideal arch is the arch in which the maximum stress at every cross-section is the same. This will be found to be an arch in which the centre line of the arch ring is a link polygon for the system of loads, but, for an arch ring of uniform thickness, the true line of pressure would not coincide with the centre line except at the springings, the stress there being uniform and the same at the extrados and intrados, and the same as at the extrados of every other section. Such an arch, if designed for the maximum load, would be strong enough to support a smaller load, though it would not be the Ideal arch for the decreased load.

The centre line of a circular arch is not a link polygon for the system of loads on an arch; hence the maximum stress at every cross-section will not be the same for any position of the line of pressure. The true line of pressure, however, takes up such a position that the maximum stress at the extrados of one cross-section is equal to the maximum stress at the springings, and greater than the maximum stress at any other cross-section.

The advantages of the Ideal arch over the circular arch are illustrated in Table I. and in the drawings, where it is shown that an Ideal arch 3 ft. thick is as strong as a circular arch 4 ft. thick.

The Backing or Filling.—It is usual in masonry arches to introduce a certain amount of backing or filling above the arch ring. If this is intended to give additional strength to the arch, it is unnecessary to design the arch ring to carry the additional load, which is the excess of the weight of the backing over the same number of cubic feet of gravel. If the intention is to increase the dead load in order to reduce, as far as possible, the variations in the stresses during the passage of a live load, the dead load should be increased at the crown, where the variations are likely to be greatest. If any backing is introduced, it should extend over the crown so as to form an arch, which would thus tend to distribute the load on the arch ring. A backing which does not extend over the crown acts like a cantilever, and, in case of failure in tension at any point, would tend to exert an excessive pressure at or near the crown.

Though, in the designs submitted, no backing has been introduced, the design of the Ideal arch may be easily adapted to arches with a certain amount of backing.

Horizontal Pressure on the Arch Ring.—According to theories on earth pressure, the vertical pressure at any point gives rise to a horizontal pressure, bearing a certain ratio to the vertical pressure. An inclined surface, such as the extrados of the arch ring, is thus subjected to a horizontal pressure. The resultant horizontal pressure, except in the case of very flat arches, acts below the centre of the cross-section at the crown, and would thus tend to lower the position of the line of pressure at that section. The effect is, however, small, and as the tendency is to strengthen the arch by counteracting the influence of the vertical load, it has not been taken into consideration in the designs.

Explanation of Diagrams.—The weight of gravel is taken as 110 lbs. per cubic foot, and the weight of the material of the arch ring as 160 lbs. per cubic foot. The depth of the gravel at the crown is 4 ft., but this is equivalent to a depth of gravel of 2 ft., and a uniformly distributed live load of 220 lbs. per square foot, or a depth of gravel of 3 ft. and a live load of 110 lbs. per square foot.

Circular Arch (Fig. 1).—On the right-hand side, the lines of pressure Nos. 2 and 3 have been drawn, in accordance with the second and third assumptions respectively, for a circular arch 4 ft. thick. The radius of the extrados middle third is 91.5 ft. and the total weight of a section of the arch, 1 ft. wide, at the crown is 1,080 lb.; hence the horizontal thrust for the line of pressure No. 2 must not exceed 98,820 lbs. This line of pressure cuts the intrados middle third towards the springings, so that the arch is unstable according to the second assumption. The link polygon, which touches the extrados middle third at the crown, and which passes through the intrados middle third at the springings, lies outside the extrados middle third near the crown, though this might not be apparent unless the figures are drawn to a large scale.

The line of pressure No. 3 cuts the cross-section at the crown just below the centre line. Between the crown and springings it cuts the centre line at two points, and lies for a part of the distance above the centre line. The maximum stress on the cross-section at the point M is about 40,500 lbs. per square foot, and is equal to the maximum stress at the springings and greater than the maximum stress on any other cross-section. Hence this line has been drawn in accordance with the third assumption.

The vector polygon has not been drawn for the line of pressure No. 3, but the pole is indicated by a small circle, the polar distance being greater than for line No. 2. On the left-hand side the dotted curve GA_0 indicates the surface of the gravel in a circular arch 4 ft. thick, which would make the centre line of the arch ring a link polygon for the system of loads. The load in this case is evidently much less than the actual load on an arch, and it is difficult to imagine that an arch is ever loaded in such a manner as to make a circular arch the ideal arch for the system of loads.

For a semi-circular or semi-elliptic arch, the centre line is a link polygon for a load which would be infinite at the springings, the load curve being as indicated in Fig. 3. This figure is drawn for a semi-circular arch, but the figure for a semi-elliptic arch would be similar. The load is represented by the vertical distance between the load curve and the centre line.

Ideal Arch (Fig. 2).—The same lines of pressure are drawn as for the circular arch, the line No. 2 being drawn on the right-hand side and the line No. 3 on the left-hand side. Portions of the middle third lines are shown in dotted lines in this as well as in the circular arch. The line of pressure No. 2 lies entirely between the two middle third lines; hence the arch will not fail in tension. The line of pressure No. 3 lies a little above the centre line at the crown and between the crown and springings, and coincides with the same at the springings. The maximum stress at each section is found to be about 40,500 lbs. per square foot, and the line therefore satisfies the third assumption.

The diagrams may be drawn from Table II., the extrados and intrados being the curves which touch the circles drawn with their centres on the centre line and of diameter equal to the thickness of the arch ring. The centre line of the circular arch may be drawn with a beam compass, the radius being 90.83 ft., or from the ordinates given in the table:—

Notation.

x = distances on each side from the vertical line at the crown.
AC = ordinates of centre line.
AP_2 = ordinates of line of pressure No. 2.
AP_3 = ordinates of line of pressure No. 3.
AG = ordinates of line GA_0.
H_c = horizontal thrust for link polygon coinciding with centre line.
H_2 = horizontal thrust for line of pressure No. 2.
H_3 = horizontal thrust for line of pressure No. 3.
t = thickness of arch ring.

Table II.

Circular Arch.

H_c = 98,090 lbs. [for gravel up to GA_0]
H_2 = 98,820 lbs.
H_3 = 112,200 lbs.
t = 4 ft.

Ideal Arch.

H_c = 97,500 lbs.
H_2 = 90,200 lbs.
H_3 = 96,720 lbs.
t = 3 ft.

All distances measured in feet.

AG	AP_2	AP_3	AC	x	AC	AP_3	AP_2
0	6.20	5.33	6	0	5.50	5.38	5
0.03	....	....	6.03	2	5.52	5.40	..
0.15	....	....	6.20	6	5.67	5.55	..
0.40	....	....	6.55	10	5.98	5.86	..
0.78	....	....	7.09	14	6.44	6.33	..
1.27	....	....	7.81	18	7.08	6.97	..
1.89	....	....	8.71	22	7.90	7.80	..
2.63	....	....	9.79	26	8.91	8.81	..
3.48	....	....	11.09	30	10.14	10.05	.
4.41	....	....	12.61	34	11.61	11.54	..
5.44	....	....	14.34	38	13.34	13.28	..
6.51	....	....	16.29	42	15.37	15.33	..
7.65	....	....	18.49	46	17.75	17.73	..
8.72	....	....	21.00	50	20.50	20.50	..
....	....	....	.....	54	23.69	.....	..

Though the remarks made in this article are intended to apply to masonry and concrete arches, most of the remarks are applicable to reinforced concrete arches as well, and it would evidently be an advantage to design such arches so that the centre line of the arch ring is a link polygon for the system of loads.

It is reported from Pittsburgh, Pa., that a process for extracting ferro alloys of manganese and silica from slag, which it is claimed will result in an immense saving to steel manufacturers, has been discovered by two students.

SASKATCHEWAN WATER COMMISSION.

We print below some extracts from the report of the Saskatchewan Water Commission which was read before the Legislature at the recent session, which report deals with the question of the feasibility of diverting water from the Saskatchewan River for domestic and industrial purposes throughout central and southern Saskatchewan. The report was presented by the Saskatchewan Water Commission, of which the Hon. Senator J. H. Ross and Mr. A. J. McPherson were members. With the assistance of several well-known engineers, the whole area to be supplied was thoroughly examined and definite knowledge has been secured as to the practicability or otherwise of the scheme. The whole question is one of extreme importance in that it vitally affects the future of two of the large cities in the province, as well as the rural population of a large and thickly settled region.

The area proposed to be served is bounded by lines running on the north along the Qu'Appelle River from Elbow to Lumsden, through Balgonie, Francis and Weyburn on the east, and from Truax, skirting the Dirt Hills to Mortlach and the hills south of Thunder Creek, to Log Valley on the Saskatchewan.

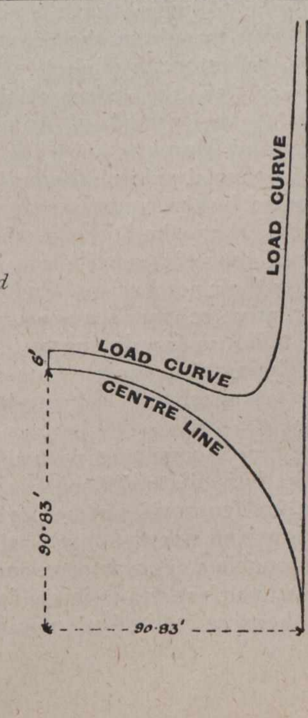
The water would have to be raised some 330 feet above the level of the Saskatchewan River and conveyed long distances with numerous pumping stations to where it would be used. The enormous expense of this can only be met if great quantities of water are used, and it is therefore necessary that the cities of Moose Jaw and Regina be included in the scheme unless its cost is to be prohibitive.

Over a large part of the area described above, water is scarce, no matter how deep wells are sunk, and there are stretches of country in which no water has been found, owing to the thickness of the clay deposit which is characteristic of most of the district. This means that many farmers have to haul water, often for great distances, during a part of each season.

Dealing with the present water supply for Moose Jaw, Mr. W. J. Francis, a consulting engineer of Montreal, states that after deducting the requirements of the railways, the city of Moose Jaw can only depend on about 400,000 gallons of water per day, or 20 gallons per capita

FIGURE 3

Design of Masonry and Concrete Arches.



per day, which is a quite inadequate supply. If the future development of the city is not to be endangered a further supply must be found, but in Mr. Francis' opinion the local sources of supply are even now being fully utilized. The city of Regina is slightly better off, as the local sources of water supply have not yet been fully developed, and it is considered that enough for a city of 100,000 population could be secured.

One of the gravest features of the whole situation is the question of supplying the requirements of the railways. At the present time here and there along the railway lines tanks are supplied from dams built across ravines and small creeks to hold the water collected in these basins. This source of supply, however, can at best only be termed precarious. It is, of course, at the divisional points that the railway requirements are largest. It has been estimated that the trains passing through Regina alone require from 600,000 to 700,000 gallons per day. In addition, both at Moose Jaw and Regina there are machine and repair shops and round houses taking about 1,000,000 gallons per day at the two points. At Moose Jaw a dam across the Moose Jaw Creek gives a supply of water which would be only barely sufficient in a dry season, while at Regina a gravity pipe line from Pilot Butte supplies about 500,000 gallons per day, but this is about all the water which can be supplied from this source. It will thus be readily seen that if a dry season should come, and if at the same time there should be any extra pressure of business, the railways would be faced with very serious difficulty in obtaining adequate water supplies.

A suggested method of diverting the water is as follows: Install a pumping plant at the river, and pump to the top of the hill east of the river, a distance of about 5,500 feet. From this point the water could be conveyed in an open channel by gravity to the head of Thunder Creek, and thence down the Thunder Creek Valley by an open channel and in the creek to Pelican Lake. Construct a reservoir of a suitable size at the upper end of Pelican Lake, and from this pump the water, after filtering it through some 50,000 feet of pipe line, to join with the line leading from the head works reservoir of the Sandy Creek Moose Jaw water supply, to Moose Jaw. Construct an open channel from the Pelican Lake reservoir to join with Thunder Creek to Moose Jaw. About one mile near the outlet of this latter line from the Pelican Lake will have to be a closed gravity channel.

In order to insure that the city of Saskatoon will not suffer in any way from the diversion of this water, it is proposed to store sufficient water in the reservoir for winter use, as the effect of the withdrawal would be greatest at the period of minimum flow in January, February and March.

The financial side of the problem has also been carefully studied by the commissioners. In their opinion it is imperative that the scheme should be financed on the security of those interested in such a way that other interests, as their need arises, could be added to the system. An alternative scheme for the improvement of the water supply at Moose Jaw is suggested which would meet for the time being the requirements of the situation until the time arrives when this scheme in its entirety becomes a necessity.

The report concludes with the following paragraphs:

"The immediate difficulty is to devise such a system that the first cost will not be beyond the means of the interests involved nor the cost of the water prohibitive. It is questionable under present conditions if the sum of $850,000, which is the estimate for the initial construction by the cheapest method yet devised and reported on that will give the comparatively small quantity required at present is not beyond the abilities of those immediately interested to finance.

"The desirability of both the above modifications should be canvassed before exact plans for construction are prepared or construction undertaken, or before a decision is made that it is beyond the possibility of construction under the present conditions."

TRADE INQUIRIES.

The following inquiries relating to Canadian trade have been received by the Department of Trade and Commerce, Ottawa. The names of the firms making these inquiries, with their addresses, can be obtained only by those especially interested in the respective commodities upon application to: The Inquiries Branch, the Department of Trade and Commerce, Ottawa, or the Secretary of the Canadian Manufacturers' Association, Toronto, or the Secretary of the Board of Trade at London, Toronto, Hamilton, Kingston, Brandon, Halifax, Montreal, St. John, Sherbrooke, Vancouver, Victoria, Winnipeg, Edmonton, Calgary, Saskatoon, Chambre de Commerce de Montreal and Moncton, N.B. Please quote the reference number when requesting addresses.—

349. Pitprops.—A North of England firm of importers would like quotations per 72 lineal feet, c.i.f. Hull, on pitprops of the following dimensions: 3-inch top diameter, 3 to 9 feet long 3½-inch top diameter, 3½ to 9 feet long; 4-inch top diameter, 4 to 9 feet long; 4½-inch top diameter, 4½ to 9 feet long; 5-inch top diameter, 5 to 9 feet long; 5½-inch top diameter, 5½ to 9 feet long; 6-inch top diameter, 6 to 9 feet long; 6½-inch top diameter, 6½ to 9 feet long; 7-inch top diameter, 7 to 9 feet long.

362.—Steam-Electric Power Plant Apparatus and Engineering Specialties.—A gentleman who intends visiting New Zealand during the coming summer is desirous of securing the agencies of Canadian engineering manufacturers of steam-electric plant apparatus and engineering specialties, and is desirous of receiving full technical description of apparatus, together with illustrations, weight of apparatus, shipping weight, and weight of heaviest piece, and over-all dimensions. Present prices either f.o.b. Canadian or American port or c.i.f. New Zealand port.

370. Tungsten Ores.—A Liverpool firm of mineral and metal importers would be glad to receive offers from Canadian producers of tungsten ores, of which they seek supplies.

371. Asbestos Millboard.—A London firm desires the addresses of Canadian manufacturers of asbestos millboard.

387. Trade with India.—A large importing firm in India desires catalogues and wholesale price lists from Canadian manufacturers of hardware, implements, tools, plantation supplies, etc., as outlined on page 863 in Weekly Bulletin No. 638.

389. Agencies.—A Cape Town firm of commission agents, having a number of travellers on the road are prepared to take up Canadian agencies. Correspondence requested.

392. Calcium Carbide.—A London firm asks to be placed in touch with Canadian manufacturers of carbide of calcium with a view to shipment to Australia.

395. Foundry Requisites or Foundry Plant of any Kind.—A Glasgow firm would be glad to hear from Canadian firms making a specialty of above.

396. Haematite Iron Suitable for Malleable Castings.—A Glasgow firm is anxious to obtain supplies of above from Canada.

397. Heavy Steel Riveted Crane-Casting Ladles.—A Glasgow firm wishes to receive quotations, c.i.f. Glasgow, for eleven crane-casting ladles, steel riveted, each 50 tons and complete with double set of stopper gear; also a considerable quantity of steel mandril bars for drawbenches, the bars to be cut from 1½ to 2⅜ inches diameter by 30 feet long and to be machine straightened. The material for these bars must be of a hard and ductile quality as per following analysis:—

Approximate analysis:—

Phosphorus	0.028
Sulphur	0.030
Silicon	0.203
Manganese	0.8
Combined carbon	0.6

THE NICK AND BREAK TEST IN THE INSPECTION OF STEEL RAILS.*

STEEL metallurgists will recall that prior to the general dependence upon the services of the analytical chemist, that is, in the days when but few steel works had their own laboratories, the grading of crucible steel in the ingot, and before it was drawn down into bars, was based upon the appearance of the fracture of each separate ingot. After the ingots became cold, a piece was broken off one corner and an expert workman judged of the hardness of the metal by the exposed fracture, and marked the ingot accordingly. Thus one would be used for tool, another for drill, another for spring steel, and so on.

In later years, when the dissatisfaction with the results given by steel rails led to much discussion as to what changes should be made in the specifications governing their manufacture, the Rail Committee of the American Railway Association called in consultation the late William Metcalf, Past-President of the American Institute of Mining Engineers, 1881; Past-President of the American Society of Civil Engineers, 1898-99, and for years a steel maker. Previous to that time drop tests of pieces of rail representing each heat of steel had been included in some of the specifications, but the object of such tests had been limited to determining the ductility of the steel. There had not been any prescribed breaking tests with a view of disclosing the internal structure of the rail.

Mr. Metcalf, based no doubt upon his experience as a maker of crucible steel, urged that the then current testing did not go far enough, and that several pieces of rail from each heat should be broken, and by the disclosed fractures the rails from that heat accepted or rejected. The committee, when reporting, did not adopt his suggestions, but, based largely upon his insistence that the drop testing as then conducted did not go far enough, many railroad engineers gradually enlarged the scope of their drop-testing requirements until it became the general practice to break, say, three pieces from each heat of open-hearth steel and to accept or reject certain rails according to whether or not interior defects were revealed. It was argued that the practice should be extended to include the breaking of a piece of rail from the top end of each ingot rolled, and in fact some experimental rollings were made under such provisions, but opposition to the plan of making this fracture test on a piece of rail from each ingot developed among rail makers, with the result that what seems to us to be a perfectly logical method of testing rails to insure against acceptance of defective material, failed to have a fair working trial; and thus it remained, about a year ago, for the Algoma Steel Corporation, whose mill is at Sault Ste. Marie, Ont., to open the door commercially, so to speak, to the possibilities of a specification for rails, marking, we believe, a distinct step forward in the direction of safer and better wearing rails.

A contract for 10,000 tons of rails made by the Canadian Pacific Railway with the Algoma company was the first to require what has been commonly termed "the nick and break test on each ingot," and this was quickly followed by others for rails to be shipped to United States under similar conditions of testing. In justice to the Algoma company it may be said that they have become so appreciative of the logic, as well as the economy, of the nick and break test that they have seen fit to have it incorporated freely and without extra compensation in many of their specifications.

By the nick and break test mentioned above is meant, firstly, the nicking; and secondly, the breaking, by some mechanical means, of a short length of rail selected as required by the specification. This, it will be noted, must be, for the first, or the original test, the top end of the top rail of each ingot rolled, and naturally for this sample, the crop end, which must be cut by the hot saws, from the top of the "A" rail was used. These crop ends were ordinarily from 18 ins. to 24 ins. long, and after being stamped with the heat and ingot number, to permit of identification, were allowed to cool for a little over thirty minutes, and were then quenched in water, pains being taken to insure quenching from a temperature color of near black or natural cold steel, so as to render no appreciable change in steel structure possible. Then the pieces were nicked as desired; and, for the purpose of breaking, inserted in a specially designed anvil of a bulldozer (Fig. 1) so arranged that the ram readily broke the rail where it had been nicked, giving, without trouble in most cases, the square character of fracture desired for examination. Thus the fractures were ready for judging

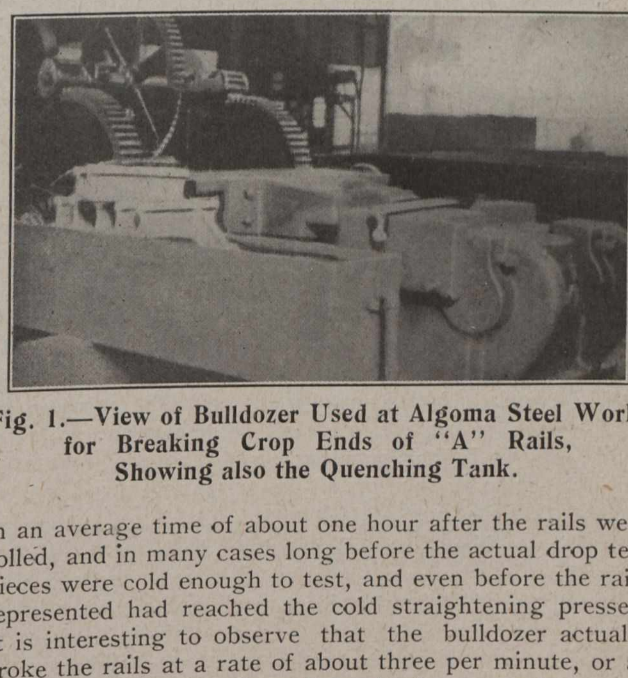


Fig. 1.—View of Bulldozer Used at Algoma Steel Works for Breaking Crop Ends of "A" Rails, Showing also the Quenching Tank.

in an average time of about one hour after the rails were rolled, and in many cases long before the actual drop test pieces were cold enough to test, and even before the rails represented had reached the cold straightening presses. It is interesting to observe that the bulldozer actually broke the rails at a rate of about three per minute, or at a rate, say, of 2,000 pieces in twelve hours; and, as each piece represented an ingot, the rate of breaking possible shows it to be well in excess of any probable tonnage that could be rolled with any present mill equipment. In case of the fracture on this original test showing bad, thus incurring the rejection of the top rail of the particular ingot represented, it was necessary to locate that rail in front of the straightening presses by identifying the heat and ingot number and rail letter on it, and from its bottom end to break a piece to represent the second rail of the same ingot. This requirement continued to all of the rails of the ingot as far as necessary, and it was found possible to accomplish the desired end easily. A little care in the distribution in front of the straightening presses of the rails from the hot beds made the identification possible without the necessity for extended searching, and when the particular rail for retest was located, it was marked and in due course taken to the nearest straightening press, where a piece readily was broken from its lower or back end and the fracture scrutinized by the inspector without

*Abstracted from the report of Robt. W. Hunt and C. W. Gennet, Jr., to the Rail Committee of the American Railway Engineering Association.

delay or trouble to the regular operation of the mill. In fact, no greater trouble arose with regard to locating and making the necessary retests than is demanded in any mill when all the top rails of a heat, or even a whole heat, have to be located and identified in order to comply with rejection requirements, a matter of more or less everyday occurrence in some mills.

Undeniably the judging of the fractures produced by the nick and break test is a matter of great importance, and requires the services of experienced and competent men; but so do all the detailed parts of intelligent and efficient rail inspection; in fact, the same statement can be truthfully made in regard to every detail of steel rail making. The trend of all matters pertaining to rails is indisputably toward obtaining a safer and better wearing product, railroad officials and manufacturers alike being more appreciative of conditions in this respect than ever before; this attitude, no doubt, being stimulated because of the activities of the different governmental and state commissions. Recent improvements in mill practice have been acknowledged, and it is equally true that railroads are taking greater pains than formerly with the maintenance of their tracks and equipment, and thus of greatly increased importance is the employment of experienced and competent inspectors with whom to entrust the duties of rail inspection. Any specification and any detail of inspection becomes a hardship to the manufacturer and wasted expenditure to the purchaser when inexperience and incapable inspectors are employed, and under such circumstances the nick and break test specification is of no greater assurance against accepting bad rails than it is against making bad steel.

THE BUILDING AND FINANCING OF SUBWAYS.*

FROM a careful analysis of increase in population in various cities, compared with the increase in street railway patronage, this increase is at a slightly higher rate per year than the square of the increase in population of the territory served.

As a result of the marked increase in patronage in such cities as New York, Philadelphia and Boston, a condition was reached on various highways where it was deemed impossible, or at least uneconomical to further increase the number of street cars per hour. There is some difference of opinion as to the exact point of saturation for surface car service. To analyze in detail this condition requires an assumption as to minimum headway between surface cars. Various estimates show that an interval of nine seconds between moving units on the street is consistent with safety. Assuming this fact and adding to it the estimated period of rest of seven seconds for a car, to permit of passengers boarding and leaving would result in cars passing a certain point at the rate of every sixteen seconds. Under these conditions a maximum speed of twelve miles per hour and an average speed of eight miles per hour can be maintained where the usual number of stops are made. This figure is probably correct for practical operation.

In the report to the Merchants' Association, of New York, by its Committee on Transportation and Engineering, 1903, it is stated: "With a time interval of sixteen seconds the number of cars that may be moved past a given point per hour is 225." The committee did not believe that on congested streets like Broadway, New York, a service of more than 220 cars per hour passing a point in any one direction could be reasonably expected under the most favorable circumstances likely to occur, but believed that this number per hour was a reasonable estimate of what should be done.

They further stated: "We are confirmed in this belief by our own observations of what is being done at this time in Boston, and the large number of headway observations on Broadway at Chambers and at Houston Streets appear to practically confirm the above conditions."

Experience in Boston partially confirms the opinion of the Commission, for previous to the opening of the Washington Street tunnel it was believed that a point of saturation had been reached, at which time there were operated between two points on Washington Street a maximum of 213 cars per hour in each direction. Previous to the opening of the Boylston Street subway in Boston as high a number as 260 cars per hour were operated in one direction over a very short section of a certain line on a special occasion, but this was made possible by part of the service operating in the Tremont Street subway and around the Park Street station loop.

The Public Service Commission for the First District of New York, April 17th, 1908, ordered "a minimum number of 25 cars in one direction in each fifteen-minute period on certain sections of Broadway." This would be at the rate of one car every thirty-six seconds, and it is believed by some that this is the lowest headway consistent with reasonably rapid movement of cars when all conditions are considered, such as vehicular interference, line intersections, joint usage of certain stretches of track, etc. Further, this thirty-six second headway is exceeded on some lines in New York on certain short stretches of track, where they operate from two to three times as many cars as are required for a thirty-six second headway.

There should be kept clearly in mind also in the study of maximum capacity of surface lines the difference between maximum number of cars that it is possible to operate and the speed consistent with good service.

In view of the above it is fair to assume, therefore, that when street car service for short stretches of track has reached a number slightly in excess of 200 cars per hour capacity the capacity on this stretch of track might be said to have reached a saturation point after which additional arteries must be utilized or other transportation facilities provided. Of course, this figure is also governed by the width and alignment of streets, as well as the size of the units and general traffic conditions.

Very often the saturation point of surface tracks is not the governing feature in added facilities, for necessity for such additional arteries is due to the demands of the public or public authorities for a more expeditious and convenient means of travel. Regardless, therefore, of the cause of providing high speed transportation facilities in the congested districts, there is no question but what the construction of same is unavoidable for one reason or the other.

When tracks on a certain street have reached the saturation point, whatever that may be, and additional transportation facilities must be provided, every conceivable effort should be made to use parallel streets for additional surface tracks, or even build an elevated structure. It is absolute economic waste to recklessly spend enormous sums of money for subway construction merely

*Paper prepared for the mid-year meeting of the American Electric Railway Association at Chicago, February, 1916.

because a particular highway has operating upon it all the surface cars consistent with either good transportation, or economy and subway construction should only be decided upon after other and less expensive means of furnishing additional transportation have been sufficiently studied to justify their inexpediency.

The enormous amount of traffic absolutely necessary to support expensive subway construction makes it incumbent upon those responsible for such expenditures to thoroughly satisfy themselves that the traffic offered and the conditions prevailing compel subway construction rather than the use of other arteries on the highway, or even private right-of-way construction on the surface.

From the commencement of operation of surface car service over a specific stretch of track, up to the time when such track is completely saturated with cars, the interest charges for the investment on this particular stretch of roadbed per passenger decreases as passengers and riding over same increase, and, therefore, up to the point of saturation, or up to the point when the total capacity of the roadbed is availed of, the greater number of passengers, the less expense for fixed charges per passenger.

On several properties in the United States there have been constructed high-speed underground thoroughfares, either as result of surface tracks having reached a point of saturation or as result of the demand of the public for more expeditious transportation. Immediately upon such construction taking place the fixed charges per passenger jump entirely out of proportion to what they were at the moment of surface track saturation, and ordinarily due to the nature of construction of the subway where it is necessary to build the same cross-section for a one-car train on fifteen minute headway, as is required for a 10-car train on a minute and a half headway, the fixed charges per passenger carried are entirely out of proportion to the ultimate capacity of the subway.

A marked example of the enormous investment necessary for construction of a subway is that of the Washington Street tunnel in Boston, built in 1908. The surface car tracks over the highway under which the Washington Street tunnel was constructed for a distance of approximately one mile represent an investment of approximately $253,000, while the tunnel cost approximately nine and a half million dollars, which, by the way, so far as we are able to learn, is the most expensive mile of roadbed and track in the world, not excepting the Jungfrau Tunnel in Switzerland.

In other words, the transportation companies building or leasing subways have been compelled to meet the enormous fixed charge for comparatively small patronage and pay the same rent or interest, whether the demands of traffic require the operation of a few cars per hour or the maximum capacity of the subway.

In certain instances there has been no substantial increase in rate of patronage where rapid transit service has become necessary. That is, the rate of increase of passengers carried per annum is not materially changed upon the inauguration of rapid transit service.

Generally speaking, it is granted that the cost of operation per passenger capacity with trains in a subway is materially less than electric car service on the highway, but unless the load factor is such as to give an opportunity for use of a reasonable capacity of the subway throughout a large percentage of the twenty-four hours, the fixed charges per passenger considerably more than offset the reduction in operating expense per car passenger capacity.

The original basis of establishment of rate of fare was entirely without regard to enormous subway investments, with a right-of-way furnished by the community, and if as result of entirely changed conditions, such as the outgrowing of the highway capacity or the pressure of the community, it becomes necessary to construct expensive underground thoroughfares, then either the rate of fare must be changed to meet these changed conditions or the community as a whole, benefited as result of such subway must bear, in a measure at least, proportionately to the indirect benefits accruing, a certain portion of the fixed charges until such time, if ever, as the ultimate capacity of the tunnel is reached and the load factor more nearly approaches 100 per cent.

There can be no question of the equity of such an arrangement, for it has been established without question that upon the construction of the subway the complexion of the community served radically changes, property values increase, particularly in the outlying district, and rents are correspondingly raised by landlords.

There is no reason, therefore, why the patron renting a home in the community benefited should pay an increased rate of fare and at the same time pay increased rental for his home as a result of the landlord's values having been increased by the subway construction.

The effect upon capital of companies who are endeavoring to furnish adequate transportation facilities, and who are required to pay interest or rentals on enormous investments entirely out of proportion to revenue received, can be readily concluded, and the consistency of the arguments, as well as their equity, compel recognition to the extent that where investments of this character become necessary the community as a whole must be compelled to participate in the support of same. This has been well evidenced by the case in New York, where in the construction of the latest subways the city of New York contributes in part towards the investment and fixed charges until such time as the net earnings resulting from the operation of the subway permit, after proper charges of every character, including operation, depreciation, etc., of the company bearing same.

The construction of subways, which are nothing more nor less than public highways, differs from other similar public improvements, such as surface highways, sewers, water systems, park systems, etc., in that instead of being constructed from time to time in proportion to the degree to which its capacity is to be used it is necessary, due to the physical nature of tunnels to build them substantially as large and at as great an expense in the first instance as is necessary to provide for not only the immediate requirements, but for the requirements of several years in the future. In other words, State highways, Metropolitan waterworks, sewerage systems, State parks, etc., are built and added to from time to time, and the ability of the community to digest same governs very largely the rapidity with which such systems are enlarged. In the case of a subway, however, it costs so much per running foot to construct, and a cross-section is just as expensive construction for a one-car train run once an hour as for a ten-car train run on a minute and a half headway, or its ultimate use.

It is thoroughly unfair, therefore, that a street railway company should be called upon to pay the entire interest on such an investment when the demands of the traffic and the amount of business available requires at the moment only a small proportion of the total available capacity.

In view of the marked increase in land values and general benefit to the community as a whole as result of subway construction it would seem equitable that those property owners who so materially benefit should contribute in some proportion toward the fixed charges for such improvement. In contradistinction of this, if the unit of fare was increased the tenants of the buildings in the territory involved would not only pay, as result of the subway, increased fare, but also increased rent, while the property owner would receive all of the benefits without participating in the expense.

It is entirely fair and proper that the community should have improved rapid transit facilities and thoroughfares just as rapidly as they are willing to equitably digest it.

In concluding, therefore, when the conditions on a certain highway have reached such a point that additional transportation facilities are necessary, there should first be an effort made to utilize parallel highways with surface tracks at a reasonable and proper investment consistent with the traffic offered. If this for proper reasons is dismissed there should then be effort made to construct surface tracks on private land or elevated tracks on either private land or the highway. If for good and proper reasons these other means are dismissed there is but one alternative left, and that is the construction of subways.

In other words, every conceivable effort should be made to provide additional transportation facilities at as low an investment as is consistent with the demands and the traffic offered, and the construction of subways should be only entered into after the most careful, thorough and conservative study and consideration of other means of furnishing transportation and with a full knowledge of the seriousness of burdening the community with tremendous investment and correspondingly large fixed charges.

If, therefore, it is finally concluded with a perfectly clear perception of what the financial results would be that subway construction is necessary it would seem fair that in the first place the Municipality, Metropolitan District or State should finance same, as undoubtedly money can be raised at a lower rate of interest than where such financing is done by private owners; and secondly, the community as a whole should participate with the company and riding public in the payment of interest charges.

More specifically, upon the completion of subways or tunnels built by the community, they should be leased to the transportation company serving that community on a sliding scale, charging such company rental in proportion to the relation of the capacity used to the total capacity. By such an absolutely fair and equitable arrangement the movement for subway construction automatically regulates itself in a fair and equitable manner to all interests.

There are approximately 82,530 deaths annually in the United States due to accidents, and in connection with the carrying on of dangerous industries there are 25,000 deaths and 700,000 injuries involving a disability of longer than four weeks.

Stellite is not steel, it contains neither iron nor carbon, but is a tungsten. It is entirely unaffected by any degree of heat that can be generated by cutting, and, it is claimed, will maintain its edge at speeds which no high-speed steel can stand, as well as be used on materials which high-speed steel will not cut. Stellite must be held in a tool holder, as it is of a brittle nature.

SLAG PORTLAND CEMENT.

In a paper on "Portland Cement" recently read by B. J. Day, M.I.Mech.E., before the Institution of Engineers and Shipbuilders in Scotland, some particulars were given regarding cement of which blast furnace slag forms one of the ingredients. Mr. Day, although recognizing that slag Portland cement is not as good as the best Portland cement, and hence does not command quite such a high price, yet is evidently in favor of its manufacture, and for several reasons. He states that, though it is true that it does not comply strictly with the British Standard Specification for Portland Cement, it nevertheless, if manufactured with care in accordance with the most up-to-date process, may be made to approximate very closely to it. As reasons why the manufacture should be proceeded with, Mr. Day shows first that the slag is in the ordinary course of events a waste product which costs in some cases a considerable sum annually to dispose of; secondly, that where the gases of the blast furnaces are available the cost of the power required to make the cement is a negligible quantity; and, thirdly, that in any case, owing to the fact that the lime in the slag occurs as oxide and not as a carbonate, as in chalk and limestone, less fuel is required in the kiln. According to him a plant producing 1,000 tons of cement per week would require 250 tons of coal less to produce that quantity if the cement were made with slag than it would if the raw materials were limestone and clay.

It is not all slags, however, which can be satisfactorily used to produce cement. Mr. Day gives some typical analyses of slags, as follows:—

	(1)	(2)	(3)	(4)	(5)
SiO_2	30.00	30.72	32.51	32.90	31.5
Al_2O_3	28.00	16.40	13.91	13.25	18.58
Fe_2O_3	0.75	0.43	0.48	0.46	.....
CaO	32.75	48.59	44.75	47.30	42.22
MgO	5.25	1.28	2.20	1.37	3.18
CaS	1.90	2.16	4.90	3.42	.....

It will be observed that the composition of these five samples of slags varies pretty considerably. The variation as concerns silica is not great, but the alumina content varies between 13.25 and 28.0, that is to say, there is more than twice the quantity in No. 1 that there is in No. 4. Then, again, there is considerable variation in the CaO figures, from 32.75 to 48.59 in the two extreme cases, the difference being thus nearly 50 per cent. Slags Nos. 2, 3 and 4 would be suitable for use in cement manufacture, whilst Nos. 1 and 5 would not be so suitable. The composition of the slag naturally varies with the composition of the ore, and the slags from some ores will not produce good cement. It is to this cause that certain failures of the past are attributed. Sufficient care was not exercised in ascertaining whether or not the slag possessed the requisite qualities for the purpose to which it was proposed to put it.

Mr. Day explains that, in order to treat blast-furnace slags, they should first of all be granulated. The effect of doing this is to cause the material to split up into fine sand-like particles; and to remove a large percentage of the sulphur and increase the hydraulic properties of the material. The ground slag is mixed with limestone in the correct proportion, the mixture being then ground and burnt in a kiln, the resulting clinker being in its turn ground to form the cement. The greatest care must, of course, be taken in getting the proportions right. All Portland cement manufacturers are aware of the vital importance of correct mixtures when using other raw materials, and it is the same when using slag, and it is there that the trouble of the varying composition of the slag comes in. Still, with reasonable care and a competent chemist, this difficulty need not be insurmountable. There is, however, in addition, the mechanical difficulty that slag cement clinker is particularly hard to grind satisfactorily, and failure to appreciate that fact has been the cause of much trouble. Still, with adequate grinding plant the grinding can be effectively carried out. Then, again, slag Portland cement, owing possibly, remarks Mr. Day, to its high alumina content, is naturally very quick in setting. This, however, can be readily adjusted by known means, so that any specified setting time can be obtained.

The following table shows in what way slag Portland cement is not in accordance with the British Standard Specification, and how it compares in its properties with cement produced from limestone and clay.

	British Standard Specification for Portland cement.	Aberthaw "Druid" brand Portland cement	Slag Portland cement.
Neat Tensile (a) 7 days ...	450 lb.	644 lb. sq. in.	623 lb. sq. in.
Neat Tensile (b) 28 days...	$a + \frac{40,000}{a}$ or, say, 539	783 ,,	729 ,,
Sand (c) 7 days	250	283 ,,	207 ,,
Sand (d) 28 days....	$c + \frac{10,000}{c}$ or 290	382 ,,	280 ,,
Specific gravity	Not less than 3.1	3.203	2.96
Expansion	Not to exceed 10 mm.	.66 mm.	1.5 mm.

It will be seen that whereas the slag cement has a plentiful margin in excess of the standard requirements as regards neat-briquette tests, both at 7 and 28 days, the strength of the sand briquettes is not equal to standard requirements. The 28-day test, however, is not greatly below the standard figure and the rise in strength between 7 and 28 days is greater than is expressed by the formula $c + \frac{10,000}{c}$. It will be noticed, too, that the specific gravity is low.

Slag Portland cement is usually manufactured on the dry or semi-dry system, but Mr. Day, in conjunction with some clients, is carrying out some experiments with a view to manufacturing on the wet system. So far, we gather, these experiments give promise of success. Mr. Day strongly recommends blast-furnace owners to consider seriously the question of turning their slag into cement.

In the discussion following the paper it was pointed out by a speaker that the sulphur in blast-furnace slag would disintegrate the cement and therefore it would be necessary to take very great pains in removing the free sulphur from the slag. For reinforced work the use of slag cement would be very dangerous. Other speakers mentioned cases in which slag cement had been successfully used. It appears that with very efficient inspection and proper tests of each shipment, and the storage of the cement until the laboratory results are known, that slag cement for certain uses is economical and efficient, employing as it does a product which otherwise is more or less wasted.

In proceedings by one railroad company in United States to condemn for railroad purposes the land of another, the Pennsylvania Supreme Court holds that the fact that the latter had ceased to operate did not limit the damages to the value of the ground for agricultural purposes, but permitted recovery on the basis of its value by reason of its availability for the location of a railroad.

STANDARD FORM FOR CONCRETE ROADS.*

THIS form is for the concrete pavement only. Cost of other items, such as grading, drainage, bridges, culverts, railings, etc., should be kept separately.

In consideration of the items mentioned, a division should be made indicating those portions of the highway improvement which can be considered as permanent as differentiated from portions which will need renewal in the course of time. Such a distinction is necessary in order to work out any reasonable system of highway financing.

Name and Location of Road..........................
Length ....Width ....Thickness ....
Proportions of Mix......Number of Cubic Yards......

		Per Cu. Yd.
1. *Labor:		
On subgrade..................	$......	
On forms....................	......	
Material to mixer..............	......	
Mixer to place................	......	
Covering and cleaning.........	......	
Total labor........................		$......
2. Concrete Materials:		
Cement, f.o.b....................	$......	
Hauling	......	
Storage	......	
Lost sacks and waste..........	......	
Sand, f.o.b......................	......	
Unloading	......	
Hauling	......	
Stone, f.o.b. or in bins...........	......	
Unloading	......	
Hauling	......	
Total concrete materials...........		$......
3. Water:		
Charge for....................	$......	
Piping	......	
Pump	......	
Labor, etc....................	......	
Total water........................		$......
5. Plant for forms (interest and depreciation).		......
6. Reinforcement		......
7. Joints		......
Total cost concrete pavement.......		$......

WAGE SCALE.

Superintendent ......Teams ......Common labor......
Assistant superintendent.......Auto trucks............
Skilled labor..........Length of working day.........

(Remarks on features of plant and materials which have special bearing on costs.)

* Includes supervision.

It will be noted that the form calls for reporting the cost on a cubic yard and not on a square-yard basis. The latter has been a popular method of reporting city paving costs, but the former is probably now the prevailing practice on concrete road work. The cubic yard system has the disadvantage of preventing ready comparison with the costs of other types, but possesses other advantages which, in the committee's judgment, more than counterbalance the disadvantage. The square-yard basis, on the other hand, is not definite, for it neglects the thickness of pavement, making comparison between two concrete slabs of different thicknesses difficult. The cubic-yard basis is not open to this objection. The cubic-yard method of reporting gives repeated checks on the amount of stone and aggregate used and on the thickness of pavement itself.

*From report of Committee to National Conference on Concrete Road Building.

TESTS OF EFFECT OF METHOD OF BENDING UPON THE SUPPORTING STRENGTH OF DRAIN TILE AND SEWER PIPE.*

By N. J. Schlick,
Drainage Engineer, Engineering Experiment Station,
Iowa State College.

TESTS were made on 24-in. pipe, with the types of bedding indicated by the accompanying diagram. The general method of procedure was to bed the pipe in the various ways and then to ascertain their actual supporting strength by applying load through standard upper sand bearing. A hydraulic jack suspended from a beam anchored to two large concrete blocks was used for the loading, the amount of the jack load being indicated on a gauge attached to the pump which operated the jack.

The test pipe was laid in a trench dug in made soil. The top soil was a rather close black loam and the subsoil a firm yellow clay. The location chosen for the tests of pipe in earth beddings was such that only the lower portion of each pipe was in clay. In all cases of earth bedding the filling material was loose top soil.

The work was done with labor unskilled in pipe laying. For this reason, and also to insure uniformity in the manner of bedding, the specified dimensions of the trenches and concrete cradles were adhered to somewhat more closely than they probably would be in a drainage practice. Aside from the care taken to insure uniformity the quality of the work was much the same as might reasonably be obtained in any drainage district.

The pipe used were selected at the factory primarily for uniformity. They were evenly burned and were free from structural defects. The concrete used in the concrete beddings was made with gravel from the pit on the campus. This gravel is not an exceptionally high grade and is probably no better than the average which would be used for this purpose over the State. It was screened and then remixed so that 50 per cent. would pass a ¼-in. screen. Two grades of concrete were used, grade A, a 1 : 5, and grade B, a 1 : 8 mixture of Portland cement and the remixed gravel.

The tests were made when the concrete beddings were approximately one month old. Classes 4-A, 4-B and 8 were the last put in, so that, because of a slightly shorter time of setting and considerably cooler weather, the concrete did not obtain as great strength as that in the other types of concrete cradles.

The concrete cradles, except those of class 7, were all constructed with the concrete at the sides carried up to a height equal to one-fourth the inside diameter of the pipe above the mid height. In the earth beddings the side filling was carried up to a little above the mid height of the pipe. In each case this allowed the use of the standard upper sand bearing over 90° of the pipe circumference.

The types of bedding tested might be divided into three general classes, namely, earth beddings, concrete beddings for firm soils and concrete beddings for yielding soils. This division can not be adhered to rigidly as some types of bedding might be used in any soil stable enough to prevent the pipe from settling. This is particularly true of class 7, which was patterned after a concrete bedding tested and by the Philadelphia Board of Public Works.

*Extract from a paper read at the meeting of the Iowa Drainage Association.

The first of the earth beddings, class 1, was made in accordance with the "Ordinary" method described in the "Standard Specifications for Drain Tile" of the American Society for Testing Materials except that the pipe were only bedded to a little above the mid height. The trench was shaped in the bottom to approximately fit the lower 90° of the pipe and the ditch filling shovelled in without tamping. There was quite a wide range in the supporting strength of these pipe, but the average agreed quite closely with the average strength as shown by standard strength tests with sand bearings. Because of this close agreement the average supporting strength of class 1 is taken as a basis for comparing the strengths developed by the other types of bedding.

The second class of bedding was the "First Class" method described in the standard specifications mentioned above. The trench bottom was sloped more accurately and was covered with 1 in. to 2 ins. of loose top soil before the pipe were laid. The filling was carefully tamped in, especially at the lower ⅛ points, up to a little above the mid height. The average strength of this class was 28% greater than that of class 1 and there was considerably less variation in the results from the individual specimens.

In the other type of earth bedding, class 9, the pipe were laid in a flat-bottomed trench and the spaces between

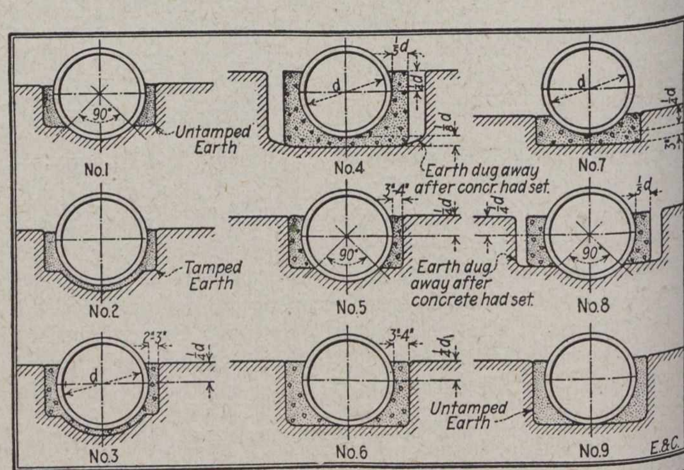


Diagram Showing Nine Methods of Bedding Drain Tile in Testing Supporting Power.

the pipe and the sides of the trench shovelled full of loose earth. No especial care was taken to see that the spaces between the bottom of the trench and the pipe were filled, and examination after the test showed that the filling there was so loose as to give the pipe no support. The average strength of these pipe was 26 per cent. greater than those of class 1. This increase in strength is thought to be due to the frozen condition of the ditch filling material at the sides of the pipe at the time the tests were made. There is reason to believe that this type of bedding will usually give lower strengths than class 1.

The results of these tests of pipe in earth beddings bring out two especially interesting facts. First: The strength of the pipe laid in the "Ordinary" method agreed very closely with that shown by standard strength tests of similar pipe, and second, that an increase in strength of 25 per cent. can be obtained by more careful bedding, as is specified for "First Class" pipe laying. This latter fact is especially noteworthy as in many cases the value of the 25 per cent. increase in supporting strength will be much greater than the extra cost of construction, including the salary of an inspector.

None of the pipe in earth beddings would support a larger load than that at which they cracked. All of the tests indicated very clearly that the supporting strength of the pipe after cracking depended upon the bearing power of the soil at the sides of the trench. The soil in which these tests were made was probably more firm than the average in drainage work so that the values of the supporting strength after cracking are valuable for comparing with each other rather than for indicating what may be expected in other places.

The pipe laid in concrete cradles as specified in the standard specifications for "Concrete Cradles" for "Solid Soils" were tested as class 3. The concrete used was proportioned 1:8, as mentioned above. The bottom of the trench was shaped to fit the lower 90° of the pipe and 2 ins. of concrete placed on it. The space between the sides of the trench and the pipe, about 2½ ins. at the mid height of the pipe, was then spaded full of concrete up to a height of one-fourth the nominal diameter of the pipe above the mid height. These pipe had an average cracking strength 64 per cent. greater than those of class 1.

Class 5 beddings were a combination of the earth beddings and the concrete cradle just described. The bottom of the trench was shaped to fit the lower quarter of the circumference of the pipe and the spaces between the pipe and the sides of the trench, about 3 ins., filled with 1:8 concrete. These pipe showed a cracking strength of 46 per cent. greater than those of class 1.

The third class of concrete bedding for solid or firm soils was class 6. The trench was dug with a flat bottom and was about 6 ins. to 8 ins. wider than the outside diameter of the pipe. The pipe was laid in the trench and concrete poured in at the sides, care being taken to get the concrete well around the pipe. Tests of this type of bedding were made with two grades of concrete. In class 6-A a 1:5 mixture was used and in class 6-B a 1:8 proportion. The pipe of class 6-A supported a load 96 per cent greater than class 1 before cracking. Those of class 6-B developed a cracking strength 80 per cent. greater than that of class 1.

It is not certain that the tests determined the maximum supporting strength of the pipe of these three classes as the limit of the apparatus was reached on several occasions. When a large load was left on a cracked pipe for any considerable time, the uneven settlement caused derangements in the best apparatus. However, the maximum loads recorded were very large, the average being more than twice those supported by the pipe in earth beddings.

The tests of these classes also indicated that the supporting strength of a pipe after cracking depends upon the bearing power of the soil. For example, the average maximum loads supported by the pipe of class 6-B was greater than that of the pipe of class 6-A. These two classes were the same except that the concrete used in class 6-B was a leaner mixture than that used in class 6-A. The yielding of the lateral support was a gradual one. These tests all indicated that if the maximum applied load could have been held for a longer time, all the pipe would have collapsed.

The pipe of these three classes showed a marked tendency to develop side cracks at or near the top of the concrete at the sides. Where the side cracks in the pipe were below the top of the concrete it usually cracked opposite the crack in the pipe. In each case in class 3, the concrete was cracked along the centre-line at the bottom, the crack appearing simultaneously with the crack in the bottom of the pipe. In a great many cases the cradle was cracked near the lower ⅛ points by the continued application of pressure after the pipe had cracked.

The pipe all cracked at the top at the same or less load than at the bottom. In general, the development of a single crack at the top was indicated by a slight decrease in the indicated load, and the appearance of cracks in both top and bottom by a marked decrease in the indicated load. The side cracks usually developed while the load was being again raised to that at which caused the cracks in the top or top and bottom.

The bedding designated as class 7 was patterned after the Philadelphia method. This type of bedding or cradle would be equally effective in all soils firm enough to allow of the construction. The trench was dug a little wider than the outside diameter of the pipe and the bottom left flat. About 3 ins. of 1:8 concrete was placed the full width of the trench and the pipe laid upon it. Concrete was then placed around the pipe to a height of 6 ins. or one-fourth the inside diameter, above the bottom of the pipe. This bedded the pipe in concrete for a little over 90° but furnished no side support whatever, as the top of the concrete was just about even with the surface of the ground.

The pipe of this class showed an average strength before cracking 82 per cent. larger than those of class 1. As these pipe received no side support, they collapsed as soon as the main fractures were developed. These pipe all cracked at the top at the same time, or before, they did at other points. In no case did one of these pipe crack through the portion bedded in the concrete. The general failure was at the top and at the sides at the top of the concrete. Some pipe also cracked at one ¼ point at the side but in no case at both sides ¼ points.

An examination after the tested pipe were removed from the concrete showed that each of the concrete cradle was free from cracks. It may be that as great a supporting strength can be produced in the pipe with a lighter cradle of this type. This type of cradle is easier to construct and required less concrete than some of the other types in which the pipe had no greater supporting strengths.

As it was impossible to secure soils which would reproduce the conditions met with in work in what are termed yielding soils, a condition which was more severe was provided. After the concrete in the cradles had set, the earth was dug away at the sides down to the bottom of the concrete. This method gave the pipe no side support except that furnished by the concrete cradle.

Tests were made of pipe bedded in "Concrete Cradles" for "Yielding Soils" as specified in the "Standard Specifications for Drain Tile." In class 4-A a 1:5 concrete was used and in class 4-B 1:8 concrete.

The trench was dug 10 ins. wider than the outside diameter of the pipe and with a flat bottom. A 3-in. layer of concrete was placed in the trench and the pipe laid upon it. Concrete was then poured in at the sides up to the specified height of ¼ the inside diameter above the mid height.

The pipe of class 4-A showed an average strength before cracking 38 per cent. larger than those of class 1, while those of class 4-B supported 50 per cent. more load before cracking than did those of class 1. The fact that the cradle of the leaner concrete gave the larger support is attributed to the fact that the pipe of class 4-B were laid before those of class 4-A and that cool weather and frosty nights prevailed after the cradle of class 4-A were poured.

The pipe of these two classes usually cracked at or near the four ¼ points at the same time, though the side cracks were often at or near the top of the concrete. In all cases the concrete cradle cracked along the centre line in the bottom, and often at about the lower ⅛ points of the pipe, at the same time the pipe developed fractures. After the cradles were cracked in the bottom, the two sections revolved around the lower outside edges and the pipe would support practically no load.

The bedding of class 8 were very similar to the combined earth and concrete bedding of class 5, except that the earth was dug away from the outside of the concrete so as to reproduce as nearly as possible the conditions prevailing when this type of bedding is used in yielding soils.

The concrete used in these beddings was proportioned 1:9. It was poured in cool weather and had developed only a comparatively small portion of its final strength at the time the tests were made.

The pipe of this class had an average supporting strength only 18 per cent. larger than those of class 1. The concrete received no side support so that the load which developed the cracks in the pipe was the maximum. These tests indicated that this type of bedding would give but little side support other than that due to distributing the pressure over a larger area. In many soils this would result in a noticeable increase in supporting strength but in very wet soils the increase would be small.

The class of bedding still to be tested will be of the same general type as class 4, which is the "Concrete Cradle" for "Yielding Soils" of the "Standard Specifications for Drain Tile." The cradles of class 4 were made with the minimum dimensions specified, while the new type will be designed to safely support a 24-in. tile when cracked at the four ¼ points and receiving the estimated maximum load from ditch filling.

The data given above are from only one series of tests and can not be taken as final until they are verified by further work. There are, however, some very important general facts which are pretty definitely shown.

These results might be summarized in three general statements, as follows:—

1. The supporting strength of tile laid in the "Ordinary" method is practically the same as the "Ordinary Supporting Strength" shown by the standard tests.

2. The supporting strength can be increased 25 per cent. by more careful earth bedding and 80 per cent. or 90 per cent. by the use of concrete cradles.

3. The supporting strength after the pipe is cracked depends upon the bearing power of the soil at the sides of trenches, irrespective of the type of the bedding.

A SUBSTITUTE FOR PLATINUM.

An alloy for use in contact and spark devices to replace platinum has been patented by Mr. Paul R. Heyl, of New Rochelle, N.Y. (assigned to Commercial Research Co., of New York City). This alloy consists of silver and palladium, in varying proportions according to the conditions under which it is to be used. An alloy of silver with 2 per cent. of palladium has been found to give satisfactory results under many circumstances. When the contacts or spark points are exposed to sulphur compounds, 5 per cent. or more of palladium should be used. The alloy which was found to give the greatest resistance to spark erosion was that of 60 per cent. palladium and 40 per cent. silver. Additions of palladium to silver raise the melting point and lower the thermal conductivity. It has been found that, on account of the high thermal conductivity of silver, the heat from the spark will be conducted away fast enough to prevent melting of the silver. In view of this fact, silver-palladium alloys with very high percentages of silver can be used in a great many cases.

SHIPBUILDING IN CANADA

The Cunard Steamship Company recently bought three second-hand steamers, having failed to find builders able to quote for new tonnage. For the three boats, the company paid a higher rate per ton than they would have paid before the war for new vessels. Two years ago the little British schooner "Coquitlam City" was built on the Pitt River. She had her adventures and, becoming severely strained during a voyage, was laid up. The boat has just been chartered in San Francisco to load lumber for Australia next July. A $200,000 cement order recently had to be refused by a Canadian firm on account of the shortage in tonnage.

These are but three incidents of a tonnage shortage which is daily becoming worse. It affects the conduct and the length of the war and the transaction of business during the war. Its most serious effect is likely to come after the war, when we will all be clamoring for tonnage during the big commercial campaign which will then be waged.

In the House at Ottawa recently Sir George Foster, minister of trade and commerce, said that the government had made efforts to have vessels built. In the first place, it had asked responsible persons what amount of tonnage subsidy would be required to encourage the building of wooden vessels of economical tonnage, say, from 2,000 to 5,000 tons. In reply it had received an offer to construct such ships if a subsidy of $6 a ton were paid for 15 years, or $90 a ton in all. He did not think that was reasonable.

The government had also received an offer to build steel ships at the rate of from $125 to $135 a ton with delivery in the latter part of 1917. Sir George said the price was high and that the time of completion was too far distant. Therefore, he thought that it would be necessary to consider first the period of emergencies and then the period following the close of the war. As far as the latter period was concerned, he held that a country with Canada's producing capacity should have a considerable and a growing merchant marine, and that government assistance might be necessary to that end.

It is doubtful whether this country will be able to build many ships for "the period of emergencies," but it is certain that if we are to enter the shipbuilding business, with any success, for the period following the war, we must begin at once. Sir George Foster intimated that the government might be willing to co-operate in a shipbuilding enterprise.

Walter J. Francis and Co., consulting engineers, Montreal, have moved to more commodious offices in the new Bank of Toronto Building, 260 St. James St.

The Acting British Consul-General at Moscow reports on Railway Development in his district as follows in "Railway Gazette," London: Between Vladimir and Moscow on the Nijni line there is a large and important manufacturing district, of which Oriechovo-Zuevo is the chief centre. The factories in this district receive their cotton and much of their food supplies from the south, the goods in question coming by the Kazan line. Owing to the 10 versts (about 6⅔ miles) between Ilinski Pogost and Egorievsk, which would unite the Kazan and Nijni lines, not having been linked up by rail, the cotton for the Oriechovo-Zuevo manufacturing district has hitherto been compelled to travel up the Kazan line all the way to Moscow and then back by the Nijni line to Oriechovo-Zuevo. The connecting line between the Kazan and Nijni railways having recently been completed by linking up Ilinski Pogost and Egorievsk, and opened for traffic, it is estimated that the manufacturers of the latter town will be saved many thousand roubles yearly in freight charges. A similar project has been formed to connect the Yaroslav and Nijni lines.

MONTREAL AQUEDUCT PETITION.

Following is the text of the petition handed last week to the city council and board of control of the city of Montreal:—

"To His Worship the Mayor and the members of the Board of Commissioners of the city of Montreal.

"L. N. Senecal, Esq., Secretary.

"and to

"His Worship the Mayor and the members of the city council of the city of Montreal.

"Gentlemen,—

"Under dates of July 29, 1915, and October 7, 1915, the Council of the Canadian Society of Civil Engineers submitted to the mayor and council and to the commissioners of the city of Montreal then in office a recommendation that before further large expenditures were made on the enlargement of the aqueduct or toward the construction of the proposed hydro-electric power house at the pumping station the project should be studied and reported on by a commission of engineers of recognized standing in the profession.

"The Council of the Society communicated with all the engineers who had been named in the reply of Mr. Cote as having reported on the project, and learned that no one of them had studied and reported on it as a whole, but that only isolated portions of the work had been submitted to them for consideration.

"*The Canadian Engineer*, in its issue of November 11, 1915, published a comprehensive article in which it gave the history of the various enlargements of the aqueduct which have been considered, the estimated cost of the different proposals, and the approximate amounts which had been expended up to that time. It also gave the estimated probable expenditures still necessary to complete the enlargement of the aqueduct, the construction of intake and controlling works, the bridges and drains across the aqueduct and the building and equipping of the power house and pumping station. The data for the article were said to have been obtained from the engineers of the city, and the conclusions drawn as to the ultimate cost of the works appear reasonable. Unless the figures of cost given in the above-mentioned article are very far astray it would seem wise to re-consider the whole project and perhaps to modify it greatly.

"The opinion is quite generally held by local engineers having some knowledge of the work, but by no means full knowledge, that the proposed enlargement of the aqueduct and development of hydro-electric power sufficient to do the lighting of the city and to pump its water is not a project which could be recommended from an economic point of view.

"When the Council of the Canadian Society of Civil Engineers made its recommendation, many members were firmly of the opinion that:—

"(1) No thorough study had ever been made of the cost and economic value of the great enlargement of the aqueduct now proposed and of its attendant works.

"(2) No complete design had ever been prepared for the power house and its equipment or for the intake and controlling works, and only approximate estimates had been made of the cost of these very important and costly portions of the work.

"(3) The original estimates submitted by the engineers of the city were inadequate and the work as it progressed was costing far in excess of these original estimates.

"(4) The project as a whole had never been studied and reported on by independent or disinterested engineers.

"In view of all the circumstances, and particularly because of the fact that all the engineers named by Mr. Cote deny in writing the statement attributed to them that they approved of the project, we, the subscribing engineers, endorse and repeat the recommendation of the Council of the Canadian Society of Civil Engineers, and respectfully urge that a commission of prominent engineers, specially qualified to pass judgment on the project, be retained to make a comprehensive study and report upon the cost of the work as now projected, and to advise to what extent, if at all, the project may to advantage be modified or changed.

"Montreal, April 20th, 1916."

The petition was signed by the following Montreal engineers:—

Sir John Kennedy, consulting engineer; Ernest Marceau, superintendent-engineer, canals of the province of Quebec; Herbert Wallis, M.Inst.C.E., M.Inst.Mech. E.; K. W. Blackwell, vice-president, Canadian Steel Foundries; Phelps Johnson, president, St. Lawrence Bridge Co.; J. A. Jamieson, consulting engineer; Henry Holgate, consulting engineer; M. J. Butler, director, Armstrong, Whitworth of Canada; G. H. Duggan, general manager, Dominion Bridge Co.; R. A. Ross, consulting engineer; C. N. Monsarrat, chairman and chief engineer, Quebec Bridge Commission; Walter J. Francis, consulting engineer; Arthur Surveyer, consulting engineer; C. H. McLeod, consulting engineer and secretary of the Canadian Society of Civil Engineers; John B. Porter, consulting engineer and professor of Mining Engineering, McGill University; W. Chase Thomson, consulting engineer; H. M. MacKay, professor of Civil Engineering, McGill University; E. Brown, professor of applied mechanics and hydraulics, McGill University; H. O. Keay, professor of transportation, McGill University; G. R. Heckle, engineer and contractor; H. P. Borden, member Quebec Bridge Commission; James S. Costigan, consulting engineer; J. M. Robertson, consulting engineer; C. Lelau, professor at Laval University and consulting engineer; William McNab, valuation engineer, Grand Trunk Railway System; H. H. Vaughan, third vice-president, Dominion Bridge Co.; H. M. Jaquays, works manager, Steel Company of Canada; W. F. Angus, vice-president, Canadian Steel Foundries, Limited; R. J. Durley, consulting engineer; L. A. Herdt, professor of electrical engineering, McGill University, and member of the Montreal Electrical Service Commission; Alex. Pringle, consulting engineer.

Engineers employed by the various Montreal power companies were not allowed to sign the petition because Mayor Martin attributed the previous petitions to selfish interests on the part of the local power concerns, and the signers wished to make impossible such a charge in connection with the above petition.

The Scottish railway companies recently gave public notice that from March 20 the rate from Caledonian and North British stations to other stations in Scotland would, where they are not already at the maximum, be raised to the maximum, less 10 per cent.

GOOD ROADS ONE OF CANADA'S GREATEST NEEDS.*

By W. A. McLean, Deputy Minister of Highways, Ontario.

RURAL roads are the primary channel of traffic. Along them, production, industry and commerce have their origin. Let the common roads be closed, and railways will decay in idleness; ocean liners will rust at their moorings. Nations have prospered without railways; but common roads, "Good Roads," have always been vital to national progress and development.

The lessening of the cost of transportation is a measure of economy, of national thrift, which will produce a large return on the expenditure. On this continent, the cost of team haulage is rarely less than 25 cents per ton-mile and is sometimes twice that amount. Under the favorable conditions of good roads in Europe, the cost is reduced to between 8 and 12 cents a ton-mile.

The tonnage carried over the country roads of Canada is not readily estimated; but railway statistics show that the total amount of freight carried by the railways and originating in Canada, is about 60,000,000 tons. This, for the most part, at one or both ends of the railway journey, must pass over the wagon road. And a considerable additional amount, consumed locally, passes over the wagon road without railway transportation. The average wagon haul for farm and natural produce is estimated at between seven and eight miles. It is probably a moderate assumption for Canada that a total of not less than 100,000,000 tons passes over the roads of the country with an average haul of five miles.

Compared with European costs, good roads would effect a saving of not less than ten cents per ton-mile. Putting the amount saved at only five cents a ton-mile, or 25 cents per ton for the average haul of five miles, an adequate system of improved roads would create a profit of $25,000,000 annually on the produce and merchandise now passing over the roads of Canada.

The time lost in travelling over bad roads is very great. It has been estimated that bad roads occasion a loss of a man and team for two weeks (12 working days) annually to the average farm.

Bad roads limit the output of farms to the kind and quality of produce that can be drawn to market. Good roads permit the farmer to take advantage to the utmost of the location and fertility of his land. In other words, it may be broadly said that with bad roads the production is restricted to the produce that can be hauled over the roads; whereas with good roads it is restricted only to the amount and quality that can be grown and sold on the market.

If the nation and the city are to reap the advantage of increased farm population and production, rural conditions must be made to compete with city, by making them profitable and agreeable.

Road-building is clearly one of the most important public works remaining for Canada to undertake. When the war is ended and our armies return, with a large additional influx of immigration, it will be well if we are so organized that roads can be built on an adequate scale, not only to aid in the development of Canada, but, temporarily, to assist in giving employment during what will probably be a trying period of industrial readjustment.

Only a very wealthy country, improvident of its resources, can progress under the handicap of bad roads. Those who have bad roads consider good roads an expensive luxury. But those who have the advantages of good roads, know that Good Roads are a necessity.

Road-building is a slow process in part, because it is expensive. And because the work is expensive, it must be distributed over a term of years and among various administrative organizations. But so distributed, and looked at from the standpoint of annual ability, the undertaking becomes less difficult. The total twenty-year cost of maintaining a household does not worry the average man—if his annual income is sufficient for the annual outlay. Road-building is a continuous work; if properly carried on, is cumulative in its growth, and is a question of annual expenditure available to meet direct outlay, plus sinking fund, interest and cost of maintenance.

In the Dominion of Canada there are about 250,000 miles of graded roads. The immediate objective in Canada should be to substantially improve about 16 per cent. of the total, or 40,000 miles, which would carry the more concentrated market or farm traffic; while about 2 per cent. additional, or 5,000 miles, should be treated on a trunk road basis. The total cost might be approximately estimated at $250,000,000, of which about $50,000,000 has been spent.

*Reprinted from "Production and Thrift," Agricultural War Book, issued by the Department of Agriculture, Ottawa.

LETTER TO THE EDITOR.

Need of Sewage Disposal Plants.

Sir,—I have read with interest your editorial on the Lethbridge epidemic, but beg to differ from you regarding the solution of the problem.

The fact that the supply was being chlorinated raises the presumption that the authorities were aware that the water was subject to either continuous or intermittent pollution, and yet it is evident that the efficacy of the treatment was only checked by the examination of samples taken at long intervals.

Chlorination, when properly supervised, has been proved by scores of instances to be effective in preventing undue typhoid incidence, and the cost of such supervision is cheap compared with that of an epidemic.

If Lethbridge wishes to obtain a satisfactory supply, I would suggest that such means of purification be adopted as will ensure a water of safe quality, and not depend upon the prevention of pollution by some other authority. It is becoming deplorably prevalent for corporations to endeavor to place the responsibility for epidemics on other corporations because they have utilized the natural watercourses for the disposal of their sewage; and to petition legislative authorities for assistance when the remedy lies in their own hands. The sooner the cities of this Dominion realize that the rivers are the natural drainage courses for sewage, and that such streams must not be utilized for domestic purposes without proper purification, the quicker will typhoid become a disease of the past. Only when the sewage of one community so pollutes a river as to render it impossible for its neighbor to adequately purify it by reasonable measures, is there any warrant for interference. If one community neglects to protect itself, I cannot conceive that it is the duty of its neighbors to relieve it of that task. This is, of course, contrary to the principles of riparian law, but I submit that it is the sane solution of the problem if municipalities are not to be unduly burdened with excessive expenditures with consequent retardation of development.

JOSEPH RACE,
City Bacteriologist.

Ottawa, May 6th, 1916.

FOREST FIRES AND HYDRAULICS.

ROBSON BLACK, secretary of the Canadian Forestry Association, Ottawa, has distributed 25,000 copies of a booklet called "A Matter of Opinion," which is intended to educate the public to the importance of forest fire prevention.

Mr. Black discusses the matter from the viewpoints of the settler, the camper, the banker, the railway man, the power engineer, the fire ranger and the taxpayer. The discussion from the viewpoint of the power engineer contains the following interesting summary of the relations between forest fires and hydraulic engineering:—

A chain is no stronger than its weakest link, and a power development system is no stronger than the water supply that turns its turbines. But we cannot stop there. The best hydro proposition in America is just as reliable as the forces that control the water flow, and if those forces are out of hand, the entire undertaking, from the president in the head office down to the three horse-power consumer in the basement workshop, is likewise out of hand.

When I talk about controlling stream flow, I mostly mean forests. Some power propositions have to equalize the extremes of flood and drought by storage dams, but storage dams are to a certain extent "engineering crutches" to make up for a natural shortcoming. The million-dollar levees on the Mississippi are man's method of off-setting the effects of stripping the forests from the watersheds of countless streams back on the Ohio and other tributaries. The levees work—when they do work—and at an enormous annual expense, but had a reasonable amount of the original forest growth been left on the northern watersheds, the extent of levee building would have been considerably reduced and the menace of annual floods less to be feared.

I do not need to name the Canadian rivers from coast to coast—that run to flood during the spring break-up and to drought in midsummer. Every province has them. Whether in British Columbia or Nova Scotia, municipalities and factories and hydro-electric companies face the common difficulty of regulating stream flow so as to avoid dangerous extremes. Floods in Ontario, for instance, along such rivers as the Thames, Moira, Credit, and Grand, cause hundreds of thousands of dollars annual loss. Where shall we look for the cause?

Nature designed the forests on our watersheds to be the bit-and-rein of our streams. You have seen the thick spongy "floor" to a well-canopied woodland. That is nature's reservoir, designed for surplus waters of the spring break-up. Destroy this reservoir with fire or careless cutting, and the logic of nature loses no time in coming into play. Gravity has a clear field. And that spells flood, erosion of hillsides, damaged farmlands, streams out of hand, and hampered power facilities in the industrial towns.

Should there be, then, no cutting whatever on watershed forests? That would hardly seem reasonable. The rich agricultural lands will be stripped for field crops and their forest cover, whether valuable for watershed purposes or not, cannot be retained. The needs of agricultural expansion are supreme. Even on non-agricultural forested lands, it is only good economy to permit cutting under proper regulations regarding diameter limit. Taking out mature timber or pulpwood need not depreciate the value of a forest for watershed uses, although indiscriminate "skinning" will spell a speedy ruin. What I mean is that a spruce forest can be cut to a 12-inch diameter limit and yet 76.8 per cent. of the volume remain in growing condition. In other words, the reservoir properties would be unaffected. Protection against fire is, of course, most important of all considerations.

Natural forests perform a service for streams which cannot be measured in dollars. For power purposes we must often supplement with storage dams, for even in the primitive days before tree growth was touched by an axe, the inequalities of flow between spring and August were often too great to serve the needs of the modern power plant. At the same time, the living forest is a most necessary ally of the storage reservoir. Its functions are much the same and the absence of storage capacity in nature places that much more burden and expense on artificial devices.

I have not mentioned the danger to all storage and irrigation works, of the erosion of hillsides due to denuding of tree growth and the consequent silting up of the reservoirs. From that angle as from others forest destruction on watersheds plays the enemy to the power engineer.

ONTARIO HEALTH OFFICERS ASSOCIATION.

The Fifth Annual Meeting of the Ontario Health Officers Association will be held in Convocation Hall, University of Toronto, on Tuesday and Wednesday, May 30th and 31st, 1916. Programme for this conference is as follows:—

Tuesday, May 30th.

10.00-11.00 a.m.—Registration.

11.00 a.m.-12.45 p.m.—"The Quarantine Period for Measles," M. B. Whyte, Isolation Hospital, Toronto. "Measles," A. D. Smith, M.O.H., Mitchell. "Should the Breadwinner be Quarantined?" V. A. Hart, M.O.H., Vespra. "Some Observations on Typhoid Fever in Toronto," Fred. Adams, Epidemiologist, Department of Health, Toronto. "Epidemic Cerebro-Spinal Meningitis," J. G. Fitzgerald, Director Antitoxin Laboratories, University of Toronto. Appointment of committees: (1) Nominations; (2) Papers and Arrangements.

2.30-5.00 p,m.—President's Address, A. J. Macauley, M.O.H., Brockville. "Modern Methods of Diagnosis and Treatment of Diphtheria," W. H. Park, Director of Laboratory, Public Health Department, New York City. "Tonsils and Adenoids," G. R. Cruickshank, M.O.H., Windsor. "Suggestions for Improvement of Association Meetings," F. A. Dales, M.O.H., Stouffville. "Deductions of a New Ontario Medical Officer of Health," Edgar Brandon,. M.O.H., North Bay.

8.15 p.m.—Public meeting. "Sanitation in Serbia," W. D. Sharpe, Major, R.A.M.C., Brampton (with views). War Scenes (views), Ruggles George, Capt., A.M.C., Toronto.

Wednesday, May 31st.

10.00 a.m.-12.45 p.m.—"Auxiliary Aids in Public Health Work," H. W. Hill, M.O.H., London. "Rural Sanitation," P. J. Moloney, District Officer of Health. "Methods of Collection and Disposal of Domestic Wastes in Small Municipalities," F. A. Dallyn, Provincial Sanitary Engineer. "Treatment of Sewage by Activated Sludge," T. Chalkley Hatton, Chief Engineer, Sewerage Commission, Milwaukee, U.S.A. Reports of Committees.

2.30-4.00 p.m.—"Prevention of Tuberculosis in Children," H. Logan, M.O.H., Niagara Falls. "Water Supply and Sewage Disposal for Suburban Residences," J. S. Nelson, M.O.H., Westboro. "Forms for Keeping Records of Communicable Diseases," E. C. Henderson, Assistant Statistician, Local Board of Health, London.

COAST TO COAST

Guelph, Ont.—The Board of Health has requested City Engineer McArthur to make a report on the city's water supply.

Sarnia, Ont.—The new Northern Navigation dock has been completed and is now ready for the use of the boats and wagons. The dock adds greatly to the appearance of the water front.

Quebec, P.Q.—The contractors on the St. Charles River improvements are busily engaged in dredging operations, so that navigation will be possible as soon as the locks and dam are finished.

Calgary, Alta.—A new proposition to provide pure water has been suggested by Ald. Fawkes. The scheme is one in which a series of filters would be installed, and would cost about $80,000.

London, Ont.—The London and Port Stanley Railway Commission has decided to purchase the incline railway at Port Stanley, running from the beach to Fraser Heights, from the Port Stanley Amusement Company for $1,600.

Montreal, Que.—M. J. Tremblay, chief of the fire department, has advised different commercial establishments that the city will shortly adopt the new system of underground wires for the special fire alarm system in the central part of the city.

Vancouver, B.C.—More than 22,000 feet, approximately 4½ miles, of the C.P.R. Roger's Pass tunnel under the Selkirk Range has been completed, and 25,000 feet, about 4¾ miles, of the main heading has been driven, according to late progress reports received by the C.P.R.

Ottawa, Ont.—Formal notice has been given by the government of a bill respecting the Quebec and Saguenay Railway. It is understood that under the terms of the measure to be submitted to parliament the sum of $4,000,000 will be set apart for the purchase and completion of the road.

Toronto, Ont.—The work on the Bloor Street viaduct is progressing very favorably. His Royal Highness the Duke of Connaught and Sir John Hendrie recently inspected the work and manifested great interest in the undertaking, which is perhaps the biggest the city has ever seen.

Moose Jaw, Sask.—The fifth annual report of the Moose Jaw Electric Railway Company, covering the year 1915, which has just been issued, shows the company to have operated at a gross profit of $6,402.19 during that year, though this profit was more than absorbed by some damage actions against the company.

Winnipeg, Man.—Construction operations have been resumed on the Shoal Lake aqueduct. With the exception of Boggy River, where water is holding up the engineers, every part of the aqueduct groove is dry. The construction companies will proceed on all their contracts and within a week the work will be general. With the experience gained last year it is expected that greater progress will be made during 1916 than in 1915. Possibly 1,000 men will be employed.

St. Catharines, Ont.—The work on the Welland Ship Canal as far as the contracts have been given out is progressing favorably, and all indications are that with the exception of the section at Thorold, where considerable blasting has to be done, the work will be completed on scheduled time. The work on sections 1, 2, 3 and 5, the sections for which contracts have been let, is progressing very favorably, and with the exception of section 3, will be finished on schedule time, 1917.

Owen Sound, Ont.—The dry dock proposition, which has been before Owen Sound off and on for the last six years, is again a live issue here. When in Toronto Mayor Little was interviewed by a Mr. Stephens, of Niagara Falls, who is desirous of promoting the dry dock scheme. The late Mr. Wood, who was behind it, and in whose hands it came almost to fulfilment, was from Niagara Falls, and Mr. Stephens expresses himself as willing to take up the plans where he left off. In 1912, the government agreed to grant the usual dry dock subsidy, and a by-law was passed in Owen Sound granting $200,000 toward the scheme.

Calgary, Alta.—The Rogers Pass tunnel is nearing completion, and according to recent reports it should be ready for traffic in a couple of months. To prevent water seepage the tunnel is to be completely lined with concrete. This work is now being carried on speedily, the cement for the work coming from the Canada Cement Company at Calgary. The Rogers Pass tunnel will be the first all-concrete-lined tunnel in Canada, and one of the few on this continent. It is an expensive procedure, but assures against ordinary slides and falling rocks within and the consequent danger of derailment and wrecks. This lesson was severely learned in the case of the spiral tunnels at Field, B.C., which were partly lined with timber and partly unlined in any way, and to this day have given great trouble from streams of seeping water in summer and ice in winter.

Toronto, Ont.—The failure of expert divers last fall to detect the defective cribwork in the new ship channel in connection with the reclamation work and harbor improvements at Ashbridge's Bay has necessitated the pressing into service of the hydraulic dredge "Tornado" of the Canadian Stewart Company. Owing to the muddy condition of the water it has been impossible for the divers to examine the work properly. In order to do the work more efficiently with the assistance of the hydraulic dredge sheet piling had to be installed across the channel, while it was found necessary to dyke the channel near the turning basin. Millions of gallons of water will have to be pumped out of the channel before the engineers will be able to make a proper inspection of the defective cribwork, a portion of which has already caved in and allowed the sand to pour into the bottom of the channel.

Hamilton, Ont.—The proposed coke ovens, which have been mentioned in this column before, are to be erected, according to representatives of the United Gas and Fuel Company, who were in conference with the Board of Control. Under the agreement the Hamilton By-Product Coke Ovens Company will commence at once the erection of its ovens here, the same to be completed and in operation in 1917. To take care of the intervening time, especially the coming winter months, the United Gas and Fuel Company has agreed to make such extensions to its artificial gas plant as may be required to maintain a supply equal to the demands. Furthermore, the company will conserve all the natural gas obtainable for use in this city. As to price, it was announced that the agreement was most satisfactory, the company having stated a maximum amount for both coke gas and also for the mixed product. In the latter case until the percentage of natural gas falls below half of the whole output, the price will remain at that charged for natural gas.

Editorial

MONTREAL ENGINEERS PETITION CITY TO INVESTIGATE AQUEDUCT ENLARGEMENT.

Thirty-one of the leading engineers resident in Montreal have handed a petition to the city council and board of control, again calling upon the authorities to appoint a commission of prominent engineers for a comprehensive study and report upon the aqueduct enlargement scheme. The text of the petition is printed upon another page of this issue.

There is no doubt but that the city council should at once grant the request and appoint a strong and entirely independent commission consisting of at least three qualified engineers, a banker who is conversant with the city's finances—Sir Frederick Williams-Taylor would be most acceptable—and, as chairman, some prominent Montreal business man who has the welfare of the city at heart, and who has been efficient and successful in general business matters, but who has never "mixed in" politically. This commission should be given funds and authority with which to work unhampered, and its hearings should be public. If necessary, it should be made a Royal Commission, appointed by Quebec. The matter is worthy of it. Some ten millions of dollars may be at stake.

Whether they ever recognize the fact or not, the citizens of Montreal owe a heavy debt of gratitude to the engineers of that city who have brought this matter to their attention, and who have kept at it, despite all discouragements. To J. A. Jamieson, R. S. Lea and G. R. Heckle must go the credit for having first brought the matter to the city's attention. These three men had been appointed by the city as consulting engineers to investigate the break in the conduit which happened in December, 1913. About March 1st, 1914, in reporting upon the conduit, they made five recommendations, of which the very first was,—

"That before any further work is proceeded with, at least on the north side of the aqueduct, an investigation be made by a commission of engineers into the entire aqueduct scheme, which will include revised estimates of the cost of construction and the quantity and cost of the power developed."

This recommendation was never adopted, and the three engineers got a hearty "call-down" for touching upon matters not directly bearing upon the conduit. However, from evidence that they had uncovered in their conduit investigations, they were convinced that such a commission was needed in the public interest, and Mr. Jamieson refused to let the matter drop. He wrote many public letters to Controller Cote concerning the situation, and it was not long before other public-spirited engineers, such as Sir John Kennedy, Walter J. Francis, Phelps Johnson, R. A. Ross, Arthur Surveyer, Richard Durley, Ernest Marceau and many others, took up the cudgels and secured action by the Council of the Canadian Society of Civil Engineers and by Montreal's Board of Trade.

It is plain, therefore, that the Montreal civic authorities have had this matter before them for more than two years. During those two years large sums have been spent on the work—sums which a commission may say have been spent uselessly. *The Canadian Engineer* endorses the request to the Montreal city council that this work be stopped until a commission has reported upon it. The scheme may be sound, but it should be proven so, clearly and above-board. It is more imperative now, than ever before in the Empire's history, to prevent all economic waste. Remember the silver bullet!

WATER TRANSPORTATION IN CANADA.

In the March 2nd issue of *The Canadian Engineer* there appeared a paper on "Economic and Strategical Aspects of the Enlargement of the Welland Canal and of Construction of the Georgian Bay Ship Canal."

This paper was presented before the Canadian Society of Civil Engineers by Major R. W. Leonard, Mem.Can. Soc.C.E.

The following issue of the paper contained a discussion of this interesting theme, in which different aspects of the project were dealt with.

The question of transportation in Canada is receiving particular attention at the present time, this attention, undoubtedly, being accentuated by the fact that the war is expected to introduce new problems which will be intimately related to transportation in more ways than one.

A great deal of discussion has been given to the Georgian Bay Canal. Pamphlets approving and disapproving of the project have been printed and circulated by the thousands—special articles have appeared in all kinds of publications, and it is doubtful if any single engineering project has brought about so much discussion as it has.

In view of the importance of the transportation problem in Canada, it is to be hoped that the duties and hours of the Georgian Bay Canal Commission will be extended so as to include a thorough investigation of the whole subject of water transportation between the Lower St. Lawrence and Lake Superior by the St. Lawrence and lower lake route, as well as by the Ottawa and Georgian Bay route, and that the advantages and disadvantages of both routes be exhaustively compared with each other and also with lake and rail transportation via Georgian Bay, and by all rail routes via railways already built or hereafter to be built, because it is only by considering the Ottawa and Georgian Bay route as one of two great water routes and again by comparing these with the upper lake and rail route and with all rail routes that the Georgian Bay Canal project can be properly and intelligently dealt with.

If the Commission were empowered to extend its investigations along these lines, it would necessarily include some new surveys and estimates for dealing with the St. Lawrence and its canals and water power sites between Montreal and Prescott. Such surveys could be quickly made and at a cost which would be insignificant as compared with their value in enabling the Commission to arrive at conclusions which would be more satisfactory in every way.

PERSONAL.

P. TURNER BONE was re-elected president of the Alberta Sewer Pipe Company, of Calgary, at the annual meeting.

P. G. MAHONEY, M.L.A., has been appointed to succeed the Hon. John Morrissy as Minister of Public Works for the Province of New Brunswick.

L. G. IRELAND, general manager of Brantford Hydro-Electric Commission and Brantford Municipal Railways Commission, has handed in his resignation, to take effect at the end of May. He has been appointed chief engineer of new Hydro development in Eastern Ontario.

GEORGE McKNIGHT has been appointed city engineer of Fredericton, N.B. Mr. McKnight was formerly with the Transcontinental Railway on construction, and latterly with the St. John and Quebec Railway.

Capt. E. T. STERNE, of the Engineers, Kingston, has been loaned by the Militia Department to the Imperial Munitions Board to act as inspecting chemist of Tri Nitro Toluol at the Montreal plant Canadian Explosives, Limited.

L. G. McNEICE, B.Sc., who for three years was in London in the interests of Engineers Chipman and Power, has been appointed general manager of the public utilities at Wallaceburg. Mr. McNeice recently installed the new waterworks and sewage farms at Wallaceburg. In his new position he will have full charge of these and also of the electric department.

THOS. L. HINCKLEY, B.S., has been appointed engineer to the Bureau of Municipal Research, Toronto. Mr. Hinckley is a graduate of the Massachusetts Institute of Technology, from which he graduated in 1906. Since then he has been engaged in sanitary engineering, having been connected with the design and construction of water supply and sewage disposal works at Columbus, Ohio, Montreal, Que., and other places. For the past four years Mr. Hinckley has been especially interested in municipal research work in various cities.

LIST OF OFFICERS OF No. 1 CONSTRUCTION BATTALION.

Among the officers of No. 1 Construction Battalion, stationed in Toronto, are the following, who have been appointed under Lieut.-Col. B. Ripley:—

Captain and Adjutant T. R. Loudon, civil engineer, who is well known in Toronto, having been assistant professor of ferro-metallurgy at Toronto University and of late a member of the firm James, Loudon & Hertzberg, consulting engineers. He has for some time been instructing at the militia headquarters at Toronto.

Captain J. H. Byrne, civil engineer, graduate of the Royal Military College. He has been connected with the National Transcontinental Railway as district and government inspecting engineer and has had long and varied experience on construction, chiefly of railways.

Captain R. R. Holland, civil engineer. He has been actively connected with the construction of railways and other important engineering works for the past fifteen years, having filled positions as resident engineer, assistant engineer and division engineer on both the C.N.R. and National Transcontinental Railways.

Captain A. R. Ketterson, civil engineer, at present assistant bridge engineer of the Canadian Pacific Railway at Montreal. He has also represented the bridge engineer on Western lines C.P.R., and has had long and varied experience in engineering and construction both in Canada and Scotland.

Captain Quartermaster Victor G. Davis, formerly of the purchasing departments of both the Canadian Pacific and Canadian Northern Railways. Has also qualified as a lieutenant.

Lieutenant G. O. Fleming, civil engineer, graduate S.P.S., Toronto; experience being chiefly on construction connected with the Toronto Railway Company and with the engineers at militia headquarters at Toronto.

Lieutenant J. B. Heron, civil engineer, well known in Toronto, who has had a long experience chiefly at railway construction. This officer has had South Africa experience, having fought in the Boer War.

Lieutenant Fred. G. Cross, civil engineer, for nine years with the Canadian Pacific Railway in Western Canada.

Lieutenant H. R. McQueen, civil engineer, graduate of the Royal Military College; experience in both mining and railway work.

Lieutenant O. P. Hertzberg, civil engineer, for some years connected with the engineering department of the C.P.R. For two years he was with Lieut.-Col. Ripley on grade separation in Toronto. This young man was in several engagements in the present war and is now recuperating at home.

Lieutenant H. L. Gilmour, civil engineer, well known in Ottawa; graduate of McGill University; has been prominently connected with the lumber industry in the Ottawa valley.

Lieutenant Geo. S. Grant, contractor and construction man, well known in Ottawa, and a son of the late Mr. Hugh Grant, well-known contractor, having been connected prominently with the building of the Intercolonial Railway in Cape Breton.

CANADIAN SOCIETY OF CIVIL ENGINEERS—ELECTIONS AND TRANSFERS.

At a meeting of the Council of the Canadian Society of Civil Engineers held April 18th the following elections took place:—

Member—Thomas Taylor, Toronto.

Associate Members—Louis Napoleon Boulet, Montmagny, Que.; Andrew Galloway, Victoria, B.C.; Albert Walker Haddow, Edmonton, Alta.; J. M. Maurice LaForest, Montreal; Charles Ross Lindsey, Shawinigan Falls, Que.; Edlin Geo. Wm. Montgomery, Regina, Sask.; Kenneth Stockton Pickard, Sackville, N.B.

Juniors—Horace Malcolm Bigwood, Victoria, B.C.; George Fleming Irving, Winnipeg, Man.

The Council also announce the following transfers:—

From Associate Member to Member—Allan Beacon Aitken, Quetta, Baluchistan; G. Gordon Gale, Hull, Que.; Chauncey Marsh Goodrich, Detroit, Mich.; John Bell McRae, Ottawa.

From Junior to Associate Member—Halfden F. H. Hertzberg, Toronto; Norman Marr, Campbellford, Ont.; Robert Bruce Stewart, New Glasgow, N.S.; Jas. LeRoy Whitside, Winnipeg, Man.

From Student to Associate Member—Leonard Joseph Bisson, Fort William, Ont.; Donat Paquet, Montmagny, Quebec.

From Student to Junior—William Layton Frame, Vancouver, B.C.; Alfred John Lawrence, Montreal.