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The Canadian Engineer

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NATIONAL TRANSCONTINENTAL RAILWAY BRIDGES

A GENERAL SUMMARY OF ENGINEERING DATA ON THE 10.96 MILES OF STEEL BRIDGES AND VIADUCTS ON THE NATIONAL TRANSCONTINENTAL RAILWAY.

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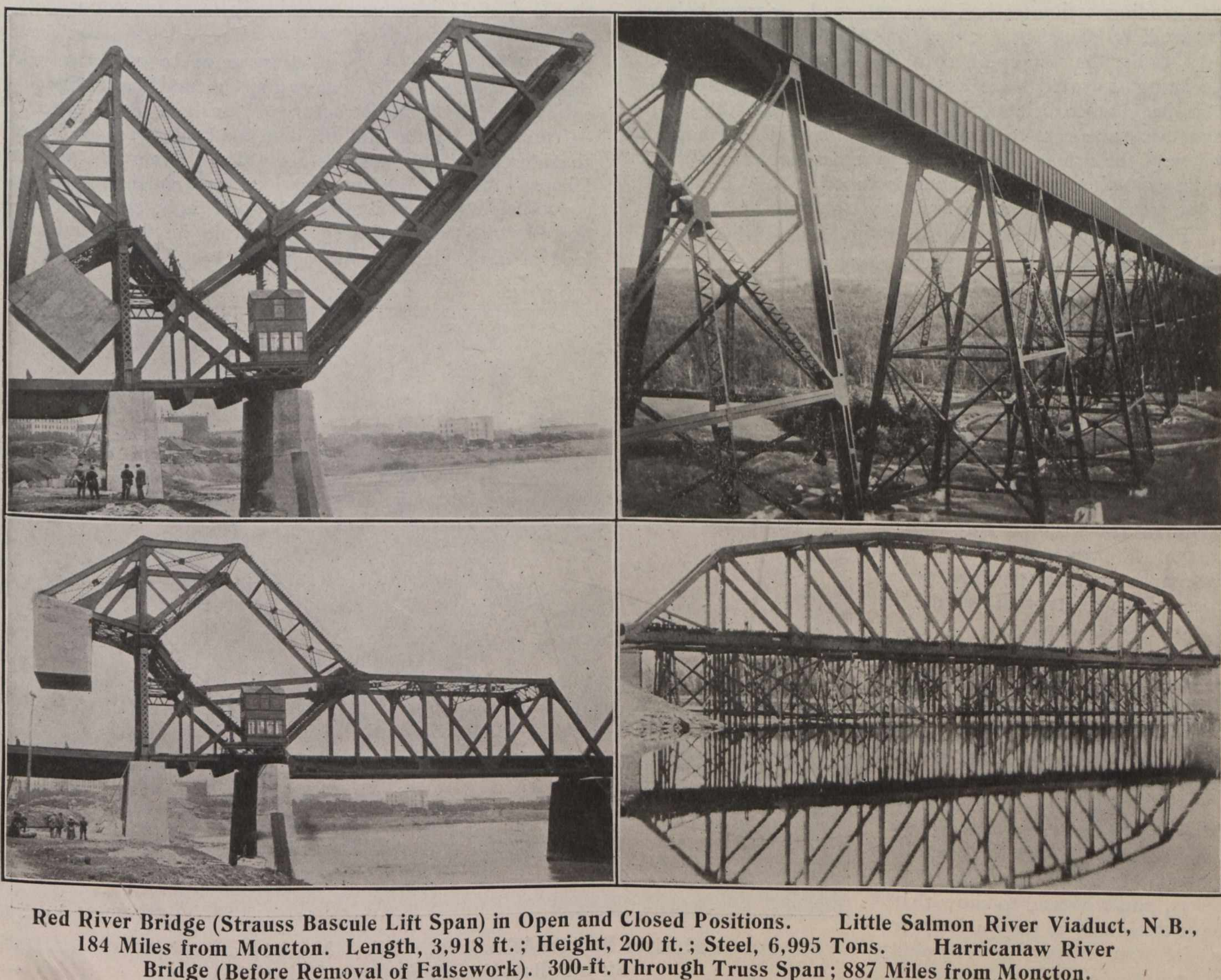
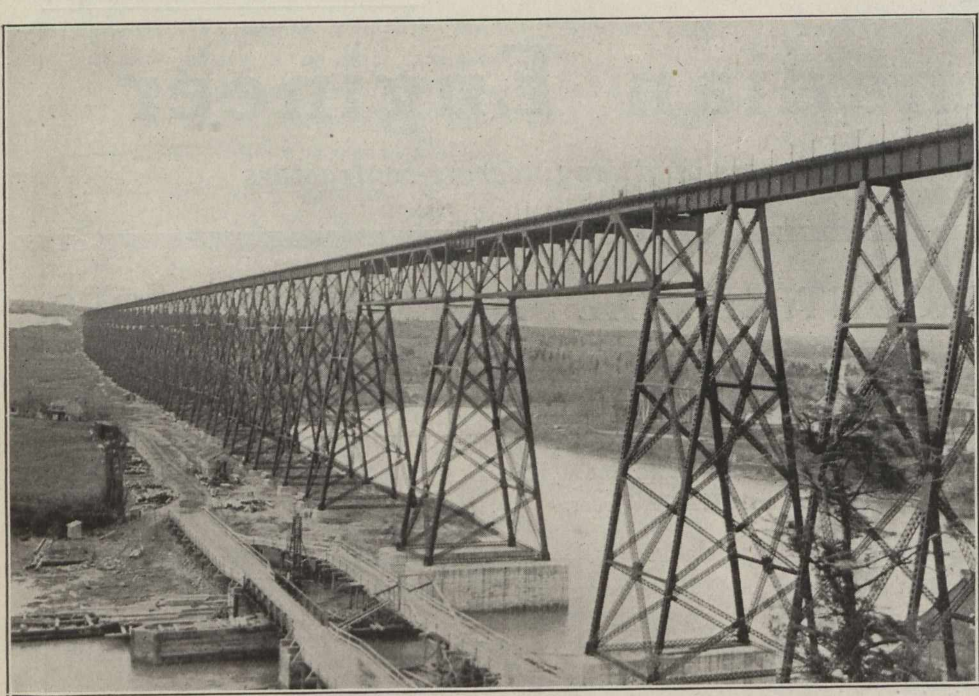
WHEN the last rail on the main line of the National Transcontinental Railway was laid in November, 1913, at a point about 130 miles east of the boundary between the Provinces of Quebec and Ontario, the construction of the eastern and western portions were thereby joined, the result being an unbroken main line from Moncton to Winnipeg, with the exception of the Quebec bridge.

The promising factor in this linking-up was the knowledge that the end of the construction of this vast project, begun in 1904, was in sight, and with the completion of construction would come the operation of the line.

For about a year after the last rail was laid the work of cleaning up the odds and ends of construction was prosecuted, with the result that by the end of 1914 all the



Red River Bridge (Strauss Bascule Lift Span) in Open and Closed Positions. Little Salmon River Viaduct, N.B., 184 Miles from Moncton. Length, 3,918 ft.; Height, 200 ft.; Steel, 6,995 Tons. Harricanaw River Bridge (Before Removal of Falsework). 300-ft. Through Truss Span; 887 Miles from Moncton.



Cap Rouge Viaduct. 2.9 Miles West of Quebec St. Lawrence River Bridge. Length, 3,335 ft. Height, 172 ft. Tons steel, 4,228.

final grading estimates had been returned, or were being prepared.

During the winter of 1914 the only portions of the line being operated were as follows: From Moncton to near the Quebec bridge, by the Intercolonial Railway; from Cochrane east to Harricanaw, and west to Hearst, by one of the firms of grading contractors, under contract to the Commission; from Superior Junction to Winnipeg, by the Grand Trunk Pacific Railway Company.

Parliamentary enactment has given the Minister of Railways and Canals the power to operate a part, or the whole, of the line, if necessary, and also to acquire the Grand Trunk Pacific branch from Fort William to Superior Junction.

Owing to the recent refusal of the Grand Trunk Pacific Company to take over the line for operation, the Minister has exercised his rights and has placed the operation under the management of the Canadian Government Railways, so that all the points between Moncton and Winnipeg are now accessible to the travelling public.

Many articles have been written on the ease of the gradients, the lightness of the curvature, and the splendid roadbed, but with all these favorable elements the chain would not be of much value if the connecting links were weak.

As the bridges are undoubtedly these links a few facts concerning them may be of interest to the readers of *The Canadian Engineer*, and will tend to show that the whole chain is fully as strong as it was originally intended to be.

While an article of considerable length might be written, giving the history of any one particular bridge built on the Transcontinental, the writer proposes in the present article to give only a general summary of the information regarding the construction of the bridges and viaducts.

The sub-structure of all steel bridges is of concrete, designed in all cases to be fully adequate for every requirement. Where the foundation for piers and abutments was not of solid rock, or other equally suitable material, piles were driven to the limit of penetration, and the concrete sub-structure laid on the foundation thus prepared. Reinforcement was used in all cases where it was considered necessary, and in cases where its use gave efficient as well as economical design. Very frequently streams of considerable size were temporarily diverted while some difficult construction was in progress. Sheet-piling of the Wakefield type was principally used for cofferdams, and proved very satisfactory.

All bridges have been constructed to conform with the "Department of Railways and Canals General Specifications for Steel Superstructures of Bridges and Viaducts"—(1905 and 1908), and the live load in all cases being considered in the designs as "Class Heavy" (as per Diagram "B" of the Specifications) and consisting of two consolidated locomotives of 180 tons each, coupled, connected with and followed by a train having a uniform load of 4,750 lbs. per lineal foot.

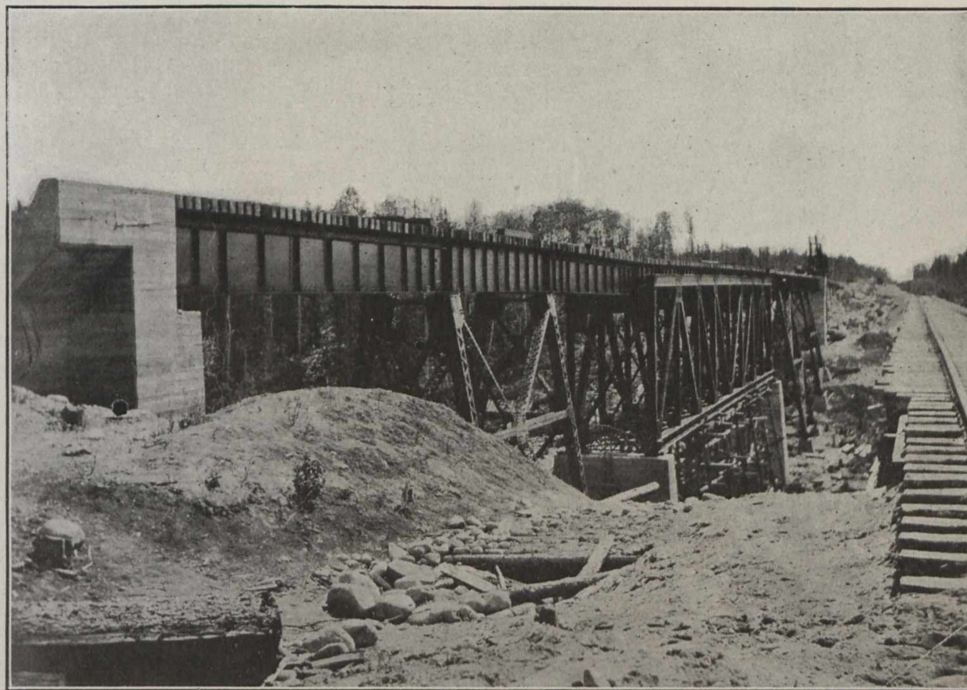
Red River Bridge, Winnipeg. Mile 1,804 from Moncton. (Strauss Bascule Lift Span of 129 ft. 6 in.)

The inspection of all bridges, covering mill, shop and erection inspection, was in accordance with the above specifications, and rigidly adhered to.

All contracts were let to Canadian firms, and although numerous difficulties were encountered in the way of getting the fabricated material on the ground, etc., the erection was in most cases fairly close to the time allotted for completion, and very few casualties occurred.

The total length of the main line from Moncton to Winnipeg is 1,803.4 miles (not including the Quebec bridge).

Of this length there is a total of 10.961 miles of steel bridges and viaducts, and 1.752 miles of permanent timber trestles, or a total of 12.713 miles of permanent bridges, representing seven-tenths of one per cent. of the total main line mileage constructed.



Frederickhouse River Bridge, Ontario. Mile 1034 from Moncton. Length, 622 ft. Height, 78 ft. Tons Steel, 670.

Table II. gives the location and lengths of permanent timber trestles, and Table III. gives the lengths, weights, etc., as constructed in the different provinces through which the line runs.

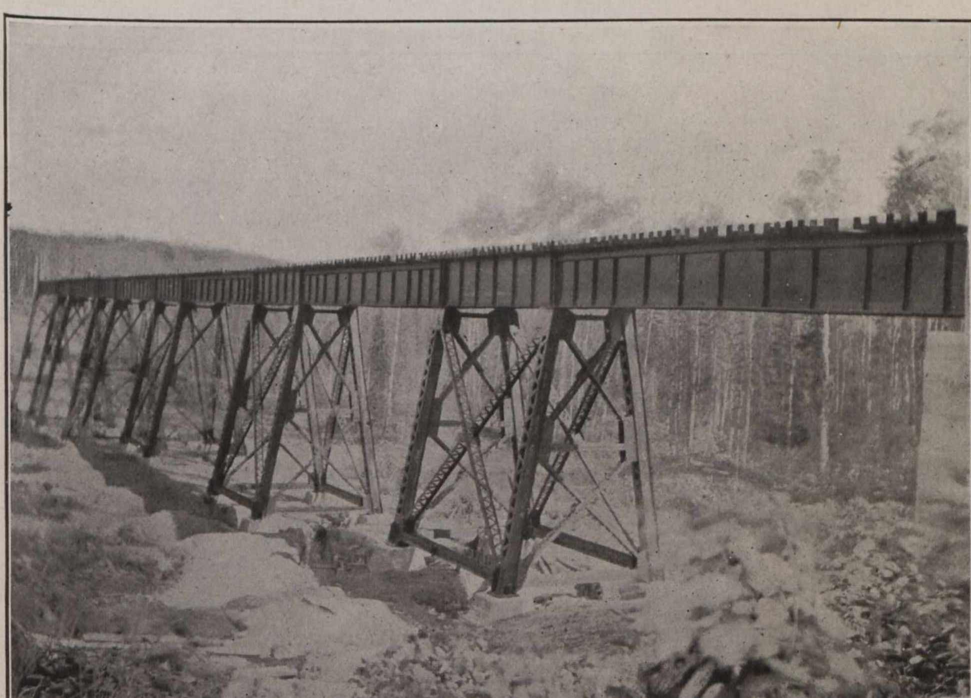
The total weight of steel in bridges and viaducts is 123,771,905 lbs., or 61,886 tons, and the average contract price paid for the material in place was 4.61 cents per pound.

The total amount of sawn ties, etc., used for flooring steel bridges and viaducts (not including permanent timber trestles, or five overhead crossings in Winnipeg where concrete was used), was 7,943,772 feet B.M., and the average contract price paid for this material in place was $51.44 per M.B.M.

The total cost of superstructure in steel bridges and viaducts, including machinery, electrical equipment, signals, etc., at the Red River bridge; flooring, inspection, etc., was approximately $6,185,000.

The total number of permanent bridges erected has been 230, the shortest single crossing being 20 feet, and the longest 3,918 feet.

Allowing an average of 40,000 lbs. to a car, or 20 tons, the number of cars that would be required for the transportation of the steel used in the bridges and viaducts would be about 3,100, representing a solid train of cars over twenty miles long.



Mistongo River Bridge, Ontario. Mile 1001 from Moncton. Length, 1,072 ft. Height, 80 ft. Tons Steel, 892.

The longest crossing occurs in New Brunswick, and is known as Little Salmon River viaduct. This is a single-track structure, and, as noted above, is 3,918 feet long, with a height from deck to water line in the valley beneath of approximately 200 feet. A through plate girder system was adopted for the entire length, resting on twenty-four towers of 58 ft. 9 in. centres, and having twenty-five intermediate spans of 100 ft. 3 in. centres—the two end spans being increased to 100 ft.-10½ in. from centre of bent to outer end of steel. The actual quantity of steel in this viaduct is 13,991,310 lbs., or nearly 7,000 tons, and 518,041 ft. B.M. of 8-in. x 12-in. bridge ties were used for flooring. The total cost of the super-

Canaan River Bridge, New Brunswick. Mile 21.6 from Moncton. Length, 532 ft. Height, 84 ft. Tons Steel, 424.

structure was approximately $680,000. The actual erection of the steel occupied 144 working days (about 50 tons per day), although from the time the erection commenced until all painting and riveting was fully completed, slightly over one calendar year had elapsed.

The second longest crossing occurs about three miles north of the Quebec bridge, and is known as the Cap Rouge viaduct. This single track structure is 3,335 feet long, and is composed of the following spans: 1 @ 125 ft.; 1 @ 150 ft.; 1 @ 160 ft. (deck trusses); 32 @ 40 ft.; 27 @ 61 ft. (deck plate girders)—the whole supported on 30 towers of 40-ft. span, and one rocker bent, the height of the towers varying from 53 ft. to 146 ft. The height from water line to deck is 172 ft. The actual quantity of steel in this viaduct is 8,456,297 lbs., or 4,228 tons, and timber used for the deck amounts to 613,122 ft. B.M. The total cost of the superstructure was approximately $360,000.

From the Transcona division yard to the terminals at Winnipeg, a distance of 5.3 miles, the line is double-tracked, and all the bridges and viaducts are arranged accordingly.

From the entrance into St. Boniface to the west side of Water Street in Winnipeg (included in the above), a distance of 2.1 miles, all crossings of streets and tracks are taken at high level, and beside these are the crossings of the Seine River and the Red River. The total quantity of steel in bridges and viaducts placed in this distance (2.1 miles) is 10,036,306 lbs., or 5,018 tons.

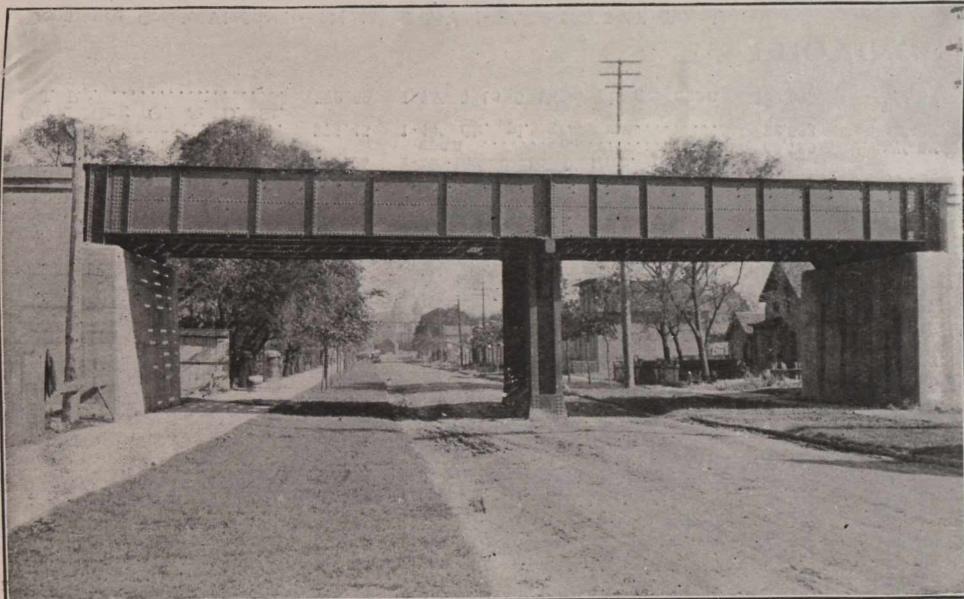
The Seine River is crossed by a viaduct, composed of the following spans: 1 @ 100 ft.; 4 @ 50 ft.; 2 @ 30 ft. (deck plate girders), resting on two towers of 30-ft. span, piers and abutments.

The Red River is crossed by four 150-ft. through truss spans, and one Strauss bascule lift span, having a length from centre of trunnion to end of span of 129 ft. 6 in., and from centre of trunnion to centre of in-shore rest pier 40 ft. 0 in. This lift span is electrically operated and the whole system thoroughly interlocked. The counterweight is of concrete contained in a steel cage, and concrete used for this purpose amounts to 467 cubic yards. The operating machinery weighs approximately 50 tons.

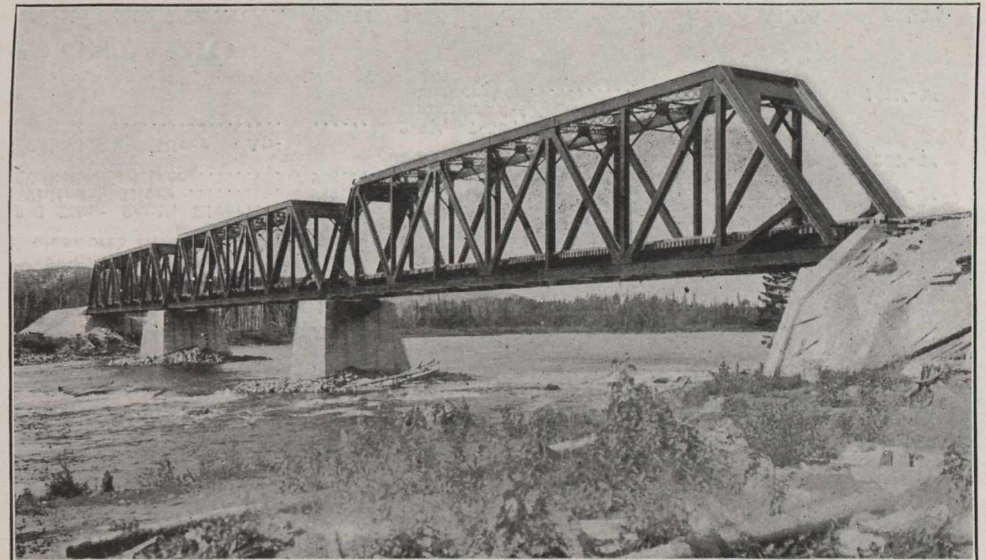
As will be seen by Table I., which gives a complete list of steel bridges and viaducts, there are a number of structures, other than those already mentioned, with weights of steel varying from 500 tons to 1,700 tons, and in lengths of crossings up to about 1,300 feet. While the timber trestles mentioned are designated "permanent," there is no doubt but that in the course of a few years these will be replaced by steel trestles or embankments.

The traveller becomes aware, immediately, of the crossing of the bridges and viaducts, but there are a large number of waterways that one would cross in a journey from Moncton to Winnipeg of which there would be no indication on the train, as concrete arch culverts have been used, some of which are 40 feet in diameter, and all are covered by embankments brought up to the permanent grade line.

Little Salmon River Viaduct, New Brunswick. Mile 184 from Moncton. Length, 3,918 ft. Height, 200 ft. Tons Steel, 6,995.



Notre Dame Street Crossing, Winnipeg. Mile 1,804.5 from Moncton.



Third Crossing St. Maurice River, Quebec. Mile 656 from Moncton. Three Skew Spans of 200 ft.; Total Length, 613 ft. Height, 35 ft. Tons Steel, 979.

TABLE I.

NATIONAL TRANSCONTINENTAL RAILWAY STEEL BRIDGES AND VIADUCTS

PROVINCE OF NEW BRUNSWICK

Name	Through Mileage from Moncton	Description	Weight of steel in pounds	Back to Back of Ballast Walls
Over Xing Highway	8.5	1-18′ dk. pl. gr. span	13,409	20′-0″
Canaan River Viaduct	21.70	5-30′, 5-60′, 1-80′ dk. pl. gr. spans and 5 towers 30′ span.	848,133	532′-2″
Over Xing Red Bank Rd.	54.60	1-66′ half thro. pl. gr. span	110,097	68′-2″
Salmon River (Chipman) Viaduct at E. End	57.00	4-40′, 4-60′, 2-80′ dk. pl. gr. spans and 4 towers 40′ span and 4-150′ dk. truss spans	2,178,372	1176′-5″
Over Xing Salmon River Rd.	57.50	1-21′-4″ dk. pl. gr. span	27,050	23′-6″
Newcastle Stream	67.00	4-40′, 6-60′ dk. pl. gr. spans, 4 towers 40′ span and 1 rocker bent	1,000,095	522′-2″
Cains River	82.00	1-80′ dk. pl. gr. span	93,570	82′-2″
S. W. Miramichi	124.50	1-175′ thro. truss span	491,911	179′-4″
N. B. S. W Miramichi	133.00	1-125′ thro. truss span	292,759	129′-0″
Juniper Brook	134.07	1-44′ thro. pl. gr. span	53,500	46′-2″
Odell Brook	150.00	1-44′ thro. pl. gr. span	70,700	47′-0″
Tobique River	165.00	3-140′ dk. trusses, 2-100′ and 1-80′ dk. pl. gr. spans	1,471,866	713′-6″
Over Xing Highway	165.30	1-22′-7″ dk. pl. gr. span	16,344	25′-0″
Graham Brook Viaduct	180.40	3-60′, 3-50′ and 5-40′ dk. pl. gr. spans and 5 towers 40′ span	998,840	532′-2″
Caton Brook Viaduct	181.60	11-60′, 10-40′ dk. pl. gr. spans and 10 towers 40′ span	2,397,478	1062′-2″
Under Xing Foley Brook Road Viaduct	182.90	3-22′ I Beams spans	31,134	67′-8″
Little Salmon River Viaduct	184.30	25-100′-3″, 24-58′-9″ thro. pl. gr. spans and 24 towers 58′-9″ span	13,991,310	3918′-2″
Under Xing Falls Brook Road	190.00	1-99′ Pony truss span	72,866	100′-8″
Little River Viaduct	191.50	11-40′, 9-60′, 2-80′ and 1-100′ dk. pl. gr. spans and 11 towers 40′ span	2,529,396	1242′-2″
Four Mile Brook Viaduct	197.20	6-30′, 1-59′-7″, 5-60′, 1-75′ dk. pl. gr. spans and 6 towers 30′ span	1,055,359	616′-0″
Grand River	207.20	2-88′ thro. pl. gr. spans	312,222	182′-0″
Sigas River	209.60	1-80′ dk. pl. gr. span	94,028	82′-2″
Quisibis River	213.50	1-99′ thro. pl. gr. span	191,778	102′-2″
Green River	219.60	2-77′ thro. pl. gr. spans	246,239	158′-1″
Iroquois River	227.80	1-66′ thro. pl. gr. span	98,949	68′-2″
Madawaska River	229.90	1-99′ and 1-83′-6″ thro. pl. gr. spans	337,233	188′-6″
Over Xing Ferry Rd.	230.30	1-33′ thro. pl. gr. span	33,473	35′-2″
Baker Brook	242.80	1-80′ dk. pl. gr. span	93,590	82′-2″
Under Xing Highway, Baker Lake	251.80	1-40′ thro. pl. gr. span	17,615	42′-3″

STEEL BRIDGES AND VIADUCTS.—*Continued.*

PROVINCE OF QUEBEC

Name	Through Mileage from Moncton	Description	Weight of steel in pounds	Back to Back of Ballast Walls
Kitchen Brook	256.31	1-33′ thro. pl. gr. span	33,924	35′-2″
Narrows Lac Long	265.45	1-66′ thro. pl. gr. span	98,733	68′-2″
Blue River	276.78	4-80′ dk. pl. gr. spans and 1-150′ dk. truss span	797,424	476′-2″
Nigger Brook	283.45	1-55′ thro. pl. gr. span	71,774	57′-2″
St. Francis River	285.84	2-55′, 1-99′ thro. pl. gr. spans	414,232	219′-4″
Boucanne River	292.49	1-150′ dk. truss, 4-60′, 3-56′, 2-40′, 5-30′ dk. pl. gr. spans 5 towers 30′ span and 2 towers 40′ span, viaduct	1,826,122	790′-2″
Rochue River	300.95	1-35′ dk. pl. gr. span	27,694	37′-2″
Main Fourchue River	305.80	1-30′ dk. pl. gr. span	22,549	32′-2″
Little Black River	312.95	1-55′ thro. pl. gr. span	72,172	57′-2″
Manie River	316.95	1-50′ dk. pl. gr. span	50,531	52′-2″
River du Loup	323.45	2-60′ & 1-80′ dk. pl. gr. span.	225,066	209′-8″
River eau Chaude	332.70	1-60′ dk. pl. gr. span	60,364	62′-2″
Outlet Lake Therrien	361.15	1-77′ thro. pl. gr. span	122,900	79′-2″
Bras d'Apic E. Br.	369.30	1-60′ dk. pl. gr. span	60,600	62′-2″
Bras d'Apic W. Br.	370.45	1-60′ dk. pl. gr. span	60,600	62′-2″
Mechant Pouce	375.45	1-60′ dk. pl. gr. span	60,620	62′-4″
Fortins Creek	375.95	1-60′ dk. pl. gr. span	60,600	62′-2″
Bras St. Nicholas	380.45	1-33′ thro. pl. gr. span	34,594	35′-2″
Fourche du Pin	395.69	2-70′ dk. pl. gr. & 1-125′ dk. truss spans	473,504	267′-2″
Abenakis River	414.25	1-100′ & 2-60′ dk. pl. gr. spans	277,000	228′-4″
Etchemin River	420.25	2-100′ & 2-70′ dk. pl. gr. spans	451,944	351′-0″
Over Xing Q. C. Ry.	433.20	1-66′ thro. pl. gr. span	110,968	68′-2″
River le Bras	446.61	1-66′ thro. pl. gr. span	100,382	68′-2″
Creek Xing M. 13.2	447.25	1-40′ dk. pl. gr. span	31,771	42′-2″
Under Xing I. R. C.	457.50	1-88′ thro. pl. gr. span	158,008	90′-2″
Highway Viaduct Mile 2.17	458.28	1-50′ & 2-40′ dk. pl. gr. spans	66,110	132′-0″
Cap Rouge Highway	463.05	1-89′-2″ thro. truss swing	44,000	90′-8″
Cap Rouge Viaduct	463.07	32-40′, 27-61′ dk. pl. gr. spans, 1-125′, 1-150′, 1-160′ dk. truss spans, 30 towers 40′ span & 1 rocker bent	8,456,297	3335′-8″
River aux Pommes	479.95	1-50′ dk. pl. gr. span	46,373	52′-2″
Jacques Cartier River Viaduct	482.18	2-30′, 2-60′, 1-80′ dk. pl. gr. spans, 1-100′ dk. truss, 2 towers 30′ span and 1 rocker bent	832,881	360′-8″
Portneuf River	489.35	2-60′ & 1-100′ dk. pl. gr. spans	265,430	221′-4″
Grand Bras d'Arme	499.35	1-40′ dk. pl. gr. span	33,278	42′-2″
Lachevrotiere River	500.35	1-33′ thro. pl. gr. span	33,431	35′-2″
Ste. Anne River	503.58	2-70′ & 1-100′ dk. pl. gr. spans	443,280	341′-4″
River Noire	505.95	2-50′ dk. pl. gr. spans & 1-125′ dk. truss span	358,920	228′-8″
Nigerette River	506.45	1-30′ dk. pl. gr. span	20,731	30′-8″
Charest River Viaduct	510.79	4-30′, 1-45′, 3-60′, 1-75′ dk. pl. gr. spans & 4 towers 30′ span	641,728	420′-8″
Batiscan River	525.36	2-40′, 3-60′ dk. pl. gr. spans, 2-100′, 1-200′ dk. truss spans & 2 towers 40′ span	1,396,453 }	740′-8″
Batiscan R., W. Span	525.75	1-80′ dk. pl. gr. span	96,231 }	
Over Xing Highway	531.25	3 skewed spans	33,277	109′-0″
Tawachiche River	543.45	1-44′ thro. pl. gr. span	51,425	46′-2″
Roberge Creek	545.45	1-40 0 to 0 D.T. thro. pl. gr. span	96,405	40′-8″
R. des eaux Mortes	555.45	1-125′ dk. truss span	364,336	129′-0″
River du Millieu Viaduct	556.87	5-40′, 6-60′, 3-75′, 2-90′ dk. pl. gr. spans, 1-225′ dk. truss span, 2 towers 60′ span & 5 towers 40′ span	3,409,062	1198′-1″
1st Xing Brochet River	559.45	1-60′ dk. pl. gr. span	58,995	62′-2″
2nd Xing Brochet River	561.95	1-55′ thro. pl. gr. span	72,868	57′-2″
3rd Xing Brochet River	562.45	1-55′ thro. pl. gr. span	72,324	57′-2″
4th Xing Brochet River	568.95	1-33′ thro. pl. gr. span	33,387	35′-2″
5th Xing Brochet River	570.05	1-36′-10″ 0 to 0 thro. pl. gr. span	60,789	37′-6″
Creek a Beauce	575.45	1-40′ dk. pl. gr. span	32,533	42′-2″
Over Xing Q. & L. St. J. Ry.	578.39	1-76′ 0 to 0 thro. pl. gr. span	120,032	76′-8″
Little Bostonnais River	579.95	2-60′ & 1-100′ dk. pl. gr. spans	310,486	229′-4″
Big Bostonnais River	585.15	4-90′ dk. pl. gr. spans	519,204	373′-8″
Croche River	588.15	4-90′ skewed thro. pl. gr. spans	674,266	360′-8″
1st Xing St. Maurice	588.66	6-140′ thro. truss spans	1,951,535	864′-0″
River au Lait	589.35	1-77′ thro. pl. gr. span	122,719	79′-2″
Vermillion River	604.87	3-40′, 2-60′, 1-80′ dk. pl. gr. spans, 2-125′, 2-225′ dk. truss spans & 3 towers 40′ span	2,744,995	1036′-7″
Flamand River	626.45	1-175′ thro. truss span	517,573	179′-4″
Little Flamand River	634.95	2-55′ & 1-99′ thro. pl. gr. spans	341,009	216′-2″
2nd Xing St. Maurice River	648.05	3-200′ skewed thro. truss spans	1,981,574	630′-3″
3rd Xing St. Maurice River	655.61	3-200′ skewed thro. truss spans	1,957,375	613′-0″
Manuan River	657.36	3-180′ skewed thro. truss spans	1,637,351	552′-4″
1st Xing Ribbon River	658.33	2-150′ thro. truss spans	776,470	308′-0″
Atikmahik Creek Viaduct	662.33	8-60′, 7-30′ dk. pl. gr. spans & 7 towers 30′ span	985,457	691′-5″
Minachin Creek	679.95	1-44′ thro. pl. gr. span	52,419	46′-2″
2nd Xing Ribbon River	681.55	1-150′ thro. truss span	389,724	154′-2″
Picqui Creek	685.55	1-60′ dk. pl. gr. span	62,525	62′-2″
Lake Travers	687.13	2-77′ thro. pl. gr. spans	283,376	158′-8″
Upper Ribbon River	689.13	1-99′ thro. pl. gr. span	226,188	102′-8″
Boucher Creek	696.15	1-44′ thro. pl. gr. span	51,864	46′-2″
Gatineau R., E. Branch	706.86	2-70′ dk. pl. gr. spans	154,533	144′-2″
Marten River Viaduct	710.31	9-55′, 8-30′ dk. pl. gr. spans & 8 towers 30′ span	998,420	737′-2″
Little Pitch Pine Cr.	718.47	1-70′ & 2-35′ dk. pl. gr. spans	129,397	146′-10″
East Cache Creek	736.67	1-80′ & 2-40′ dk. pl. gr. spans	157,775	166′-10″
Oscelaneo River	739.17	1-50′ & 2-40′ dk. pl. gr. spans	109,157	136′-10″
Haycock Creek	744.47	1-70′ dk. pl. gr. span	75,636	72′-2″
Susie River	764.23	1-90′ dk. pl. gr. span	126,851	93′-8″
Dead Fox Creek	773.23	1-55′ thro. pl. gr. span	72,000	57′-2″
Kekek River	776.37	1-77′ thro. pl. gr. span	124,728	79′-2″
Mamaguish River	784.13	1-80′, 5-60′, 4-40′ dk. pl. gr. spans 4-40′ towers & 1 rocker bent	727,691	542′-2″
Durant Lake	791.43	1-30′ dk. pl. gr. span	21,862	32′-2″
1st Xing Atik River	795.63	1-80′ dk. pl. gr. span	93,510	82′-2″
2nd Xing Atik River	800.93	1-80′ & 2-50′ dk. pl. gr. spans	189,495	186′-2″
3rd Xing Atik River	803.46	1-80′ & 2-60′ dk. pl. gr. spans	213,782	206′-2″
4th Xing Atik River	807.33	1-80′ & 2-60′ dk. pl. gr. spans	213,781	206′-2″
Canyon Creek	812.53	1-80′, 5-60′, 4-40′ dk. pl. gr. spans 4-40′ towers & 1 rocker bent	844,188	542′-2″
1st Xing Megiskan River.	819.53	2-125′ dk. truss & 2-100′ dk. pl. gr. spans	876,900	457′-6″
Sunday River	830.53	1-125′ thro. truss span	296,623	125′-0″
2nd Xing Megiskan R.	835.28	2-60′ dk. pl. gr. & 1-250′ thro. truss spans	1,087,000	375′-6″
Bell River	843.33	2-60′ dk. pl. gr. & 1-160′ thro. truss spans	537,880	288′-0″
Cedar Creek	855.83	1-39′ dk. pl. gr. span	32,505	39′-8″
Natagagan River	862.15	1-70′ dk. pl. gr. span	73,700	71′-0″
Peter Brown Creek	878.48	1-100′ & 2-40′ dk. pl. gr. spans	212,735	188′-4″
Harricanaw River	887.38	1-300′ thro. truss & 2-70′ dk. pl. gr. spans	1,431,004	449′-10″
Nawapitichin Forks Viaduct	904.73	4-60′, 3-40′ dk. pl. gr. spans & 3-40′ towers	458,983	362′-2″
Deer River	913.83	1-66′ thro. pl. gr. span	97,577	68′-2″
Robertson Lake	915.13	1-77′ thro. pl. gr. span	119,145	79′-2″
Kakameonan River	922.06	1-90′ & 2-50′ dk. pl. gr. spans	216,508	198′-4″
Molesworth River	930.69	1-150′ thro. truss, 1-90′ & 1-40′ dk. pl. gr. spans	523,415	289′-9″
3rd Xing South River	940.25	1-59′ 0 to 0 dk. pl. gr. span	56,000	59′-8″
Whitefish River	942.26	1-275′ thro. truss span	1,115,776	280′-2″
Okikodasik River	956.10	1-200′ thro. truss & 1-80′ dk. pl. gr. spans	806,020	286′-6″
Okikodasik River Approach	......	2-65′, 7-50′, 6-40′ dk. pl. gr. spans, 6-40′ towers and 1 rocker bent	745,600	1011′-8″

PROVINCE OF ONTARIO

Name	Through Mileage from Moncton	Description	Weight of steel in pounds	Back to Back of Ballast Walls
Departure Creek Viaduct.	971.48	2-80′, 1-60′, 3-50′, 5-40′ dk. pl. gr. spans, 5-40′ towers	644,600	573′-8″
Circle River	986.88	1-200′ thro. truss span	616,284	204′-4″
Low Bush River	987.02	1-200′ thro. truss span	617,888	204′-4″
Little Mistongo River	1000.32	1-100′ dk. pl. gr. span	149,000	103′-8″
Mistongo River Viaduct	1001.40	11-30′, 11-60′, 1-80′ dk. pl. gr. spans & 11 towers 30′ span	1,785,239	1072′-2″
Sucker Creek	1010.09	1-30′ dk. pl. gr. span	23,334	32′-2″
Abitibi River	*1019.63*	*4-30′, 2-57′-10″, 3-60′ dk. pl. gr. spans, 2-210′ dk. truss spans, 4 towers 30′ span & 1 rocker bent*	*2,270,526*	*840′-8″*
Brule Creek M .99	*1024.12*	*1-60′ dk. pl. gr. span*	*61,905*	*62′-2″*
Frederichouse River	*1033.92*	3-40′, 5-60′ dk. pl. gr. spans, 1-200′ dk truss span & 3 towers 40′ span	1,341,480	622′-2″
Buskegow River	1038.08	2-60′ & 1-90′ dk. pl. gr. spans	255,110	218′-4″
Driftwood River	1048.62	2-50′ & 1-100′ dk. pl. gr. spans	255,173	208′-4″
Mattagama River	1059.76	2-260′ thro. truss spans	2,018,062	530′-0″
Poplar Rapids River	1066.16	2-50′ & 1-70′ dk. pl. gr. spans	183,005	176′-2″
Wellington Creek	1074.37	1-70′ dk. pl. gr. span	80,213	72′-2″
Ground Hog River	1078.07	2-250′ thro. truss spans	1,934,180	510′-0″
Brule Creek M. 156	1081.12	1-55′ thro. pl. gr. span	74,055	57′-2″
Martin Creek	1083.12	1-35′ dk. pl. gr. span	26,080	37′-2″
Bass River	1093.72	1-55′ thro. pl. gr. span	75,300	57′-2″
Kapuskasing River, E. Br.	1097.86	2-100′ dk. pl. gr. spans	297,966	207′-0″
Kapuskasing River, W. Br.	1098.12	3-100′ dk. pl. gr. spans	456,373	310′-4″
Lost River	1106.07	1-100′ dk. pl. gr. span	147,966	103′-8″
Solomon Creek	1112.12	1-30′ dk. pl. gr. span	20,732	32′-2″
Opazatika River	1117.98	1-200′ thro. truss span	619,328	204′-4″
Montcalm Creek	1123.42	1-44′ thro. pl. gr. span	74,722	47′-0″
Crow Creek	1129.12	1-44′ thro. pl. gr. span	53,690	46′-2″
Missinabi River	1138.20	7-100′ & 2-80′ dk. pl. gr. spans	1,300,648	888′-4″
McIlworth Creek	1154.12	1-50′ dk. pl. gr. spans	46,929	52′-2″
Nelles Creek	1154.62	1-40′ dk. pl. gr. span	31,692	42′-2″
Mattawishquia River	1155.37	2-40′, 2-90′ & 1-100′ dk. pl.	458,355	375′-0″
Valentine Creek	1172.12	2-50′ & 1-80′ dk. pl. gr. spans	189,322	186′-2″
St. Joseph River	1174.63	1-44′ thro. pl. gr. span	53,780	46′-2″
Kebinagagami River	1177.58	1-150′, 1-125′ dk. truss spans, 5-60′, 2-30′ dk. pl. gr. spans, 2-30′ dk. towers and 1 rocker bent	1,251,432	641′-0″
Creek Mile 15.5	1188.35	1-33′ thro. pl. gr. span	33,720	35′-2″
Creek Mile 17.21	1190.06	1-33′ thro. pl. gr. span	33,720	35′-2″
White River	1195.71	2-100′ & 2-50′ dk. pl. gr. spans	415,525	311′-8″
Skunk River	1196.55	2-100′, 3-60′, 5-40′ dk. pl. gr. spans & 4-40′ towers	1,053,335	586′-0″
Nagagami River	1197.70	2-100′, 1-60′, 3-50′, 5-30′ dk. pl. gr. spans & 5-30′ towers	983,511	562′-11″
Nagagami Branch	1205.22	2-60′ dk. pl. gr. & 1-125′ dk. truss spans	425,536	247′-2″
Bad River	1214.78	1-125′ thro. truss & 2-50′ dk. pl. gr. spans	401,065	233′-0″
Martin Creek	1220.74	1-55′ thro. pl. gr. span	76,489	57′-2″
Clarke Creek	1227.35	1-40′ dk. pl gr. span	31,855	42′-2″
Pagwauchuan River	1233.10	1-150′ dk. truss span, 2-100′, 1-80′, 1-60′ & 1-40′ dk. pl. gr. spans	947,464	535′-3″
Midway Creek	1237.85	1-44′ thro. pl. gr. span	53,715	46′-2″
Dog River	1242.14	1-100′ dk. pl. gr. span	159,260	103′-8″
Mahaffy Creek	1245.02	1-44′ thro. pl. gr. span	53,740	46′-2″
Moose River	*1248.75*	*1-90′ dk. pl. gr. span*	*133,010*	*93′-8″*
Flint River	*1250.93*	*1-99′ thro. pl. gr. span*	*194,020*	*102′-2″*
Black Creek	*1254.00*	*1-44′ thro. pl. gr. span*	*53,755*	*46′-2″*
Kenogami River	*1259.08*	*4-65′, 1-30′ dk. pl. gr. spans,* 2-125′ dk. truss spans & 1-30′ tower	945,057	548′-0″
Decaire Creek	1267.55	1-33′ thro. pl. gr. span	34,518	35′-2″
Rabbitt Creek	1274.42	1-90′ dk. pl. gr. span	120,575	93′-8″
Beaver Creek	1285.45	1-40′ dk. pl. gr. span	30,000	42′-2″
Twin River	1294.55	1-100′ dk. pl. gr. span	149,000	103′-8″
McDonald Creek, E. Br.	1297.70	1-66′ thro. pl. span	96,000	68′-2″
McDonald Creek, W. Br.	1299.04	1-40′ dk. pl. gr. span	30,000	42′-2″
Kawashkagama River	1317.25	2-30′ dk. pl. gr. spans & 1-160′ thro. truss span	412,000	226′-0″
Trout Creek	1318.25	1-44′ thro. pl. gr. span	51,000	46′-2″
Johnson Creek	1323.25	1-77′ thro. pl. gr. span	119,000	79′-2″
Emilie Creek	1345.35	1-44′ thro. pl. gr. span	51,000	46′-2″
Spruce Creek	1349.85	1-55′ thro. pl. gr. span	72,000	57′-2″
Ombabika River	1356.57	1-66′ thro. pl. gr. span	96,000	68′-2″
Jackfish River	1379.84	1-100′, 6-60′, 5-40′ dk. pl. gr. spans, 5-40′ towers & 1 rocker bent	1,035,000	662′-2″
Mud River	1388.55	1-90′, 3-60′, 3-30′ dk. pl. gr. spans & 3 towers 30′ span	461,500	362′-2″
Rapid Creek	1397.45	1-55′ thro. pl. gr. span	72,000	57′-2″
White Sand River	1404.42	1-99′ thro. pl. gr. span	184,000	102′-2″
Lookout River	1447.85	1-99′ thro. pl. gr. span	184,000	102′-2″
Allan Water	1467.37	1-150′ thro. truss span	370,000	154′-2″
Sturgeon R., Mile 94	1521.32	1-220′ thro. truss span	734,322	225′-0″
Sturgeon R., Mile 118.8	1546.86	3 D.T. skewed thro. truss spans	2,313,234	457′-7″
Sioux Lookout River	1553.81	1-88′ thro. pl. gr. span & 1-175′ thro. truss span	675,429	272′-2″
1st Xing Edith Cr.	1587.66	1-24′-4″ 0 to 0 dk. pl. gr. span	15,224	25′-0″
2nd Xing Edith Cr.	1588.06	1-24′-4″ 0 to 0 dk. pl. gr. span	15,224	25′-0″
Wabigoon River	1626.66	2-40′ & 1-93′ 0 to 0 dk. pl. gr. spans	182,832	174′-0″
Creek Xing, M. 108	1662.66	1-20′-4″ 0 to 0 thro. pl. gr. span	20,016	21′-0″
Creek Xing, M. 118.25	1672.91	1-20′-4″ 0 to 0 thro. pl. gr. span	20,016	21′-0″
Macfarlane River	1684.32	1-100′ dk. pl. gr. span	147,384	103′-8″
Winnipeg River	1689.62	1-100′ dk. pl. gr. span	146,450 }	406′-10″
	......	1-300′ thro. truss span	1,196,103 }	
Creek Xing, M. 158.75	1713.41	1-20′-4″ 0 to 0 thro. pl. gr. span	20,016	21′-0″

PROVINCE OF MANITOBA

Name	Through Mileage from Moncton	Description	Weight of steel in pounds	Back to Back of Ballast Walls
Over Xing C.P.R.	1736.04	2-50′ dk. pl. gr. & 1-78′ thro. pl. gr. spans	228,390	183′-0″
Whitemouth River	1748.91	2-90′ dk. pl. gr. spans	231,474	180′-8″
Brokenhead River, E. Br.	1763.94	1-89′-10″ 0 to 0 thro. pl. gr. span	173,989	90′-8″
Brokenhead River, W. Br.	1770.54	1-59′-10″ 0 to 0 thro. pl. gr. span	98,502	60′-8″
Over Xing Poulin St., Mile 245.9	1802.44	1-55′ D.T. dk. pl. gr. span	176,139	57′-2″
Over Xing Russell Street	1802.63	1-55′ D.T. dk. pl. gr. span	141,055	57′-2″
Over Xing C.P.R. & Bickerton Street	1802.93	1-100′ D.T. pony truss, 4-31′-9″, 1-67′ D.T. dk. pl. gr. spans and 2 towers 31′-9″ span	918,462	297′-5″
Over Xing Archibald Street	1802.94	1-81′ D.T. dk. pl. gr. span	246,506 }	186′-0″
	....	2-50′ D.T. dk. pl. gr. spans	188,876 }	
Seine River Viaduct	1803.19	1-100′, 4-50′ and 2-30′ dk. pl. gr. spans and 2-30′ towers	819,178	368′-4″
Over Xing Highway, Mile 248.36	1803.20	1-71′-8″ D.T. dk. pl. gr. span	164,173	73′-10″
Over Xing C.N.R.	1803.58	Viaduct	702,446	301′-9″
Over Xing St. Joseph	1804.03	1-71′ D.T. dk. pl. gr. span	192,205	73′-2″
Over Xing Tache Ave.	1804.16	1-71′ D.T. dk. pl. gr. span	215,261	73′-2″
Over Xing C.N.R.	1804.20	1-55′-4″ D.T. thro. pl. gr. span	(weight incl. below)	58′-0″
Red River Bridge	1804.21	4-150′ D.T. thro. truss spans, 1 Bascule lift span and viaduct crossings over Notre Dame Ave., Mill and Water Sts.	6,272,005	970′-0″

TABLE II.
PERMANENT TIMBER TRESTLES

PROVINCE OF QUEBEC

Name	Through Mileage from Moncton	Length Feet	Remarks
Crooked Creek	824.43	405	
Sunday River	830.53	190	Approaches to 125′ through truss span.
Christmas Creek	839.43	1200	
Adelphus Creek	841.93	1817	
Poplar River	846.23	330	
Coffee Creek	850.03	495	
Clear Creek	854.23	75	
Cedar Creek	855.83	781	Approaches to 39′ dk. pl. gr. span.
Natagagan River	862.15	700	Approaches to 70′ dk. pl. gr. span.
Nawapitichin Forks	904.73	250	Approaches to Viaduct.
Molesworth River	930.69	639	Approaches to Bridge.
South River (1st Crossing)	936.12	950	

PROVINCE OF ONTARIO

Name	Through Mileage from Moncton	Length Feet	Remarks
Mistongo River	1001.40	1420	Approaches to Viaduct.

TABLE III.
BRIDGES AND VIADUCTS BY PROVINCES

Province	Miles of Main Line Track (not including Quebec Bridge)	Miles of Steel Bridges and Viaducts	Miles of Permanent Timber Trestles	Total Miles of Permanent Bridges	Proportional length of Bridges to Main Line Track	Tons of Steel in Bridges and Viaducts
New Brunswick	256.31	2.283	.....	2.283	.009%	14,585
Quebec	698.80	4.980	1.483	6.463	.009%	25,685
Ontario	758.63	3.124	0.269	3.393	.004%	16,232
Manitoba	89.70	0.574		0.574	.006%	5,384
Totals	1803.44	10.961	1.752	12.713	.007%	61,886

RAIL SPECIFICATIONS.*

By A. W. Gibbs.

IN America we are using heavier concentrated loads than are carried elsewhere. Much has been written to show the relative increases of the weights of rail and of loads carried, and conclusions have been drawn that one or the other has unduly increased. The variables in the conditions of service are very great and very perplexing. The climatic conditions are directly reflected in the monthly record of failures of all kinds, and a spell of unusually severe winter weather is immediately marked by a sudden increase in the number of failures. On the other hand, a succession of mild winters may show such a comparative immunity from failures as to delude us into the belief that at last we are making definite progress. The number of rails which fail annually, as compared with the total number in service, is very small when reduced to percentages. In many materials it could be ignored as purely an economic loss, and not very large at that. It is because the rail is part of a chain that its occasional failure assumes such importance.

With the above points in mind, it must be said that the available data do not show that progress in performance which we have a right to expect. That the real answer to this great problem has not been reached is proved by the continued unrest in our specifications, and by the everlasting changes in sections.

What answer can we make? First, as users, we can and should lessen as far as possible unnecessary punishment of the rail by improvements in the mechanical design and maintenance of our equipment. We can be expected to improve our structure under the rail as our loads increase, and this change is in progress. It is but fair to say that bad conditions, both as to equipment and track structure, have contributed to rail failures. That the large number has attracted no more attention is because of the vigilance of the track inspection. In the very great majority of cases the rails are removed before any serious results ensue.

Against these unsatisfactory conditions we have several possible solutions: Better steel, in the sense of more uniform steel; better steel in connection with more rational sections; materially heavier sections; or retrogression in loads and speeds. To date, a combination of the first and second has been chosen. There has been a very general change to open-hearth steel, at an increased cost.

Neither the American Society for Testing Materials nor the American Railway Engineering Association specifications really protects the buyer as to chemistry. Neither puts any limit on the amount of segregation permitted, and it is well known that this ranges over wider limits than would be permitted in the ladle analysis.

In investigating the causes of the failures of individual rails, many analyses have shown such startling discrepancies between the composition of the failed rail and the analysis purporting to represent the heat that it was difficult to believe that they could represent the same material. Either the ladle analysis is an unreliable index of the quality of the material in the rail or there is a great need for chemical reform. We know by experience that when put to it the chemists of the producers and the consumers can tally within very reasonable limits. This is a serious matter for the consumer. How far the difference between chemists is due to difference in methods I do not know, but possibly the methods by which the chemistry is determined may have to be agreed upon and made a part of our specifications. Dr. C. B. Dudley, who did much work on standardizing methods of chemical analysis, would in his specifications not only state the composition required, but also the methods by which the determination was to be made.

From the physical standpoint both specifications are defective, as both contain the provision that if the test piece meets the requirements the material will be accepted; but in the event of the failure of the first test piece, two more tests are made, and if both pass, the material is accepted. We hold that this is a pernicious practice, in that the consumer has positive proof that some of the accepted material does not meet the requirements. The American Society for Testing Materials specification includes all the machinery for detecting physically unsound material by nicking and breaking, and then provides that the rails represented by these unsound test pieces shall be accepted as "Special" rails. Presumably they are to be used in some unimportant location. This is another very bad practice. It is not always possible to find unimportant places.

Summed up, the rail specification of the society does not put a proper premium on the selection of the better part of the ingot for one of the most exacting services for which steel is used. Where our specification differs from that of the American Railway Engineering Association it is not so good.

The rail committee is composed of able men. Among them are some of the ablest metallurgists in the country, and we should look to them for that constructive work which would make our specification beyond criticism. The purpose of the society is to make specifications and have them used. If year after year we retain provisions that lessen the incentive to improve the product, we cannot wonder if other specifications are preferred.

If we consider all the steps in our rail industry, we find very few improvements in methods other than those which lend themselves to increased output or reduced cost. There are some notable exceptions to this, three in particular; namely, the electric furnace, for producing steel; the sinkhead process for casting ingots, for producing better ingots; and the deseaming process, for producing better rails, by mechanically removing some surface defects which would later develop into seams. All of these processes are represented by rails actually in track under observation, but it is yet too soon to justify an opinion as to their value, nor have any of these methods been generally adopted.

It is to be hoped that some of the large-scale experiments now in progress will show what is to be looked for from a more uniform product. One of these includes the requirement that the chemistry shall be from the rail, instead of from the ladle test ingot, and the segregation must be within reasonable limits. This experiment will, at least, give a quantity of fairly uniform material, so far as any practical method of representative testing will insure it.

Aside from these, and some experiments on too small a scale to deserve special notice, the rail situation remains very much as it was seven or eight years ago. Any deviation from the beaten path is immediately met by an increase in the price asked, the reasonableness of which the purchaser has no means of determining. In at least one case of which I have knowledge, the actual expense of

*Abstract of presidential address delivered before the American Society for Testing Materials, at Atlantic City, June 22-26.

every kind, so far as it could be ascertained, due to rail breakage on a certain system was less than one-fifth of the annual increase in the cost of rail due to the introduction of a proposed new specification designed to secure the quality of rail desired. The year taken was not an abnormal one in any way. One serious wreck would, however, entirely have changed this showing. It requires a lot of courage and a strong sense of duty to justify such an expenditure when the direct return is problematical.

There are many who believe that we cannot hope for relief by the use of more uniform steel. They make the point that, if this is the solution, it can be obtained by a discard larger than the ordinary. They cite the records of the carriers to show that the failures, especially the breakages, are fairly well distributed throughout the ingot, so that no practicable discard would eliminate the trouble. They also call attention to the many examinations of broken rail which reveal no defect that we can recognize as such. From these conditions they argue that the only remedy is to use more steel—that is, heavier sections—without any change in the specifications as to quality Possibly this is correct, but we would call attention to the fact that post mortems on rail sometimes give negative results, because we have not before us all the related evidence. The rail may have been damaged by unfair usage, of which there is no evidence. If due to defective support, the evidence is lost when the track is repaired. Damage from defective wheels, etc., leaves no permanent mark. There is a growing belief that the straightening press, by straining the material beyond the elastic limit, is responsible for many otherwise unexplainable failures, and it would also explain why rails from the lower part of the ingot figure so prominently in the breakage record.

As to the quality, we cannot ignore the fact of the difference between rails from different mills. There have been some notoriously bad rollings, as shown by the records of various roads, and these mills have subsequently turned out an excellent product. If all of the rail was as good as the best, we would have very little room for complaint.

The present line of progress includes a general increase in the weight of sections throughout the country. The 100-lb. mark, or that neighborhood, seems to be one of the halting spots, but some sections go considerably beyond this figure. A careful study has been made of the sections, and the new ones, especially of the heavier weights, are believed to be better adapted to secure good mill results, as well as better performance in the track.

Personally, I believe that the time has arrived for a considerable increase in the weight of sections, and I am not so certain that a change of quality is required at the same time. One reason that appeals is the presence within recent years of that class of failures known as "transverse fissures." So far there seems to be no satisfactory explanation. It seems surprising, if this class of breakage develops in the rail, that it should not also do so in the tire, which is subject to the same intensity of pressure. The tire, however, has an immensely greater section than the head of the rail. If the mere fact of the relatively large area of section of the tire contributes immunity from this class of failure, it is fair to assume that somewhat the same result could be looked for in the case of the rail head.

Certain practices, such as the present system of straightening, have long called for improvement. Nearly all rail passes through the gagging press. The rail specifications are possibly too exacting in requiring that all rails shall be "smooth, straight in line and surface, and without any twists, waves, or kinks." It is a question whether this is not asking too much for the good of the rail and whether it would not be well to make the greatest possible tolerance in the way of accepting rail with such variations from straightness as can be reasonably eliminated in laying.

In the search for a remedy for our troubles, some have proposed to improve the product by more or less radical changes in the mill practice. It must be remembered, however, that a modern steel mill, like the railroad, can only exist by being operated on a large scale. It is designed in advance with a view to a certain sequence of operations, and if proper provision has been made for each, smooth operation follows. The mill, however, is only balanced when it performs these operations in the prearranged order, and to make a radical change—as, for instance, slow rolling, cold rolling, more passes, or one of the many other innovations suggested—may seriously unbalance the whole operation. It is not to be expected that a mill will be willing to make changes in its practice until after experimental work has demonstrated that the proposed practice is practicable and valuable. In conclusion, I must repeat that the rail situation, as we see it, is disappointing. To add to the complexity of the situation, the government, through some of its bureaus, is taking a hand and investigating every serious failure, apportioning blame and suggesting remedies. This will probably increase rather than diminish, and may some day be very awkward for the producer as well as for the user.

NEW WATERWORKS DIRECTORY.

Some very interesting data relating to waterworks plants in Canada and the United States is contained in the recently published second edition of the McGraw Waterworks Directory. The following statistical summary relating to Canadian plants is abstracted therefrom:

The directory presents information regarding 312 Canadian plants, 255 of which are municipally owned.

Province.	Number of towns listed.	Municipally owned.	Privately owned.	Mixed ownership.	Supplied from other towns	Combined light and waterworks.	Using electrical equipment.	Plants using water power.
Alberta	18	16	2	..	..	2	4	..
British Columbia	27	19	8	..	..	4	3	..
Manitoba	11	9	2	..	..	..	4	..
New Brunswick	17	15	1	..	1	..	2	..
Nova Scotia	31	27	3	..	1	2	3	1
Ontario	129	114	13	2	..	13	41	17
Prince Edward Island	2	2	..	..	..	..	..	..
Quebec	62	38	19	2	3	3	14	8
Saskatchewan	15	15	..	..	..	..	4	..

METHODS OF BORING AND DRILLING ON OILFIELDS.

Although recent times have witnessed substantial progress in the drilling methods adopted, progress has from a practical view not been so great as one might at first sight be led to believe. Generally speaking, the old methods, dating back to the days of earthy China, are still copied largely in all pole and percussion systems; and, although steam has replaced manual labor, the operating principles are to-day the same as then. The sole exception is, of course, the advent and growing popularity of the rotary method of drilling. In oilfield work the principal types of percussion drills used are known as (1) the Pennsylvanian cable, (2) the Canadian pole, and (3) Russian freefall, and although from time to time many attempts have been made to introduce modifications of these, the vast majority have been unsuccessful in their operation. A recent paper read before the Institution of Mining Engineers, of Great Britain, describes them as follows:—

The Pennsylvanian Cable System.—As may be gathered from the name, the principal feature of this system is the cable by which the tools are suspended and connected to the walking-beam. In the hands of competent drillers it gives most satisfactory results; while for prospecting work in more or less virgin territory, the cable system has no equal.

When first introduced into the Pennsylvanian fields, the cable system of drilling was particularly simple, and did remarkably good work—for the reason that the strata usually encountered were of such a nature that they did not cave in, and as a result the well-pipe was only lowered when the full depth for that string was drilled. In order to impart the rotary motion to the bit, the continuous twisting of the cable to and fro was necessary; but when in other fields, where deeper strata had to be explored, the cable system was introduced, the semi-sandy nature of the strata called for wells of larger diameter, with correspondingly larger drilling bits. As a consequence of the additional weight of the drilling bit, it was found that the swing of the tools was sufficient to give them a rotating movement for the drilling of a circular hole. In regions where caving-in of the walls of the hole was liable to occur, the string of pipe had to follow closely the tools, which with the old Pennsylvanian type of rig meant frequent winding of the cable from the bull-wheel, so as to allow of the well-pipe being handled. In order to prevent the waste of time which these operations occasioned, the calf-wheel was added, by means of which the pipe could be lowered into the hole without the removal of the drilling cable. The cable almost invariably used was of Manila hemp.

The writer, Dr. Paul Dvorkovitz, urges the necessity which always exists for the employment of the finest tools for oil-well drilling. The sinking of a hole some hundreds of thousands of feet into the earth is no easy matter; but this operation is rendered all the more difficult if one has to contend with tools of an inferior nature.

The Canadian Pole System.—This system, which is largely in use in the oilfields, like the first-mentioned method, is of the percussion type, and differs but slightly from the Pennsylvanian system, the essential difference being that, instead of a cable connecting the tools to the surface, poles are used. The rig used with the Canadian pole system is not so powerful as that for the Pennsylvanian method; but the one great advantage of this system of drilling is that for shallow wells—say, not exceeding 1,300 or 1,400 ft. in depth—the system can be operated by men of less experience. The success which has attended the operation of this pole system lies in the fact that although drilling by means of it is very slow—seldom exceeding 200 ft. per month—it is one of the best methods of drilling through complicated strata, and in the hands of conscientious men does very satisfactory work. This is the primary reason why the Canadian system still holds great sway in the oilfields of the world. It is the system to be adopted where labor is plentiful, though experienced work is scarce.

The Russian Freefall System.—This method still continues to be responsible for the majority of wells drilled in the Russian oilfields. Bearing in mind the great depth to which wells have to be sunk in order to reach the prolific oil-horizons in the majority of the Russian fields, which necessitates starting the well with a very large diameter—frequently 18 in.—it will be easily appreciated that the loss of a hole in the course of drilling is an expensive mishap. Several attempts have been made to introduce more up-to-date systems of boring, but until the advent of the rotary drill, to which the writer will refer presently, little or no progress was made, and the freefall system used to-day differs but little from that which brought in the prolific oil-fountains in the Baku region a quarter of a century ago. By reason of the large diameter of the wells, and the depths to which they must ultimately go, the tools employed must of necessity be of the heavy nature.

The Russian freefall system of boring necessitates patience and hard manual labor. The system is also of the percussive type, and, as the name implies, the drilling tools have a practically free drop, being picked up when the walking-beam is at its lowest point and released at the top of the stroke. The tools when released naturally force their way downwards in the strata, and then are only released with difficulty, although in a measure this difficulty is minimized on account of the fact that underreaming is done simultaneously with the drilling.

After a Russian well has been started by means of a slip-hook suspended from a haulage rope, and a depth of some 30 ft. obtained, the freefall is added to the string of tools. This freefall is composed of two separate parts—the rod and the body—and these are held together by means of a wedge working in vertical slots cut in the sides of the body. In operating the freefall, the handles, fixed to the temper screw, are held by the driller. On the downward stroke these are pushed forward from right to left, but so soon as the downward stroke is completed, they are quickly pulled backwards. The steel wedge enters the recess, and the tools are carried to the top of the stroke, where by a quick forward jerk, the wedge is thrown clear of the recess, and the tools drop freely, the momentum of the string of tools driving the drilling-bit into the strata.

Modern Hydraulic Rotary Drill.—Now designed and marketed by British manufacturers, the rotary drilling machine has completely revolutionized the drilling of oil-wells in almost every part of the world. With the old percussion methods progress in drilling must necessarily be very slow at the best; with the hydraulic rotary the drilling of over 100 ft. per day has frequently been accomplished in favorable territory. The hole in the rotary system is made by the constant rotation of the bit upon the formations, the loose formation being washed from the well by a continuous stream of water forced down the drill-stem under pressure. The writer considers the utilization of mud a distinct improvement in the efficiency of the rotary drill for oilfield work. With the mud-flush system all loose formation is held back, and caving-in thus prevented by the pressure of a column of mud of varying consistency (according to the nature of the formation being passed through), which is pumped down the well, through the drill pipe, and circulates from the bottom of the hole round the drill-stem to the surface, thereby plastering the walls of the well. The mud emerges in streams of high velocity from two holes in the drilling-bit, thereby striking against the formations being drilled, and upon its return to the surface carries with it the cuttings, which, owing to the reduced velocity, are deposited in the mud trough during the course of the mud from the flow-line back to the pump.

Much objection has been raised in certain quarters to the use of the rotary system in general, inasmuch as it prevents an accurate log from being obtained of the strata passed through; but in the operation which the writer witnessed with the mud-flush system the time required for the stream of mud to carry the pieces of formation from the bottom of the well to the surface is only a few minutes, and therefore the driller can be constantly informed of the nature of the strata being passed through.

Dr. Paul Dvorkovitz is of opinion that, although it may be inadvisable to use the rotary system exclusively in territory the geological formations of which are unknown, there is no doubt that the trend of progress in oilfields but partly developed will be to employ the rotary method in conjunction with the older percussive systems, a combination of which can easily be arranged.

CHAINING OVER A WIDE GULCH.

It is seldom that a surveying party on a preliminary railway line come to a gulch or ravine across which it is impossible to chain or to triangulate with accuracy. Mr. J. A. Macdonald, in a recent survey east of Winnipeg, in a piece of country where rock outcrop shows up everywhere, encountered a gulch about 40 feet deep and 150 feet wide, across which it was impossible to chain with accuracy, as the sides sloped, and the 100-ft. chain would not reach across. To triangulate was also almost impossible on account of the difficulty of cutting the shrub

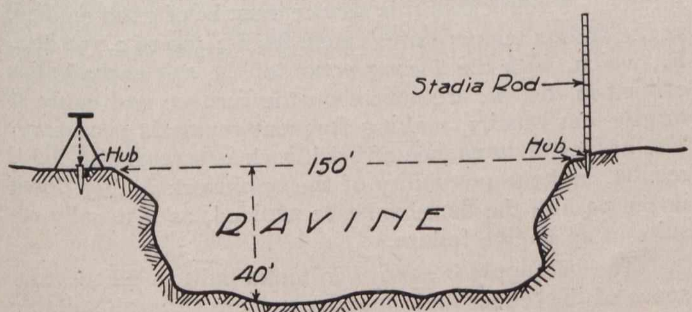


Fig. 1.—Stadia Method of Crossing a Ravine.

and underbrush along the margin of the ravine in order to get a view sight through the transit telescope. Mr. Macdonald informs us that the measurement was quickly made by the stadia method. The transit was set up on the near hub, as shown in the figure, and, a hub being set at the far side of the gulch, the level rod was set up on this hub, as shown, and the reading taken. The method is easy and simple, but is seldom used under like circumstances.

FUEL OIL FOR LOCOMOTIVE USE.*

From 1907 to 1914 the use of fuel oil by railroads increased 112 per cent., until a total of 31,000 miles, distributed over 50 railways, was operated with this fuel. For a time during the years 1912 and 1913 there appeared to be a tendency to discontinue the use of oil, on account of the great demand for the distilled products of crude oil used for other purposes, leaving a diminished supply of fuel oil and residuum. Opening up of new fields, more efficient methods of distillation, the production of gasoline from natural gas, etc., have again increased the fuel oil supply, and its use is again extending.

In the combustion of fuel oil, where a steam spray is used for vaporization, we are confronted with the fact that in the process of atomization the particles of oil started on their way to the flues even before they are partly burned. The first result of these particles coming into the heated portion of the furnace is to separate the carbon from the hydrogen, the former thus being left as a fine dust floating in the furnace in such a manner as to be easily carried to the flues unconsumed, to be deposited as an insulating layer of soot, or to be carried out of the stack in the form of black smoke. If these fine particles of carbon were attached, as in a bed of coals, a supply of air could easily complete their combustion. With liquid fuel, therefore, the diffusion must be simultaneous with ignition, with the resultant long flame. The surface tension of oil, especially when the particles are finely divided, is such as to make the drops assume a spherical form of extreme rigidity and therefore expose the least possible area to the oxygen. We are thus brought to realize that large furnace volume is essential to the burning of fuel oil. While the relative dimensions are of minor import to the volume, it is evident that a flame passage of sufficient length to prevent unconsumed particles passing to the flues must be provided. It was the realization of the limited volume of the locomotive furnace that brought about the change from back to front-end burner arrangement a few years ago, in an attempt to lengthen the flame path.

While it is generally conceded that lack of oxygen is responsible for smoke, the restricted furnace volume and the attending lack of time for the proper mixture of the gases in the more highly heated portion of the furnace is the most common cause for black smoke from an oil-burning locomotive. One of the difficulties met with in the use of oil in the locomotive is the frequent necessity for the removal of soot from the flues, by means of sanding out. This, of course, is attended with several disadvantages, not the least of which is the resultant loss of fuel.

Special attention is brought to this point in connection with locomotive oil-burner furnace design because of the general tendency to restrict the furnace volume by carrying draft pan and brickwork too high in the firebox, covering up valuable heating surface and bringing about the continual necessity for forcing the fire at the expense of the remaining exposed surfaces.

One of the principal requirements in the burning of oil is to expose the fuel to the furnace heat so that the greatest possible area is presented to the oxygen. A study of the atomization of oil is therefore of some importance, and it will be readily seen that the stretching of the surface of fuel oil is a study of capillary action and that it is not hard to determine the work necessary. Oil in bulk has

*Abstract of paper read by G. M. Bean before the International Railway Fuel Association, Chicago, May 17-20, 1915.

little surface, but when broken up into fine particles it has the combined surface of the spherical areas of the drops thus formed, and the work of atomization is the work of stretching the surface of exposure.

Theoretically, it should be possible to atomize oil to a definite fineness of spray by means of a mechanical device much more economically than by means of the steam jet. Many attempts have been made along this line, with almost as many failures. The simplicity and flexibility of the steam-jet burner make that method difficult to improve, and the fact that the type of burner now in use on the majority of locomotives is practically the same as the one first introduced in this country would lead to the belief that when improvement is made in the oil-burning locomotive furnace, it will not be made in the burner. One of the simplest of all burners and now standard on the Santa Fé Railway has been in continuous use on that line since oil was first introduced as fuel, and has never failed, in itself, to show up well in connection with any furnace design. In other words, where failures in design or arrangement were met with, it was always traced to other features being wrong, rather than the burner. The type of burner, therefore, seems of minor importance, so long as it is simple, substantial, not easily stopped up and easily cleaned.

Locomotive furnaces are not considered ideal for the use of fuel oil, and for this reason as much as any other there have been as many different furnace arrangements as there have been localities in which oil fuel has been used.

At the first inception of the idea in this country it was natural that the designs used in Russia should be followed. The burner was placed under the rear of the firebox, and directed forward with an upward incline, so that the flame shot under a low, short brick arch, with the result that combustion became so intense in this limited space as to cause the flame to pass from under the arch with such velocity as to impinge on the door-sheet, side-sheets and crown-sheet, with detrimental results. Bad water conditions throughout the southwest aggravated this to such an extent that the life of fireboxes was only about eighteen months or two years, and the replacing of them soon became a severe burden. The back-end burner arrangement also required an excessive quantity of firebrick, which not only gave trouble by continually burning out, but also served to cover up valuable heating surface, restrict the furnace volume and throw an increased load on the remaining heating surface.

While the back-end burner arrangement is still in use to some extent throughout Texas, it has entirely disappeared from every other section. The burner is now placed in the front end of the draft pan, and directed toward the rear in such a manner that the draft is forced to reverse the direction of the flame before it passes to the flues. The furnace is open, the brickwork is kept low and the maximum of heating surface is exposed. The correct drafting of this arrangement is still a somewhat debatable subject, but the general idea seems to favor the admission of the principal volume of air through openings in the vicinity of the flash-wall, which is built up under the door, it being the plan to admit this air through numerous small openings, preferably circular in shape and distributed well over the rear third of the draft pan in such a manner that the air is brought in contact with the flame from several directions and not in too concentrated a volume. A small amount is also admitted around or under the burner, so as to prevent it from over-heating and to keep the flame from dragging on the floor of the pan. This arrangement results in a uniform distribution of heat and the consequent lengthened life of the fireboxes and flues, until it can safely be said that for service under like conditions, a firebox on a locomotive burning oil will last longer than one in a coal burner if consideration is given to the extra work possible to be obtained from the oil burner.

Oil requires from 20 to 30 per cent. more air per pound of fuel than the average bituminous coal. There is a tendency to restrict the the air openings in draft pans of oil burners, and it is generally the rule that with locomotives of the same class in both oil and coal-burner service, the oil burner will have the smaller nozzle, indicating the necessity for maintaining a higher front-end vacuum to draw in the necessary amount of air to make the engine steam properly. This is attended with the added difficulty that the high velocity of the entering air produces a more concentrated column or stream, which is difficult to break up, requiring a heavy atomizer, the use of which has its disadvantages.

There is a question whether the open furnace created by the front-end burner arrangement is all that can be desired, for it is true that the gases will follow the path of least resistance and the velocity at the centre of the combustion space will be much higher than at the sides, this indicating the necessity of some sort of a baffle to increase the velocity of flow at the top and sides where the gases wipe the heat-absorbing firebox sheets. It is also apparent that when the flame path is surrounded by heat-absorbing surfaces to hasten the process of diffusion and shorten flame length, the subjecting of the gases to the presence of incandescent baffles is desirable.

Aside from the two furnaces outlined there is in service on one of the southwestern railways, as well as on some Mexican railways, an arrangement differing from the others in that it has a burner in both the front and the rear of the draft pan, directed toward each other, the line of flame of the front burner being slightly higher than that of the rear. This furnace also has the advantage of the low brickwork and large exposed heating surface. In fact, the opposing burners do away with the necessity for a high flash-wall under the door.

In the two last-named types it is the practice to keep the brick low on the sides and expose all possible heating surface. Firebrick for this service must be of good quality, as the firebox temperatures range from 2,500 to 2,750 deg. F., which, with the fluxing action of the salt and alkalies carried in the oil, are severe on the furnace and cause it to give out readily, making frequent renewals necessary. The proper maintenance of brickwork is essential to good results, and the possibility of the brickwork falling down in the path of the flame must be avoided, as it usually results in an engine failure.

The oil supply is carried in tanks built to fill the coal space of the tender and piped from there through suitable connections to the burner. It is generally necessary to provide means for heating the oil so as to insure a proper flow, as gravity is depended upon for the necessary pressure. This heating is also an aid in atomizing, and various means are provided for the purpose. The original practice was to turn steam directly into the oil, but aside from an emergency feature, this has been generally abandoned, as the accumulation of condensation gave trouble in disposal, as well as by getting into the oil line and interfering with the burner operation. The draining of the condensation from the tank was always accompanied by some loss of oil, and the direct heating often resulted in overheating the entire contents of the tank, with the attending loss. An improvement was to place steam coils in the space and heat indirectly. This had some advantages, but it also caused trouble by overheating and by the pipes leaking at the joints. It is probable that the box heater is the most desirable arrangement. It is indirect in its action, only heats a sufficient volume to insure a supply at the burner and is not liable to cause trouble by allowing water to get into the oil storage.

The oil-storage tanks are provided with suitable gauges or measuring devices to give a check on their contents at all times. Means are also provided for cutting off the supply of oil to the burner in case of accident, such as a wreck or a break between the engine and tender. The supply of oil is regulated by means of a suitable valve placed near the burner and operated through connections by the fireman. In some climates it is necessary to provide an auxiliary heater in the pipe line to reheat the oil before it goes to the burner. Such a heater should be used only when necessary, as extensive heating tends to carbonize the fuel in the oil-supply line and the burner.

Emphasis should be placed on the fact that the oil fireman is an important factor in the success of the operation of oil-burning locomotives. He must intelligently follow every movement of the engineer that demands regulation of the fire. He has two gauges to guide him—the top of the stack and the steam gauge. That is, the proper steam pressure must be maintained with the least possible smoke. A thin gray color at the top of the stack is usually indicative of proper combustion.

Given a modern locomotive with a furnace designed along the lines indicated, with equipment in proper adjustment and an intelligent engine crew, the result should be of as high an order as is so far attainable with steam-operated motive power.

U.S. RAILWAYS IN RECEIVERS' HANDS.

At present there are approximately 30,500 miles of American railroad in the hands of receivers. On June 30, 1896, 30,475 miles were in receivers' hands. With the exception of the year 1908, there has been no year since 1896 in which as much as 4,000 miles of railroads was in the hands of receivers. An interesting tabulation of the similarity of the situation to-day was that of 19 years ago has been compiled:—

June 30, 1896.

	Miles.
Northern Pacific	4,533
Union Pacific	1,836
Union Pacific subsidiaries	5,900
Atchison	2,000
Baltimore and Ohio	2,073
Norfolk and Western	1,571
Philadelphia and Reading and others	884
Total mileage	30,475

Par value of securities, $1,795,900,000.

June 30, 1915.

	Miles.
Rock Island	8,328
St. Louis and San Francisco	4,747
Wabash	2,514
Pere Marquette	2,322
Chicago and Eastern Illinois	1,282
International and Great Northern	1,106
Cincinnati, Hamilton and Dayton and others	1,015
Total mileage	30,500

WATERPROOFING CONCRETE SURFACES.

Mr. J. L. Lytel, project manager of the Strawberry Valley project, Utah, records in the Reclamation Record, April, 1915, an interesting experience in waterproofing of concrete surfaces. The storage works and tunnel of the Strawberry Valley project are located in the Wasatch Mountains at an elevation of 7,500 feet. There is a wide variation in temperatures in this vicinity and the climate is very severe during the winter months, the lowest temperature on record being 50° below zero. The snowfall ranges from 10 to 24 feet in depth.

The extreme cold, with alternate thawing and freezing of water in the ports of the exposed faces of the structures, was found to have a very destructive effect on these concrete structures and the waterproofing of the surfaces was decided upon as a preventive against their continued disintegration.

It was decided to treat the vertical surfaces with alum and soap solutions and the horizontal surfaces with paraffine. The alum solution was made by dissolving 2 ounces of alum [$KAl(SO_4)_2$] in 1 gallon of hot water. The soap solution was composed of three-fourths pound of castile soap dissolved in 1 gallon of hot water. The paraffine was boiled to drive off water, as the presence of water rendered it hard to apply. Ordinary commercial products were used.

The surface to be treated with paraffine was first thoroughly dried and cleaned of loose concrete, dirt, and other foreign substances. The paraffine was then heated and applied with a paint brush, and was forced into the pores by the heat of a blow torch on the surface. Only one coat of paraffine was applied as the concrete would not absorb more.

The surface to be treated with soap and alum was prepared as above stated. The alum solution was applied at a temperature of 100° F. with a moderately stiff brush and was then worked in with a stiff horse brush. While the surface was still moist from this treatment the hot soap solution was applied in the same manner as the alum solution. One treatment by each solution in the manner described above constituted a coat. If other coats were considered necessary, they were applied in like manner after the preceding coat had been allowed to stand 24 hours or more.

Twelve structures were given this treatment, the surface area covered being approximately 28,000 square feet. Four thousand square feet were treated with paraffine, at the rate of 1 pound for 11¾ square feet, and the remainder with soap and alum. It required 1 gallon of alum solution and a half gallon of soap solution to cover 50 square feet with two coats. Two coats of alum and soap were applied at an average total cost of 75 cents per 100 square feet, and the cost varied from 41 cents minimum to $1.28 maximum. The cost of one coat of paraffine varied from $1.70 to $3.78 per 100 square feet, and averaged $2.11. This cost covers everything except general expense. The two men who did this work received $75 and $80 per month. Brushes cost $6.06, castile soap 12½ cents per pound, alum 18 cents per pound, and crude paraffine $4.80 per hundred-weight.

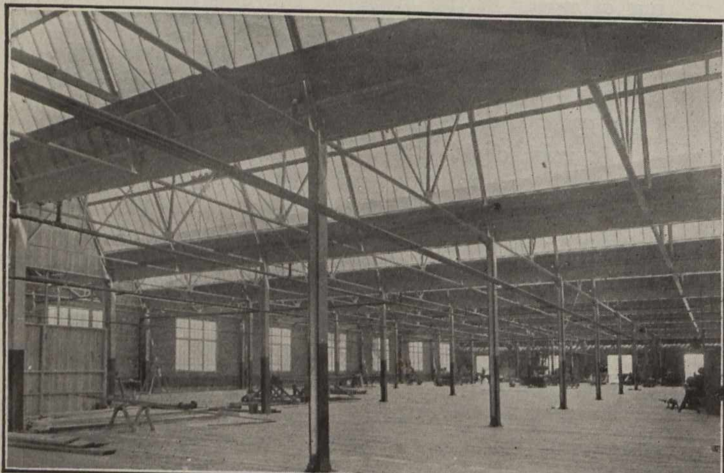
The results obtained by this style of waterproofing are considered very satisfactory. The structures that were repaired and treated have gone through two severe winters and no further disintegration of the concrete on any part has occurred.

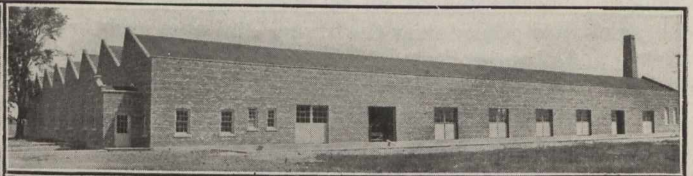
GREENHOUSE FACTORY AT ST. CATHARINES, ONTARIO.

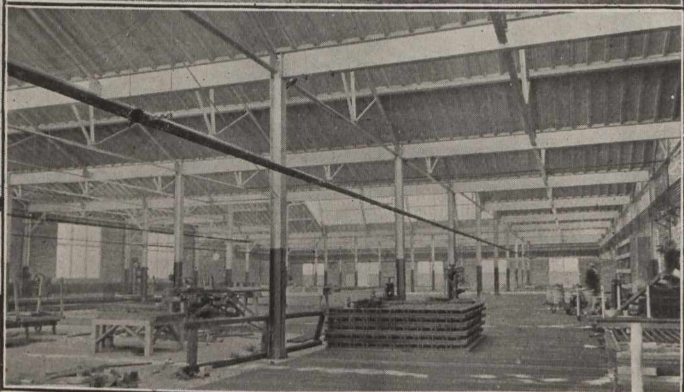
THE Lord and Burnham Company, Limited, with plants in the United States at Irvington, N.Y., and Des Plains, Ill., have recently established a Canadian factory at St. Catharines, Ont., opposite the Yale and Towne plant constructed there several years ago. The accompanying illustrations show the new plant practically at its completed stage. It will be devoted to greenhouse manufacture, and in this connection it is interesting to note that the owners are the largest users of glass in America.

The floor is probably one of the most substantial and best ever put into a factory building for machine shop work. It consists of a concrete sub-base, with two inches of tar-rok, a 2-inch hemlock sub-floor, and a ⅞ finished factory maple floor. This gives ample substantial beds for all except the heaviest machines and affords good protection against rotting of the sub-floor from dampness or other causes.

The owners are now installing their own heating system, operated with Burnham boilers. The machinery has all been placed in position and is rapidly turning the raw wood and iron into shape for the construction of the numerous greenhouses which the firm have under contract.







Views of the Lord and Burnham Building, St. Catharines, Ont., Showing Interesting Type of Construction.

The building follows a highly standardized design. The owners, themselves, have had years of experience as designers in light steel work, and their standards, combined with those of the Standard Steel Construction Company, of Welland, and The Samuel Austin & Son Company, of Cleveland, builders, resulted in a factory building of extremely low cost.

The building is approximately 225 x 250 feet, of one-story saw-tooth construction, with steel frame, brick exterior, maple finish floor, cement tile roof, and with clear glass throughout.

There are no pilasters. The 9-inch brick walls run straight by all the columns, with anchor bolts to insure each stiffening the other. This gives a maximum of floor space with a minimum of steel work. The cement roofing tile, Austin standard, Hollospan type, was made on the ground; the purlins are spaced at 8-foot centres, which long span is made possible by the vertical members of the tile, and makes possible a still further reduction in the structural steel.

The saw-tooth trusses were designed by the Lord & Burnham Company, and refigured by the Standard Steel Construction Company, with a considerable resultant saving in steel.

Good ventilation is assured by the opening of a continuous row of ventilators in each saw-tooth by the owners' own sash operating device, and ample clear glass area in saw-tooth and side walls gives one of the best lighted factory floors in Canada. The saw-tooth sash are all wood, of selected quality cypress, Lord & Burnham standard. Wood frames and sash are used in the rest of the building as well.

Mr. W. A. Burnham is president of Lord & Burnham Company, Limited, and Mr. David Warwick is manager of the new Canadian plant.

PRODUCTION OF EXPLOSIVES.

The total production of explosives in the United States during the year 1914, exclusive of exports, according to figures compiled by Albert H. Fay, of the United States Bureau of Mines, was 450,251,489 pounds or 225,126 short tons, as compared with 500,015,845 pounds or 250,008 short tons for 1913. The production for 1914 is segregated as follows: Black powder, 206,099,700 pounds; "high" explosives other than permissible explosives, 218,453,971 pounds; and permissible explosives, 25,697,818 pounds.

The figures represent a decrease of 23,839,831 pounds of black powder, 23,932,573 pounds of high explosives, and 1,-9[illegible]7,952 pounds of permissible explosives, as compared with 1913.

THE DELAWARE AND HUDSON COMPANY IN CANADA.

The Delaware and Hudson Co. owns two railways in Canada—the Quebec, Montreal and Southern, extending from Noyan Junction to Belleville, 81 miles, from a junction with the G.T.R. at St. Lambert to Fortierville, 109.69 miles, and from St. Constant Junction to Napierville Junction, 1.40 miles, a total of 192.09 miles; and the Napierville Junction, from St. Constant Junction to Rouse's Point, Que., 27.06 miles. At the latter point connection is made with the Delaware and Hudson road's main line, which extends south to Wilkesbarre, Pa. Together, these roads form 25 per cent. of the total mileage of railways owned and operated by the company.

NOTES ON TRANSMISSION LINE CONSTRUCTION.

In our issue of July 8th a description appeared of the types of transmission line tower foundations used by the Toronto Power Company on its Niagara-Toronto line. The following notes relate to the general subject of line construction. It is shown conclusively that the weakest link of any transmission system is the line and that this part of the system has never been given adequate consideration. The author, Mr. P. M. Downing, strongly advocates the use of towers for important trunk lines and recommends the use of concrete footings in preference to those of metal set directly in the ground. The paper from which the following notes are abstracted was presented by Mr. Downing at the annual convention in June of the American Institute of Electrical Engineers.

The use of wooden poles in connection with high-voltage transmission lines, especially important trunk lines, is fast being superseded by steel towers. The wonderful growth of the electrical industry during the past few years has resulted in the construction of larger generating stations, and the transmission lines carrying these heavier loads have become of correspondingly greater importance.

During all of this time, except for a noticeable increase in the sizes of the units used, there has not been any radical change in the equipment of hydro-electric generating stations. The same general types of turbines and impulse wheels as were used fifteen or twenty years ago, during the infancy of the industry, are still being used. Slight modifications in the design of the generators, the use of the better material now available, and higher speeds have resulted in larger units and increased efficiencies. Transformers have kept pace with the generators and water-wheels, both as regards size and efficiency, but have never been in any respect the limiting feature in high-voltage transmission work.

The line is and has always been the weakest link of the entire system, and it is only during the last few years that this part of the work has received the attention it deserves. Wooden pole lines with pin type insulators were for many years used almost exclusively, regardless of the voltage, or the importance of the line; in fact, it was not until 1903 that the first commercial tower line in America was constructed by the Guanajuato Power Co., in Mexico. The first line using towers with suspension insulators was the 140-mile 100,000-volt line of the Stanislaus Power Company in California (now the Sierra and San Francisco Power Company).

The tower designs first constructed called for each structure to be self-supporting under strains due to the breakage of all conductors on one side of the tower together with maximum ice and wind strains. This resulted in a heavy, durable structure of high first cost, and imposed a very much more severe condition than could be met by pole lines.

Little attention had ever been given to the determination of the strength of wood poles, either by calculation or actual test, and there is no doubt but that such strength requirements in line towers was unreasonable. Subsequent experience has shown that the average tower is too complicated a structure to accurately calculate the stresses in the different members, and it is now generally conceded that the best and only safe way to get reliable information as to the stability of a tower is to subject it to actual test.

A very safe condition under which to test towers to be used in a country not subject to severe snow and sleet conditions, is to consider a wind pressure of 14¼ lb. per sq. ft. on flat surfaces, combined with a temperature range of 125 deg. F., or a pressure of 21 lb. per sq. ft. on flat surfaces under ordinary temperatures; also two broken wires in any span of a circuit carrying six wires. These breakages to be in such positions on the tower as will give maximum strain. The height of the tower will depend on the spacing and the required clearance of the conductor above the ground. Considerable difference of opinion exists as to the most economical length of span that can be used. These range from 400 to 1,200 ft., depending to a considerable extent on the character of the country, the climatic conditions and the voltage of the line.

Where the line is subject to heavy snow and sleet conditions, the spans must be short, and very often under such conditions it is inadvisable to place the three conductors in a vertical plane. A very much better and safer construction can be had by using single circuit towers with the conductors in a horizontal plane. Under these conditions any unequal distribution of the snow load on the different conductors will not cause them to come in contact with each other. On 100,000-volt lines carrying two circuits of three wires each, located in vertical planes on the two sides of the tower, a spacing of 800 to 1,000 ft. will generally be found to give maximum economy.

Tower foundations depend largely on the character of the soil in which they are located. In heavy ground a metal footing having sufficient resistance against up-lift may be used, but they are not to be recommended. The permissible strains borne by well tamped dry earth do not always obtain under water-soaked flood conditions. Where metal footings without concrete have been used, too often they have been found inadequate and resulted in the ultimate failure of the tower. Under no circumstances, except on very short towers, should single post footings be used. Two or three posts give a much more rigid and substantial construction, but materially increase the first cost of the structure; in fact, for the same factor of safety, it is very doubtful whether under any normal conditions the difference in first cost between the metal and concrete footings will be great enough to justify a decision in favor of the metal.

On a number of different lines originally constructed with all metal footings, tower failures have occurred, and it has since been found necessary to reinforce them with concrete.

On the basis of an 800-ft. spacing between towers, and an allowable stress of 15,500 lb. per sq. in. for copper conductors, the sag at 60 deg. F. would be approximately 20 ft. On a double-circuit tower line, having conductors strung to this tension and spaced 10 ft. apart, with a required clearance of 30 ft. above the ground, a 75 to 80-ft. tower would have to be used. The footings of a tower of this height under the assumed load conditions should contain not less than 1¼ cu. yds. of concrete per leg. On the basis of concrete weighing 140 lbs. per cu. ft., earth 110 lb. per cu. ft., and assuming the angle of cleavage of the earth as 30 deg. from the vertical, a footing of this kind would have a factor of safety of approximately two.

In pouring the concrete in a footing of this kind, the bottom pan-cake is placed without a form, and allowed to set just long enough to support a metal form for the upper portion.

To insure against weakness due to possible poor bonding along the plane of contact between the upper and lower portions of concrete, it is advisable to use short pieces of reinforcing, or let the metal footing extend well down toward the bottom of the foundation.

The cost of footings of this kind on a line run through average country such as will be found between a hydro-electric plant in the mountains, and a distributing centre in the valley, that is, where the route is about equally divided between mountains and valley, is, approximately, $90 per tower, divided as follows: Labor, $40; material, $16; hauling material, $34. These prices are based on labor at $2.50 to $3 per day, and concrete mixed by hand at each tower; average haul for material 6 to 8 miles.

In a country that is not too steep, the most economical way of erecting towers of this size is to assemble them on the ground and end them up in position. One very easy and satisfactory way of doing this is to set a 30 or 35-ft. gin pole just outside of the footings holding it in position by three guys fastened to iron stakes driven into the ground for anchors. Over an open sheave on the top of this gin pole is carried a 0.5-in. flexible steel cable one end of which is connected to the tower at the lower cross-arm, the other to a set of triple blocks made fast to another anchorage 300 or 400 feet from the base of the tower. Where the ground around the footings is not well packed, it is advisable to use hold-back anchors on the ground legs, as otherwise the heavy pull against the footings when the tower starts to raise is liable to damage them. A back guy should also be provided to prevent the tower dropping into place as it comes up to a vertical position. Ordinarily side guys are unnecessary, but during windy weather it is well to have them held loosely as the tower raises. The best motive power for this work is a 3-ton motor truck which can be used not only for raising the towers, but also for transporting tools and equipment between towers. A crew of nine men with a truck will raise and fasten to the footings an average of 9 towers per work day of 8 to 9 hours. The insulators are attached to the tower while it is on the ground and raised with it.

While there are few, if any, tower lines that have been in service long enough to determine the relative merits as between galvanizing and painting of steel structures of this kind, there is every reason to think that hot dip galvanizing when properly done will prove the more satisfactory in the end. The first cost of painted towers is less than galvanized, but at the very best, the painting will last only a few years. As an offset to the lower first cost of painting, there would be the increased maintenance cost. Moreover, the tops of the tower could not be painted with voltage on the line. To do this part of the work, service would have to be interrupted. This objection alone would in many instances be a most serious one, and doubtless, would oftentimes be the determining factor in deciding in favor of the galvanized structures.

There is nothing, thus far, to indicate that there is any appreciable deterioration of the galvanizing when set either in the concrete or directly in the ground. Galvanized tower bolts are not entirely satisfactory. It has been found that almost invariably the bottom of the threads will be so filled up with the galvanizing that the nuts cannot be run on. Sherardizing overcomes this trouble, but is open to the objection that this process is inferior to hot dip galvanizing, and it is often only a matter of a short time when the sherardizing will disappear and the bolts rust. After the tower is erected is should be gone over carefully, all bolts tightened and the threads upset, so that the nuts cannot work loose.

Unless this is done the vibration of the tower due to the wind will, within a few months or a year, cause the nuts to loosen and back off a turn or two, thus materially reducing the rigidity of the tower. The same thing will happen on the clamp bolts holding the conductor, unless lock washers, or some other means, are provided to prevent it.

DETERMINATION OF PRESSURE ON BINS AND WALLS.

A PAPER, read by Mr. J. H. Smith at the recent annual meeting of the American Society for Testing Materials, comprises the description of a special apparatus for determining the point of application, line of action, direction, and intensity of resultant pressures on walls and bins; also the results from several series of tests. Since it is possible with this apparatus to determine all the elements of a force, it it suitable, not only for the determination of pressures on walls and bins, but the principle may also be used in many other ways for laboratory testing, where unknown forces are to be determined.

Tests were made, using river sand and river gravel as fills, the depth of fill being varied from 6 in. to 4 ft. on the retaining wall or weighing gate. The thickness of fill ranges from 6 to 18 in. The fills were also varied by changing the amount of moisture, the method of packing the material, and changing the angle of the surface from horizontal to the angle of repose.

It is shown that the pressure increases with the thickness of fill, and that moist or wet material gives a higher resultant pressure than dry material. As would be expected, packed material gives the highest pressure of all conditions tried, with the centre of pressure in many cases above the centre of the retaining surface.

There seems to be no definite relation between the angle of surface and the line of action of the resultant pressure, as deduced by well-known theoretical formulas. Without very much more exhaustive tests, the author would not attempt to reduce these experimental results to the form of formulas for designing. The tests were started last year, and are still being carried on, but it is only a beginning, and it is hoped that something more definite may be written into a report in the future.

For a proposed design, an excellent method would be to test out a sample of the fill in an apparatus similar to the one described, with the retaining surface arranged as the proposed wall or bin is to be built. From data thus obtained, the structure could be more intelligently designed.

RAILWAYS IN NEW ZEALAND.

All the steam railways in New Zealand are owned and operated by the Government. There were 2,945 miles in operation on March 31, 1915, which earned $1,459,801 during March this year, at an operating expense of $1,235,911 for the same period. New lines are under construction and others are contemplated, and railway development is one of the important items of internal improvements now before the government.

Of the 15 coal briquetting plants in operation in the United States during 1914, five used anthracite culm as a raw material; two, semi-anthracite; one, bituminous slack; two, a mixture of anthracite culm and bituminous slack; two, petroleum residuum; two, semi-bituminous slack, and one, a mixture of anthracite culm, bituminous slack, coke and lignite. Eight plants used coal-tar pitch for a binder, four used secret binders, and one used petrolastic cement. No binder is required in the briquetting of carbon residues from oil-gas works.

PRACTICAL APPLICATION OF THE "SALTPETER METHOD" FOR DETERMINING THE STRENGTH OF SEWAGES.*

By Arthur Lederer,
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SINCE the publication of the saltpeter method of determining the biochemical oxygen demand of sewages and polluted waters, I have made a number of observations which throw more light on the reliability and practicability of the method. I have also simplified the procedure so as to make it more adaptable to working conditions. At the present time the operation of the sewage-testing stations of the Sanitary District is entirely controlled by this method. It has also been employed in sanitary surveys of polluted streams.

The method is based upon the biochemical consumption of saltpeter oxygen by a sewage during an incubation period of ten days at 20° C. The initial minus the residual available oxygen expressed as parts per million oxygen indicates the biochemical oxygen demand. The original procedure consisted in the addition of varying quantities of saltpeter to the sewage in stoppered bottles, either with or without the addition of methylene blue. If no coloring matter was present, the "septization" of the sediment served as the index of the oxidation. The residual nitrite-nitrate oxygen was determined in the bottle in which the sediment did not turn septic after ten days' incubation. This method of employing varying quantities of saltpeter is necessary of course in preliminary tests when one deals with a sewage of unknown strength. There is, however, no additional labor involved, since only one bottle is selected for the final analysis. The other bottles are discarded. Once the approximate maximum strength of a certain sewage is established, a definite excess of saltpeter can be employed, thus reducing the number of bottles to one. I have found on various occasions that a reasonable excess of saltpeter does not result in an increased oxygen consumption. In this respect the method is vastly superior to all of the methods involving fresh water dilutions, such as required in the Modified English Incubation Test, accepted as a provisional procedure for the "Standard Methods of Water Analysis." It is true that in any dilution method, only free oxygen determinations are required which are much simpler than nitrate-nitrite determinations, from the analytical standpoint. However, the precautions and amount of preliminary work required in a dilution test such as the English incubation test are great and emphasize the difficulties of obtaining comparable results with such a test.

In order to have comparable results with the English Incubation Test, it is absolutely essential to prepare a dilution which is just sufficient to insure stability. The saltpeter method was originally developed on this basis. Various dilutions were made of the sewage with fresh water and methylene blue was added as an indicator. The dilution, just sufficient to retain the color, expressed in parts per million of oxygen, gave the same result as when an equivalent of saltpeter of oxygen was added to the undiluted sewage. The saltpeter solution was prepared on the basis of five oxygen atoms being released from two sodium nitrate molecules. It is obviously wrong to prepare *ad libitum* any kind of sewage-water mixture and compare the free-oxygen consumption thus obtained with the saltpeter-oxygen consumption. Matters are still worse if a dilution is incubated at one temperature and the saltpeter sewage at another. An intelligent comparison can only be drawn by adhering to the procedure indicated above. That a serious error can occur in comparing the free-oxygen consumption with the saltpeter-oxygen consumption, if the proper required concentration is not adhered to, was impressed on me during the co-operative work on the Modified English Incubation Test. In a number of the series of experiments I worked out the saltpeter-oxygen consumptions, as well as the free-oxygen consumptions in the various concentrations. Such a comparison is recorded in the following Table I., the results being expressed in parts per million.

Table I.—Free-Oxygen Consumptions in Various Concentrations Compared to Saltpeter-Oxygen Consumptions at 20° C.

Serial No.	Time of incubation in days.	Fresh water oxygen demand, P. P. M. Original concentration of sewage in per cent. 1.0	1.5	2.0	2.5	3.0	4.0	5.0	Saltpeter oxygen demand P. P. M.
1	1	60	27	..	..	20	..	..	38
	5	180	113	..	..	97	..	..	71
	10	230	146	..	..	120	..	..	81
	..	(26)	(26)	..	..	(43)	..	..	..
2	1	50	33	..	..	33	..	..	18
	5	130	100	..	..	67	..	..	57
	10	180	126	..	..	90	..	..	81
	..	(20)	(22)	..	..	(31)	..	..	..
3	1	20	..	15	..	..	20	..	19
	5	150	..	90	..	..	75	..	78
	10	190	..	135	..	..	92	..	86
	..	(22)	..	(32)	..	..	(44)	..	..
4	1	50	..	40	..	..	32	..	—
	5	140	..	95	..	..	75	..	63
	10	210	..	135	..	..	98	..	80
	..	(24)	..	(31)	..	..	(45)	..	..
5	1	50	..	..	32	..	..	22	32
	5	110	..	..	84	..	..	66	66
	10	120	..	..	92	..	..	88	75
	..	(14)	..	..	(27)	..	..	(53)	..
6	1	30	..	..	24	..	..	22	30
	5	100	..	..	68	..	..	64	60
	10	140	..	..	100	..	..	—	71
	..	(16)	..	..	(30)	..	..	..	..
7	1	70	..	..	32	..	..	32	24
	5	150	..	..	96	..	..	60	52
	10	180	..	..	104	..	..	76	66
	..	(20)	..	..	(30)	..	..	(45)	..
8	1	50	..	..	28	..	..	26	23
	5	130	..	..	96	..	..	80	66
	10	150	..	..	116	..	..	98	78
	..	(17)	..	..	(34)	..	..	(58)	..
9	1	70	..	..	36	..	..	36	27
	5	190	..	..	112	..	..	100	67
	10	240	..	..	124	..	..	100	89
	..	(28)	..	..	(36)	..	..	(65)	..

The figures in parenthesis indicate the percentage of oxygen absorbed by the sewage after ten days' incubation. The influence of concentration upon oxygen absorption is strikingly illustrated in the table. However, when the per cent. of oxygen absorbed by the sewage approaches 50 or

*Read before the Laboratory Section, American Public Health Association, Jacksonville, Fla., December, 1914.

thereabouts the two absorption figures do not differ very greatly, making allowance for unavoidable working errors in either method.

One difficulty encountered by the sub-committee on the determination of the biochemical oxygen demand of the laboratory section of the American Public Health Association was the fluctuation of the oxygen content during the incubation of a sewage-water mixture from one day to the other. Such fluctuations have been noted by nearly all of the co-workers, and account for the unreliability of the method. The reasons for these irregularities has not been satisfactorily explained, but it is probably that the re-aëration through loose stoppers is only a minor factor. Nevertheless, mixtures in which the free-oxygen is measured after incubation must be guarded from contact with the air. Re-aëration constitutes an almost negligible source of error in the saltpeter method. A number of experiments have been carried on incubating sewages with various stoppers, one seal,* and without a stopper at 20° C. and 37° C. The results are recorded in the following Table II.

Table II.—Influence of Exposure to Air Upon the Results Obtained by the Saltpeter Method.

	Bio-chemical oxygen demand P. P. M.									
	Incubation at 20° C.					Incubation at 37° C.				
Serial No.	No. of days.	Glass stopper.	Cork stopper.	Bunsen seal.	Open bottle.	No. of days.	Glass stopper.	Cork stopper.	Bunsen seal.	Open bottle.
1	9	94	94	94	85	5	94	96	93	86
2	..	..	..	..	..	5	121	118	115	97
3	11	192	194	191	185	4	166	160	163	147
4	11	178	179	177	168	4	140	140	140	123
5	11	190	192	191	185	4	168	170	170	160
6	12	790	816	787	777	6	782	753	753	620

This table shows clearly that the precautions against re-aëration in the saltpeter method need by no means be rigid. A seal is not required, in spite of the appreciable quantity of gas accumulating beneath the stopper during incubation. Any kind of a stopper will do, even though the incubation be carried on at 37° C.

I wish to correct a statement made in the original article concerning the amount of free-ammonia formed during the nitrate reduction process. A number of observers, cited in the original article, assumed on the basis of experimental data that no free-ammonia is formed. Since this point has no actual bearing upon the availability of the oxygen present, it was not reinvestigated by me at that time. Mr. C. B. Hoover, of Columbus, Ohio, found that free-ammonia is formed (not published), and this has since been substantiated by me in a number of experiments. Table III. will show the results obtained.

The increase of free ammonia appears appreciable.

Since the absorption of oxygen from the air in the saltpeter method seemed to be a negligible factor, it appeared likely that no error was introduced by incubating a large number of samples collected at frequent intervals and by mixing these individual samples after incubation. This would furnish a much better control of a sewage disposal plant, giving more precise information on the actual strength of a sewage or tank effluent than other available methods. The solution of this question hinged on whether, in mixing the samples, the nitrites would be oxidized, thus resulting in lower oxygen demand figures. A large number of samples were, therefore, incubated with saltpeter. At the end of the incubation period the bottles were opened and air passed through the liquid for ten minutes. Such a procedure would at once spoil any result based upon free oxygen consumptions. As a matter of fact, it did not alter the result of the saltpeter method at all. The quantities of free-ammonia, nitrites and nitrates were unchanged by the aëration. Composites, therefore, can be made from samples taken at frequent intervals. Large quantities of sewage may be collected in jugs or bottles, containing a sufficient excess of saltpeter, and the oxygen demand may be determined. The larger the size and number of samples, the closer the true figures can be obtained.

*Bachman, J. Ind. Eng. Chem., Vol. 6, Sept., 1914, p. 764.

The next question of interest concerns the correctness of figures obtained by incubating at 37° C., instead of 20° C. While doubtless it is inconvenient to wait ten days for a result in the operation of a plant or in any particular investigation, it is often advisable to sacrifice accuracy to convenience, providing comparable figures can be obtained. The conclusions to be drawn from the following table should not be generalized. Each operator or laboratory should obtain his or its own temperature relation. It is probable that the relation in different places will not vary greatly with domestic sewages. When working with an unknown sewage or trade-waste, accurate figures can only be obtained by incubating at 20° C. for ten days, this consumption representing between 90 and 100 per cent. of the total. Table IV. on the following page will show the relation obtained by me.

Table III.—Formation of Free-ammonia During Saltpeter-Oxygen Consumption.

Serial No.	Temperature of incubation deg. C.	Time of incubation in days.	Free-ammonia in P. P. M as N. Before incubation.	After incubation.
1	37	3	7.2	9.2
2	37	3	8.8	12.4
3	37	3	12.4	14.4
4	20	5	7.2	10.0
5	20	5	8.8	11.6
6	20	5	12.4	12.8
7	37	3	10.8	15.2
8	37	3	14.0	16.4
9	37	3	12.0	14.8
10	20	5	10.8	15.2
11	20	5	14.0	18.0
12	20	5	12.0	17.6

According to this table, no appreciable error is introduced by incubating the samples for five or six days at 37° C. instead of 10 days at 20° C. The figures for the five- and six-day incubations are both within 5 per cent. of the 20° C. figures. A maximum of 5 per cent. has been found to be the approximate working error of the method. After the fifth day of incubation at 37° C., the absorption of oxygen is very slight. I, therefore, resort to five-day incubations at 37° C. for rapid work with my particular sewage. The cut can be made shorter by ascertaining a rough relation between the first day and tenth day incubation figure. Personally, I do not advise such a short incubation period, on account of a possibility of serious error. In eight tests which I made, the one-day incubation at 20° C. was approximately 33 per cent. of the ten-day figure. The figures fluctuated between 22 and 43 per cent., showing the inaccuracies of an extremely short incubation period. Very often it is highly desirable to obtain information on the twenty-four-hour and ten-day oxygen absorption as well, where this relation gives a clue to the deoxygenating quality of a sewage during the first stretch after discharge into a river.

Table IV.—Saltpeter Oxygen Demand of Sewages at 20° C. and 37° C.

Serial No.	37° C. Incubation in days.	Oxygen demand P. P. M.	20° C. Incubation in days.	Oxygen demand P. P. M.
1	5	180	10	198
2	5	124	10	133
3	5	162	10	171
4	5	165	10	178
5	5	184	10	191
6	5	190	10	198
7	5	107	10	107
8	5	150	10	165
9	5	190	10	198
10	5	190	10	188
11	5	176	10	185
12	5	112	10	125
13	5	149	10	160
14	5	189	10	191
15	5	134	10	142
16	5	156	10	167
Average		160		168

Serial No.	37° C. Incubation in days.	Oxygen demand P. P. M.	20° C. Incubation in days.	Oxygen demand P. P. M.
17	6	130	10	126
18	6	129	10	107
19	6	102	10	102
20	6	174	10	156
21	6	142	10	138
22	6	128	10	102
23	6	247	10	241
24	6	127	10	132
25	6	148	10	158
26	6	244	10	246
27	6	157	10	148
28	6	189	10	180
29	6	134	10	132
30	6	79	10	81
31	6	120	10	122
32	6	177	10	170
Average		152		146

The nitrate reduction does not seem to be influenced by the artificial addition of many common bacterial species ordinarily found in water and sewage. This was found true with B. fluorescens liquefaciens, B. acidi lactici, B. megatherium, B. subtilis, Str. pyogenes, B. enteritidis, B. lactis aerogenes, B. coli, B. cloaceae, B. vulgatus, and B. prodigiosus.

A word of caution is required to prevent the indiscriminate application of the method to trade-wastes. All of the original observations have been made on domestic sewage and polluted river waters. The enormous variation in the character of trade-wastes makes it impossible to recommend the method unqualifiedly without preliminary tests. My experience with the application of this method to trade-wastes relates, so far, only to slaughtering house-waste, on which it is working very satisfactorily. A trade-waste should be alkaline and should contain bacteria, or this method is not applicable. An acid trade-waste or too alkaline a waste should not be taken without adjusting the reaction to a slightly alkaline. If sterile, the contents should be contaminated artificially with sewage. Even this may not prove sufficient.

The residual nitrate-nitrite should be carefully determined to avoid the liability to error in making readings, due to the large dilutions required for the colorimetric determinations. The error in reading ought not exceed 5 per cent.

Lately I have carried on some work on the method discussed in this paper, employing, however, a sodium nitrite instead of sodium nitrate solution. The quantities employed are calculated, of course, on the availability of oxygen, five oxygen atoms being available from two saltpeter molecules and three oxygen atoms from two sodium nitrite molecules. The intention was to eliminate one determination at the end of the incubation, since only nitrites would have to be determined and not nitrates as well. A considerable number of results seems to indicate that an equivalent of sodium nitrite will give results such as are obtained by using saltpeter, but I withhold a definite opinion until I have investigated further.

The method in its present form should be applied as follows:

For Sewages: The initial available oxygen can ordinarily be disregarded, since it is very small compared with the total biochemical oxygen demand. The maximum oxygen consumption, once established by preliminary tests, may serve as a guide for future tests on that particular sewage. A solution of 26.56 grams of sodium nitrate, c.p., per liter should be employed. One c.c. of this solution in 250 c.c. sewage represents 50 p.p.m. of oxygen. The strength of the saltpeter solution may be varied to suit conditions. Incubate the sewage containing the saltpeter for ten days at 20° C. If 37° C. incubation is chosen, determine the relation of this incubation to that of 20° C. A seal is not required during the incubations. Composites may be made at the end of the incubation from samples taken at close time intervals. The appearance of a black sediment and the development of a putrid odor during incubation indicates that too little saltpeter oxygen has been added. Methylene blue may be added at the start to serve as an indicator during the incubations with saltpeter. Decolorization indicates the absence of sufficient oxygen. Domestic sewage usually varies in its oxygen demand from 100 to 300 p.p.m. At the end of the incubation determine the residual nitrite and nitrates, the latter by the aluminum reduction method. In order to convert the nitrogen into oxygen equivalents, multiply the nitrite nitrogen by 1.7 and the nitrate oxygen by 2.9. The initial available oxygen minus the residual oxygen gives the biochemical oxygen demand, which should be expressed in p.p.m.

For Trade-Wastes: Employ the same procedure with larger quantities of saltpeter. The reaction should be slightly alkaline. Acid reaction should be adjusted with sodium bicarbonate, and a too strong alkaline reaction with a weak hydrochloric acid solution. If the liquid is sterile, inoculate it with sewage, after adjusting the reaction. When working with a new waste, obtain checks with the dilution method.

For filter effluents and polluted river waters, this method can be supplanted by obtaining Phelps "relative stabilities" (Methylene Blue Method), provided colloidal matter is absent. The initial available oxygen must be determined analytically. It is best to make up a stock solution of 10,624 grams of sodium nitrate c.p. to one liter of distilled water. One c.c. of this solution in 250 c.c. liquid represents 2 p.p.m. of oxygen. Unless the river water is badly polluted it is hardly required to add more than 10 p.p.m. of saltpeter oxygen. If the methylene blue is absorbed by the colloidal matter of river waters, correct "relative stabilities" cannot be obtained. Filter effluents are ordinarily sufficiently devoid of colloidal matter, and there is no trouble in obtaining correct "relative stabilities" by the simple addition of methylene blue, followed by incubation at 20° C. for ten or twenty days. In waters carrying clay and other colloidal suspensions, the determination of correct "relative stabilities" necessitates the incubation of two samples, one to determine the residual free oxygen, the other to determine the residual nitrite-nitrate oxygen. This procedure is rather tedious but no substitute can be offered at present.

NEW 300-MILE RAILWAY FOR ONTARIO.

The National Engineering Company, Marshall Building, Cleveland, O., has been awarded a contract by the Lake Huron & Northern Ontario Railway Company for the construction of 300 miles of railroad, including telegraph lines, stations, repair shops, engine houses, and office buildings. The railroad will begin at Bruce Mines on the Soo branch of the Canadian Pacific Railway, and will run northeasterly along the Missisaga River through the Missisaga Forest Reserve through the district of Sudbury crossing the main line of the Canadian Pacific, thence across the Canadian & Northern Ontario Railway Company, terminating at its junction with the Grand Trunk Pacific at Alexandria in the district of Timiskaming, whence it is proposed to continue northeasterly to the outlet on salt water on James Bay. Present project from Bruce Mines to Alexandria comprises about 300 miles. The National Engineering Company has the general contract for all engineering and all construction of this road. There are about 14 bridges to be built on this route, one of which will be in the neighborhood of 700 feet long.

The chief revenue derivatives of the railroad will be timber, iron ore, copper ore, pulp wood, wheat and coal.

DAMAGE TO GOVERNMENT PROPERTY ALONG RED DEER AND NORTH SASKATCHEWAN RIVERS IN ALBERTA.

The abnormal floods in the valleys of the Red Deer and North Saskatchewan rivers have washed away a large number of bridges and ferries belonging to the provincial government, according to the latest information in the possession of John Stocks, deputy minister of public works. The floods in the southern part of Alberta were not beyond their usual seasonal height, but the Red Deer and North Saskatchewan rivers and their tributaries rose to record proportions. Over the Clearwater River there was a steel bridge retaining two spans, 80 and 125 feet respectively, and the 80-foot span was carried away on a raft of driftwood and washed up on an island in the Saskatchewan River, where it is now high and dry.

At least one steel bridge on the Clearwater was washed away, and another further up stream is believed to have been lost.

Two steel bridges over the Red Deer River were driven down stream—one west of Olds and the other west of Innisfail. A third steel bridge was not lost, the valley being very wide at that point and the current leaving the main channel and passing around the bridge, but the flood took away several small timber bridges and grades leading to it.

Below the city of Red Deer a number of ferries have been washed away. In some cases the towers were knocked down by driftwood.

The ferry at Rocky Mountain House, though washed away, was landed upon the bank and saved. At one point between Rocky Mountain House and Edmonton the ferry scow went down the river. Below Edmonton several ferry cables were struck by floating debris and pulled from their supports, *viz.*, at Pine Creek, Bruso, and at some other points from which definite information has not yet been received.

On the Athabasca, Peace, Smoky, and other large rivers in the north the floods do not appear to have been nearly as bad as on the Red Deer and North Saskatchewan rivers.

Steps have been taken by the public works department to replace bridges and ferries as quickly as possible.

DEFINITION OF OTTAWA (ILL.) SAND.

Ottawa sand is so often spoken of as the standard of comparison that the following information regarding it will be of interest. This information was brought out in the discussion of a paper by Mr. F. M. McCullough before the Engineering Society of Western Pennsylvania.

The silica sand which is produced in such large quantities in the vicinity of Ottawa, Illinois, comes from the St. Peter sandstone, one of the formations in the lower portion of the Ordovician in the Upper Mississippi Valley region. The St. Peter formation is a very pure quartz sandstone often containing over 99 per cent silica. It has little or no binding material between the grains, so that it can usually be crumbled readily between the fingers into a loose sand. In size the individual grains range from one millimeter down to 0.01 of a millimeter in diameter, the bulk of the material falling between 0.4 and 0.05 millimeters. The large grains are usually well rounded. In thickness the formation varies from a few inches to 225 feet.

This sand was deposited on a low-lying coastal plain left exposed when the sea, which had occupied the greater part of the Mississippi Valley region during the beginning of the Ordovician period, retreated. Part of the sand was spread over the area by the sea during its gradual retreat; part of it was washed onto it by streams which derived the sand from sandstones and other rocks containing quartz grains which were undergoing weathering and erosion along the northern margins of the area; and a portion of it was blown across the coastal plain by prevailing northerly winds. The wind was also very active in transporting the sand already deposited so that the area presented the aspect of a slowly shifting sand plain, the sand gradually moving southward in the form of dunes. This resulted in the removal of all the finer, lighter, clayey material, leaving behind a very fine quartz sand. The action of the wind also accounts for the rounded nature of the grains. Later, when the sea again advanced over the area the upper portion of the sand was re-worked by the waves, and finally limestones and other strata were deposited on top of it. It is only in places where erosion has removed these overlying beds that the St. Peter sandstone can be worked to-day.

The literary programme, which is being prepared for the Pan-American Road Congress, covers the entire range of subjects connected with the construction and maintenance of country roads and city streets. The men who will present papers or deliver addresses are the best known authorities in the United States and Canada.

Editorial

TWO GEOLOGICAL REPORTS OF IMPORTANCE.

Manufacturers of clay products in search of raw materials will find much of value in the latest report on the clay and shale deposits of the Province of Quebec. This is a preliminary report, prepared by Mr. Joseph Keele, of the Geological Survey, Department of Mines, Ottawa. It covers an investigation, made in 1912 and 13, in the thickly-settled portions of the province, localities convenient as to transportation and reasonably close to markets, wherein lies the economic value of all clay and shale deposits.

The investigation has shown that there is in Quebec a lack of high-grade clays, like fireclays or pottery clays; but that there is an abundance of raw material suitable for the manufacture of rough clay products, and well situated, too, with regard to transportation. As to what the probabilities are of finding high-grade clays in the vast undeveloped portions of the province in the future, little is said, except that their value will depend primarily upon their nearness to railways, or their branches, or to water transport.

Another Geological Survey report of great value is that by Mr. D. B. Dowling on the coal fields of Manitoba, Saskatchewan, Alberta and Eastern British Columbia. As indicated on another page of this issue, the total estimate for this portion of the Dominion approximates 95,598 square miles of coal lands with 1,176,825,000,000 tons of coal in reserve. Approximately 70 per cent. of this is classed as sub-bituminous coal.

During the past few years the increase in population, extension of railways and introduction of manufacturing industries has developed a rapid increase in consumption, and it is not unlikely that before many years the present operating mines will be taxed to their full capacity unless many new mines are opened.

INCREASING USE OF HYDRO-ELECTRIC POWER IN ONTARIO.

So rapidly have the municipalities in the Western Peninsular of Ontario taken advantage of the power facilities afforded by the Hydro-Electric Power Commission for the utilization of Niagara power that the Commission has been obliged to notify its source of supply, the Ontario Power Company, to prepare for furnishing the last ten-thousand-horse-power consignment of the 100,000 h.p. contract. Sir Adam Beck, chairman of the Commission, reports that, in spite of the war, the consumption of hydro power has increased enormously, the municipalities have added to their surpluses notwithstanding the reductions in rates to consumers, and the Commission itself has come through with a fine margin. The total revenue from the 84 municipalities, railways and large users from the Niagara circuit of the Hydro-Electric system for the six months ending on May 1st is $710,324.95. After providing some $303,000 for the cost of power, $49,000 for maintenance, $155,000 for interest, $30,000 for operation, $156,000 for engineering and construction, the sum of $69,808.37 has been applied to the sinking fund and $50,210.35 to the depreciation and reserve account.

In order now to provide for future demands, since the limit of available power under the present arrangement will shortly be reached, the engineering staff of the Commission is investigating the development at Niagara of a hydro-electric plant of its own. It is understood that the plans are being prepared for a 250,000 h.p. development. It is altogether likely that the Commission will have something definite to announce relative to this big undertaking before the summer is over. There are other sites under consideration in different parts of Ontario. One at Gravenhurst is likely to be undertaken at an early date, providing a supply of about 1,500 h.p. The plant at Eugenia Falls, of which mention has been made on numerous occasions in these pages, will shortly undergo its final test. Power lines from it are now being constructed through various municipalities and operation will be under way in the course of a month. The plant at Wasdell's Falls was placed in operation last October; it provides about 1,200 h,p. for a group of municipalities around Lake Simcoe.

According to Sir Adam, the schemes for new developments will shortly be submitted to the government with a recommendation that action be taken at once.

"The demand for municipally-owned power," he states, "is far from being on the wane. It is going to keep us jumping to keep our producing facilities up to the call for power. Towns and villages all over Ontario are demanding, rather than asking, service from the government's power scheme. They find that it is cheaper and more dependable, and of more benefit to the country at large than paying money into the private corporations."

NEW WATER LEVELS COMMISSION APPOINTED.

An Ottawa despatch states that a commission to inquire into water conditions in Montreal harbor and to report on certain suggested improvements in the harbor facilities has been appointed by the Government. It succeeds the commission which reported last session on water levels in the St. Lawrence, and will in effect continue its work, but confine the investigations to Montreal harbor. It consists of Dean Haskell, chairman; Mr. W. J. Stewart, chief hydrographer of the Marine Department, and Mr. F. W. Cowie, chief engineer of the Montreal Harbor Works.

The first commission reported on the levels of the St. Lawrence, showing how the works in the river had lowered the water therein and suggested dams at various places to remedy these conditions. Following this, the Minister of Marine considered it would be a good opportunity to investigate conditions in the Montreal harbor, the most important place on the St. Lawrence system, hence the appointment of the present body. The commission will report upon the probable effect on Montreal harbor of the various improvements suggested for the St. Lawrence. It will go more into detail in connection with the actual lowering of harbor levels which has taken place at many points. It will examine carefully into the effect of the diversion of water by the Chicago drainage canal and the effect of storing water in the Ottawa Valley. The improvement of ice conditions in the harbor and the construction of the proposed bridge connecting the north and south shores of the harbor will also be looked into.

The commission will take about two years to complete its work.

CONCRETE IN DRY DOCK CONSTRUCTION.

PRIOR to the construction of the Pearl Harbor dry dock, a series of experiments were performed to determine the mixture that would produce the most dense and plastic concrete. These tests are outlined in a paper by Mr. H. S. Stanford, appearing in the Proceedings for May of the American Society of Civil Engineers. The paper describes in detail the construction of the docks, but only his discussion of the tests on concrete and his conclusions regarding the use of tremies will be referred to here.

In connection with the experiments the ingredients in each mixing were carefully weighed, then mixed with shovels and placed in an 8-in. pipe closed at one end, to determine the volume of the mixture. The degree of density was obtained by comparing the volume with the weight. The plasticity was determined by observing the action of the concrete when handled with shovels and by the settlement into the mass of two wooden rods having sectional areas of 1 and 2½ sq. in. respectively, under the weight of a man.

It was found that, other conditions being the same, the concrete made with the 1-in. stone was more dense and plastic than that obtained with the larger stone. Graded stone, containing such percentages of each size that when plotted it gave a straight line, produced concrete which was at the same time most dense and plastic. An excess in the percentage of small pieces increased the plasticity but decreased the density, whereas a deficiency in the smaller sizes had little effect on the density but reduced the plasticity. Mixtures in proportion of 1 : 2.5 : 4 were more plastic than 1 : 2 : 4 but not as dense; 1 : 2 : 4 mixtures were more dense than those of 1 : 2 : 3.5 but not as plastic.

Results of Crushing Tests.

Class.	Sand.	Age.	Crushing strength in pounds per square inch. In salt water.	In fresh water.
I.	Three parts screenings passing ⅛-in. mesh with dust retained on 30-mesh, with 1 part Puget Sound sand	3 days	685	620
		28 days	1,435	1,320
		2½ mos.	1,860	2,285
II.	Screenings passing 3/16-in. mesh with dust retained on 30-mesh	3 days	590	470
		28 days	1,280	1,230
		3 mos.	1,985	1,985
III.	Screenings passing 3/16-in. mesh containing all the dust of fracture	3 days	630	565
		28 days	1,505	1,390
		3 mos.	2,655	2,370
IV.	Sand from Puget Sound ...	3 days	905	845
		28 days	1,745	1,780
		2½ mos.	2,450	2,360

A series of 132 laboratory crushing tests were made on 6-in. tubes. Nine sets of 12 blocks were made of concrete mixed in proportions of 1 : 2 : 3.5, using for each test uniformly graded stones not larger than 1 in. but with differently mixed or prepared sands for the different tests. The results are given in the accompanying table.

In addition to that, fifteen large-sized test blocks were made under conditions which resembled those actually existing when placing under-water concrete for the bottom of the dock. The concrete for these tests was deposited with tremies in water about 52 ft. deep, the end of the tremie being held near one corner of the form, so that the concrete had to flow an extreme distance of about 6 ft. after leaving the tremie.

A great deal of interesting experience in the use of tremies has been acquired in handling a product at first practically worthless, and then gradually improved until it finally attained a high degree of excellence. Tremies 12 in., 15 in. and 18 in. in diameter were used in these experiments (approximately 14,840 cu. yd. of concrete were deposited through tremies), and the author arrived at the following conclusions:—

The results obtained from a tremie depend to a great extent on the proportions, character of materials and plasticity of the concrete which is being used; the excessive frictional resistance to the movement of concrete in a 12-in. pipe causes frequent clogging in the pipe and gradually increases the pressure at the exit, making it impracticable to hold the end of the tremie embedded in the deposited concrete; the frictional resistance to the movement of concrete in an 18-in. pipe is not sufficient to prevent the occasional loss of a charge in the tremie, thereby interrupting the filling of the form, with added uncertainty as to the quality of the product; the frictional resistance in a 15-in. tremie is apparently just about right to obtain the proper discharge pressure necessary for efficiently regulating the flow of concrete by raising and lowering the tremie with the end maintained within the deposited mass. The concrete flows freely to distant parts of the form without causing disturbance in the mass. The tremie 15 in. in diameter is best suited for the work, and in the Pearl Harbor dry dock construction the size was adopted and actually used for placing the greater part of the tremie concrete.

Approved designs, however, eliminated practically all tremie-placed concrete, without involving endangering conditions. This fact is considered a most valuable feature of the plan of construction, inasmuch as there can be no absolute certainty that concrete deposited under water will possess the uniform degree of perfection essential to dock construction.

RUSSIAN RAILWAY EXTENSION.

The administration of railways in Russia has made the following appropriations in the estimate of expenses for 1915: The sum of $13,056,589 has been appropriated for the purchase of 90 passenger engines and 390 freight engines, with equipment. The amount of $6,366,237 is assigned for the purchase of 8,350 freight cars, and $2,994,308 has been appropriated for the purchase of 505 passenger cars. In connection with the proposed direct international railway communication, the Russian tariff committee proposes to construct direct lines connecting Archangel with Vologda, Petrograd, Moscow, Kief, Warsaw, Saratof, Kharkof, Odessa, Ekaterinoslav, Omsk, Riga and Reval, and through Archangel connecting with the ports of New York, Halifax, Liverpool and Glasgow.

COAST TO COAST

Galt, Ont.—Work has been commenced by the Lake Erie and Northern Railway on the State Street retaining wall.

Sydney, N.S.—There are now four furnaces in operation at the Dominion Steel plant, the fourth having been blown in on July 5th.

Hamilton, Ont.—The T., H. and B. grade separation problem was again considered by the Dominion Railway Commission, sitting in Hamilton, on July 17th.

Halifax, N.S.—A new train ferry, "Prince Edward Island," has arrived from Newcastle, England, for use by the Intercolonial Railway to carry cars between Prince Edward Island and Cape Tormentine, N.B.

St. John, N.B.—Mr. A. R. Wetmore, District Engineer for the Department of Public Works at Ottawa, states that the new bridge across the Reversible Falls will be open for traffic in August. He is arranging for the removal of the existing suspension bridge.

Port Colborne, Ont.—Work has commenced on a small section of the proposed pipe line to supply the towns along the new Welland Canal with water. It is stated that only a small section will be installed at the present time and will be used for test purposes prior to the construction of the entire line.

Hamilton, Ont.—The malleable iron factory of the International Harvester Co. opens again on July 19th and in a few weeks the entire plant will be in operation. The activities are due, not to war orders, but to orders for agricultural implements for the West. The Oliver Plow Works will also be working to full capacity soon.

Ottawa, Ont.—The lease of the Grand Trunk Pacific properties at the head of the lakes, including the Superior Junction section and the terminal and elevator facilities, has been signed up and the government has now full control for a period of 999 years of the property It is stated that the consideration is $600,000 per year, this being on the basis of 4½ per cent. upon the cost of the property.

Vancouver, B.C.—Among the seven money by-laws that met their Waterloo when submitted to the ratepayers last month was a $65,000 by-law for the repair of the Connaught bridge, recently put out of service by fire. The city council is eagerly searching for some other means of financing the necessary repairs, and in the meantime tenders are being considered for the construction of a temporary structure.

Galt, Ont.—Since the Lake Erie and Northern purchase of the Grand Valley Railway from Paris to Galt it has been announced by Mr. M. N. Todd, general manager of the Lake Erie and Northern, and also president of the Galt, Preston and Hespeler Railway, that these two lines, both of which are closely affiliated with the C.P.R., may shortly be amalgamated, providing a through electric line from Berlin to Port Dover.

Chatham, Ont.—It is stated that the Hydro-Electric Power Commission of Ontario is negotiating with the C.N.R. for the purchase of the Chatham, Wallaceburg and Lake Erie Railway, which runs from Erie Beach on the south to Wallaceburg on the north. If purchased, the line will be made the nucleus for a hydro radial system in this part of the province, and the road will be extended to Sarnia through Petrolea and other places about to install Niagara power.

Sarnia, Ont.—The Sarnia Gas and Electric Light Company has received from the city council an offer for its entire electrical plant, lines and properties, the sum offered by the corporation being $155,000. If the company will accept this figure the council will have a by-law prepared to submit the question to the ratepayers, who will decide whether they wish to buy the local concern out, and install hydro, or whether they wish to install another plant and run it in opposition to the present company.

Stratford, Ont.—The Stratford Public Utilities' Commission, composed of the old water commission and the light and heat commission, which have amalgamated, organized its new forces recently, and appointed Mr. Angus McDonald, formerly chairman of the light and heat commission, as chairman over the new body. Mr. R. H. Myers, superintendent of the light and heat commission, was appointed secretary-treasurer of the new body, and Mr. Wm. Trethewey was appointed secretary of the water committee.

Victoria, B.C—The city engineering department is proceeding by day labor with the pile foundations for the Selkirk syphon of the north-west sewer, and tenders are in for the supply of 930 feet of steel pipe. It will be laid about 14 ft. below water level, and the sewage from the north shore will pass through it under pressure to the Sunnyside tunnel. These tunnels, mentioned in a recent issue of this journal, will be completed in about two months, and it is expected that the syphon will also be in place by that time.

Toronto, Ont.—Another rumor is going the rounds regarding an early start on the new Union Station and railway terminals. It is stated that an arrangement has been made for advances of $4,000,000 by the Bank of Montreal on the guarantee of the Canadian Pacific and Grand Trunk Railways, and that all details have been worked out, including the arrangement with the government in regard to the question of a postal station. However, there's no harm in observing that, like its numerous predecessors, the rumor appears to lack something.

Halifax, N.S.—The city is considering an offer from the Halifax Power Co. covering a half interest in the concern. It owns the nearest and best water-power, eighteen miles distant, and combining the waters of the Indian and North-east Rivers with large reservoirs. Mr. S. M. Brookfield, who is president of the company, claims that the city can thereby derive fifty per cent. more light than it receives at present for the price. It is expected that the new ocean terminals under construction will take about twenty-five hundred horse-power and the new dock will take even more.

St. John, N.B.—A decision was handed out by the supreme court against the city contention that it could compel the street railway when making rail changes to substitute grooved for "T" rails and to lay concrete foundations. The one point of the reference on which the city contention appears to have been upheld by the court was that the company must keep its rails level with the street, whatever the street grade may be. This is a most important decision, and, read in conjunction with the declaration that the company must provide good foundations for the tracks, gives the city the needed assurance of a satisfactory roadway.

PERSONAL

GEO. H. THOMAS succeeds Mr. Alex. Baird on the Galt Waterworks Commission.

GEORGE HENDERSON, assistant engineer at the Beach pumping station, Hamilton, has resigned.

F. McARTHUR has been appointed city engineer of Guelph, Ont., with complete charge of the engineering department.

WALTER NIEFORTH, of Milford, N.S., has been appointed commissioner of sewers for the county of Halifax, N.S.

J. B. TYRRELL, consulting mining engineer, Toronto, has been elected president of the geological section of the Royal Society of Canada.

WM. M. GUY, recently appointed general traffic manager of the London and Port Stanley Railway, the electrification of which has just been completed, has resigned.

WM. McLAREN, formerly with the Canadian General Electric Co., Peterboro', has engaged in the manufacture of munitions with the Ross Rifle Company, Quebec.

JOHN T. REID has been appointed superintendent of the Quebec Central Railway, succeeding Mr. J. Fortin, resigned. The position of assistant superintendent, which Mr. Reid has held for a number of years, has been abolished.

W. S. McGIBBON has been appointed town engineer of Transcona, Man. Mr. McGibbon has been resident engineer in Transcona for the past three years for Mr. W. M. Scott, M. Can. Soc. C.E., under whose design and supervision the waterworks, sewerage system and other public works in the town have been installed.

H. S. PHILLIPS, chief draftsman of the main drainage section of the Department of Works, Toronto, has been loaned for a few months by the city to the International Joint Commission and is assisting in a study of drainage conditions of the city of Buffalo. The Commission is investigating the drainage of Buffalo and Detroit with a view to acquiring more light on a solution of the problems that have arisen out of the recent investigation into the pollution of boundary waters. Mr. Phillips has had much to do with drainage studies in Toronto.

OBITUARY.

On June 15th, Sapper Albert McKenzie, of the 1st Field Company, Canadian Engineers, B.E.F., was killed, according to a recent casualty notice. Prior to enlistment he was in the employ of Burnett Bros., electrical contractors, Vancouver, B.C.

COMING MEETINGS.

AMERICAN SOCIETY OF CIVIL ENGINEERS.—Annual convention to be held in San Francisco, Cal., September 16th to 18th, 1915. Secretary, Charles Warren Hunt, 220 West 57th Street, New York.

McGILL AND TORONTO MEN IN SOLDIERS' GRAVES.

The University of Toronto Engineering Society advises us that the following constitutes the list of killed among the graduates and students of the Faculty of Applied Science at the front: Graduates—Capt. J. G. Helliwell, Lieut. H. N. Klotz, Lieut. F. C. Andrews, and Driver Norman Lawless. Undergraduates—Lieut. G. B. Taylor (Rhodes scholar), and Pte. F. L. Eardley-Wilmot.

Through the courtesy of Dean Adams, of the Faculty of Applied Science, McGill University, we are also able to present a fairly complete list of names of engineering graduates and undergraduates who have been killed while in service at the front. The names are: Of graduates—O. C. F. Hague, A. H. Helmer, R. E. L. Hollinsed, H. A. Paddon, A. J. Richardson, and A. L. Powter; and the undergraduates, F. Fisher, F. D. L. Green, and J. H. Rocher.

G. T. P. APPOINTMENTS IN THE WEST.

A. H. Mahan, locomotive foreman of the Grand Trunk Pacific at Prince George, B.C., has been appointed general locomotive foreman in charge of territory from Prince George to Edmonton, Alta., including intervening branch lines; J. F. Moffatt, road foreman at Wainwright, Alta., has been appointed general locomotive foreman in charge of the territory from Transcona, Man., to Fort William, Ont.; H. R. Simpson, road foreman at Jasper, Alta., has been appointed general locomotive foreman in charge of the territory from Watrous, Sask., to Winnipeg, Man., including intervening branch lines; W. G. McConachie, road foreman at Edmonton, Alta., has been appointed general locomotive foreman in charge of the territory from Edmonton to Watrous, including intervening branch lines, and A. Watt, general foreman at Prince Rupert, B.C., has been appointed general locomotive foreman in charge of the territory from Prince Rupert to Prince George. D. W. Hay has been appointed locomotive foreman, with office at Prince George, B.C., succeeding A. H. Mahan, and J. A. Miller has been appointed locomotive foreman at Endako, succeeding G. H. Laycock, transferred to Jasper, Alta.

PROGRESS ON THE ROGER'S PASS TUNNEL.

Messrs. Foley Bros., Welch and Stewart, contractors for the Canadian Pacific Railway on the construction of the 5-mile tunnel under Roger's Pass, Selkirks, report the following footages up to July 1st:—

Section.	Progress in June.	Total to July 1st, 1915.
Pioneer Heading—		
East end	776 ft.	10,118 ft.
West end	830 "	8,236 "
Centre Heading—		
East end	471 ft.	5,866 ft.
West end	431 "	6,598 "
Finished Double-track Tunnel—		
East end	659 ft.	4,556 ft.
West end	729 "	3,032 "