PAGES

MISSING

Volume 30. Toronto, June 8, 1916.

Contents of this issue on page 5.

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

SOME ASPECTS OF CHLORINATION*

IN VIEW OF THE INCREASING USE OF LIQUID CHLORINE OR HYPOCHLORITE FOR THE STERILIZATION OF WATER, THE OBSERVATIONS OF THE AUTHOR OF THIS PAPER SHOULD BE OF CONSIDERABLE INTEREST TO WATERWORKS ENGINEERS.

By JOSEPH RACE,
City Bacteriologist, Ottawa, Canada.

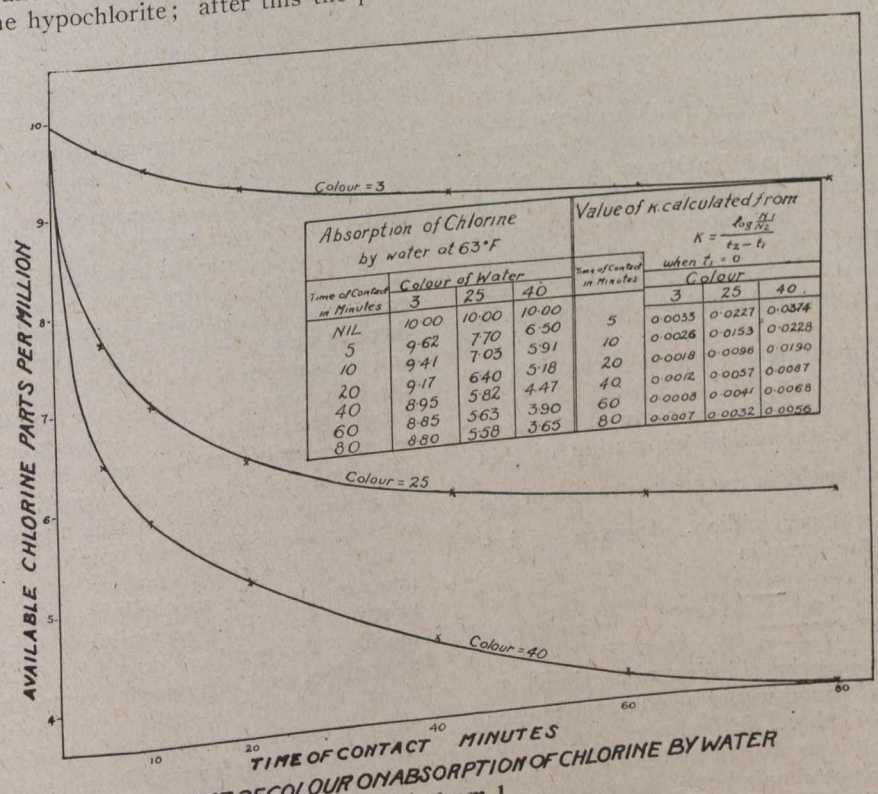
ALTHOUGH the treatment of water by chlorine or hypochlorite has been very extensively practised for several years it is a regrettable fact that comparatively few investigations have been made into this process with a view to elucidating the basic principles and the modifications required to meet various conditions.

When chlorination was first introduced for the sterilization of water and sewage, all that was required was the addition of the hypochlorite; after this the process was supposed to take care of itself. Now we realize that to obtain the best results the process requires careful supervision and close attention to certain points. It is the purpose of the writer to draw attention to some of these details in this paper.

Mechanical Admixture.—Due attention has not always been given to this phase of the chlorination problem because of the prevalent opinion that the all-important point was contact period. The writer has previously recorded (Journ. Soc. Chem. Ind., 1912, 31, 611-616, and 1915, 34, 931-934) experiments made for the purpose of comparing the importance of these two factors. In 1914, a sedimentation basin was placed in operation at the mouth of the Ottawa intake pipe and during July the hypochlorite solution was added at the entrance to this basin. The method of addition was by means of a perforated pipe which stretched across the entrance to the basin and the bleach solution and water were there mixed as thoroughly as was possible without having recourse to mechanical methods. The basin was baffled and had a normal capacity equal to approximately two hours' consumption (1.7 million Imp. gallons). The results obtained were as follows:—

Available Chlorine = 1.88 p.p.m. Bacteria per c.c.

	Agar 3 days at 20°C.	Agar 1 day at 37°C.	B Coli Index per c.c.
Raw water	410	104	0.280
Treated water	49	26	0.036
Percentage purification..	88.2	75.0	87.500



Absorption of Chlorine by water at 63°F

Time of Contact in Minutes	Colour of Water 3	25	40
NIL	10.00	10.00	10.00
5	9.62	7.70	6.50
10	9.41	7.03	5.91
20	9.17	6.40	5.18
40	8.95	5.82	4.47
60	8.85	5.63	3.90
80	8.80	5.58	3.65

Value of K calculated from $K = \frac{\log \frac{N_1}{N_2}}{t_2 - t_1}$ when $t_1 = 0$

Time of Contact in Minutes	Colour 3	25	40
5	0.0033	0.0227	0.0374
10	0.0026	0.0153	0.0228
20	0.0018	0.0096	0.0190
40	0.0012	0.0057	0.0087
60	0.0008	0.0041	0.0068
80	0.0007	0.0032	0.0056

EFFECT OF COLOUR ON ABSORPTION OF CHLORINE BY WATER

Diagram 1.

During August the connection at the entrance to the basin was closed and the bleach liquor added directly to the suctions of the low-lift pumps, which take water from the sedimentation basin and place it in the intake pipe under a small positive pressure until it reaches the high-lift pumps. During both months the samples of treated water were taken from the well which receives the mixed discharges of the low-lift pumps. These results, which are the averages of daily analyses, show that the efficient mechanical admixture produced much superior results with a smaller consumption of chlorine. The results for August were:—

Available Chlorine = 1.55 p.p.m. Bacteria per c.c.

	Agar 3 days at 20°C.	Agar 1 day at 37°C.	B. Coli Index per c.c.
Raw water	448	100	0.600
Treated water	26	12	0.005
Percentage purification..	91.9	88.0	99.200

Color.—The effect of color, as is well known, is to reduce the efficiency of chlorination and to necessitate the use of a much larger dose. This is well exemplified in the following table, which gives the results of chlorination experiments on B. Coli seeded into water. Water "B" was

*Read before the American Waterworks Association, June 8th, 1916.

the raw Ottawa River water containing 40 parts per million of color and water "A," with a color of 3 parts per million was produced from "B" by precipitating with sulphate of alumina and subsequently filtering. The B. Coli count was made by platting out 10 cubic centimeters of water in neutral red bile salt agar and counting the typical red colonies. Counts were made after 24, 48 and 72 hours, but in this table only the 24-hour count is recorded. The counts at later periods were made to determine whether the organisms were actually killed or the reproductive capacity merely delayed, as was observed on a former occasion. (Journ. Soc. Chem. Ind., July, 1912.) In none of the experiments was any evidence obtained of any revival of the organisms.

TABLE I.

Colonies Per 10 c.cms. of Water. Temp. = 63°F.

Contact Period.	Water "A," Color 3 Available Chlorine p p.m.	Water "B," Color 40 Available Chlorine p.p.m.		
	0.2	0.2	0.4	0.5
Nil	194	194	194	194
5 minutes	121	165	129	66
1 hour	7	95	20	1
5 hours	0	4	0	0
24 hours	0	1	1	0
48 hours	0	0	0	0

To obtain the same result with about one hour's contact at 63° F. it is necessary to use about two and one-half times as much chlorine with a water of color 40 as with one practically free from color. Somewhat similar results have been obtained at Montreal by Harrington (Journ. Am. Waterworks Assoc. Vol. 3, 438). For the greater part of the year St. Lawrence water free from color is obtained at the inlet to the Montreal intake pipe and only requires approximately 0.3 parts per million of available chlorine for satisfactory treatment. During the spring floods the currents are altered and the Ottawa River water is obtained. This requires as much as 1.5 p.p.m. of chlorine but a portion of this high dose is necessitated by the increase of turbidity. During the flood period the color is somewhat reduced but its effect in the chlorination efficiency is more than counterbalanced by the increase in turbidity.

The effect of color upon the absorption of chlorine, in the form of hypochlorite, by water, is well shown in Diagram 1. The absorption takes the form of a monomolecular reaction, the mathematical expression of this law being $\frac{dN}{dt} = KN$ where N is the concentration of the available chlorine in parts per million. Integrating between t_1 and t_2 we get the formula

$$K = \frac{\log. \frac{N_1}{N_2}}{t_2 - t_1}$$

If the compound absorbing the chlorine were simple in character, the value of K found would be constant in each experiment. Instead of that, we find a constantly diminishing quantity which is explained by the fact that the compound acted upon is not simple but a mixture of complex molecules having different affinities for oxygen.

Temperature.—The effect of temperature on a culture of B. Coli in unsterilized water (color 40) is well illustrated in the two following tables.

TABLE II.—EFFECT OF TEMPERATURE.

Colonies Per 10 c.cms. of Water. Available Chlorine 0.4 p.p.m.

Contact Period.	Temperature Degrees Fahrenheit 36.	70.	98.
Nil	424	424	424
5 minutes	320	280	240
1.5 hours	148	76	12
4.5 hours	38	14	3
24 hours	2	0	0
48 hours	2	0	0

TABLE III.

Colonies Per 10 c.cms. of Water. Available Chlorine 0.2 p.p.m.

Contact Period.	Temperature Degrees Fahrenheit 36.	70.	98.
Nil	240	240	240
5 minutes	240	250	235
1 hour	245	235	195
4 hours	215	190	170
24 hours	143	130	115
48 hours	130	59	19
72 hours	...	28	..
96 hours	...	16	..
120 hours	...	6	..

In the 70° F. experiment, the sample, after 3, 4 and 5 days' contact, was inoculated into lactose bile and lactose broth with the following results:—

Contact Period.	Lactose Bile.	Lactose Broth.	B. Coli Per 10 c.c. Most probable number. Lactose Bile.	Lactose Broth.	Colonies per 10 c.c. on Rebipelagar.
72 hours	2/5	5/5	5	20	28
96 hours	0/5	4/5	1	16	16
120 hours	0/5	2/5	1	5	6

When these results are calculated to the most probable numbers by McCrady's method (Journ. Inf. Dis., 1915, 17, 183-212) some interesting comparisons are obtained. The lactose broth and rebipelagar plates are in close agreement but yield results very much higher than the lactose bile. If lactose bile only takes account of virile organisms it must be assumed that the majority of the B. Coli remaining after 72 hours' contact, are attenuated. This dictum would appear to be somewhat arbitrary and empirical.

The effect of temperature upon the absorption of the available chlorine is shown in Diagram 2.

Aftergrowths.—In connection with chlorination many well-authenticated reports have been made that after the preliminary germicidal action has subsided a second phase occurs in which there is an accelerated growth of organisms. This is usually known as aftergrowth. When there is only a short contact period between chlorination and consumption, the reaction does not proceed beyond the first phase, but when the treated water is stored in service reservoirs the second phase may ensue and is usually ascribed to a change in pabulum effected by the action of the chlorine or oxygen on the organic matter. Regarding the nature of this aftergrowth there has been considerable difference of opinion; some hold that it is the result of the multiplication of a resistant minority of practically all the species present in the untreated water; others, that it is partially due to the bacteria being merely "slugged" or "doped," *i.e.*, in a state of suspended animation, and afterwards resuming their anabolic functions, whilst others believe that with the proper dose of chlorine only spore-forming organisms escape destruction and that the aftergrowth is the result of these cells again becoming vegetative. The aftergrowths obtained under the usual working conditions vary according to the dosage of chlorine employed and none of the above hypotheses alone provides an adequate explanation. When the dosage is small a small number of active organisms in addition to spore-bearers will escape destruction, and others, as was shown by the writer in a previous paper (Journ. Soc. Chem. Ind., 1912, 31, pp. 611-616), will suffer a reduction of reproductive capacity. The flora of the aftergrowth in this case will only differ from the original flora by the elimination of species that are very susceptible to chlorine As the dose is increased these two factors become relatively less important until a stage is reached when only the most resistant cells, the spores, are left; the resultant aftergrowth must necessarily be entirely composed of

spore-forming organisms. Chlorination operators do not usually use a dose that would eliminate all but spore-bearers and it therefore becomes essential that we should know whether the aftergrowth has any sanitary significance. Concerning the secondary development of B. Coli, the usual index of pollution, there is but very meagre information. H. E. Jordon (Eng. Rec. 1915, May 17) reported that of 201 samples, 21 gave a positive B. Coli reaction immediately after treatment, 39 after 24 hours' standing and 42 after 48 hours. These increases were confined to the warm months, the cold months actually showing a decrease. The following figures, taken from the writer's routine tests for 1913 and 1914, show a similar tendency, but an analysis of the results by months did not show that this was confined to the summer months.

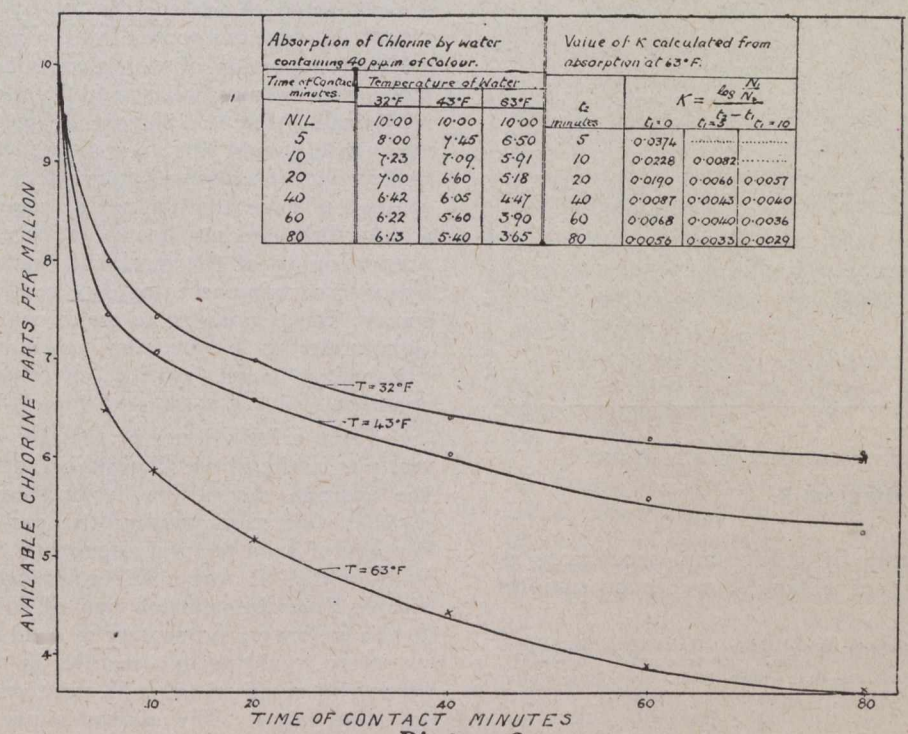
The sequence of the results from left to right in the following table is in the same order as the contact period, and each percentage represents the average of approximately 290 samples.

Percentage of Samples Showing B. Coli in 10 c.cms.

	1.	2.	3.	4.	5.
1913	15.2	14.4	16.3	16.8	26.8
1914	7.0	5.7	6.0	....	11.6

At station 2 the germicidal action was evidently still proceeding, but at station 5, representing an outlying section of the city, the increase is marked.

During 1915 and 1916 the writer attempted to duplicate these results under laboratory conditions and entirely failed. Usually these experiments, which were made with the same materials as were in use at the city plant, but in glass containers, were only carried to 48 hours' contact, as this would be the extreme limit found in practice; one, however, was prolonged to 5 days. Many experiments of this nature were made with varying conditions, but as the results are all similar there is nothing to be gained by adding to those given above in tables 1, 2 and 3. In every case there is a persistent diminution in the number of B. Coli organisms found with increase of contact period. Determination of the bacterial count on nutrient agar showed in several cases that the aftergrowth had commenced and in some instances there was evidence that the second cycle was partially complete, *i.e.*, the number had reached a maximum and then commenced to decline. The time required for the completion of the two cycles, comprising the first reduction caused by the chlorine, the increase or aftergrowth and the final reduction due to lack of suitable food material, is dependent upon various factors of which the dosage and temperature are the most important. With a small dosage the germicidal period is short and the second phase quickly reached; with large doses the second phase is not reached within 48 hours. Low temperatures reduce the velocity of the germicidal action but extend the period over which it is effective. The higher the temperature the quicker is the action and the development of the aftergrowth. These statements refer only to the total bacteria as found by development on nutrient agar. The B. Coli did not act in this way and persistently diminished in every case. If B. Typhosus acts in a similar manner to B. Coli, the laboratory experiments show that aftergrowths are of no sanitary significance and can be safely ignored, but as the results obtained in actual practice are apparently contradictory the matter should be regarded as *sub judice* until more definite evidence is available. Perhaps the remarkable photochemical properties of chlorine are concerned in this matter.



Absorption of Chlorine by water containing 40 p.p.m. of Colour.

Time of Contact minutes.	Temperature of Water 32°F	43°F	63°F
NIL	10·00	10·00	10·00
5	8·00	7·45	6·50
10	7·23	7·09	5·91
20	7·00	6·60	5·18
40	6·42	6·05	4·47
60	6·22	5·60	3·90
80	6·13	5·40	3·65

Value of K calculated from absorption at 63°F.

$K = \frac{\log N_1}{t_2 - t_1}$

t_2 minutes	$t_1 = 0$	$t_1 = 5$	$t_1 = 10$
5	0·0374	.....	.....
10	0·0228	0·0082	.....
20	0·0190	0·0066	0·0057
40	0·0087	0·0043	0·0040
60	0·0068	0·0040	0·0036
80	0·0056	0·0033	0·0029

Diagram 2.

Corrosion.—Numerous complaints regarding corrosion of piping systems in Ottawa led to the routine determination of free carbonic acid in the raw and treated waters. During a period of excessive turbidity and pollution a very heavy dose of chlorine was used and an increase in the free carbonic acid resulted. During the past 18 months the average results show a decrease, so that there could scarcely be an increased corrosive action due to carbonic acid.

If the treatment is considered according to the electrolytic theory, a slight increase in corrosion might be expected due to an increased electrical conductivity. The conductivities of various chlorinated mixtures were therefore determined with the results as shown in Diagram 3.

With the usual dosages of chlorine it is inconceivable that the increased electrical conductivity has any practical significance at ordinary temperatures. At temperatures approaching the boiling point of water the percentage increase in conductivity would be somewhat greater and may possibly assume practical importance.

Surviving Types of B. Coli.—Several experiments were made with a view to ascertaining whether the B. Coli found after chlorination were more resistant to chlorine than the original culture. The colonies surviving after treatment with comparatively large doses were fished into lactose broth and this culture used for a second chlorination. The surviving organisms were again fished and the process repeated several times. The velocity of the chlorination reaction varied somewhat, but not always in the same direction and the variations were not greater than was found in duplicate experiments with the original culture. No evidence was obtained that the surviving organisms were in any way more resistant to chlorine than the original culture. It should be remembered, how-

ever, that the surviving types were cultivated twice on media free from chlorine before being again subjected to chlorination. A number of the colonies surviving several chlorinations were cultivated in lactose broth and the acidity determined quantitatively. All the cultures produced less acid than the original culture and the average was materially less than the original cultivated under the same conditions. This points to a diminution in the biochemical activity.

A point of perhaps more scientific interest than practical utility is the relative proportion of the various types of B. Coli found before and after treatment with chlorine. The writer, in 1914 commenced the analysis of the various types, using the division of the American

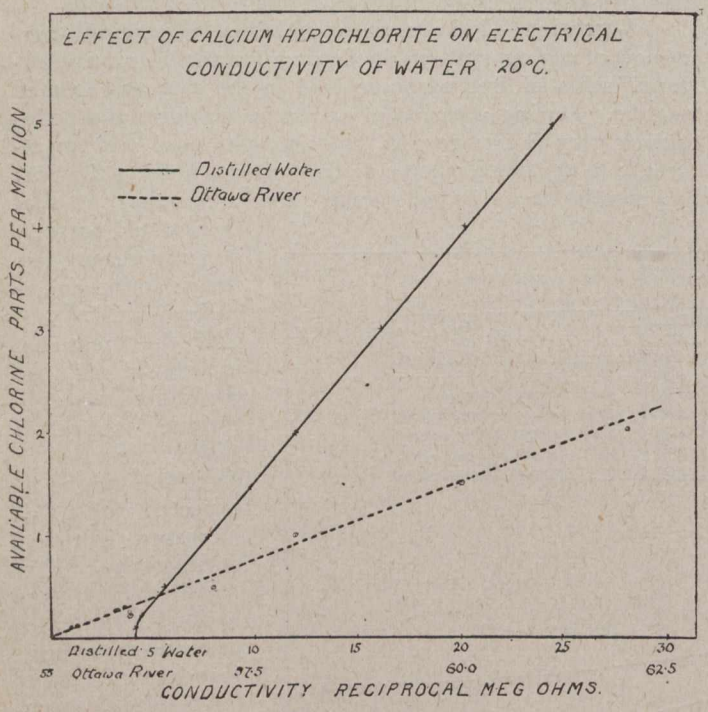


Diagram 3.

Public Health Association by dulcite and saccharose as a basis. The averages of a large number of samples were as follows:—

	B. Coli Communis Raw	B. Coli Communis Chlorinated.	B. Lactis Aerogenes Raw	B. Lactis Aerogenes Chlorinated.	B. Acidi Lactici Raw	B. Acidi Lactici Chlorinated.
Ottawa, 1914	5	4	40	48	44	36	11	12
Ottawa, 1915	8	8	50	46	34	31	8	15
*Baltimore, 1913 ..	11	14	33	25	35	31	21	30

*Thomas and Sandman, J. Ind. and Eng. Chem, 1914. 6 p. 638.

Although there is a slight difference in the relative proportions of the types found at Ottawa and Baltimore, both sets of results show definitely that there is no difference in the resistance of the various types to chlorine.

The net earnings of the Manitoba Government telephones for the five months ended April 30, totalled $202,571.41, according to the condensed earnings report and balance sheet recently issued by the public utilities commissioner.

Announcement has been made to the effect that the British Columbia Government will introduce legislation to provide $200,000 for the purpose of opening up roads and trails to places in the mountains where there are "pioneer" prospects.

AGGREGATE STUDIES AT THE WINNIPEG AQUEDUCT.*

By James H. Fuertes.

THE Greater Winnipeg Water District is now building works for securing by gravity about 100,000,000 U.S. gallons of water per day from the Lake of the Woods, which lies about 100 miles east of, and some 300 ft. higher in elevation than, the city of Winnipeg.

Under the terms of the contract the District agrees to deliver the sand and gravel to the contractor at a stated price per cubic yard. Actually the District is shipping these mixed, but billed as sand and gravel in accordance with the ratios of the volumes that the sand and gravel would make separately, these having been determined from an extended laboratory study of the materials. It would be impossible, within space limits, to do justice to this phase of the subject. Owing to the percentage of sand in the gravel pit it is necessary to dig considerably more material than can be made into concrete aggregate. Thus in August there were excavated at the pit approximately 24,000 cu. yds. of material, of which 6,000 cu. yds. was stripping and 18,000 cu. yds. of sand and gravel; of the 18,000 cu. yds., 13,000 cu. yds. were concrete aggregate, a large proportion of which contained 50% of sand, and 5,000 cu. yds. was ballast and foundation fill material. It is desirable that the percentage of sand in the concrete aggregate should not exceed 35% of the whole in order to have an economical concrete. With a larger percentage of sand the amount of cement required to make a watertight concrete has to be increased. With a proper proportioning of the materials, particularly of the sand, by using certain percentages of sand passing the 100-mesh screen, it was possible to make concrete that was watertight under 80 lbs. pressure per square inch, with about 1 Canadian barrel (350 lbs.) of cement per cubic yard of concrete.

From a long series of samples of the materials from test pits in the gravel deposits at the pit it was found that the average run of the better samples contained about 3·3% of fine sand passing the 100-mesh sieve, the percentage of sand to total aggregate varying between quite wide limits. It was also recognized that it would be desirable from the point of view of economical development to use as large a proportion of sand in the final aggregate as safety would permit, bearing in mind that the amount of cement required to make tight concrete should be kept in a minimum. The allowable percentage of sand was finally fixed at 35% of the total aggregate, by weight, and the series of tests for permeability is based largely on this percentage, although a few tests were made with larger and smaller percentages.

Fig. 1, made up from the data obtained in the tests, shows the percentages of fine sand (passing the 100-mesh sieve) required to make watertight concrete with 10% of cement (370 lbs. of cement per cubic yard of set concrete) when the sand is 35% by weight of the total aggregate, with varying percentages of intermediate and coarse materials.

Using 12% cement, with sand having 3·3% passing the 100-mesh sieve, watertight concrete could be made with sand varying from 23% to 43% of total aggregate and with intermediate and coarse, in equal proportions varying from 77% to 57% respectively, or, if coarse were

*Extract from a paper read before the Western Society of Engineers.

absent, with sand at 35% and intermediate at 65%. Fairly good results were obtained with 12% cement, even with 49% sand and 51% intermediate, but this concrete slowly absorbed considerable water, showing a fairly large percentage of very small voids.

In order to be on the side of safety, in starting a new plant, the minimum quantity of cement that has been used when aggregate containing 35% sand has been shipped out, has been 12%, corresponding to about 1.27 bbls. (Canadian) to the cubic yard. The first cut in the gravel pit, arranged for a convenient lay-out for operating conditions, has taken the excavating machines into a part of the deposits running high in sand, and in order to keep the total sand in the finished aggregate down to 35% required a considerable wastage of sand after screening, which cuts down the net output and increases the amount of material to be handled. As the demands of the contractors have taxed the plant heavily, due to a number of causes, among which were delays due to breaks in machinery, lack of storage for the mixed aggregate, shortage of cars at times when the haul was long, or when large amounts of foundation fill materials were being shipped, it was found necessary, at times, to ship out material containing 50% sand, and in some cases, pit-run material. In such cases the cement has been increased to about 15% or 1.7 bbls. (Canadian) per cubic yard. This policy is very expensive, however, as it increases the cost of concrete to the District by about $1 per cubic yard net, over the cost of concrete made with an aggregate containing 35% of sand. As the estimated volume of concrete in the whole aqueduct is about 330,000 cu. yds., the District is, this winter, planning to open another pit, equipped somewhat differently, near the eastern end of the line, to relieve the pressure on the existing plant both by furnishing more aggregate and by shortening the haul, thus getting better efficiency out of the transportation equipment.

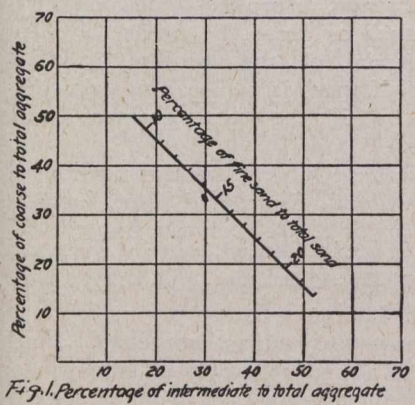


Fig. 1. Percentage of intermediate to total aggregate

The mixed sand and gravel is loaded into 20-yd. air-dump cars at the screening plant, hauled to the contractor's platforms and dumped. The cars are loaded, as nearly as possible to a loose measurement of 23 cu. yds., then scaled, and billed out to the nearest even yard below the scaling. Of 110 cars loaded and billed out, in one test, 15 contained by scaling 22 cu. yds., 75 contained 23 cu. yds., 19 contained 24 cu. yds., and one contained 25 cu. yds. The total measured yardage in the cars was 2583.1 cu. yds., and the total billing was 2,536 cu. yds., a difference of 47.1 cu. yds. or 1.85% more material shipped than billed for, due to taking the nearest even yard below the scaling; or, roughly, the deliveries averaged nearly ½ yd. per car in excess of the billing. A further excess of deliveries over billing, in cars levelled off for measurement, also arises from the mechanical effect of the consolidation of the material in the cars of measured aggregate by the men when levelling off the cars. For example, 17 cars were measured at the plant, then levelled off and trimmed. Before levelling, the measured contents was 392 cu. yds. and after levelling off 380.6 cu. yds., a difference of 11.4 cu. yds., of 3% shrinkage due to consolidation by the men's feet.

The relative weights of the aggregate per cubic foot under different conditions as to moisture and compacting are shown in the following table, the sand in the moist aggregate being about 37% by weight:—

Weight per cubic foot loose and moist	114	lbs.
Weight per cubic foot shaken and moist	122	lbs.
Weight per cubic foot tamped and moist	132.5	lbs.
Weight per cubic foot loose and dry	125.0	lbs.

from which it will be seen that the percentage shrinkage from the loose and moist condition to loose and dry was 9.65% and to shaken and moist 7% and to tamped and moist 15.8%.

The shrinkage in volume during transportation from the pit at mile 30.8 to different points along the line is shown in Table I.

In order to determine the ratio of aggregate billed out from the plant to the yardage of concrete put in place, measurements of both aggregate yardage and yardage of concrete laid were kept by all the division engineers for a week. Owing to inaccuracies in trimming the bottoms of trenches and to the small excess quantities of concrete in the arch sections, due to hand finishing the tops a little higher than the theoretical lines, the payment concrete

Table I.

Shrinkage in yardage of aggregate during shipment from mile 30.8 to different points along aqueduct line.

(Aggregate 50% sand; 4 cu. ft. cement to 16 cu. ft. aggregate = about 1.7 bbls. cement per cubic yard of concrete.

Date.	Mile at which sand was delivered.	Cu. yds. billed.	Cu. yds. measured at pit.	Cu. yds. at plant after levelling and trimming.	Cu. yds. as measured at point of delivery.	Ratio of billed to cu. yds. measured at delivery.	Ratio of cu. yds. measured to cu. yds. delivered and measured there.
August 26	40	23	23.6	22.2	21.8	1.055	1.08
August 26	43	46	46.6	44.2	43.3	1.060	1.08
August 27	51	46	46.2	46.2	42.2	1.090	1.09
August 27	57	69	69.6	67.8	66.6	1.045	1.055
August 27	65	69	[1]68.1	68.1	64.1	1.075	1.06
August 27	71	45	45.4	44.3	41.5	1.085	1.095
August 27	77	45	45.4	44.8	40.8	1.100	1.110
August 27	85	46	45.8	45.0	42.4	[2]1.085	1.08

[1]Car levelled up for measurement at plant and settled in process of levelling.

[2]Side doors of car raised in transit about 2 inches and some material leaked out.

ever, that the surviving types were cultivated twice on media free from chlorine before being again subjected to chlorination. A number of the colonies surviving several chlorinations were cultivated in lactose broth and the acidity determined quantitatively. All the cultures produced less acid than the original culture and the average was materially less than the original cultivated under the same conditions. This points to a diminution in the biochemical activity.

A point of perhaps more scientific interest than practical utility is the relative proportion of the various types of B. Coli found before and after treatment with chlorine. The writer, in 1914 commenced the analysis of the various types, using the division of the American

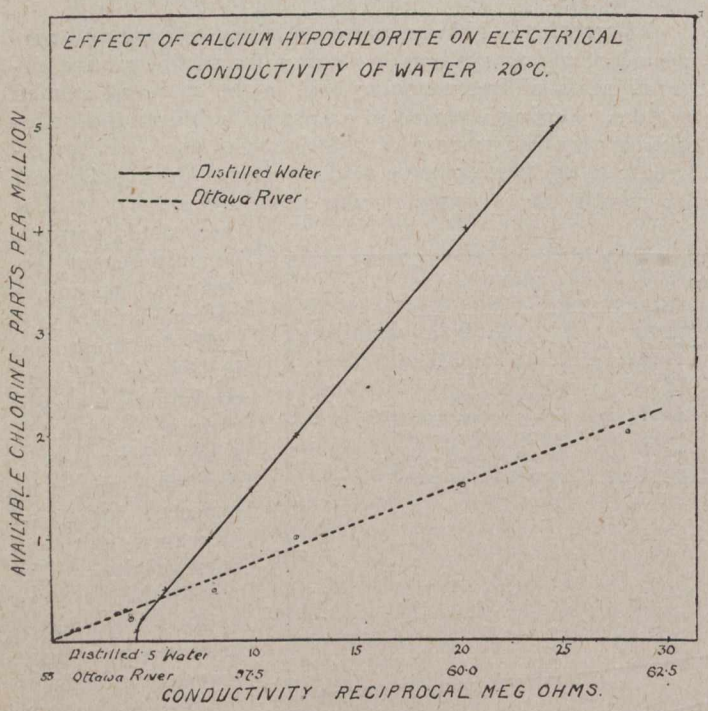


Diagram 3.

Public Health Association by dulcite and saccharose as a basis. The averages of a large number of samples were as follows:—

	B. Coli Communis Raw	B. Coli Communis Chlorinated.	B. Lactis Aerogenes Raw	B. Lactis Aerogenes Chlorinated.	B. Acidi Lactici Raw	B. Acidi Lactici Chlorinated.
Ottawa, 1914	5	4	40	48	44	36	11	12
Ottawa, 1915	8	8	50	46	34	31	8	15
*Baltimore, 1913 ..	11	14	33	25	35	31	21	30

*Thomas and Sandman, J. Ind. and Eng. Chem, 1914. 6 p. 638.

Although there is a slight difference in the relative proportions of the types found at Ottawa and Baltimore, both sets of results show definitely that there is no difference in the resistance of the various types to chlorine.

The net earnings of the Manitoba Government telephones for the five months ended April 30, totalled $202,571.41, according to the condensed earnings report and balance sheet recently issued by the public utilities commissioner.

Announcement has been made to the effect that the British Columbia Government will introduce legislation to provide $200,000 for the purpose of opening up roads and trails to places in the mountains where there are "pioneer" prospects.

AGGREGATE STUDIES AT THE WINNIPEG AQUEDUCT.*

By James H. Fuertes.

THE Greater Winnipeg Water District is now building works for securing by gravity about 100,000,000 U.S. gallons of water per day from the Lake of the Woods, which lies about 100 miles east of, and some 300 ft. higher in elevation than, the city of Winnipeg.

Under the terms of the contract the District agrees to deliver the sand and gravel to the contractor at a stated price per cubic yard. Actually the District is shipping these mixed, but billed as sand and gravel in accordance with the ratios of the volumes that the sand and gravel would make separately, these having been determined from an extended laboratory study of the materials. It would be impossible, within space limits, to do justice to this phase of the subject. Owing to the percentage of sand in the gravel pit it is necessary to dig considerably more material than can be made into concrete aggregate. Thus in August there were excavated at the pit approximately 24,000 cu. yds. of material, of which 6,000 cu. yds. was stripping and 18,000 cu. yds. of sand and gravel; of the 18,000 cu. yds., 13,000 cu. yds. were concrete aggregate, a large proportion of which contained 50% of sand, and 5,000 cu. yds. was ballast and foundation fill material. It is desirable that the percentage of sand in the concrete aggregate should not exceed 35% of the whole in order to have an economical concrete. With a larger percentage of sand the amount of cement required to make a watertight concrete has to be increased. With a proper proportioning of the materials, particularly of the sand, by using certain percentages of sand passing the 100-mesh screen, it was possible to make concrete that was watertight under 80 lbs. pressure per square inch, with about 1 Canadian barrel (350 lbs.) of cement per cubic yard of concrete.

From a long series of samples of the materials from test pits in the gravel deposits at the pit it was found that the average run of the better samples contained about 3·3% of fine sand passing the 100-mesh sieve, the percentage of sand to total aggregate varying between quite wide limits. It was also recognized that it would be desirable from the point of view of economical development to use as large a proportion of sand in the final aggregate as safety would permit, bearing in mind that the amount of cement required to make tight concrete should be kept in a minimum. The allowable percentage of sand was finally fixed at 35% of the total aggregate, by weight, and the series of tests for permeability is based largely on this percentage, although a few tests were made with larger and smaller percentages.

Fig. 1, made up from the data obtained in the tests, shows the percentages of fine sand (passing the 100-mesh sieve) required to make watertight concrete with 10% of cement (370 lbs. of cement per cubic yard of set concrete) when the sand is 35% by weight of the total aggregate, with varying percentages of intermediate and coarse materials.

Using 12% cement, with sand having 3.3% passing the 100-mesh sieve, watertight concrete could be made with sand varying from 23% to 43% of total aggregate and with intermediate and coarse, in equal proportions varying from 77% to 57% respectively, or, if coarse were

*Extract from a paper read before the Western Society of Engineers.

absent, with sand at 35% and intermediate at 65%. Fairly good results were obtained with 12% cement, even with 49% sand and 51% intermediate, but this concrete slowly absorbed considerable water, showing a fairly large percentage of very small voids.

In order to be on the side of safety, in starting a new plant, the minimum quantity of cement that has been used when aggregate containing 35% sand has been shipped out, has been 12%, corresponding to about 1.27 bbls. (Canadian) to the cubic yard. The first cut in the gravel pit, arranged for a convenient lay-out for operating conditions, has taken the excavating machines into a part of the deposits running high in sand, and in order to keep the total sand in the finished aggregate down to 35% required a considerable wastage of sand after screening, which cuts down the net output and increases the amount of material to be handled. As the demands of the contractors have taxed the plant heavily, due to a number of causes, among which were delays due to breaks in machinery, lack of storage for the mixed aggregate, shortage of cars at times when the haul was long, or when large amounts of foundation fill materials were being shipped, it was found necessary, at times, to ship out material containing 50% sand, and in some cases, pit-run material. In such cases the cement has been increased to about 15% or 1.7 bbls. (Canadian) per cubic yard. This policy is very expensive, however, as it increases the cost of concrete to the District by about $1 per cubic yard net, over the cost of concrete made with an aggregate containing 35% of sand. As the estimated volume of concrete in the whole aqueduct is about 330,000 cu. yds., the District is, this winter, planning to open another pit, equipped somewhat differently, near the eastern end of the line, to relieve the pressure on the existing plant both by furnishing more aggregate and by shortening the haul, thus getting better efficiency out of the transportation equipment.

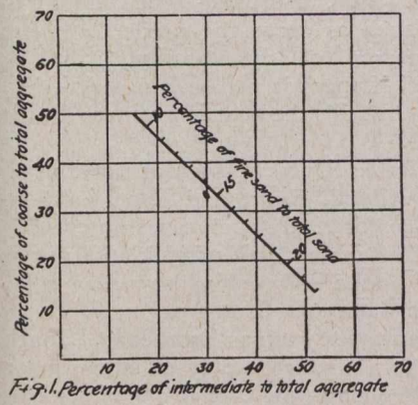


Fig. 1. Percentage of intermediate to total aggregate

The mixed sand and gravel is loaded into 20-yd. air-dump cars at the screening plant, hauled to the contractor's platforms and dumped. The cars are loaded, as nearly as possible to a loose measurement of 23 cu. yds., then scaled, and billed out to the nearest even yard below the scaling. Of 110 cars loaded and billed out, in one test, 15 contained by scaling 22 cu. yds., 75 contained 23 cu. yds., 19 contained 24 cu. yds., and one contained 25 cu. yds. The total measured yardage in the cars was 2583.1 cu. yds., and the total billing was 2,536 cu. yds., a difference of 47.1 cu. yds. or 1.85% more material shipped than billed for, due to taking the nearest even yard below the scaling; or, roughly, the deliveries averaged nearly ½ yd. per car in excess of the billing. A further excess of deliveries over billing, in cars levelled off for measurement, also arises from the mechanical effect of the consolidation of the material in the cars of measured aggregate by the men when levelling off the cars. For example, 17 cars were measured at the plant, then levelled off and trimmed. Before levelling, the measured contents was 392 cu. yds. and after levelling off 380.6 cu. yds., a difference of 11.4 cu. yds., of 3% shrinkage due to consolidation by the men's feet.

The relative weights of the aggregate per cubic foot under different conditions as to moisture and compacting are shown in the following table, the sand in the moist aggregate being about 37% by weight:—

Weight per cubic foot loose and moist	114 lbs.
Weight per cubic foot shaken and moist	122 lbs.
Weight per cubic foot tamped and moist	132.5 lbs.
Weight per cubic foot loose and dry	125.0 lbs.

from which it will be seen that the percentage shrinkage from the loose and moist condition to loose and dry was 9.65% and to shaken and moist 7% and to tamped and moist 15.8%.

The shrinkage in volume during transportation from the pit at mile 30.8 to different points along the line is shown in Table I.

In order to determine the ratio of aggregate billed out from the plant to the yardage of concrete put in place, measurements of both aggregate yardage and yardage of concrete laid were kept by all the division engineers for a week. Owing to inaccuracies in trimming the bottoms of trenches and to the small excess quantities of concrete in the arch sections, due to hand finishing the tops a little higher than the theoretical lines, the payment concrete

Table I.

Shrinkage in yardage of aggregate during shipment from mile 30.8 to different points along aqueduct line.

(Aggregate 50% sand; 4 cu. ft. cement to 16 cu. ft. aggregate = about 1.7 bbls. cement per cubic yard of concrete.

Date.	Mile at which sand was delivered.	Cu. yds. billed.	Cu. yds. measured at pit.	Cu. yds. at plant after levelling and trimming.	Cu. yds. as measured at point of delivery.	Ratio of billed to cu. yds. measured at delivery.	Ratio of cu. yds. measured to cu. yds. delivered and measured there.
August 26	40	23	23.6	22.2	21.8	1.055	1.08
August 26	43	46	46.6	44.2	43.3	1.060	1.08
August 27	51	46	46.2	46.2	42.2	1.090	1.09
August 27	57	69	69.6	67.8	66.6	1.045	1.055
August 27	65	69	[1]68.1	68.1	64.1	1.075	1.06
August 27	71	45	45.4	44.3	41.5	1.085	1.095
August 27	77	45	45.4	44.8	40.8	1.100	1.110
August 27	85	46	45.8	45.0	42.4	[2]1.085	1.08

[1]Car levelled up for measurement at plant and settled in process of levelling.

[2]Side doors of car raised in transit about 2 inches and some material leaked out.

averages less than the actual quantities placed. These ratios are shown to be about as follows:

Total cu. yds. of aggregate billed.	= 3,633.2	
Total cu. yds. of concrete laid ...	= 3,422.7	
Excess of aggregate over total concrete	210.5 =	6%
Total cu. yds. of aggregate billed.	= 3,633.2	
Total cu. yds. of payment concrete	= 3,310.7	
Excess of aggregate over payment concrete	322.5 =	10%
Yardage of total concrete	= 3,422.7	
Yardage of payment concrete	= 3,310.7	
Yardage of excess concrete	= 112.0 —	3.4%

Costs of Preparing Aggregate.—The average cost per cubic yard of the aggregate, for preparation exclusive of overhead charges, and transportation to the contractor's platforms has been as follows:

Excavation	$0.118
Hauling to plant	.031
Screening and crushing	.139
Loading	.061
Repairs to plant	.019
Repairs to cars, crane and dinkey	.011
Office	.005
Fuel	.123
Total	$0.507

It is expected that this cost will be materially reduced in the coming season.

ANNUAL REPORT ON HIGHWAY IMPROVEMENT IN ONTARIO.

ACCORDING to the annual report of the Department of Public Highways of Ontario, which has just been received, investigation shows that there are in the province approximately 55,000 miles of roads. About 20,000 miles are well graded earth roads; about 3,000 miles are surfaced with broken stone; and about 19,000 miles are surfaced with gravel. Many of the gravel roads are of inferior construction; nevertheless, the proportion of surfaced roads is very creditable to the municipal organization of the province. Unfortunately, the improvement is not uniform, and the gravelled roads are largely confined to those areas in which gravel has been plentiful; while other districts are devoid of surface improvement other than grading and drainage.

The mileage of surfaced roads is encouraging, however, in that while many may be in a neglected state, or of inferior construction, they would more readily and cheaply respond to the systematic attention which it is the desire of Mr. McLean to encourage. The building of important market roads under county systems will be of more extended benefit by reason of even moderate improvement of the local feeders; while the development of a few roads of greater commercial importance between cities can be made to join up the entire system of roads throughout the province in a most favorable manner.

The report, which contains 226 pages, is filled with data of real value to all highway engineers and contractors. Under the heading "General Features of County Road Systems," it gives briefly the features of the system as organized under the Highway Improvement Act. We reprint herewith extracts from this section of the report:

One of the first duties of a county council, when a county road system has been established under the Highway Improvement Act, is to select a road superintendent. The work is carried on by the road superintendent, under the direction of the council and the road committee of the council. Too much care cannot be taken by the council in the selection of the superintendent. His qualification for the work, and close application to its management, more than any other factor, will determine the degree of success attained. Good business management, with thoroughly practical ideas and methods, are essential. The superintendent is not required by the Act to be an engineer; but, if he is not such, occasional engineering services will be required, especially in bridge construction and details of grading. The cost of management is not great, and, compared with ordinary township methods, is one of the most profitable items of expenditure. Experienced supervision and skilled workmen are gradually trained—largely the secret of good roads wherever they are found.

Cost of County Roads.—The roads commonly built under county road systems are not necessarily expensive. They are usually gravel roads, or broken-stone roads, well graded and drained—such as serve the needs of farm traffic. Preferably material of the locality, gravel or broken stone, is used. If there is no local material, and it has to be brought in by rail, the cost is greater—but is shared by the province.

A number of districts in Ontario, such as portions of York, Peel, Halton, Welland, Essex and Kent, have no local material for road-making. In such cases an entirely new road must be built, often on a clay subsoil, and freight rates on stone must be added—all tending to higher cost, and amounting to from $4,000 to $8,000 per mile.

In other districts, however, such as Frontenac, Lanark or Hastings, there is an abundant supply of stone on or close to the road, and frequently the task is one of regarding and putting a surface over an old stone or macadam road. In such cases, a cost of $2,500 or $3,500 per mile is an ordinary expenditure.

Certain districts, on the other hand, have an abundant supply of gravel. Many of the roads have been gravelled from time to time and a good foundation has been made. In such cases, the work usually consists of removing sod shoulders, improving the drainage, and adding a new surface of gravel—costing from $1,000 to $2,000 per mile for substantial work suited to local traffic.

A standard form of construction consists of an earth grade, twenty-four feet between shoulders, outside of which are the open drains. In the centre of the grade is placed, for a "single track" road, gravel or stone to a width of ten feet, and a depth varying from six to twelve inches, according to the traffic, subsoil and existing foundation. Good grading and drainage are of first importance. The road should be rolled with a ten-ton steam roller to complete for traffic. If the road is on an important line of through traffic, or adjacent to a city, the earth grade should be twenty-seven feet wide instead of twenty-four, and provision made for a "double-track" of gravel or stone, eighteen feet wide. This, however, is rarely necessary. A single track of metal nine or ten feet wide may first be laid, and later widened to eighteen feet as traffic increases.

Duties of Patrolman.—The patrolman's primary duty is to keep the travelled surface in good condition, but there are other duties for which he should be responsible. His chief duties should be: (1) To repair the road surface; (2) to rake off loose stones and gravel; (3) to clean out ditches and their outlets; (4) to keep culverts free from obstruction; (5) to cut and burn weeds; (6) to repair guard rails; (7) to periodically inspect bridges and cul-

verts, and immediately report to the county road superintendent any defects which he himself cannot remedy.

The employment of men in pairs, with a single horse and light wagon, is frequently to be recommended. Two men working together can very often make more than twice the progress, and at considerably less than twice the cost of one man and horse, while there is a tendency to greater contentment and efficiency produced by companionship.

To make a success of patrol work the men must be selected and adapted to the work. At least one man (who will act as foreman) must be able to think for himself, as on him will rest the responsibility of seeing that both are kept employed, and that all labor is put to the best use. It is possible on work of this kind to "fritter away" a lot of time and still appear busy; therefore, the foreman should be able to distinguish between necessary and unnecessary work. The men should be assured of permanent employment, so long as their services prove satisfactory. In patrol work, as in other branches of road construction, increased experience means increased efficiency and greater value. By knowing that their work will last as long as they desire it and prove themselves capable, the men will be induced to take a greater interest in it than if they know it to be only temporary.

The work, as previously stated, is influenced by so many variables as to make a close estimate impossible, but to give an idea of what may be expected, it may be stated that two men with single horse and wagon, commencing on a properly constructed road in good condition, and working full time, should be able to patrol sections about as follows:—

1. Waterbound macadam road: (*a*) Ordinary county roads, light to moderate traffic, 12 to 15 miles; (*b*) more heavily travelled county roads, 8 to 12 miles; (*c*) county roads approaching large towns and small cities, 5 to 8 miles; (*d*) county roads in the vicinity of large cities, and heavily travelled interurban roads, 2 to 5 miles.

2. Bituminous macadam, or waterbound macadam with bituminous surface: (*a*) Lightly travelled county roads, 15 to 20 miles; (*b*) moderately travelled county roads, 8 to 15 miles; (*c*) roads approaching small cities, 5 to 10 miles; (*d*) roads approaching large cities and heavily travelled interurban roads, 3 to 6 miles.

Each man should be equipped with the following tools, which should always be carried on the wagon: Square-nosed shovel, round-nosed shovel, pick, rake, tamping iron, coarse broom, scythe.

The wagon should have a specially constructed box divided into compartments for stone, screenings and tools. In the case of repairs to bituminous-surfaced roads, the compartments will be used for stone chips, tools, and fuel for the heating kettle.

The cost of operations will include the wages of the men and cost of materials used. These cannot be definitely stated, and the amount of stone used for repairing may be expected to vary from 10 cubic yards to 100 cubic yards per mile per annum. The annual cost of repairs, in general, may be expected to range from 3 per cent. to 6 per cent. of the original cost of the roads.

It is not to be expected that patrol work will eliminate the necessity for periodic resurfacing, but it will postpone it for many years. Modern practice is to allow the road surface to wear down a certain amount and then renew it, the patrol work being for the purpose of arresting undue wear in any one place and to correct ruts or depressions in their incipient stages. In the case of bituminous-surfaced roads, if the base has been properly constructed, and the surface systematically maintained, there should be little necessity for work, as far as the travelled portion of the road is concerned, other than the prompt repair of spots where the bituminous coat has worn through.

Maintenance and Repair.—The distinction between the meaning of repair and of maintenance should be well understood in any examination of the comparative costs of various types of road for a given term of years.

"Repair" applies only to the patching of roads; the filling of holes and of wheel tracks. In the case of a brick pavement it may mean the replacing of a few bricks here and there or the restoration of a yielding foundation. In the case of a concrete road it would apply only to the patching of holes and joints or the clearing of ditches, culverts and drains.

While "repair" in all cases implies only necessary patching to keep the surface of the road smooth, the term "maintenance," on the other hand, will include "repair" and also the additional expenditure necessary to restore the road from time to time to its original thickness and condition at the time of construction. A macadam or gravel road is maintained from time to time by recharging the surface with new material to replace that which has worn away. A brick pavement, on the other hand, cannot be so maintained, but when the surface is worn out, the old brick must be removed and the entire surface relaid. Similarly a sheet asphalt surface is, from period to period, wholly removed from the concrete foundation and a new covering of the original thickness is laid.

"Maintenance," therefore, includes not only "repair" but also an annual charge equivalent to the depreciation of the pavement, such annual charge for depreciation being dependent upon the life of the pavement; or, in the case of a macadam or gravel road, it is the periodic cost of recharging the surface so as to restore it to its original condition.

It is, therefore, to be considered that when comparing the cost of macadam or gravel roads with the cost of a pavement for a period of years, the expenditure for maintaining the macadam or gravel must be offset not only by a charge for annual patching and repairing the pavement but also a charge for depreciation of the pavement.

ROAD CULVERTS IN QUEBEC PROVINCE.*

By Alexander Fraser,
Department of Highways, Province of Quebec.

THE limit of application of the word "culvert" has never been exactly established. In the following I will apply the word somewhat arbitrarily to all work, from the circular culvert of 12 inches diameter to the bridge or culvert of 8 feet span. In the province of Quebec these culverts are considered as an integral part of our roads, and their permanent improvement is made in accordance with the plans and specifications furnished or approved by the Department of Roads. The construction of a bridge of greater dimensions is generally carried out under the control of the Department of Public Works. But when work of a permanent character is projected on the probable line of a provincial road, there is an understanding between the engineers of the two departments as to the location of the bridge in order to secure the best possible alignment.

As the culverts constitute a permanent part of the improvement of our roads, and their cost forms an im-

*Abstract of paper delivered at Third Canadian and International Road Congress, Montreal.

portant item in the total cost of those improvements, special attention to them is necessary, both for good work and for economy. On our provincial roads the average cost of the permanent culverts from 12 inches diameter to 8 feet span has varied from $800 to $1,500 per mile.

In the province of Quebec we build circular culverts from 12 to 36 inches diameter. On our provincial roads all the circular culverts are of concrete. Concrete has passed the experimental stages. But our manufacturers of concrete pipe, at least as far as the province of Quebec is concerned, do not all use the best methods of manufacture. Fortunately, a movement is now under way with a view to the formation of an association of all the concrete pipes manufacturers, like that existing in the United States, whose main purpose will unquestionably be to put on the market a more uniform product.

The quality of the pipes is not, however, the only consideration that can assure to the culvert its permanency and its efficiency. It is also absolutely necessary that they are put into place with care if we want them to give good results. Many foremen or inspectors, not always understanding the importance of every detail, are frequently inclined to overlook some of them in order to save time. Consequently, the need of intelligent and experienced foremen is greater than one is commonly led to believe, because it is often very expensive to repair a culvert when breaks or dislocations are noticed after the pavement is nearly finished.

A culvert has two main purposes: To provide a safe passage to the traffic; and to secure a perfect drainage, while protecting the road.

To provide a safe passage to the traffic, the culvert must have a length equal to the width of the travelled way. This is especially important at the intersections of roads. A reduction in the width of the travelled way at each culvert would be a serious danger, especially where the culverts are numerous, as they generally are along a river or lake. Moreover, the addition of one or two pipes to a culvert in order to provide an adequate length can be done in most cases without increasing the cost of the culvert. The addition of one or two pipes will often permit a smaller headwall to be built, and so effect an economy which will compensate for the additional pipe.

The alignment of the culvert must be such as to permit a rapid flow of water. The introduction of two or four right angles in the line of a ditch, for the laying out of a culvert, as frequently happened in the old structures, must be avoided. If the line ditches at the upstream and downstream side of the culvert happen to be on two different lines of not more than 25 feet apart, we generally prefer to place the culvert at an angle with the centre line of the road, so that its ends will meet the ditches at each side of the road at the best possible angle.

To determine the opening of any culvert, we can take the empirical formulæ of Talbot or Kutter, which are most commonly used, but we must also consider the present dimensions of the old culvert, and the informations (often very important) that can be procured from those living in the locality, who know perfectly well all the local conditions.

The trench excavated for the culvert ought to be at least two feet wider than the external diameter of the pipe to be laid. I have been frequently impressed with the importance of this detail. If the trench has a width hardly more than equal to the external diameter of the culvert, it will be difficult to ram the earth in the lower part, so that it will often not be rammed at all. Consequently, the culvert will not be held firmly in place, and when the rolling starts it will tend to move, the joints will be dislocated and the pipe will frequently break.

We must be careful to give to the bottom of the trench a concave form suitable to the pipe to be placed, so as to ensure to the latter a greater and more uniform bearing surface. The minimum grade of the bottom of the trench will have to be 5 inches per 100 feet, but be at such grade that when the culvert is in place, the water will flow freely at the same grade inside the culvert as it does at the upstream and downstream ends of the culvert. It is very important that all the joints be cemented on both sides, so as to avoid all washouts or caving in of the soil around the culvert.

A very important detail, which is too frequently put aside in practice, is to backfill in parallel and successive layers not more than 6 inches thick, and to ram each layer solidly. This is vital if the culvert is to be prevented from moving and breaking under the roller. The backfilling materials must be carefully selected. The materials taken out of the trench are not always satisfactory. They will frequently have to be replaced by more stable and more dense material, such as clay or coarse sand. Light soils, fine sand or any material containing vegetable matter should never be used.

It is necessary to pave the bottom of the ditch at the upstream and downstream end of each culvert, especially if, on account of a steep grade or of a break in the profile, there is danger of erosion.

We must be careful to leave at least 12 inches of earth over the culvert. If this is not possible, it would be better to lay a cast-iron pipe culvert.

Most of the remarks made with regard to circular culverts apply to the other types of culverts of plain or reinforced concrete, quadrangular culverts, slab culverts, with or without beams, and arch culverts.

A control which cannot be exercised in the case of circular culverts, including control of the mixture, of the quality of materials, and of all the other details in the making of the concrete, can be exercised freely when building larger culverts. With this in view it is important to keep a competent foreman or inspector always at the work. His duties should not be limited to supervision of the proportioning of the mixture and the time of mixing each batch. A mechanical inspection is not sufficient. The theoretical importance of all the details must be well understood.

After the materials have been accepted by the engineer, the inspector or foreman must see that the stone and the sand are always kept clean, that the mixture is methodical, that it is not too wet, etc. He will frequently inspect the forms, to see that they are always kept in line and that they are of correct dimensions. He must see to it that the concrete is steadily rammed to ensure proper density, and that the inner surfaces are smooth.

The alignment of the road must be made judiciously with a view toward the location of culverts. Except where unavoidable, culverts should not be located on curves, specially on curves of short radius. Too frequently culverts have been located to suit the creek, and not enough consideration has been given to providing an alignment satisfactory to traffic.

ENGINEERING AND GOOD GOVERNMENT.

By T. L. Hinckley,
Engineer, Bureau of Municipal Research, Toronto.

VERY few persons, even the most thoughtful, realize how largely the successful administration of a modern city depends upon the correct solution of engineering problems.* While this has always been true in regard to such obvious matters as streets, sewers, bridges, public buildings and the like, it is now true in the case of many municipal activities which have only recently been associated with engineering research. Street cleaning, the heating and ventilation of public schools, the operation of water and sewage purification works, the motorization of fire department equipment, the installation of central testing laboratories, the establishment of municipal refuse destructors, abattoirs, refrigerating plants, the municipal ownership of street railways, power plants, docks, etc., have combined to open up a field of opportunity to the technically trained man of to-day which is as broad as society itself.

Those at the head of our more progressive city governments have had the sagacity to see that in employing the best available engineering talent to supervise and carry out public engineering schemes, a political as well as a practical purpose is served. The economical and efficient performance of public engineering work of any sort reflects credit upon the party, or the administration, which has had the good sense to secure the services of competent, technically trained men rather than to depend upon men whose chief recommendation is a partisan affiliation.

In view of the direct employment by municipalities of engineering talent, engineers who do not happen to be attached to the public service have frequently questioned the propriety of taking more than a passive interest in the technical affairs of their community. Indeed, it is the general rule for engineers in private practice to refrain from offering opinions or advice to local authorities concerning the conduct of local engineering works—except in cases of gross mismanagement—although informal discussions of local engineering matters are, of course, very common. In the writer's opinion, the adoption of such a thoroughly passive attitude in public matters constitutes serious neglect of a function which should be liberally developed, in the interests not only of technical efficiency but of good government.

The man who will not take well-meant advice, be he soldier, financial wizard, engineer or layman, is either a genius or a fool; and it is safe to say that among the technical men employed by our municipalities there are few of either persuasion. There can be no valid reason for municipal engineers or technical experts refusing to accept the advice or suggestions of a body of men of their own stamp upon matters which concern the public welfare —as engineering matters certainly do. The common financial burden which all citizens share in the prosecution of public work of any sort adds strength to the argument that, if properly qualified by education and experience, engineers owe it to their fellow citizens to take a more active interest in the technical affairs of their city, keep themselves informed of the progress of local public work, discuss public work at all professional meetings, appoint committees to study public works in detail, etc.

*Of $1,869,815,000 spent for governmental purposes by 199 United States cities in 1913, fully $1,027,402,000, or 54 per cent., was spent for activities involving engineering work of some sort.

It would perhaps be unwise to suggest that members of engineering professions, in their private capacity only, interest themselves actively in local engineering matters. This should be done officially—as a matter of fact, is now done, on a limited scale, in many cities—by the various professional organizations, as a regular part of their routine. If possible, it should have the approval and co-operation of the regular engineering staffs of the city government. Standing committees should be required to report at each meeting upon the progress of all public engineering or other technical work in the community, and resolutions expressing approval or criticism, as the case may be, should be regularly forwarded to the local authorities.

The chief point of difference between the foregoing suggestion and the present practice of engineering societies lies in the proposal to make the work which such societies do upon public problems *active and continuous* rather than passive or spasmodic—in a word, to put such action upon the basis of citizenship rather than that of professional interest. In this way engineers will not only get the information which they need, as to local public engineering activities, but they will at the same time be rounding themselves out as better and more useful citizens.

QUARTERLY REPORT OF ONTARIO BUREAU OF MINES.

RETURNS made to the Bureau of Mines, Parliament Buildings, by the metalliferous mines and works of the Province of Ontario for the first three months of 1916, show increases in all products except iron ore. Following are the figures, those for the corresponding period of 1915 being added for comparison:—

	January-March, 1915.	January-March, 1916.	Increase.
Gold, ounces	76,307	107,818	31,511
Silver, ounces	5,230,167	5,297,831	67,664
Copper, tons	3,644	5,491	1,847
Nickel, tons	6,680	10,032	3,352
Iron ore, tons	28,332	6,573	*21,759
Pig iron, tons	94,678	160,749	66,071
Cobalt, metallic, lbs.	450	36,460	36,010
Nickel, metallic, lbs.	.....	11,976	11,976
Cobalt and nickel oxides, lbs.	16,324	143,212	126,888

*Decrease.

The value of the production for the first three months of 1916 was $14,276,382 as compared with $9,358,210 for the corresponding period of last year. This large increase was due not only to the greater output but to the higher prices now prevailing for most of the metals.

Gold.—The increase in the yield of gold was 31,511 ounces, worth $656,872. Compared with the rate of production for the whole of last year the advance was less marked, but developments now under way are likely to lead to a substantial increase. Porcupine provided the bulk of production, namely, 99,282 ounces. Hollinger led in output, followed by Dome, Acme, McIntyre-Porcupine, Porcupine Crown, Vipond, Schumacher and Dome Lake in descending order. The mines situate elsewhere making up the remainder of the yield are Tough-Oakes and Croesus. Consolidation of the Hollinger, Acme and Millerton interests will no doubt lead to a more extensive development and a greater output from these properties.

Silver.—A feature of the quarter was an actual increase in the yield of silver as compared with the first three months of 1915, amounting to 67,664 ounces. In value the increase was proportionately greater, namely, $462,673. This was due to the remarkable rise in the price of silver, amounting to about 50 per cent. over the average figure for 1915. A large part of this increase took place in the latter part of the quarter and afterwards, consequently the benefit of the higher prices was only partially realized during the three months. The natural effect of the advance has been to stimulate both mining and prospecting in Cobalt and to enable low-grade ores in the mines or on the dumps to be worked, which at the former low prices of silver were without value. Nipissing continues to lead in quantity of output; Townsite-City, Seneca Superior, Kerr Lake, LaRose, Coniagas, Cobalt Lake, McKinley-Darragh-Savage, Beaver, etc., follow in the order named.

Nickel and Copper.—The demand for nickel and copper, due to the war, has been insatiable, and the Sudbury mines have shown a capacity for meeting the requirements which could scarcely have been anticipated. The output of nickel and copper in the matte was each 50 per cent. greater than in the first three months of 1915. If the present rate of production is maintained throughout the year, 1916 will see about 40,000 tons of nickel and 22,000 tons of copper turned out by the smelters in the Sudbury district, as against 34,000 tons of nickel and 19,600 tons of copper in 1915. The Canadian Copper Company and the Mond Nickel Company are the producers; the Alexo mine turning out a small quantity of ore which is sold to the Mond Company.

Iron.—The blast furnaces of the province produced about 70 per cent. more pig iron than they did in the first quarter of 1915, and the product was worth almost 100 per cent. more. About 15 per cent. of the iron ore charged into the furnaces was taken from deposits in Ontario, the remainder coming from the United States.

By-products of Silver.—Cobalt oxide and nickel oxide met with a rather better demand, though the quantities exported are still below those of normal times. Metallic cobalt is coming into use, principally in steel alloys, and there is now a small quantity of nickel refined in Ontario from the silver-cobalt ores of the Cobalt camp.

PRESERVATION OF WOODEN POLES.

At a recent meeting of the American Institute of Electrical Engineers, a paper was presented by E. L. Rhodes and R. F. Hosford, on recent results obtained from the preservative treatment of telephone poles. The paper covered the experience with treated poles over a period of eighteen years in the plant of the American Telephone and Telegraph Company and their associated companies, in the use of distillates of coal tar or wood tar for preservative treatment. The authors sum up the results of their experience in the following conclusion: "Because of the present incomplete stage of our experience with the different types of treatment described, conclusions can be reached for only a part of the problems whose solution was sought. The seasoning of poles offers at best only moderate advantages in the way of increased life. Its greatest value is as a preparation for the successful application of preservatives. The practice of applying to poles preservatives high in antiseptic power and insoluble in water has been shown to yield increased life. The amount of preservative applied and the depth to which it is made to penetrate appear to exercise controlling influences upon the results obtained. Mechanical failure of the treated layer is indicated as the principal limit to the effectiveness of light applications of preservatives."

SPHERICAL BEARINGS versus FLAT PLATES IN CRUSHING TESTS ON BRICKS.*

By E. L. Baker and Alex. F. Suss.

IT is the opinion of the investigators that there is an error introduced in the omission of a spherical bearing in compression tests of bricks. Although the error introduced by the omission of a spherical bearing may not be great enough to be of any practical significance, it is true that the theoretical crushing strength can only be obtained by the use of some device which will take care of non-parallelism of the compressive surfaces, thereby preventing the development of internal stresses in the specimen and the spalling-off of the specimen on one side.

It is the aim of the investigators to prove by these tests that the crushing strength of bricks is greater as obtained by the use of some type of spherical bearing than by the use of flat plates. In the first one hundred and seventy-three tests we have determined this difference by using flat plates and the one-piece spherical bearing. In order to have relative values we first made the ordinary cross-breaking tests, thus obtaining two halves of the same brick to be used in crushing.

One-half of the brick was crushed with the one-piece spherical bearing and the other half with the plate bearing. It is obvious from an inspection of paving bricks that no two bricks are alike. They are not homogeneous, they are not burned to the same degree of hardness, and their surfaces have different degrees of non-parallelism. Therefore, by using the two halves of the same specimen as described, we have obtained comparative values showing the difference between results as obtained by the use of the one-piece spherical bearing and flat plates.

The reader may be impressed by the wide variation in the result of these tests. The only explanation we can give for such variations is that already given, differences of homogeneity and burning. Arch bricks will necessarily be overburned, while those of the interior of the kiln may be underburned. In ordering the bricks for these tests we called for 2¼-in. by 4-in. by 8-in. vitrified paving bricks to be taken at random from any part of the kiln, thereby obtaining a sample of brick which would ordinarily be sent out on a job.

The machine used was a Riehlé Brothers, 200,000-pound, two-screw machine. The poise was run by hand. The cross-breaking test was made according to the method given in Johnson's "Materials of Construction." The brick was set edgewise on two rounded, knife-edge bearings placed six inches centre to centre and loaded in the middle. The modulus of rupture was found by applying the formula

$$f = \frac{3\,W\,l}{a\,b\,h^2}$$

where

f = modulus of rupture in pounds per square inch.
W = ultimate load in pounds.
l = distance between knife edges in inches.
b = width of brick in inches.
h = height of brick in inches.

In order to have an approximately uniform cross-section for the crushing tests, it was necessary to surface the bricks after cross-breaking them. This was accom-

*A thesis for the degree of B.S. in C.E. at Washington University, published in accordance with Sec. 9 of the Agreement of the Engineers' Club of St. Louis with Student Technical Societies in Missouri.

plished by chipping the surfaces with a cold-chisel and hammer. During the surfacing the specimen was kept on a wooden block and the hammer-blows were made as light as possible to be effective in order that the brick would suffer no injury.

The bricks were then calibrated. Six measurements were made on each dimension of the bricks in order to obtain a true average dimension. The halves were then tested with the one-piece spherical bearing and flat plates. Two smoothly surfaced plates, 10 ins. by 10 ins. by ½ in., were used, one placed on the base of the machine, upon which the specimen was centered, the other resting upon

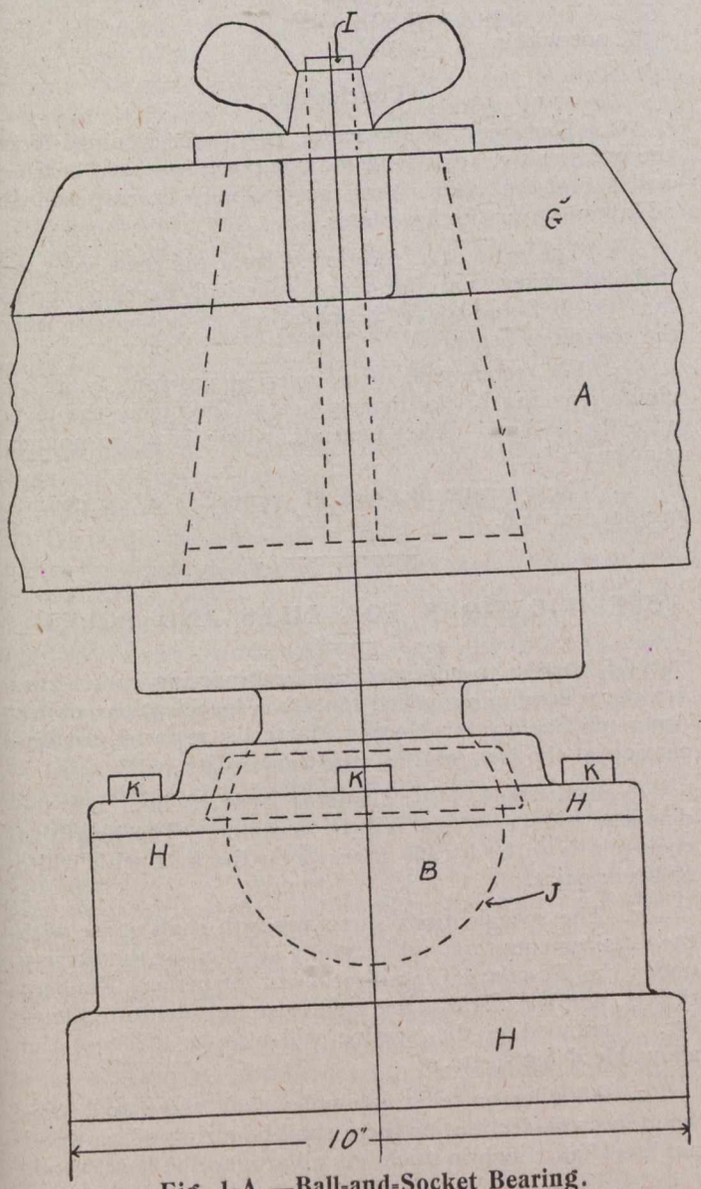


Fig. 1-A.—Ball-and-Socket Bearing.

the specimen. The one-piece spherical bearing is of cast steel, one surface of which is flat and the other spherical, having a radius of approximately 10 inches. The spherical surface rested on a flat plate on the base of the machine, the brick was centered on the flat surface of the bearing, and another flat plate was placed between the specimen and the head of the machine. The machine was run at low speed during the tests in order to secure a slow and uniform increase in load. The majority of the specimens failed all at once with a loud report, only a few spalling off and crushing without an increase in load. The crushing strength per square inch was computed by dividing the total load by the cross-sectional area of the brick.

A table has been prepared showing the results of these tests which will be furnished by the authors to any investigators who wish to use them in any further studies along these lines. In these tables are shown the modulus of rupture, crushing strength between plates, crushing strength with one-piece spherical, and the ratio of the crushing strength as obtained with the spherical bearing to that obtained with the flat plates.

One hundred and forty-seven tests were made with the one-piece spherical bearing and a ball-and-socket bearing made by Riehlé Brothers, of Philadelphia, and shown in Figs. 1-A and 1-B. F is a cast-iron cup which rests upon the base of the machine; D is a flat steel plate 10 inches in diameter, the underside of which, E, is semi-spherical and rests in the cup F. Before placing this bearing in the machine, the surfaces of E and F, which are in contact, were thoroughly lubricated with hard-oil in order that they would slide upon each other as freely as possible, thereby eliminating the friction between these surfaces. Parts A, B, G and H form the unit which is held in the head of the machine by the bolt, I, and thumbscrew. B and A are one solid casting, B being milled perfectly spherical to fit into a semi-spherical socket, J. The casting, H, is in two parts, as shown, and is held in position by four screws, K. The ball, B, and socket, J, were kept well lubricated with hard-oil. The advantage of this bearing is that there can be no flexure in the specimen regardless of how non-parallel the compressive surfaces may be.

The specimens used in these tests were cross-broken and calibrated in the same way as the specimens in the previous tests.

In order to make an intelligent study of the advantages of the spherical bearing, it is necessary to compare the values obtained by testing the two halves of each individual brick. In each case in the first one hundred and seventy-three tests we divided the spherical test value by the plate test value and set up a ratio for each brick. The average of these ratios should substantiate the theoretical advantages of the spherical bearing if enough tests are made to eliminate differences in material and accidental errors in testing. In the remaining tests the ratio was obtained by dividing the crushing value obtained from the test with the ball-and-socket bearing by that obtained from the test with the one-piece spherical bearing.

In obtaining points for a curve showing the relation between the unit crushing strength and the ratio of height to least dimension we found the average crushing strength of all the specimens having the same ratio.

Results of Tests.

1. The average ratio for the tests made with the one-piece spherical bearing and flat plates is 1.03.

35% of tests were within 10% of the average ratio.
22% " " " between 10% and 20% of average ratio.
16% " " " " 20% and 30% " " "
8% " " " " 30% and 40% " " "
8% " " " " 40% and 50% " " "
11% " " " not within 50% " " "

2. The average ratio for the tests made with the ball-and-socket bearing and the one-piece spherical bearing is 1.12.

12% of tests were within 10% of the average ratio.
30% " " " between 10% and 20% of average ratio.
17% " " " " 20% and 30% " " "
18% " " " " 30% and 40% " " "
9% " " " " 40% and 50% " " "
14% " " " not within 50% " " "

3. Average unit crushing strength obtained from the plate tests is 8,340 pounds per square inch. The average unit crushing strength obtained from the one-piece spherical bearing tests on the remaining halves of the same bricks used in the flat plate tests is 8,380 pounds per square inch.

A. Flat plate tests—

35%	within	10%	of	average	crushing	strength.	
20%	between	10%	and	20%	of	average	crushing strength.
18%	"	20%	and	30%	"	"	" "
18%	"	30%	and	40%	"	"	" "
5%	"	40%	and	50%	"	"	" "
4%	not within			50%	"	"	" "

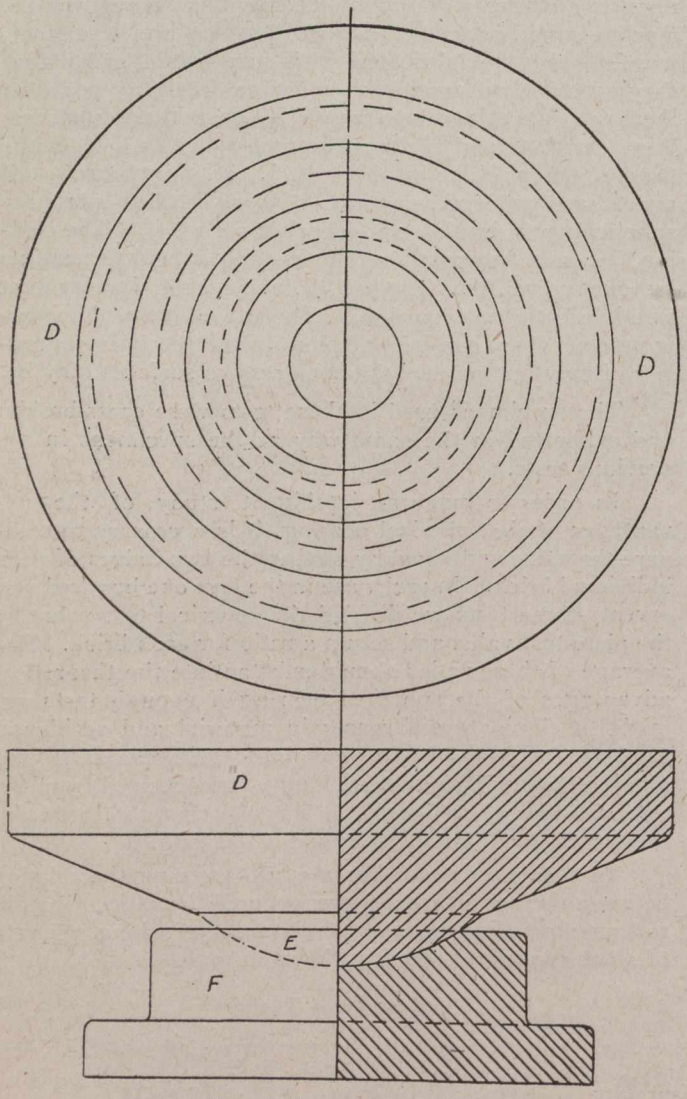


Fig. 1-B.—Ball-and-Socket Bearing.

B. One-piece spherical bearing tests—

9%	within	10%	of	average	crushing	strength.	
25%	between	10%	and	20%	of	average	crushing strength.
21%	"	20%	and	30%	"	"	" "
21%	"	30%	and	40%	"	"	" "
16%	"	40%	and	50%	"	"	" "
8%	not within			50%	"	"	" "

4. The average unit crushing strength obtained from the ball-and-socket tests is 9,340 pounds per square inch. The average unit crushing strength obtained from the one-piece spherical bearing tests on the remaining halves of the bricks used in the ball-and-socket tests is 8,760 pounds per square inch.

A. Ball-and-socket tests—

26%	within	10%	of	average	crushing	strength.	
19%	between	10%	and	20%	of	average	crushing strength.
20%	"	20%	and	30%	"	"	" "
14%	"	30%	and	40%	"	"	" "
10%	"	40%	and	50%	"	"	" "
11%	not within			50%	"	"	" "

B. One-piece spherical tests—

31%	within	10%	of	average	crushing	strength.	
31%	between	10%	and	20%	of	average	crushing strength.
15%	"	20%	and	30%	"	"	" "
13%	"	30%	and	40%	"	"	" "
5%	"	40%	and	50%	"	"	" "
5%	not within			50%	"	"	" "

Conclusions.

1. The fact that the ratio, 1.03, was obtained from the comparative tests with the one-piece spherical bearing and flat plates, shows that the one-piece bearing has an advantage over the flat plates.

2. The ratio, 1.12, obtained from the tests with the ball-and-socket and one-piece spherical bearing shows that the ball-and-socket bearing has an advantage over the one-piece bearing.

3. We recommend for an average crushing value for vitrified paving bricks that value obtained from the tests with the ball-and-socket bearing, which is 9,340 pounds per square inch.

4. The average modulus of rupture is 2,600 pounds per square inch.

SPECIFICATIONS FOR PILES AND POLES.

Of interest to engineers and engineering contractors are the following proposed tentative specifications of the American Society for Testing Materials, reported for discussion at the last meeting in Atlantic City.

No pile with butt diameter over 18 ins., nor top diameter over 13½ ins. will be accepted. The length of each pile is to be legibly marked on the butt with white or black paint.

1. The specifications as to strength shall agree with the requirements that will be finally adopted by the Society under the Standard Classification of Structural Timber; that is, number of rings per inch or some substitute therefor. (Included in this section will also be a list of the allowable defects, etc.)

2. All piles or telegraph poles shall show 40% sapwood in cross-section, or there shall be a ring of sapwood not less than 1 inch in thickness all around the heartwood.

3. (*a*) Piles and poles shall be cut from sound, live trees, of straight grain and regular taper; without crooks exceeding one-fourth the diameter of the stick at middle of crook when peeled. They shall be free from rot, red heart, holes or rotten knots, shakes and felling checks. (*b*) All piles and poles shall have the bark and inner skin carefully removed when the tree is felled; all limbs and knots trimmed flush and butts cut square.

4. The minimum diameter of piles after peeling shall be as follows:—

Length.	Butts.	Tops.
36 ft. and under	14 inches	10 inches
38 ft. and under 50 ft.	14 "	9 "
50 ft. and over	15 "	9 "

IRRIGATION SURVEYS AND INSPECTIONS.

THE following article is extracted from the report recently sent out by the Irrigation Branch of the Department of the Interior, (E. F. Drake, superintendent). In view of the economic importance to a country like Canada of this branch of engineering work, the observations made by Mr. Drake and also by F. H. Peters, Mem.Can.Soc.C.E., commissioner of irrigation and chief engineer, in the report referred to will be of interest.

Inspections.—The usual inspection work was continued throughout the year, and careful inspections were made of all irrigation and water supply works either licensed or under construction. Inspections were also made to determine the feasibility of projects for which applications had been received. The increasing demand for water for domestic, municipal, and industrial purposes has necessitated a good many careful inspections to determine the existing rights, or claims to water from the streams or springs affected; and in many cases it has been found necessary to either refuse applications or to suggest other sources of supply. In the southern portions of the provinces of Alberta and Saskatchewan the smaller streams are now in many cases fully appropriated and as the demand for water increases, as it must with continued development, the question of supply will become serious. Water must then be brought from greater distances, at increased cost, or resort must be had to deep boring and expensive pumping plants.

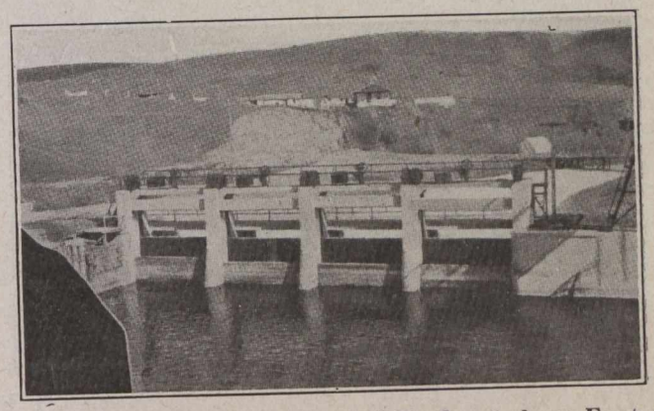
Surveys.—Four large parties were employed throughout the entire field season of 1914 in further developing surveys initiated during the previous year. Three of the parties were engaged in canal location and level work in the development of the feasibility of irrigating land in southern Alberta, south and east of the city of Lethbridge, while the fourth party was engaged in completing the preliminary development of an irrigation project north of Lethbridge.

The Alberta Railway and Irrigation Company, now controlled by the Canadian Pacific Railway Company, operates an irrigation system taking water from St. Mary River in township 1, range 25, west of the 4th meridian. The land irrigable from this system is in the vicinity of Magrath, Stirling and Lethbridge, and comprises some 170,000 acres, not all of which, however, has yet been actually irrigated. The entire district south of Lethbridge and extending eastward to the eastern boundary of the province is in the so-called dry belt and is, generally speaking, well adapted to irrigated farming. The purpose of these surveys is to fully develop the available sources of water supply, to locate possible canal routes, and to determine, in a general way, the areas commanded by such canals. The work is regarded as of great importance to the development and settlement of a very large district. It contemplates the fullest possible utilization of the available water supply from St. Mary, Milk, Belly and Waterton Rivers, including reservoirs for the conservation of flood waters, and the carriage of the water to and through the districts that can be served therefrom.

During the season of 1913 a preliminary survey was made to demonstrate the feasibility of diverting water from Belly River to St. Mary River at some point above the intake of the Alberta Railway and Irrigation Company canal. During the season of 1914 these surveys were extended with a view to developing canal routes and irrigable areas east of St. Mary River. These parties were employed, and during the season they ran 1,259 miles of level lines, 512 miles of complete traverse and level lines, 300 miles of contour surveys, developed three reservoir sites and one dam site, and set ninety-two permanent iron bench-marks. Complete reports, with plotted plans, have been submitted, but these are as yet merely preliminary studies. It is anticipated that by the end of the season of 1915 the work will be sufficiently advanced, if not completed, to warrant a full report.

Work was continued throughout the year on the project contemplating the diversion of water from Oldman River for the irrigation of several detached tracts north of Lethbridge, comprising a total area of about 100,000 acres. The preliminary work of canal and reservoir location, and the determination of the commanded areas, was completed during the season of 1914. Over 1,200 miles of level lines and some 200 miles of complete traverse and level lines were run.

Portions of the district comprised in this project suffered severely from drought in 1914, and the settlers have urged upon the department the completion of the surveys and the actual construction of irrigation works. Unless, however, the government is prepared to adopt a policy of construction and operation of irrigation works—and for many reasons this seems undesirable—there was until very recently no legislation under which such a project could be initiated, financed and constructed by the persons



Headgates, Western Section C.P.R. Canal, from Foot of Bridge Above Sector Section of Dam.

to be directly benefited thereby. The Alberta Legislature has, however, now enacted a law known as the "Irrigation District Act," which, with possibly some slight amendments, seems to be admirably suited for this purpose. The interested persons are, it is understood, now taking steps to have an irrigation district formed under the provisions of this law, and will probably apply for a water right in the near future.

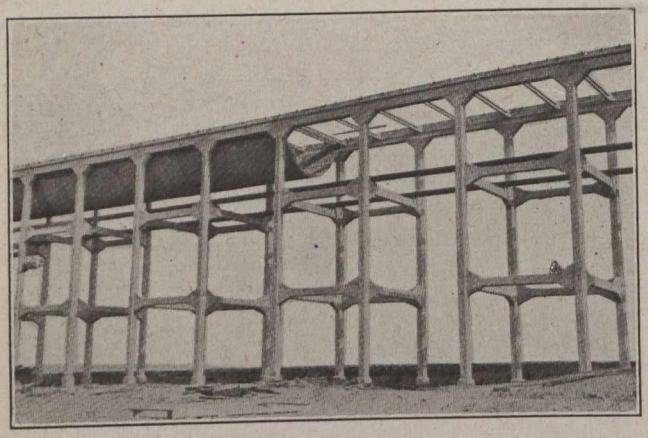
In the meantime further surveys are being made to more accurately define the irrigable lands with a view to apportioning the cost of the necessary works on the lands to be benefited. Some opposition to the scheme has developed, particularly in the western part of the district nearer the mountains, where the soil is somewhat heavier and the rainfall possibly greater. The extent of the opposition has not yet been fully developed, and it is too early to express any opinion as to whether or not it will be serious enough to jeopardize the entire project.

In the early autumn of 1914 the attention of the department was drawn to the scarcity of water for domestic use in the district lying east of Little Bow River in townships 12 and 13, ranges 18 and 19, west of the 4th meridian. It was suggested that it might be found possible to utilize the uncompleted works of the Southern Alberta Land Company for the carriage of water from Bow River, and that

canals might be run from the company's main canal through the district referred to, thus supplying water for domestic and stock-watering purposes and for irrigation as well.

Surveys made during October and November, 1914, demonstrated the feasibility of diverting water from the Southern Alberta Land Company's canal so as to serve approximately 93,000 acres in townships 14 to 17, ranges 18 and 19 (70,000 acres), townships 12 and 13, ranges 18 and 19 (13,000 acres), and township 11, range 17, west of the 4th meridian (10,000 acres), and to supply water for domestic purposes during the summer season throughout the district. Unfortunately, however, the works of the Southern Alberta Land Company are not at present sufficiently advanced to permit of the carriage of water to the points at which the diversion canals must head, and the financial difficulties which have hampered the company's operations for some time past preclude the expenditure at present of the sum necessary to place the works in serviceable condition.

The surveys have, however, served a useful purpose, and when the Southern Alberta Land Company is able to complete its works so as to serve the most westerly unit



Brooks Aqueduct, Bantry Canal, Eastern Section C.P.R.

of its irrigation tract, there is reasonable probability of an arrangement being made for the use of these works in the carriage of water to the district referred to. There is no question but that the district requires irrigation for its fullest development, and that the domestic water supply can be greatly improved by the construction and operation of irrigation canals.

It is understood that officers of the Geological Survey are making an examination of this and other districts in southern Alberta with a view to determining the depth at which water for domestic and other purposes can be obtained.

Reservoirs.—One of the most important questions that has recently engaged the attention of the engineers of this branch is the location and survey of reservoir sites for the conservation of flood water. Several large reservoir sites were located some thirteen years ago by engineers in the employ of the Alberta Railway and Irrigation Company, and it was apparently intended that some of these sites should be used in the development of the company's irrigation system in the Lethbridge district. Only one of these, the Chin Coulee reservoir, has been constructed. Our engineers have examined several of these sites with a view to their utilization for the storage of flood water from St. Mary and Milk Rivers in the development of irrigation in southern Alberta, and with special reference to the division of the waters of these streams between Canada and the United States in accordance with the provisions of the "Waterways Treaty."

Other possible reservoir sites on the headwaters of Belly and Waterton Rivers have been examined in a preliminary way, and detailed surveys will be made as soon as opportunity offers.

In the Cypress Hills district—that is, the district in southwestern Saskatchewan and southeastern Alberta, between the international boundary and the main line of the Canadian Pacific Railway—there are many irrigation projects which are dependent for water supply upon streams which usually are dry, or nearly so, just when water is most needed, but which have a very considerable flow in early spring or after heavy rains. Under existing conditions, irrigated farming cannot be satisfactorily carried on. Frequently only one irrigation can be given, and that earlier than is desirable, while if the flood waters which are now wasted could be stored, a greatly increased acreage could be brought under cultivation and satisfactorily irrigated.

Our surveys have developed three large reservoir sites, *viz.*, Cypress Lake in township 6, ranges 26 and 27, west of the 3rd meridian, where it will be possible to store the flood waters of Battle Creek and Frenchman River, including their upper tributaries; Middle Creek reservoir, on a tributary of Lodge Creek, and a large reservoir on the lower course of Frenchman River in township 5, range 16, west of the 3rd meridian.

The Cypress Lake and Middle Creek reservoirs were fully reported upon last year. The Frenchman reservoir was surveyed during 1914. It covers 3,500 acres and can be developed to hold 50,000 acre-feet of water. These three reservoirs, supplemented by smaller ones on some of the tributary streams, will give fairly good control of the flood discharge of the streams flowing south from the Cypress Hills, and provide for the irrigation of large areas of land. Their early construction is urgently required, and it is the desire of the settlers that it shall be undertaken quickly.

There are no large streams flowing north from the Cypress Hills, but several small reservoir sites have been located and a few of them have been carefully examined. Possibly some additional sites may yet be discovered. A good many small irrigation projects draw their water supply from these streams, but no general policy of water conservation seems possible. Probably the problem can best be handled by the construction of small reservoirs whenever possible, and the sharing of the cost among the few whose water rights will be improved thereby. The Dominion Government may be able to assist by reserving the vacant Dominion land required for any such reservoir —and some such reservations have already been made— but as almost all the land affected is now in private ownership it will be necessary for the interested parties to deal directly with the owners and to arrange among themselves for sharing the cost of the work. This branch will be prepared to assist by placing at the disposal of the interested parties all data already collected, including plans of such surveys as have been made.

Domestic Water Supply.—In some districts in the provinces of Saskatchewan where the domestic water supply problem has become acute, the Provincial Government has constructed a number of small reservoirs, or dugouts, which while not ideal sources of water supply, serve a useful purpose in providing water for stock and for the operation of farm machinery. In cases where such reservoirs are built on well-defined streams, and where the storage of water would have an appreciable effect on the volume of water on the lower course of the stream, the

government should—and usually has—acquired a water right under the provisions of the Irrigation Act. In many cases, however, such reservoirs are merely natural depressions which have been deepened to hold surface water, and there seems to be no necessity for the acquisition of water rights. The purpose of the Irrigation Act is to vest in the Dominion Government the ownership of all sources of surface water supply, with a view to the administration of the law so as to best serve the general public interest, and it is not the policy of this department to impose any unnecessary restrictions upon the conservation and use of water.

Duty of Water and Demonstration Work.—A very important feature of irrigation administration is the determination of the quantity of water required to produce the most beneficial results when applied for irrigation. The existing regulations define the "duty of water," or the ratio between a given quantity of water and the area of land it will irrigate, as 150 acres for each cubic foot of water per second flowing constantly throughout the irrigation season of 153 days. This quantity is equivalent to about two acre-feet of water for each acre of land irrigated, or enough to cover each acre to a depth of two feet. The best modern practice inclines towards expressing the duty of water in depth over the irrigated tract, rather than by the rate of flow, and in the revised regulations now in course of preparation the duty is defined as two acre-feet per acre, an acre-foot being equivalent to 43,560 cubic feet.

This depth may be, and probably is, too great. The duty was established some fifteen years ago and was based upon experimental work carried on principally in the Western United States. Experience has shown that there has been a general tendency on the part of irrigators to use too much water, and that the result in many cases has been to sour and waterlog the land, or to cause the rise of alkali to such an extent as to temporarily ruin the soil. Some experimental work was done in Canada several years ago, and in 1913 it was taken up in a systematic manner with a view to determining the quantity of water required to produce the most beneficial results for different crops under the varying conditions of soil and climate in the dry belt of Western Canada.

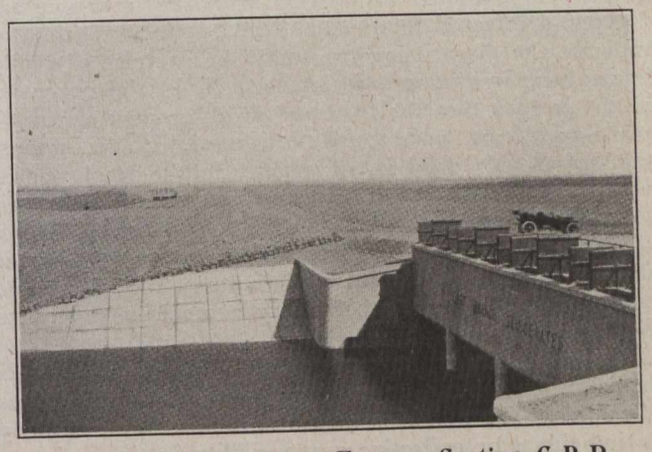
Absorption Losses in Irrigation Canals.—A question which has received too little attention in the past is that one dealing with the inevitable losses which occur on every canal system in conducting the water from the source of supply to the farmer's headgates, due to seepage and evaporation in the main, secondary, and tertiary canals. During the irrigation season one hydrometric engineer, Mr. R. J. McGuinness, was employed in making measurements with a view to determining these losses in the canals of the C.P.R. western section and the Alberta Railway and Irrigation system at Lethbridge. The work is very complicated owing to many practical difficulties which arise in the field, but during the season data were gained which, while not entirely satisfactory, have made it possible to determine the average "absorption" losses between certain limits.

Hydrometric Surveys.—This work, covering the measurement of the flow in all the important streams in Alberta and Saskatchewan, has a very wide scope and it is only possible in this summary report to indicate the work that has been carried out. The results of the work in detail will be published in a separate report on Stream Measurements.

The work was carried out under the charge of Mr. P. M. Sauder, chief hydrometric engineer, with two principal assistants, Mr. G. H. Whyte and Mr. G. R. Elliott. The office staff consisted of two office computers and recorders, and twelve hydrometric engineers were employed in the field.

The districts covered were the same as described in the previous year's report, with the addition of the Wood Mountain district, which comprises a number of streams which rise in Saskatchewan and flow across the international boundary, and are of considerable importance for this reason. During the season records were gained for 164 permanent gauging stations, 3,550 stream measurements were made by the field engineers, 29 new permanent stations were established, and 24 permanent iron benchmarks were set.

On many of the smaller irrigation streams in Saskatchewan and Western Alberta a very high percentage of the run-off takes place in the early spring due to the melting and rapid run-off of the winter's snow. Previously the hydrometric engineers had not taken the



Crawling Valley Dam, Eastern Section C.P.R.

field early enough in the spring to measure this flow, but during the spring of 1915 a special effort was made to obtain these very important measurements. In order to handle this work, eight hydrometric engineers took the field early in March and gained very valuable measurements. Six engineers were placed in the Cypress Hills district, one north and four south of the hills, another operated along the line of the Canadian Pacific Railway between Medicine Hat and Maple Creek. The hydrometric engineer in the Wood Mountain district took the field as early as possible, but owing to the difficulties of getting into this district did not get the peak measurements on all of the streams.

HUDSON BAY RAILWAY.

Estimates of the department of railways, among them appropriations of $3,000,000 to carry on the construction of the Hudson Bay Railway and its terminals at Port Nelson, and $1,500,000 for work on the National Transcontinental Railway, were passed by the commons in committee of supply this week. The discussion centred around the vote for the Hudson Bay Railway, some members still having doubts as to the practicability of the road as a grain route, and the suitability of Port Nelson as its terminus.

Mr. Robb (Huntingdon) feared that the season of navigation on Hudson's Bay and Straits would not be long enough to permit of the railway being of much use in moving the western grain crop.

Hon. J. D. Reid, who estimated that the project would cost in all $26,000,000, and would be completed in the autumn of 1917, declared himself convinced that the railway would prove of value to the country.

Hon. George P. Graham asserted that it would be of value in opening new territory and should be built, even if there were no exports for it to move to the point of embarkation.

THE TYPHOID TOLL.*

By George A. Johnson.

CERTAIN cardinal facts stand forth in opening a discussion of the significance of typhoid fever. First of all, let it be clearly understood that there is no question of its being an entirely preventable disease. Second that all typhoid is caused by taking the typhoid germ into the mouth. And, third, that typhoid fever in America is the chief disease conveyed by impure food and drink.

These premises stated, let us go a little further in the line of elaborating on these basic facts. Since the disease cannot be contracted naturally without taking the specific germ into the mouth, and since the manner in which this act is commonly performed can be said to be associated almost exclusively with the consumption of typhoid infected food and drink, it follows that to eradicate the disease involves only the exercise of really simple measures of precaution, which, in the concrete, are to see to it that the food and drink be pure, or made pure, and kept pure until consumed. Public understanding of this need is, of course, in the ideal sense, imperative, but when once the typhoid scourge has been placed under control, it is possible for public health authorities to prevent the reëstablishment of its sinister influences on the public health, in spite of the ignorance, selfishness, or almost unbelievably complacent tolerance of the public itself.

It is not for a moment denied that to effect this idealistic result is an undertaking beset with tremendous difficulties. The public is not to be blamed unqualifiedly for individual or collective responsibility in the maintenance of this filth disease among human kind. Education must be forced upon the public by those qualified to teach; public health officials must be given wider power through more exact and far-reaching laws aimed at the destruction of the roots of this filth-sustained plant; and ample funds must be appropriated to carry through the work. The vital capital needlessly dissipated by the typhoid scourge in this country amounts each year to not less than $150,000,000, yet the combined annual appropriations for all the health departments of the cities of the United States amount to less than 30 cents per capita, or not more than $15,000,000. This fund is made to cover the expenses of work on infant morbidity, inspection of school children, laboratory and dispensary service, tuberculosis, and for educational and publicity work, and this sum is clearly inadequate for the efficient prosecution of tuberculosis work alone. In New York City a very large share of the expense of such work is borne by the Department of Charities. Probably not 10 per cent. of the health department funds are devoted to holding typhoid fever in check; the prevention fund, if you like. Such an amount would be equal to 1 per cent. of the loss suffered through failure to exercise adequate and efficient measures of prevention.

If the adjuster of a municipal or state budget were knowingly threatened with illness, or one of his immediate family so affected, he would not hesitate to spend any reasonable sum of money to defray the cost of obviously necessary preventive measures. Life insurance certainly is popular, and it is not to be supposed that the officials of city and state finance departments are immune to the persuasive arguments of life insurance agents. This is protection against the effects of disease; nevertheless, such officials wield an energetic blue pencil when they reach the health department item in the annual budget. They cannot see the return of good to the public, even though they realize the protection afforded to themselves and their families from their life insurance, or they would not pay the premiums.

Twenty millions of people in the United States are now being furnished with filtered water at a cost not exceeding $8,000,000, or 40 cents per capita, per year, and in these cities having filtered supplies the water-borne typhoid fever has been practically eliminated, as reliable statistics abundantly prove. Inexpensive as water purification is, these people are spending more money for that alone than they appropriate for the work of prevention and public treatment of all diseases, whether water-borne or not, and it is not to be forgotten that out of the public health fund comes a considerable expenditure for work in the line of the conservation of purity of public water supplies.

The results of water purification always show a big balance on the right side of the ledger. Where one dollar is spent for pure water, many dollars are saved in the form of vital capital through the prevention of sickness and death. If a community of 19,000 people spends each year 40 cents per capita for filtered water, and thus each year prevents a single death and the attendant cases af illness from typhoid fever, it will come out even financially, and increase its self-respect into the bargain. In Pittsburgh, to cite a well-known example, the adoption of water filtration has saved over 600 lives, 9,000 cases of typhoid illness, and $4,500,000 in vital capital annually.

Whose is the responsibility? Who can be blamed for permitting typhoid fever to exist and thrive in this enlightened age? Is it the national government, the state governments, the municipal governments, or the people themselves? There is no law prohibiting the consumption of impure water or food unless the consumer deliberately contemplates suicide.

A community may start out with the best intentions. Legislative enactments are put through to protect the public health. This is simple, for none but the framers of health laws really know what they signify, hence there arises no antagonism to their enactment. Next comes the task of obtaining the necessary funds to enforce these laws. The average appropriation of all the cities where such funds are made available is, in round numbers, 30 cents per capita per annum. This applies only to those cities having populations of 25,000 or more. What of the remainder?

Let any thinking citizen ask himself if he considers a contribution of 30 cents each year on his part sufficient justification for his assurance of protection against preventable disease. Or, as another example, if he thinks, if given in charity, it is his proper share toward the fund for keeping in check and preventing the spread of the great white plague, which kills 130,000 people in America each year. Unquestioningly, he would give far more to street beggars in the course of a year. If every man, woman and child in the United States contributed one dollar each year to public health work, the total sum thus raised would not nearly equal the annual loss in vital capital in this country from typhoid fever alone. Not one city in America does contribute one dollar per capita for all the uses of its health department, but on an average contributes the far-famed thirty cents, which is opprobrium enough.

*Extracts from a paper read before the American Waterworks Association, June 7, 1916.

In the states best off with respect to health laws recorded on their statute books, the proper enforcement of these laws is never carried out. Observe the anti-spitting law enacted only a few years ago. No law was more proper, but in the beginning, when an arrest for its violation was made, it was so unusual a proceeding that the ensuing brief court proceedings were likely to find their way to the front page of the newspapers, and for days thereafter the cartoonists were busy with their humorous pencils creating and nursing a spirit of mockery, so often fatal to the public good. The law prevailed, nevertheless, more through the effects of ingenious placarding of the statute than a fear of legal apprehension, or an honest belief that disease was spread in this manner.

Laws looking to the prevention of contamination of food and drink commonly are allowed to lie peacefully within the covers of the books of law, seldom to be disturbed. The screening law, calling for the protection of foods exposed for sale from the explorative activities of the deadly house fly, was observed where there was no apparent way out of it, but the screens, when provided, were often improperly constructed, and since they were more or less of a nuisance to the owner in dispursing his wares, were never more than partly effective.

Campaigns for Pure Water Supplies.—No one can gainsay that in progressive states the majority of the movements looking to the improvement of public water supplies originate in the health department. Especially is this true where the community is small, and where the water department officials do not feel warranted in employing relatively expensive men who are technically trained in water analysis and matters in general relating to water pollution. Then, too, the officials of large cities often are slow to act in such matters, and too prone to fall back upon arguments based on the financial inability of the community to carry through the construction of water purification works. It can be stated unqualifiedly that no community, whatever its size, is too poor to have a pure water supply. It is better to have had streets, grade crossings, and inadequate public buildings than to tolerate a public water supply of questionable purity.

Grade crossings are a menace to life, to be sure, but not nearly as great a menace as a bad water supply; and they are more often abolished for the sake of convenience than as a measure of public safety. Good streets promote business and the public comfort, but such improvements do not measure up on a level of importance with a supply of pure water. Attractive, roomy and light public buildings are a matter of common civic pride, but it is doubtful if they tend materially to increase the efficiency of those who labor therein.

Of all public works, the waterworks is by far the most important, and should always be given preference in the allotment of moneys for the city's maintenance. Ever since it became known that bad water was dangerous to health the public has been entitled by sovereign right to receive pure water. Bad water will put out conflagrations as promptly as pure water, but it also will cause widespread disease, which is more important. In the last thirty odd years the loss in vital capital through typhoid fever alone was over three times the net property loss from fire in the United States.

It is the customary design that the waterworks department of a community shall be self-supporting, but it is rare that large sums of money are kept on hand to defray extraordinary expenses in the department. When questions arise as to the adequateness of the supply as regards volume, or more satisfactory distribution, little difficulty is experienced in obtaining the necessary funds to carry out the work, for the comfort and convenience of the public are affected. With improvements in the supply respecting purification it is different. When a city of a hundred thousand people is confronted with evidence furnished by its own officials and those of the state health department showing that the water supply requires purification, and learns that works to effect this end will cost, say, $300,000, there follows an energetic sharpening of pencils to ascertain how this is going to affect the tax rate. There is strong opposition to the movement from the very beginning.

The state health officials, realizing the necessity better than anyone else, order that purification works be built. The cost thereof being estimated, the matter of a bond issue to carry the expense is put up to the people, and very often is defeated. Then an extension of time is allowed, and the matter drifts along for years without any definite advance.

Many cities have endured an excessively high typhoid fever death rate for years, and withheld the financial support necessary for the furtherance of measures of prevention, even when it was plain that the public health of the community would be immensely benefited thereby. Great cities, such as Baltimore, Cincinnati, Louisville, Minneapolis, Philadelphia, Pittsburgh, St. Louis and Washington, temporized with the matter for years before building purification works, and in the meantime thousands of their citizens were needlessly killed by water-borne diseases. Then they built filter plants, and it is safe to say that if a candidate for public office in any of these cities should advocate the abandonment of filtration, he would stand as much chance of election as the proverbial snowball has of existence in Gehenna. The people in these cities now realize what pure water means to them, and while at first reluctant to believe, actual experience of the benefits has turned their minds just as far, or farther, in the opposite direction.

Laws have been enacted giving to the state the power to force the purification of public water supplies within their boundaries. The so-called Bense Act of Ohio is one of these. There is need of more legislation of this kind, which leads to the protection of the public against itself. Such power, placed in competent hands, and with sufficient funds to enforce it, cannot but do immeasurable good. Too much reliance is put in moral suasion in such matters nowadays. The money can always be found if it has to be found, and many a man has put off the urgently necessary visit to the dentist because of the physical pain incident to such a visit and the strain on his pocketbook; but he is always happy and satisfied when it is all over.

It is precisely so with forced expenditures of public money for water purification. The thinking citizen realizes that he is taking a chance with disease every time he drinks a glass of contaminated city water, and yet is ready with excuses, chiefly of a financial nature, for not helping along the campaign for pure water; but no matter what he finally is compelled to pay for it, when he realizes how he has been benefited he is perfectly satisfied, even though for a time he is obliged to go without new paving in front of his house, apologize to visitors for his antiquated city hall, or something of the sort.

Contaminated Wells.—The excreta of typhoid sufferers always should be thoroughly disinfected, but the cases are very numerous where it is either not done at all, because of the unpleasant labor involved, or done in

a perfunctory manner. Where there is no water carriage system of sewerage these infected discharges are emptied in the privy or some other convenient place, sometimes being covered with earth, but more often not, and from these deposits, where favorable geological and topographical conditions obtain, the typhoid germ easily finds its way through or over the ground into nearby wells, which serve as sources of drinking water for one or more families.

The attendants on a typhoid sufferer not infrequently regard the urine of such a patient as innocuous, and since it is less trouble it is emptied into a nearby sink or out of a back window. It has been positively demonstrated that the urine of a typhoid patient may contain as high as 1 to 500,000,000 typhoid germs per cubic centimeter, or from 5 to 25,000,000 in a single drop, and this is sufficient to show its very dangerous character, particularly in the contamination of dug wells.

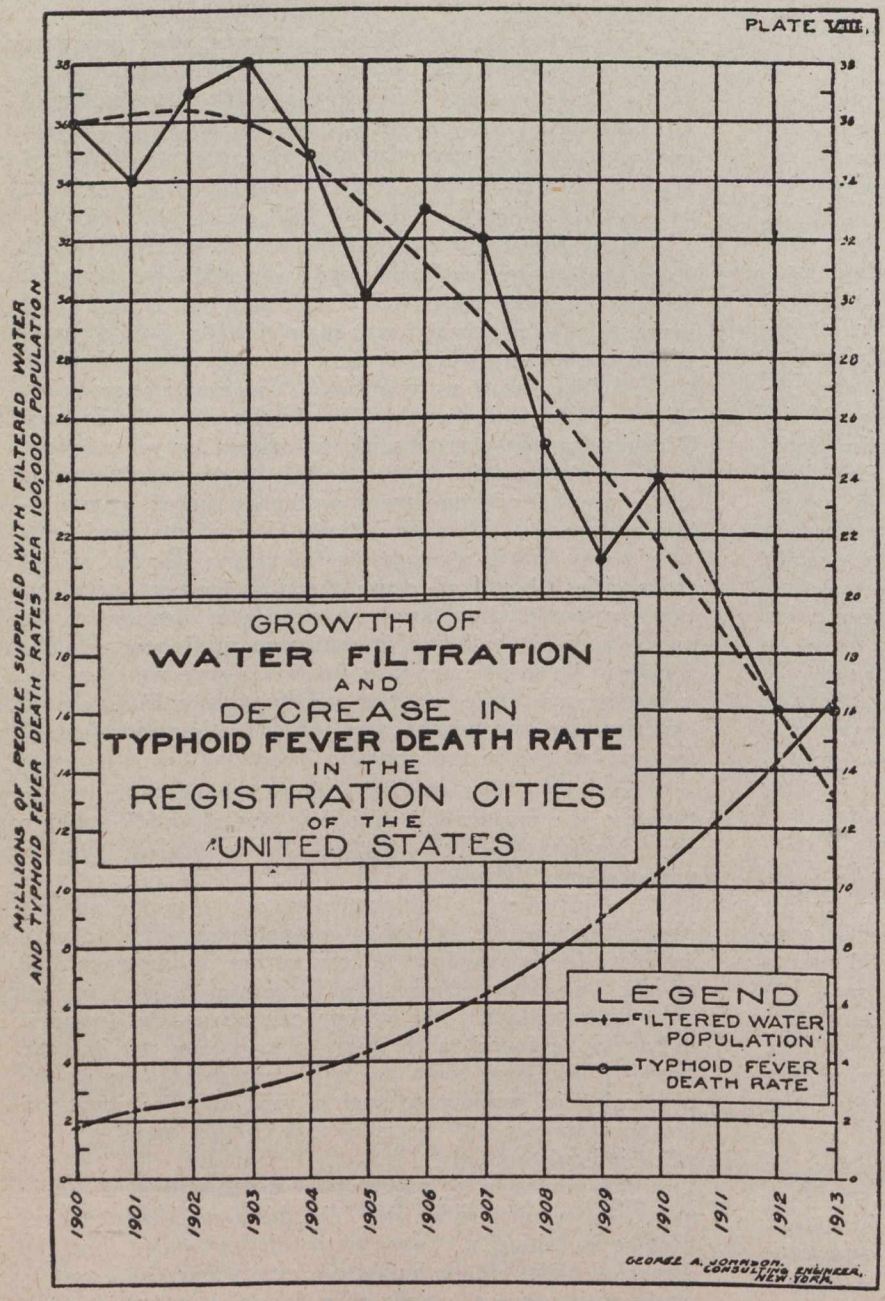
A summary of the results of a large number of examinations made of wells located on farms in eastern and western United States showed that at least 60 per cent. of the wells examined were contaminated with bacteria which are always identified with sewage. There is no doubt that a fair share of the annual typhoid grist comes from the consumption of polluted well waters, either through direct consumption, or through the contamination of milk and other foods which are brought in contact with them.

Wholesale Pollution of Public Water Supplies.—Where the house of the typhoid sufferer is provided with a convenient water closet, the temptation is great for the attendant to eschew the disagreeable task of effective disinfection, and the excreta, without such treatment, are summarily dumped therein to find unimpeded transit facilities to the nearest waterway, from which others draw their water supplies. It may be that the sewage of such communities is subjected to some form of purification before it is allowed to flow into the nearest waterway, but no form of treatment used in any part of the world at all times actually destroys all of the disease germs in such sewages. It remains for those communities whose water supplies are thus polluted to purify them before consumption. If this is carefully done, all is well; if not, then there is always a heavy endemic toll of typhoid fever in those communities, the sodden monotony of which frequently is broken by a spectacular epidemic.

Death Rate.—Dr. Allen W. Freeman, Assistant Commissioner of Health of Virginia, recently said:—*

> We have learned by sad experience that the measure of typhoid fever in any community is the measure of the distribution of human filth in that community, and that the dissemination of human excrement will inevitably result in the spread of typhoid fever. . . . The problem is no longer an investigative or scientific problem, but a problem of administration. When the people of the United States wish to pay for absolute protection against typhoid fever it can be bought with the full assurance that the goods can be delivered. As physicians and sanitarians, we are most interested in the practical question, can typhoid fever be prevented? We know that it can. We know that our methods are certain, that they will yield the desired result in every case where they are properly applied. The problem remaining for solution is how to convince the American people that protection from typhoid fever is something worth spending money for.

Dr. Freeman estimates that in the northern part of the United States the purification of all water supplies would result in the reduction of the annual typhoid rate to a figure usually less than twenty per hundred thousand population, while in the south the purification of the water supply alone would seldom reduce the rate to less than fifty per hundred thousand, other measures, such as perfect sewering or rigid screening and supervision of dry closets, being required to bring down the rate to the point which could be reached in the north by water purification alone. Below this point, in the north and south alike, reduction must be attained by the thorough super-



*The Present Status of our Knowledge Regarding the Transmission of Typhoid Fever, Public Health Reports, issued by the United States Public Health Service, January 10, 1913.

vision of cases of illness, which means the requirement of morbidity returns and the prompt notification of all suspicious cases, protection of milk and other foods from typhoid contamination, elimination of flies and their breeding-places, control of typhoid carriers, and the use of anti-typhoid vaccine wherever feasible.

Dr. Freeman's viewpoint is unquestionably sound, but in the broad analysis his estimates of what filtration would do are perhaps a little too low. For years it has been recognized that efficient filtration of the public water supply of a community will result in a reduction of from two-thirds to three-quarters in the typhoid fever death rate. Where the initial rate is high the percentage reduction following filtration of the water supply usually is correspondingly high, as noted particularly in the cities of Albany, Cincinnati, Columbus, Lawrence, Philadelphia and Pittsburgh. In these cities the average typhoid fever death rate for the five-year periods before and after filtration, respectively, showed a reduction of 76 per cent., or a typhoid fever death rate per 100,000 population of seventy-nine reduced to nineteen. The combined result of water filtration in twenty representative cities showed that filtration was followed by an average reduction in the typhoid fever death rate of 65 per cent.

Table 16.

Reduction in typhoid fever death rates in American cities following the filtration of their public water supplies (averages for five years before and five years after filtration):—

City	Average Typhoid Fever Death Rate		Per cent. reduction in Typhoid Fever Death Rates which followed the filtration of the Public Water Supply
	Before Filtration	After Filtration	
Albany, N.Y.	109	28	74
Charleston, S.C.	106	62	41
Cincinnati, O.	56	11	80
Columbus, O.	83	17	78
Harrisburg, Pa.	72	33	54
Hoboken, N.J.	18	13	28
Indianapolis, Ind.	46	28	39
Lawrence, Mass.	110	23	79
Louisville, Ky.	57	24	58
New Haven, Conn.	40	25	38
New Orleans, La.	39	26	33
Paterson, N.J.	29	9	69
Philadelphia, Pa.	63	20	68
Pittsburgh, Pa.	132	19	85
Providence, R.I.	19	13	31
Reading, Pa.	53	35	34
Scranton, Pa.	25	10	60
Springfield, Mass.	22	22	0
Washington, D.C.	55	31	43
Wilmington, Del.	35	24	31
Weighted averages...	60	21	65

Among sanitarians there appears to be little, if any, dissension from the view that modern filtration practices actually eliminate the water-borne diseases, or typhoid fever and allied disorders at the very least. That is to say, where the plants are properly designed, well constructed, and intelligently operated, water filtration, in practical terms, is one hundred per cent. hygienically efficient.

Table 17.

Relationship between the increase in population supplied with filtered water and the decrease in the typhoid fever death rate in the registration cities of the United States:—

Year	Populations		Per cent. which filtered water population was of		
	Total for registration cities	Total in United States supplied with filtered water	Total population of United States	Total population registration cities	Typhoid fever death rate in registration cities
1900 ..	21,477,000	1,860,000	2.4	8.7	36
1 ..	22,146,000	2,400,000	3.1	10.8	34
2 ..	22,679,000	2,700,000	3.4	11.9	37
3 ..	23,221,000	3,100,000	3.8	13.3	38
4 ..	23,724,000	3,800,000	4.6	16.0	35
5 ..	24,729,000	4,300,000	5.1	17.4	30
6 ..	26,342,000	5,400,000	6.7	20.5	33
7 ..	27,145,000	6,300,000	7.2	23.2	32
8 ..	28,501,000	7,500,000	8.4	23.3	25
9 ..	29,655,000	8,900,000	9.8	30.1	21
1910 ..	21,342,000	10,805,000	11.7	34.6	24
11 ..	32,376,000	12,000,000	12.8	37.2	20
12 ..	33,304,000	14,100,000	14.7	42.4	16
13 ..	34,230,000	16,500,000	17.0	48.0	16

In Table 17 and Plate VIII. some instructive statistics are presented to show how the urban typhoid fever death rate has been reduced as water filtration developed. The relationship between the two is strikingly proportional, and holds out every good promise for the future.

FIRE PROTECTION ON RAILWAYS.

The Board of Railway Commissioners' Fire Inspection Department issued orders recently, under general order 107, directing the C.P.R., the Canadian Northern Railway and the Grand Trunk Pacific Railway to maintain a sufficient force of fire rangers for efficient patrol and fire fighting duty on their lines, between April 1 and November 1, except in so far as they may be relieved from so doing by an order in writing from an authorized officer of the Board. The directions of the order are specific in each case, and the areas within which the patrols are to be maintained are fully set out. The directions to the C.P.R. cover mileages on the Manitoba, Alberta and British Columbia Divisions; to the Canadian Northern Railway, mileages on the Central Division, and to the Grand Trunk Pacific Railway, mileages on the Mountain Division. For the supervision of the work, the Board has appointed inspectors, located as follows: E. J. Zavitz, Toronto; Thos. McNaughton, Prince Albert, Sask.; P. C. B. Hervey, Edmonton, Alta.; E. H. Finlayson, Calgary, Alta.; D. R. Cameron, Kamloops, B.C.; M. A. Grainger, Victoria, B.C.; H. S. Irwin, Prince Rupert, B.C.; R. E. Allen, Hazelton, B.C.; H. G. Marvin, South Fort George, B.C., and P. S. Bonney, Tete Jaune, B.C. The object sought to be obtained is the prevention of fires along railways, and to avoid as far as possible the imposition of unnecessary expenditure upon the companies for that purpose. An efficient system of fire patrol can be established at a minimum expenditure, and as the conditions vary from time to time and from place to place, the fire inspectors appointed by the Board have authority to waive the requirements wholly or in part from time to time as practicable. The order in each case calls for the minimum of adequate protection.

COAST TO COAST

Milverton, Ont.—On May 18th Hydro-Electric power was turned on here for the first time. The system is part of an extension from Stratford, taking in the towns of Milverton, Listowel, Palmerston and Harriston.

Calgary, Alta.—Assistant City Engineer Sidenius reports that the second main arch of the Centre Street bridge will be finished this week. This leaves only one more arch to complete. The bridge will be completed late in the fall, it is thought. There has been some little delay in the work in connection with the big fill on the north side. Earthwork cannot be commenced until frost is out, but the engineers hope to be able to start on June 1. There are 110,000 yards of earth still to be handled.

Ottawa, Ont.—The government bill providing for the purchase of the Quebec & Saguenay Railway, the Quebec & Montmorency and the Lotbiniere & Megantic Railways, passed the House of Commons last week. The government's proposal provides for the fixing of the price which is to be paid for the Quebec & Saguenay by the arbitration of the Exchequer Court. The value is to be the actual cost of the road less depreciation, but not to exceed $4,465,000. In addition, the government is to assume the bonded indebtedness of the Quebec & Montmorency, the electric end of the system, but not exceeding in all $2,500,000.

The Pas, Man.—Steel-laying has been resumed on the last half of the Hudson Bay Railway on the 90-mile stretch between Manitou Rapids and Kettle Rapids. The construction company says the track will be at the Kettle Rapids by August 1, where further advance will be delayed pending the erection of an 1,100-foot girder bridge over the Nelson River. In any event the contractors are sure to have the steel track laid into Port Nelson by next summer at the latest.

Ottawa, Ont.—There is a likelihood that Dr. J. S. Plaskett will be appointed chief astronomer for the Dominion. He is in charge of the new observatory at Victoria, B.C., where was installed recently the largest telescope of its kind in the world. Dr. Plaskett went to Victoria from the staff at Ottawa. The proposal is to keep Dr. Plaskett at Victoria on account of the fact that the observatory there is now the most important one in Canada. In that case, Dr. Otta J. Klotz will be placed in charge of the observatory at Ottawa, which he virtually has been since the death of Dr. King.

Toronto, Ont.—A. D. MacTier, general manager, eastern lines of the Canadian Pacific Railway Company, has announced that the new North Toronto station will be ready for use in June.

Dundas, Ont.—The formal opening of the public utilities commission's new offices took place on May 9th. The building is of red brick and was erected by the Dickson Building Company.

Victoria, B.C.—A number of new works were approved by the city council recently. One was the placing of a quantity of rock before the Ross Bay seawall, thus affording it extra protection. For this an appropriation of $6,000 was ordered. For necessary work on Douglas Street a $1,000 vote was authorized. It was decided also to make some repairs to the James Bay Causeway landing, and for this purpose the expenditure of $250 was approved.

St. John, N.B.—The city of St. John, N.B., has adopted as standard time that of the forty-fifth meridian, one hour faster than that of the sixtieth meridian, which heretofore has been used. This change is made at this time with a view to making it easy for everybody to adjust his day's work so as to get into it the maximum number of hours of daylight. The Canadian Pacific, which runs to St. John, uses, at present, Eastern Standard time, hitherto one hour slower than the time used in the city; and now, unless it changes, the road's clocks will be two hours slower than those showing city time.

Calgary, Alta.—The one-year power agreement between the city of Calgary and the Calgary Power Company for power needed above 5,000 horse-power has expired. The city is now taking only 5,000 horse-power from the power company, and power needed over and above this amount is being generated at the city power-house. Gas is being used at the present time as fuel. Power Engineer J. F. McCall has recommended that the agreement be not entered into this year, believing it to be a better policy for the city to use its million-dollar power plant to develop any power needed above the 5,000 horse-power maximum contracted supply.

Ottawa, Ont.—The revised plans for the new Parliament Buildings carry out the present architectural design, and, as a matter of fact, are in accord with the original design for the building, which contemplated four stories instead of three. No change is made in the plans for the interior grouping of offices, Commons and Senate chambers, etc., as submitted in the architects' plans of a month or so ago. The new upper story will be devoted to restaurant accommodation and additional rooms for the members. From the architectural standpoint the raising of the building is an improvement, according to the architects. The additional cost is estimated at something over $1,000,000.

Listowel, Ont.—Hydro power was turned on for the first time on May 28th.

Sarnia, Ont.—The city of Sarnia has taken over the power plant and lines of the local electric company, and will operate it until Niagara power arrives in a couple of months. The plant will be changed from a 60-cycle power to 25 as soon as the Hydro arrives. The Hydro transmission line is now nearing Sarnia.

Montreal, Que.—The new subway on Park Avenue at the corner of Van Horne Avenue, actual construction on which was commenced on May 6, 1915, has been opened for traffic purposes. Laurin and Leitch were the contractors, the price being $176,000. Seven separate tracks of the C.P.R. run over the subway bridge, which is 80 feet wide, 900 feet long and 17 feet 5 inches from the ground. While authorization was given for the construction of the subway in 1909, it was the winter of 1914-1915 before the work of diverting sewers was commenced.

South Vancouver, B.C.—The George Street sewer will be completed in the early part of June. It is also expected that the laterals in Wards 3 and 4 will be completed by the end of June.

Ottawa, Ont.—Hon. F. G. Macdiarmid, Provincial Minister of Public Works, Toronto, has instructed a survey to be made shortly of the proposed Ottawa-Prescott highway, approximately 60 miles in extent. After the survey has been made and all the data collected it is likely that a commission will be appointed, the highway declared a main road, and come under general legislation.

Angus, Ont.—Col. Low, who has charge of the construction at Camp Borden, informed the Militia Department that he has struck another gusher flow of water of over half a million gallons per day pouring out of a two-foot pipe. This ensures a magnificent water supply.

Editorial

THE FLUXING OF ASPHALT.

In an early edition of *The Canadian Engineer* there will appear an article, by a well-known authority, explaining how asphalt can be easily fluxed to any desired penetration.

It is generally recognized that any properly refined asphalt, whatever may be its penetration, can be brought to any given higher penetration without difficulty and without doing any harm whatever to the asphalt, provided that a true asphaltic flux is added. It is apparent, however, that all municipal engineers in Canada do not yet realize this fact, because one Canadian city recently paid $7,900 for 300 tons of fluxed asphalt of about 60 penetration, when they were offered an exactly similar asphalt, of 47 penetration, for $5,800. By doing the fluxing themselves, the city could have saved upwards of $2,000. But the city refused to consider any unfluxed material.

Incidentally, the specification issued by this particular city merely mentioned "refined asphalt" and did not call solely for fluxed asphalt. Nor was the required penetration stated anywhere in the specification, so that it was, to a certain extent, guess-work for any firm to bid on a fluxed material, not knowing to what penetration it would have to be fluxed. Moreover, no specification was issued defining the fluxing material to be used, thus allowing the possible use of light paraffin oils.

In view of incidents of this nature, we feel that an article reviewing the entire situation as regards fluxes and fluxing, will be of general use and interest.

PREVENTION OF TYPHOID.

At the convention of the American Waterworks Association, which is still in session in New York City as we go to press, a noteworthy paper entitled "The Typhoid Toll" was read by Mr. George A. Johnson, consulting engineer, New York. While it is impossible to print the paper in its entirety, we have in this issue reproduced such portions of it as are of particular interest to readers of *The Canadian Engineer*. From this extract it will perhaps be possible for our readers to realize with what care and thoroughness Mr. Johnson has gone into his subject.

Municipal engineers, especially those directly in charge of water supply, very frequently have to expend a great deal of effort to convince civic authorities of the economic waste resulting from impure water. The statistics which Mr. Johnson has produced and placed in proper sequence are most impressive, and should be quite sufficient to convince those who are responsible for the appropriation of monies for waterworks construction and maintenance, that typhoid fever, which is altogether too common in many of our communities, can be successfully prevented.

The results of water purification, as Mr. Johnson most convincingly shows, always give a large balance on the right side of the ledger. Where one dollar is spent for pure water, many dollars are saved in the form of vital capital through the prevention of sickness and death.

MONTREAL AQUEDUCT SCHEME APPROVED.

After the developments of the past three weeks, it is very unlikely that any change will be made in the Montreal aqueduct scheme.

On May 26th Controller Cote, who has charge of the Montreal works department, seemed partially to admit the need of some outside opinion being brought to bear upon the undertaking. He gave notice that on May 29th he would introduce a motion to appoint J. G. Sullivan and M. J. Butler as consulting engineers to advise Mr. Mercier *whenever their advice might be needed.*

When the time for his motion arrived, however, the controller failed to make it, and instead introduced to the Board of Control G. W. Fuller and J. M. Gregory, consulting engineers of New York City. According to newspaper reports, these gentlemen advised the controllers that the aqueduct scheme is a feasible commercial undertaking, and that the completion of the work should be left entirely in the hands of the city's engineers.

After several days of discussion, Mr. Cote withdrew his motion, and then Controller Villeneuve moved that Mr. Sullivan and A. St. Laurent be invited *to report upon the whole project.* As only Controller Ross supported him, the motion was defeated 3 to 2.

There are many very able men in the Montreal city engineering department, particularly the chief engineer. But they have inherited a scheme to which birth was given by their predecessors, and having become foster-fathers to the undertaking, they have assumed—perhaps unwisely—full responsibility for their adoption. Considering the large amount involved, and the heavy capital expenditures per expected horse-power, it would have been desirable for the Montreal board to have passed Controller Villeneuve's motion.

Messrs. Fuller and Gregory must have information not available to the general public, otherwise engineers of their repute surely would not have declared that the scheme is commercially feasible. Their O.K. upon the work and the plans has apparently ended the matter. Montreal must now sit back and pull straws to determine whether it is headed toward bankruptcy or toward prosperity effected through savings in light and power bills. After all, it's only the twentieth century and there's lots of time left yet for Montreal's government to progress!

SOO CANAL LOSES TRAFFIC.

Chiefly because the United States has constructed a large lock at Sault Ste. Marie, traffic through the canals of Canada last year decreased 58.9 per cent. In 1914, the traffic totalled 37,023,237 tons and in 1915, only 15,198,803 tons. The Sault Ste. Marie situation was responsible for 91 per cent. of the decrease.

In his annual report on canals, just published, Mr. J. L. Payne, comptroller of statistics, department of railways, Ottawa, points out that of the decline of 19,848,227 tons at the Soo, 1,049,241 tons were in Canadian boats and 18,798,986 tons in United States boats.

This meant a loss to the Canadian canal of 5.1 per cent. of the Canadian traffic and 94.9 per cent. of the

United States traffic. The cause of these losses was the that the new lock on the United States side has a much larger capacity than the lock on the Canadian side.

There are now three locks on the United States side of the St. Mary's River, the last to be opened having a depth of 24.5 feet at extreme low water. There is but one lock on the Canadian side, with a minimum depth of 18.25 feet. The ease of navigating the heavier loads through the new United States lock drew nearly all the iron ore and a good deal of wheat away from the Canadian canal.

PERSONAL.

R. H. BRAND, C.M.G., has been appointed an additional member of the Imperial Munitions Board, to act as the representative of the board in London.

T. A. JARDINE FORRESTER, city waterworks engineer, has resigned, having received orders from England to return home to rejoin his regiment for active service.

THOS. MAXWELL FYSHE, A.M.Can.Soc.C.E., a prominent contractor of Calgary, Alta., has become Canadian manager for Gunn, Richards & Company, production engineers.

H. VICTOR BRAYLEY, C.E., has resigned as Canadian manager for Gunn, Richards & Co., to accept a position as executive assistant to Mortimer B. Davis, a prominent Montreal manufacturer and capitalist.

Sapper NATHANIEL A. BURWASH, 6th Brigade, Canadian Engineers, who has been reported among the list of wounded, was born in Cobourg, Ont., and graduated at Toronto University in Mining and Engineering.

Lieut.-Col. C. H. MITCHELL, of the general staff, and Major THOS. C. IRVING, of the Canadian Engineers, were among those who received birthday honors conferred by King George last week, both of them receiving the D.S.O.

STANLEY H. ROSE, until recently in charge of the New York office of the Bureau of Foreign and Domestic Commerce of the Department of Commerce, has been engaged by the Barber Asphalt Paving Company to direct its foreign trade department.

G. S. KELLEY, formerly with the Digger Machinery Co., Inc., has recently been appointed sales representative of the John F. Allen Co., of New York City, in connection with the new department they have established for the manufacture of coal-handling and hoisting machinery.

W. J. RENIX, district master mechanic of the Canadian Pacific Railway at Revelstoke, B.C., has been appointed master mechanic of the Saskatchewan division, with headquarters at Moose Jaw, Sask. He is succeeded by A. BROWN, formerly district master mechanic at Winnipeg, Man., who in turn is succeeded by G. TWIST, locomotive fireman at Fort William, Ont.

OBITUARY.

Major NORMAN C. PILCHER, whose death in action was recently announced, was formerly general manager of the Sherbrooke Railway and Power Company.

A. N. MUNGALL, civil engineer, who was engaged in the construction of the National Transcontinental and other lines, died recently at his home in Fredericton, N.B., at the age of 28 years.

HUGH F. COYLE, formerly superintendent of the Belleville division of the Grand Trunk Railway, and later general superintendent, died suddenly last week in his private car while returning home from a visit to his son at Meadville, Penn.

SIMPSON FLEMING, who died in Ottawa recently at the age of 89 years, was the first superintendent of the Ottawa waterworks, and constructed the first system of mains to be laid. He served with both City Engineers Keefer and Surtees, and held his waterworks position for 30 years, retiring 15 years ago. His advice was frequently sought since on waterworks matters, and he went to Arnprior for a time to conduct an inspection of the waterworks system there. The late Mr. Fleming came to Canada when 20 years of age from County Armagh, Ireland.

ENGINEERS' CLUB OF MONTREAL.

The Engineers' Club of Montreal shows a most prosperous financial statement for the year ending March 31, 1916, with net profits of $12,805. The profits were applied to writing off portions of the general equipment account, furniture and fixtures account, etc., from 20 per cent. to 33⅓ per cent. being written off each account. The club now has assets totaling $281,000, and a surplus of assets over liabilities of $91,000.

There are 515 members on the roll, including 19 who are on active military service overseas. Four members were killed in action during the year, namely, Major J. N. Warminton, Lieut. W. C. Brotherhood, Lieut. A. F. Revol and Major Geo. Janin.

Henry Holgate is president of the club and R. W. H. Smith, secretary. The executive committee consists of Lawford Grant, J. M. Miller, John C. Russell, Julian C. Smith, R. M. Wilson, Leslie H. Boyd and E. Herb. Brown. The statement speaks very well for the support that the engineers have given to the club during the past year.

ENGINEERS' CLUB OF THOROLD.

The Engineers' Club of Thorold is the name of a new organization, the purpose of which is to bring together in a social and professional manner the numerous members of the Welland Ship Canal engineering and contracting staff, on all the sections, and prominent residents of Thorold and St. Catharines whose business associates them with the engineering profession. The club has secured suitable quarters at 55 Chappel Street, Thorold, which have been newly decorated and furnished throughout, and a steward is employed at the club for the furnishing of meals. It also provides lodging for members. The membership of the club is about 70, the officers being as follows: Honorary president, Mr. J. L. Weller, engineer-in-charge, Welland Ship Canal, St. Catharines; president, Mr. E. G. Cameron, resident engineer, Section No. 3, Thorold; vice-president, Mr. F. H. Keefer, K.C., Canadian counsel for International Joint Commission; secretary, Mr. H. L. Clifford, assistant resident engineer, Section No. 3, Thorold; treasurer, Mr. J. A. Elliott, manager, Royal Bank, Thorold.

It is proposed from time to time to have papers presented to the club which would be of interest to members of the engineering profession.