PAGES

MISSING

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

MANITOBA HYDROMETRIC SURVEY

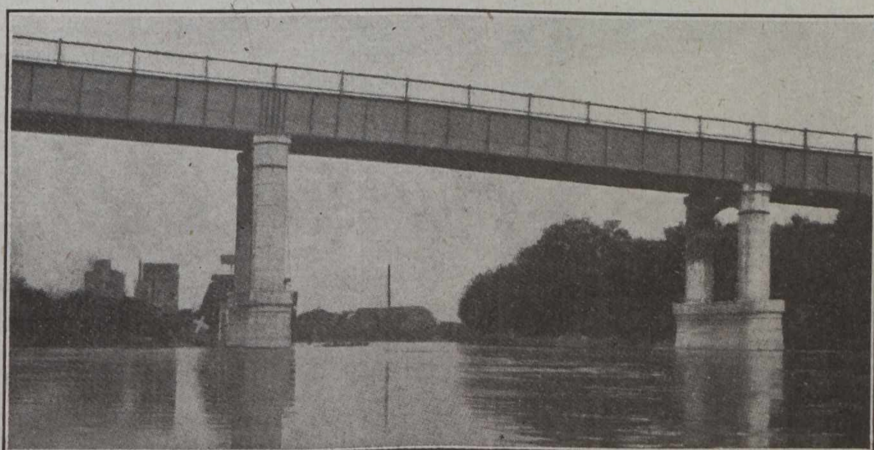
SOME INTERESTING FACTS CONCERNING THE METHODS EMPLOYED IN THE SECURING OF HYDROMETRIC DATA IN THE PROVINCE OF MANITOBA.

THE gathering of hydrometric data is of prime importance, not only from a hydraulic power standpoint but also in connection with other uses of the surface water supply. These various uses may be enumerated as follows: Domestic, municipal and manufacturing purposes, irrigation, water power, drainage, sewage disposal, navigation, flood prevention. The following observations on this subject are taken from the progress report of the Manitoba Hydrometric Survey, the name of the organization of the Dominion Water Power branch covering the province of Manitoba.

In the province of Manitoba, information regarding stream flow or surface water supply is, or may be, required for any one of these uses. Throughout the province, numerous towns and villages are depending upon the rivers for their domestic water supply. This demand will rapidly grow as the population increases, and further information in regard to the amount of water available will be required. In the southwestern part of the province, where the average annual rainfall varies between 14 and 17 inches, and where agriculture is the chief pursuit, the use of water for irrigation purposes is to be expected. Many of the rivers throughout the province present power possibilities, and studies have been made to determine their probable economic value. The true value of the potential water-powers cannot be determined without a thorough knowledge of the water available in the streams, especially under conditions of low discharge. In the northern and southwestern portions of the province the reclamation of large tracts of lands by drainage may profitably be undertaken. As settlement becomes more dense the necessity for the reclamation of these lands will become more pressing. It is essential, therefore, that accurate information concerning the regimen of flow of streams forming the natural outlets for such drainage be obtained.

The use of the streams of the province in connection with sewage disposal will, at no distant date, command attention since the rapid growth of the towns and villages will soon render necessary the formulation of a policy relative to the disposal of their waste in such a manner as will obviate any possible danger to the community as a whole. In order that this question may be handled intelligently, a thorough knowledge of the run-off conditions of the streams is of extreme importance.

Several of the main rivers in the province might be utilized for navigation purposes; in fact, before the advent of the railway in Manitoba, the Red River formed the only means of communication with the outside world. Improvement for navigation purposes is being urged in many quarters, and for this purpose a study of the hydrology of these streams is necessary.

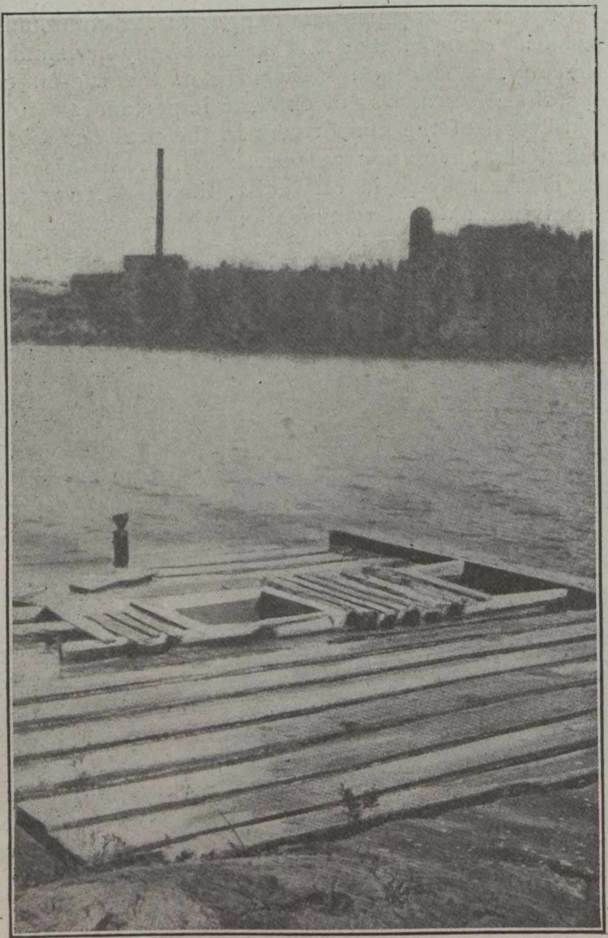

Assiniboine River, Brandon. Gauge at Bridge.

Owing to the fluctuation of stream flow, not only from day to day but from month to month and from year to year, and the effect that such variation may have upon any one of the uses to which the streams may be adapted, it is imperative that the gathering of stream flow data be made to extend over a considerable term of years, so that a true idea of the stream regimen may ultimately be formed.

Organization and Scope.—When the Manitoba Hydrometric Survey was organized early in 1912, it was decided that the work should be carried on in as comprehensive a manner as possible, and that as funds became available and the opportunity offered, the work should be extended to embrace the whole of the province of Manitoba. At its inception, however, the district in which stream flow data were particularly required was that tributary to the Winnipeg River, as surveys were being carried on to determine the power possibilities of that river. Since the organization of the survey the work has been extended from time to time until it now covers all the principal rivers of the province.

In organizing this work, it was recognized that probably the best and most comprehensive methods for gathering hydrometric data were those employed by the Water Resources Division of the United States Geological Survey. Through the courtesy of the officers of that organization, studies were made of their field and office methods, both districts covered by their engineers and at the head office in Washington. The work was then mapped out and has since been carried on along lines closely following the practice of the United States engineers.

The different streams to be studied were investigated and suitable locations selected for the establishment of metering stations, the selection of the stations depending upon the physical features and the need of data in that particular locality. At these metering stations, gauges were also established and the services of some person living in the locality were secured to read the gauge daily. These daily observations are recorded in a book provided for the purpose and examined by the engineer on each of his trips to the station. The readings as entered in the book are transferred to cards by the gauge



Keewatin, M.H.S. Evaporation Station.

reader, and are forwarded weekly to the chief engineer. From a study of these readings and the meterings, the daily discharges are arrived at.

On the organization of the Manitoba Hydrometric Survey the work of the Winnipeg River Power Survey was merged with it. Since then all investigations, whether hydrometric, storage, power or river improvement, have been carried on under the one central control. By this arrangement the work naturally falling within the scope of the survey has been carried on efficiently and systematically. Conservation investigations for power and storage are being dealt with in a comprehensive manner with a view to determining the best use of the available water supply.

In gathering the stream flow data it is believed that the results obtained are sufficiently accurate for all practical purposes; the aim being not so much to concentrate on a few streams and so obtain records of extreme accuracy, but rather to spread the effort over a wide territory and so serve as many purposes as possible without unduly sacrificing the accuracy of results. In this connection it is essential that the records, in order that they may properly cover all possible range in stage of the rivers investigated, should extend over a considerable term of years. On some streams this term should be from five to ten years, while in other cases it should extend over a much longer period, say, from ten to twenty years. The length of term will depend largely on the character and relative importance of the stream and the possibility of estimating the discharge by comparison with records of other streams in the vicinity. To quote from an authority on this subject, "the object should be to gauge a certain number of streams at all seasons of the year so as to ascertain their total discharge and its seasonal distribution, also to gauge others at certain stages which have been determined to be critical points in their regimen." It may be stated here that the standpoint taken by the United States Geological Survey is, that owing to the constantly changing flow of the streams, data of reasonable accuracy showing the distribution of flow over several consecutive years, are of more importance than very accurate measurements covering short periods of time.

In dealing with the work of the survey, the territory covered, due principally to geographic conditions, falls naturally into several main divisions. From time to time the work in these several divisions may be extended, since up to the present time only the principal streams have been examined. The divisions may be enumerated as follows: (1) Lake of the Woods tributaries and outlet; (2) Winnipeg River and tributaries; (3) Red River and tributaries; (4) Assiniboine River and tributaries; (5) the district to the west of Lake Winnipegosis, including the Saskatchewan River and its tributaries; (6) the east shore of Lake Winnipeg; (7) the Nelson River.

Methods of Determining Discharge.—Three separate methods are commonly followed in the determination of discharge of streams, and these methods involve the use of certain formulæ based on physical data more or less easily ascertained. The three methods referred to are: (1) The slope method; (2) the weir method; (3) The mean velocity method.

The Slope Method.—In the slope method of determining the discharge, the fact that the slope of the bed of the stream, and consequently the surface slope bears some definite relation to the discharge is made use of. A number of empirical formulæ have been deduced from time to time in an effort to express this relationship, and among these in most common use are the Chezy, the Kutter, and the Bazin formulæ.

What is known as the Chezy formula was deduced by a French engineer of that name about the year 1775, and takes the form of:—

$V = C\sqrt{rs}$ in which V is the velocity, C a coefficient depending upon the slope, the roughness of the channel and the wetted perimeter; r is the hydraulic radius, being the cross-sectional area divided by the wetted perimeter, and s the slope, being the head or fall in the section divided by the length of the section. This formula: $V = C\sqrt{rs}$ may be considered the fundamental slope formula. Various modifications of it have been deduced from time to time depending upon values of C obtained from formulæ based upon experiments and observations. The Kutter and Bazin formulæ belong to this class, and the former is perhaps the better known, taking the form of: $V = C\sqrt{rs}$ where C is obtained from the equation:

$$C = \frac{41.6 + \frac{.00281}{S} + \frac{1.811}{n}}{1 + \left\{41.6 + \frac{.00281}{S}\right\}\frac{n}{\sqrt{r}}}$$

Where r and S have the same significance as in the Chezy formula, the factor n is known as the coefficient of roughness.

The Bazin formula, often considered to be one of the best for the determination of flow in open channels, takes the form: $V = C\sqrt{rs}$ where

$$C = \frac{157.6}{1 + \frac{c}{\sqrt{r}}}$$

the coefficient c depending upon the roughness of the channel; values being determined for different classes of material by experiment.

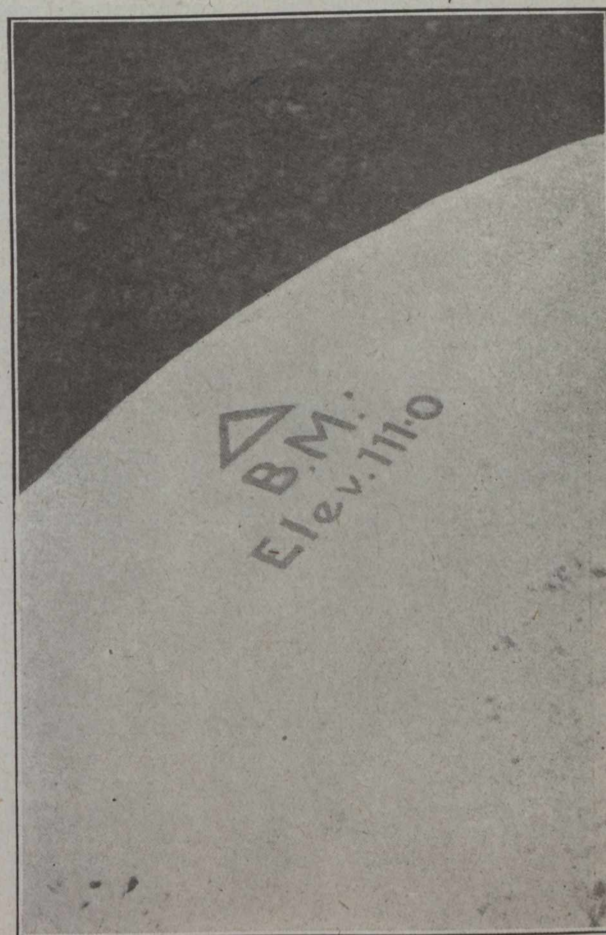
Humphreys and Abbott made determinations of C from which they also derived a formula. As the first-named formula depended on experiments carried on in small channels of various natures, and the latter upon observations made on the Mississippi River, the governing conditions were of a widely different nature. It is therefore to be expected that neither of the formulæ could be considered as generally applicable. The diversity of the results obtained from the use of these two formulæ was the subject of investigation by Kutter and Ganguillet and undoubtedly influenced the final determination of Kutter's formula.

Tables have been prepared giving values for the coefficient n in Kutter's formula and c in the Bazin formula, and are to be found in practically every handbook. It is, however, very difficult to choose the correct value for these coefficients, and it is therefore advisable that whenever possible the value of n and c in the two formulæ be computed from a measured discharge.

In the Manitoba work it is seldom necessary to make use of the slope method of determining the discharge; in fact, about the only application of the method is in the determination of flood discharges, or, in conjunction with meterings on rivers where the gauge height does not always bear a constant relation to the discharge. For the Kutter formula it is, however, possible in each of these cases, to arrive at a value for the factor n since from a determination of the hydraulic radius at the time of metering, the slope and the mean velocity, the value c may be found from the equation: $V = C\sqrt{rs}$; then, having found the value of C, this may be equated to Kutter's formula and the value of n derived, or may be found in the tables prepared for this purpose in any engineering handbook. A value for the coefficient c in the Bazin formula may be found in the same way.

Weir Method.—The weir method of determining discharge may be made use of in connection with widely varying discharges. Very often estimates of flow both under conditions of flood and of extremely low water may be arrived at by this method. Where funds are available, and the value of the records warrants the expense of installation, a permanent weir undoubtedly provides the best method of determining discharge. When the stream flow to be measured is of a comparatively small volume (a few second-feet), and the discharge is to be determined from time to time, a temporary weir may be utilized in conjunction with a gauge in the natural river channel.

This temporary weir would consist of a standard sharp-crested weir fastened for convenience to a wooden plank, the method of using it being as follows: A point in the stream below the gauge is selected and, after reading the gauge height, a temporary dam of earth and sods is thrown across the stream, in which dam the weir is placed; care being taken to place the crest absolutely level. Sods and earth are tamped about the weir to prevent leakage. The site of this small temporary dam should be so selected that the depth of water above will be at least twice the head on the weir, while the pond created should have a total width of several times the length of the crest. On the downstream side care must



Assiniboine River, Brandon, M.H.S. Bench Mark.

be taken to permit free access of air below the napp when the weir is discharging.

When the weir is installed, readings with the level are taken upon the crest, a gauge is placed 8 or 10 feet upstream from the dam and is set to the same datum as the weir crest. Readings of the water level on this gauge will then indicate the head on the crest of the weir.

In computing discharges by this method, a modification of the Francis formula may be made use of, these modifications being in the nature of corrections for end contraction and elimination of velocity of approach, the formula taking the form of: $Q = 3.33\,(L - .2H)\,H^{3/2}$, in which:

Q = discharge in second-feet.
L = length of crest in feet.
H = head in feet.

As mentioned before, where the value of the records warrants it and accurate continuous discharges are required, a permanent weir may be built. This, however, is seldom necessary, as dams, if suitably situated and constructed, may be utilized. The main features governing the use of such structures as a means of determining the discharge are those relating to the characteristics of the dam itself, and also the consideration of the possible diversion of varying quantities of water around or through the dam. The physical requirements, in order that good records may be obtained, are as follows:—

1. Crest all at the same elevation or divided into sections of the same elevation.

2. Sufficient beight to eliminate backwater effect from below.

3. Absence of leaks.

4. Crest of such type that the coefficient of discharge may be readily arrived at.

5. Absence of flash boards or careful records of the use of same.

Whitemouth River, M.H.S. Bench Mark.

There are many things that may be said both for and against the use of dams as a means of determining discharge, which, generally speaking, may be summarized as follows: The use of a weir or dam has every advantage of continuity of records through the period of ice formation and flood discharge, while, on the other hand, it has the disadvantages of the uncertainty in connection with the proper coefficient to be used and the effect of debris, logs, etc., gathering on the crest, and the possibly varying amounts of water diverted for other uses.

Velocity Method.—The quantity of water flowing past a given point is derived from the product of two factors: (*a*) the mean velocity of the water past the point, and (*b*) the area of the cross-section of the river at that point. The area of the section depends upon the contour of the bed of the stream and the fluctuation of the water surface, the mean velocity being a function of the wetted perimeter, the roughness of the stream bed, and the slope of the water surface.

There are two principal methods of determining the mean velocity: (*a*) by current-meter, and (*b*) by float measurement. The requirements of these two methods are essentially the same, the method being to observe the velocity of the stream at a number of points throughout the cross-section. In order that good results may be obtained, care should be exercised in selecting the metering section. The section selected should be situated at a point in the stream where the banks are nearly parallel for a considerable distance both above and below the section. Also, the cross-section of the stream throughout this distance should be as nearly uniform as possible, the bottom free from projections, holes, large boulders, etc., and the banks of sufficient height to obviate the possibility of overflow under flood conditions. In selecting the site, due regard should be paid to its relation or proximity to tributaries of the stream, or to lakes, in order that sudden changes in the surface level or stage may be eliminated, the object being to secure a location where the stage or gauge height will truly indicate the discharge. In this northern country the stations are preferably located adjacent to the crest of a rapid or fall, so that backwater effects from tributaries lower down may be to a large extent eliminated, and open-water conditions may obtain under a greater range of temperature.

The equipment of a metering station usually consists of a gauge for determining the fluctuation of the water surface referred to a permanent bench mark, in order that any change in datum may be checked, and a permanently referenced initial point of measurement of the cross-section so that the same points at which the velocities are determined may always be found. Very often these points are located by stretching a tagged line across the river, or where a bridge is made use of, the points are marked upon the structure. Where the stream is swift or deep and no bridge is available, a cable or boat station may be established. The velocity at different points throughout the cross-section of the river is ascertained by either of the two methods mentioned, and the mean velocity over the whole section is then determined. Applying this mean velocity to the cross-sectional area gives the discharge of the stream at that point.

Chemical Method.—The most recent method of determining discharge in a stream, and possibly the most accurate, is what is known as the chemical method. In many cases, especially in turbulent mountain streams, determination of velocity and discharge by the float or current-meter method is impossible, owing to the difficulty in securing a station where the stream bed is uniform and the velocity sufficiently low. On the other hand, an application of the weir method would very often involve considerable expense on account of the necessity of rugged construction. In such cases the chemical method is particularly applicable.

Another purpose to which this method can be favorably applied is the rating of power stations. Owing to the advance in the art of water-wheel design and construction, the high degree of efficiency obtained and the premium placed upon such efficiency by purchasers, it is necessary that very careful determination be made. For wheels of large capacity the volume of water involved is great, and hence there is a possibility of errors of considerable magnitude creeping in, if the ordinary methods of determining discharge are used. With a view to eliminating these errors and securing the degree of accuracy required, there has recently been evolved what is known as the "chemical method" of measuring discharge. This method may be outlined as follows:—

Knowing approximately the volume of water to be measured, a definite quantity of chemical solution of known strength is added at a given rate to the stream or intake above the point of measurement. Owing to the turbulent nature of the stream or the churning action of the turbine wheels, this solution is thoroughly mixed throughout the whole volume of the water to be measured. In the case of a stream, samples of the water are taken some distance below the point of application of the solution, and in the case of power plants, in the tail-race. A chemical analysis of this water will reveal the amount of added chemical held in solution. Knowing the volume of the sample and the amount of solution added per unit of time, the determination of the volume of water flowing per unit of time involves only a simple calculation, for it may be readily seen that if:

Q = discharge of turbine or river.
q = discharge of salt solution.
N^0 = concentration of salt solution.
N_1 = concentration of water before addition of salt solution.
N_2 = concentration of water in tail-race or river at sampling station.

Then: $$Q = \frac{N^0 \times q}{N_2 - N_1}$$

This method of measurement has been quite recently brought forward, and the opinion is ventured that its use, especially in the case of power plant rating, will be generally adopted.

Summary and Recommendations.—The records contained in the report are the result of investigations carried on by the survey since its inception in 1912. Some stations have for various reasons been discontinued, while others have been established, the net result being a marked increase in the number of stations operated, and when the streams where miscellaneous readings are secured are considered, it will be seen that the southern part of the province is now well covered.

In the northern part of the province the work is being extended as opportunity offers and occasion arises, though, as far as possible, the need of stream flow data should be anticipated.

It is recommended that in view of the necessity of anticipating the requirement of data, that the work be extended to cover as much of the northern part of the province as possible. This extension will necessarily depend to a very great extent upon the accessibility of the various rivers and the possibility of securing continuous records. The work instituted on the Nelson should be vigorously carried on and an attempt made to secure a station that will permit of an all-year-round rating. In addition, slope gauges should be established, and if possible a suitable site for an automatic gauge selected and the same installed for the purpose of securing a rating of the river. The storage possibilities of Lac Seul should be looked into and an automatic gauge installed at some point on that lake, so that records of its variation in stage may be secured.

The necessity of some investigation into the underground water resources of the province is a question that is becoming pressing. The year 1914 was one of exceptionally low flow, and where the communities and individuals were dependent upon surface water for a domestic supply, hardship was experienced. A careful survey of the ground-water supply should make valuable and reliable information on the subject available to the general public, and as it is so closely allied to the gathering of data regarding the surface supply, it is suggested that it be carried out by this survey as soon as the necessary funds and assistance can be made available.

STUDIES REGARDING CONCRETE MIXTURES EMPLOYED IN CONSTRUCTION OF SHOAL LAKE AQUEDUCT.*

By W. G. Chace and Douglas L. McLean.

THE studies and observations on gravel concrete described in this paper were made during 1914-15 in connection with the construction of the concrete aqueduct of the Greater Winnipeg water supply from Shoal Lake, Ontario. The object of the tests was: "With a given gravel pit to obtain an aggregate which, with a minimum quantity of cement would give a concrete that would be watertight and strong."

While the major portion of published data is lacking in detail, yet the general principles which apply to the question are known and there is at present a number of methods by which lean mixtures for concrete may be made impermeable under moderate pressures. For concrete with mortar consisting of, say, one part by weight of cement to three parts by weight of sand the following methods or additions may be used to obtain the desired results: (1) Special grading of sand and stone; (2) addition of cement; (3) addition of hydrated lime; (4) addition of clay; (5) addition of fine sand; (6) use of a mixture of cement and puzzolanic material; (7) use of sand-cement. In general, gravel gives more impermeable concrete than that made from crushed stone and sand.

General Considerations Relating to Materials Available for the Water District Construction.—The country through which the aqueduct was located from Indian Bay to Winnipeg was at one time subject to glacial action and at the same or later period formed a portion of the bed of Lake Agassiz. The effect of the glaciers and the action of the waters of Lake Agassiz resulted in numerous deposits of fine sand, coarse sand and gravel throughout the country traversed by the aqueduct. At Indian Bay the deposits consist principally of fragments of igneous rocks, while close to Winnipeg they consist for the most part of limestone gravels.

As the average cost of cement per barrel of 350 pounds delivered on the site of the work was about $2.75 and as the stresses in the concrete on firm foundation were low, requiring a concrete of only moderate strength, a lean mixture with fine sand added for purpose of making the mix more impermeable appeared to be desirable.

The laboratory samples of dry aggregate varied from 25 pounds to 100 pounds, depending on the quantity of large sized material in the sample from which the laboratory sample was taken. For the sand samples one pound of dry material was used.

For use on the district work the following classification was made of the different sizes of materials: Oversize—material retained on 1½-inch screen; coarse—material passing 1½-inch screen and held on ½-inch screen; intermediate—material passing ½-inch screen and

*Abstracted from Supplement to Paper on the Shoal Lake Aqueduct. Read before the Canadian Society of Civil Engineers, October 5, 1916.

held on ⅛-inch screen; sand—material passing ⅛-inch screen; fine sand—material passing No. 100 sieve; gravel—material retained on ⅛-inch screen; aggregate—sand and gravel mixed in various proportions.

Numerous mechanical analyses were made of samples from test pits on several deposits along the aqueduct right-of-way. Some of these are given in the following table:—

Table 1.—Mechanical Analysis of Various Natural Deposits.

Reference No.	Sample from	Oversize in lbs. per 100 lbs. held on 1½ in. Screens.	Percentage by Weight Passing Screens 1½ in.	1 in.	¾ in.	½ in.	¼ in.	⅛ in.	No. 10	No. 20	No. 40	No. 75	No. 100
201	Pit 2, Sec. 11-9-8			100	91.4	80.0	66.9	56.1	36.7	17.9	8.5	2.2	1.9
203	Pit 6, Sec. 11-9-8		100	96.1	93.3	89.1	79.0	68.4	53.1	34.2	13.9	1.1	0.8
204	Pit 2, N.E. ¼ 6-10-8			100	96.6	85.2	56.6	33.9	22.2	11.4	4.4	0.6	0.4
205	Pit 1, S.E. ¼ 7-10-8			100	99.7	97.7	88.2	68.6	30.5	12.0	4.5	0.6	0.5
206	Pit 3, N.E. ¼ 7-10-8		100	97.7	94.0	88.0	75.8	65.6	50.3	23.3	6.4	1.0	0.6
207	Pit 4, Sec. 10-9-8		100	92.3	84.4	76.0	62.5	53.9	43.0	29.8	18.0	1.5	0.7
210	Pit 7, Sec. 11-9-8		100	88.8	79.3	65.5	46.8	37.2	29.0	19.8	12.0	2.6	2.1
215	Pit 5, S.W. ¼ 10-10-7	23.8	100	94.2	86.6	77.8	59.4	44.2	29.0	17.4	7.8	2.7	2.2
220	Pit 3, S.E. ¼ 10-10-7	0.	100	90.4	86.0	75.9	58.8	47.7	34.2	15.4	4.3	1.7	1.5
225	Sec. 23-24, T.8. R.14	0.	100	90.5	83.4	75.1	64.9	58.2	49.9	37.3	29.3	1.2	0.8
227	Average 8 Pits 10-10-7E	8.95	100	91.2	83.8	73.9	56.6	44.7	31.7	18.3	8.6	1.9	1.5

It will be noted that practically all the gravel deposits contain an excess of sand. The intermediate (material passing ½-in. and held on ⅛-in. screen) is also found in excess in most of the deposits. The sands as shown in the above examples are coarse but each deposit usually contains or has adjacent to it quantities of fine sands.

The grading of the sands varied, as may be gathered from the following examples in Table 2.

Table 2.—Mechanical Analysis of Various Sand Samples.

Sand No.	Sample from	⅛ in.	No. 10	No. 20	No. 40	No. 75	No. 100
2	Pit 8, S.W. ¼ 10-10-7	100.0	80.1	55.6	35.7	3.0	1.8
3	Pit 5, S.W. ¼ 10-10-7	100.0	65.4	39.2	17.5	5.9	4.9
5	Pit 7, S.W. ¼ 10-10-7	100.0	62.7	27.0	12.6	5.8	5.0
8	Pit 3, S.E. ¼ 10-10-7	100.0	71.8	32.4	9.1	3.6	3.1
9	Average 8 Pits 10-10-7	100.0	70.9	40.9	19.4	4.2	3.3
10	Fine sand from 10-10-7			100.0	98.3	21.6	16.5
12	Pit 2, S.E. ¼ (fine) 10-10-7	100.0	94.5	87.8	78.5	65.7	18.6
22A	Government Pit Wye Fine Sand						100.0

Table 3.—Weights and Voids of Various Dry Artificial Mixtures from Materials of Gravel Pit No. 1.

Materials Weight of sand.	Weight of intermediate		Weight of coarse.	Total weight in lbs.	Volume Loose in cu. ins.	Rammed in cu. ins.	Weight per cu. ft. Loose.	Rammed.	Voids Loose.	Rammed.	Percentage of intermediate to total coarse and intermediate.
25	0	b	75	100	1,483	1,320	116.5	130.9	29.5	20.6	0.0
25	5	b	70	100	1,467	1,310	117.8	131.9	28.5	20.1	6.7
25	10	b	65	100	1,467	1,291	117.8	133.8	28.5	18.7	13.3
25	20	b	55	100	1,411	1,260	122.5	137.2	25.7	16.9	26.7
25	30	b	45	100	1,385	1,296	124.7	133.2	24.4	19.2	40.0
25	40	b	35	100	1,364	1,326	126.7	130.3	23.2	21.2	53.3
25	50	c	25	100	1,389	1,320	124.4	130.9	24.8	20.7	66.7
25	60	c	15	100	1,411	1,348	122.5	128.2	25.9	22.5	80.0
25	75	c	0	100	1,445	1,392	119.5	124.1	27.7	24.9	100.
25	—		—	25	400.6	351.9	108	122.8	34.6	25.5	0
	—		75	75	1,297	1,172	99.9	110.6	39.5	33.1	0
	5	b	70	75	1,285	1,162	100.9	111.4	38.7	32.6	6.7
	10	b	65	75	1,254	1,141	103.4	113.6	37.4	31.4	13.3
	20	b	55	75	1,197	1,093	108.3	118.5	34.5	28.3	26.7
	30	b	45	75	1,147	1,065	112.9	121.7	31.5	26.3	40.0
	40	b	35	75	1,137	1,081	113.9	119.9	31.0	27.3	53.3
	50	c	25	75	1,141	1,093	113.6	118.5	31.2	28.3	66.7
	60	c	15	75	1,153	1,115	112.4	116.2	32.0	29.7	80.0
	75	c	0	75	1,206	1,150	107.4	112.7	35.0	31.8	100
	20	b		20	351.9	314.2	98.2	110	40.6	33.4	100
	29.2	c	26.1	55.3	851.6	801.3	112.5	119.3	31.9	27.8	52.8

a. Sand, ⅛″ — 100%; No. 10 — 70.9%; No. 20 — 40.9%; No. 40 — 19.4%; No. 75 — 4.2%; No. 100 — 33%.
b. Intermediate, ½″ — 100%; ¼″ — 50%; ⅛″ — 0%.
c. Intermediate, ½″ — 100%; ¼″ — 40.8%; ⅛″ — 0%.
d. Coarse, 1½″ — 100%; 1¼″ — 83%; 1″ — 66.1%; ¾″ — 37.8%; ½″ — 0%.

Table 3 gives the weight per cubic foot and voids of various artificial mixtures (specific gravity of gravel and sand taken as 2.65).

Table 4 gives the weight per cubic foot of a number of miscellaneous materials tested in the laboratory.

Table 4.—Weights Per Cubic Foot of Miscellaneous Materials.

Material From District Pit No. 1	Weight Per Cu. Foot Loose and Dry	Weight Per Cu. Foot Shaken and Dry
Passing 1½ in. screen and held on 1 in. screen		102
" 1 in. " " ¾ in. "		106
" ¾ in. " " ½ in. "	95.8	105
" ½ in. " " ¼ in. "	96.6	106.7
" ¼ in. " " ⅛ in. "	96.6	108.5
" ⅛ in. " " No. 10 "	92.6	106.0
" No. 10 " " No. 20 "	92.6	104.5
" No. 20 " " No. 40 "	89.2	102.5
" No. 40 " " No. 75 "	91.3	102.0
" No. 1 " " ¼ in. (St. Line Grading)	103.0	

The effect of moisture on weight per cubic foot of a typical sand may be seen from Table 5.

Table 5.—Mechanical Analysis of Sand.

Sieve No.	Percentage passing, dry weight.
⅛"	100
No. 10	91
No. 20	66
No. 40	43
No. 75	15
No. 100	12

Weight per cubic foot, loose and moist.	Percentage of water by weight of dry sand.
100	0.
79	3.6
83	6.0
85.5	8.4
106.5	13.
118	16.

Miscellaneous Tests.—To check the value for specific gravity of 2.65 used in determination of voids in aggregate, Table 6 shows the value obtained from various materials taken from District Pit No. 1:—

Table 6.—Specific Gravity of Various Materials.

Material	Size	Specific Gravity	Average Specific Gravity (For Group)
Limestone (Gravel)	1 in.	2.60	
"	1 in.	2.63	
"	1 in.	2.68	2.64
Granite (Gravel)	1 in.	2.67	
"	1 in.	2.67	
"	1 in.	2.64	2.66
Gravel from Bins	¾ to ½ in.	2.64	
"	½ to ¼ in.	2.69	
"	¼ to ⅛ in.	2.65	
Sand from Bins	⅛ to No. 10	2.65	
"	No. 10 to No. 20	2.67	
"	No. 20 to No. 40	2.64	
"	No. 40 to No. 70	2.64	2.65

The amount of silt in the sand from McCorkell pit averaged by decanting test 1.1% of dry weight of sand sample.

Comparisons with the strength of Ottawa sand 1:3 mortar were made using various sands. The analysis shows the grading of an artificially graded sand representing the average of eight test pits from District Pit No. 1.

Mechanical Analysis.

Sieve No.	Percentage by Weight passing.
⅛"	100
No. 10	71
No. 20	41
No. 40	19
No. 75	4
No. 100	3

When made up in 1:3 mortars of the following percentages of strength to compare with standard Ottawa sand, it gave a strength of Ottawa sand—each average of four briquettes:—

7 Days.	28 Days.	90 Days.
126%	117%	134%

The effect of adding fine sand is shown in Table 7, which gives the mechanical analysis of the sands used for the 1:3 mortars. Table 8 gives the tensile strengths (results are average of four briquettes) at various ages.

Table 7.—Mechanical Analysis of Sand.

Sand No.	Percentage by Weight passing Sieve: ⅛ in.	No. 10	No. 20	No. 30	No. 40	No. 75	No. 100	Weights per cubic foot dry: Loose	Rammed
1			100	0					
2	100	71	41		19	4	3	106	116
3	100	71	42		21	6	5	107	119
4	100	72	43		23	9	8	108	119
5	100	74	47		27	13	12	110	119
6	100	75	50		32	19	18	110	121

Table 8.—Tensile Strength of 1:3 (by weight) Mortars.

Sand.	Tensile strength in lbs. per square inch. 7 Days.	28 Days.	90 Days.
(1) Standard Ottawa sand	196	305	338
(2) Average of 8 test pits	248	356	455
(3) Average of 8 test pits with fine to give 5% fine in total..	275	334	448
(4) Average of 8 test pits with fine to give 8% fine in total..	303	364	503
(5) Average of 8 test pits with fine to give 12% fine in total..	246	300	432
(6) Average of 8 test pits with fine to give 18% fine in total..	237	285	352

Proportioning and Mixing Materials.—All proportioning was carefully done by weight measurement. The aggregate for each specimen was made up by weighing out definite amounts of the various sizes required by the mechanical analysis for that particular mixture. The cement and water were also measured by weight. For the tensile strength briquettes a consistency similar to that used for the Ottawa sand was used. A medium wet or mushy consistency which allowed for the mixture to flow well into the forms was used for the permeability and compression test mixtures; 50 revolutions of a cube mixer gave thorough mixing to the different specimen batches.

Compressive Strength.—Standard 8-in. diameter by 16-in. long cylinders were used for the compression test specimens. All mixtures with the medium wet consistency used worked well in the forms except three mixtures which were deficient in mortar and so required considerable spading and working. When 24 hours old all surplus water was removed from the top of the cylinder and the surface was roughed to receive a 1 : 2 mortar cap. After capping, the specimens were covered with a damp cloth and at 48 hours age the moulds were stripped. The specimens were then placed in water tank. Those for 28-day test were kept in the tank until a few hours before testing, while those for 90-day test were placed in air after having been kept in water for a month.

The forty-seven crushing test specimens were broken in the University of Manitoba Testing Laboratory; a 200,000 lb. Riehle testing machine equipped with spherical bearing head was used.

Permeability Tests.—Twenty-nine permeability specimens were made up from a corresponding number of mixtures. These specimens consisted of cylinders 13 ins. in diameter and 14½ ins. long. A 2-in. pipe with stop-water and lock-nut was cast 7 ins. into the specimen and led to a pressure chamber 2 ins. deep by 2 ins. in diameter. Galvanized iron cans were used for outside forms and a brass plug was used as a form for the pressure chamber. The mixture, which was of medium consistency after mixing in a cube mixer, was placed in the form with sufficient working to ensure a uniform distribution of material throughout the mass. As soon as the concrete had set, the brass plug used for forming the pressure chamber was withdrawn and the surface of the pressure chamber was scraped with a chisel and a wire brush. Water was then placed in the pipe in the specimen and over the top of the specimen in the can. When ready for testing, the galvanized outer form was removed and the pressure chamber was washed out, after which Ottawa sand was placed in the pressure chamber.

The quantity of cement per cubic yard of field concrete has been more than that used in a number of laboratory specimens which showed that impermeable concrete could be obtained with certain aggregates, using one barrel of cement per yard of set concrete. Under field conditions there are variations in the grading of the sand and of the gravel in the aggregate and variations in field proportioning due to slight segregation on platforms and due to irregularities in measurement, that require an additional quantity of cement to insure impermeable concrete. The field mixture adopted of 3 bags (87½ lbs. each) of cement to 16 cubic feet of loose aggregate was chosen to give a concrete having a mortar with 1 part of cement by weight to 3 parts of dry sand, when the aggregate contained moisture and when the sand in the aggregate was as high as 40 per cent. by weight of the aggregate. Due to the field variations set out above, the actual quantity of cement per cubic yard of set concrete of the standard mixture varied from 1.25 to 1.38 barrels.

Conclusions.—From observation of these tests it was concluded that with lean mixtures and with the gravel materials available, the addition of fine sand would give for the work contemplated impermeable concrete of desired strength.

The McCorkell Gravel Deposit, District Pit No. 1.—Among the gravel deposits investigated during the summer and fall of 1914, the McCorkell pit, situated close to the District railway at Mile 31, appeared from examination of some 38 test pits thereon to be a desirable source of supply for concrete aggregate. It appeared to contain large quantities of gravel with a well-graded sand. The southeast corner of the deposit contains fine sand. The oversize present is available to give on crushing, stone to satisfy much of the surplus sand in the deposit. This pit was secured by the District and opened up in the spring of 1915. As the pit was opened up it became evident that the deposit was more irregular than had been shown by the test pits. It also contained more surplus sand than had been anticipated.

The cement which was required to be tested by standard methods of the Canadian Society of Civil Engineers, and to conform to District Specifications (which are similar to those of the American Society for Testing Materials), for acceptance was given the following tests in the District Laboratory in the Boyd Building:—

(1) Every sample was tested for soundness.

(2) Every third sample from the belt was tested for fineness, time of set, tensile strength neat, and with three parts by weight of standard Ottawa sand.

(3) One test per bin was made for specific gravity; some long-time tests were also made.

The cement supplied was of first-class quality, and not a single car had to be turned down for failure to pass tests.

The cement was shipped from the cement plant daily as required to G.W.W.D. siding at Paddington Transfer. Every Monday, Wednesday and Friday the car load lots as required were hauled out by District train and spotted at the contractor's field store houses. Here they were unloaded by the contractors, and the empty cars were collected the following day on the return trip of the train. A cement storehouse of 6,000 barrels capacity was located at Deacon to ensure against interruption in supply to the contractors.

Aqueduct Concrete.—The concrete was mixed to a wet consistency for the arch, and to a mushy consistency for the invert. On water-bearing foundation the invert concrete was poured drier and was tamped into place. The invert was shaped to the profile form by means of screeds formed from 3½-in. x 3-in. x ¼-in. angles 16 ft. 0 in. long, provided with handles at each end so that each could be handled by two men. A smooth finish was given to the surface by floating and trowelling.

Different methods were tried by the contractors to obtain the required smooth finish on the inside of the arch, free from pittings due to air bubbles or drops of water. The best results appeared to be obtained from the use of a wet mixture with careful spading. Too much or too energetic spading resulted in the inclusion rather than the expulsion of air.

The time of stripping forms depended on the temperature of the air, on the wetness of the concrete as poured, and varied also with the season. By artificially heating the interior of the arches the forms could be stripped at early periods. In good weather in the summer months the outside arch forms were stripped in twelve hours and the interior forms in 24 to 48 hours after pouring.

The 3 : 16 mixture gave better results than the sandier mixtures, which were more difficult to work due to the larger quantities of water required for proper consistency.

Field tests for permeability on various sections of completed aqueduct were made under natural working heads. No signs of leakage were found except slight seeping at the arch joints and through the grout in occasional form-spacing bolt-holes which showed slight signs of dampness.

Permeability tests were made on two pieces of concrete taken from an arch removed on account of structural defects. The mixture used for this arch was the adopted field mixture of three bags of cement to 16 cubic feet of aggregate. The arch had been poured on October 13th and was removed on October 22nd and 23rd. One of the blocks was taken from the concrete underneath the chute

(Continued on page 344.)

THE TREATMENT OF WOOD PAVING BLOCKS.*

By Clyde H. Teesdale,
Engineer in Forest Products, Forest Products Laboratory, Madison, Wisconsin.

IN discussions of wood block paving specifications the principal consideration has in the past been given to the properties of the oil. So much attention has been paid to this factor that it seems possible the importance of the method of treatment has been underestimated. Engineers are now, however, coming to realize that the treatment of the blocks is possibly the most vital consideration in the successful construction of wood block pavements. Upon the care used and the method adopted for handling the blocks through the treating cylinder will depend to a large extent the ultimate durability of the pavement and its freedom from the troubles of bleeding and expansion. From the standpoint of durability, the process of treatment is possibly of greater importance than the quality of the oil, as even the highest obtainable grade of coal-tar creosote will not prevent decay if it is poorly distributed through the wood.

The essential features in the proper treatment of the blocks consist, first, in obtaining so far as possible an even and thorough diffusion of the oil through each block; and second, in so controlling the operations of treatment that subsequent bleeding and swelling of the pavement will be reduced to a minimum. For these reasons it is felt that much more consideration should be given to specifications for treatment than has been done in the past, and possibly less speculation as to the exact quality of oil which ought to be used.

In selecting a preservative its penetrating qualities must, of course, be considered. The results of some experiments made at the Forest Products Laboratory on the penetrability of mixtures of creosote and coal tar were published in 1913.† Briefly, it was shown that the penetration of creosote into longleaf pine was retarded when coal tar was mixed with it, and that this retardation became greater as the percent. of tar was increased. Penetration was also retarded by free carbon. There was a great difference in the penetrating properties of tars from different sources, and those tars which normally contained the lowest contents of free carbon penetrated the best, even after the free carbon was removed.

Since publishing the above results, the work on penetrations and absorptions was continued. The later data have not yet been published, and this opportunity is taken to make some of the results available, although they should be used in conjunction with the previously published tests. In this work, penetrance tests, made on 2-in. x 4-in. x 2-ft. specimens, and impregnation tests on paving block specimens were made. Some of the results obtained in these tests are given in Figs. 1 to 7. In general, the additional work confirmed the results obtained in the previously published tests. Thus, Fig. 1 shows how, in penetrance tests, the penetration and absorption in longleaf pine were decreased as the percent. of tar increased. The additional work was principally, however, a study of the effect of changes in treatment on penetrations and absorptions.

For example, the results of some impregnation tests are given in Fig. 2 on three mixtures of creosote and tar from which the free carbon has been removed.* In each case, the absorptions were approximately the same, the time of treatment and pressure being increased as the percentage of tar was raised. The absorptions obtained are shown at the top of the chart. Fig. 3 shows in a similar manner the effect of increasing the free carbon in a given mixture. In both of these cases the resistance to treatment is indicated by using the product of pressure in pounds and time in minutes. The influence of the time and pressure variables taken separately is shown in Fig. 4 for impregnation tests on paving blocks, and in Fig. 5 for penetrance tests. The paving blocks in each case were given an absorption of 16 pounds per cubic foot. The penetrance tests (Fig. 5) were then made, using the same pressures, times and temperatures as in the impregnation tests of Fig. 4. Another test in the penetrance apparatus is given in Fig. 6, in which, so far as possible, each piece was given the same absorption. In Fig. 7 is shown the effect of increasing the temperature of the preservative. Thus, an increase in temperature from 160 to 220 resulted in an increase of 2 1/7 times in the absorption and 1.8 times in penetration, in penetrance tests. These relations are not comparable to commercial practice, however, but simply indicate greater penetrability with rise in temperature.

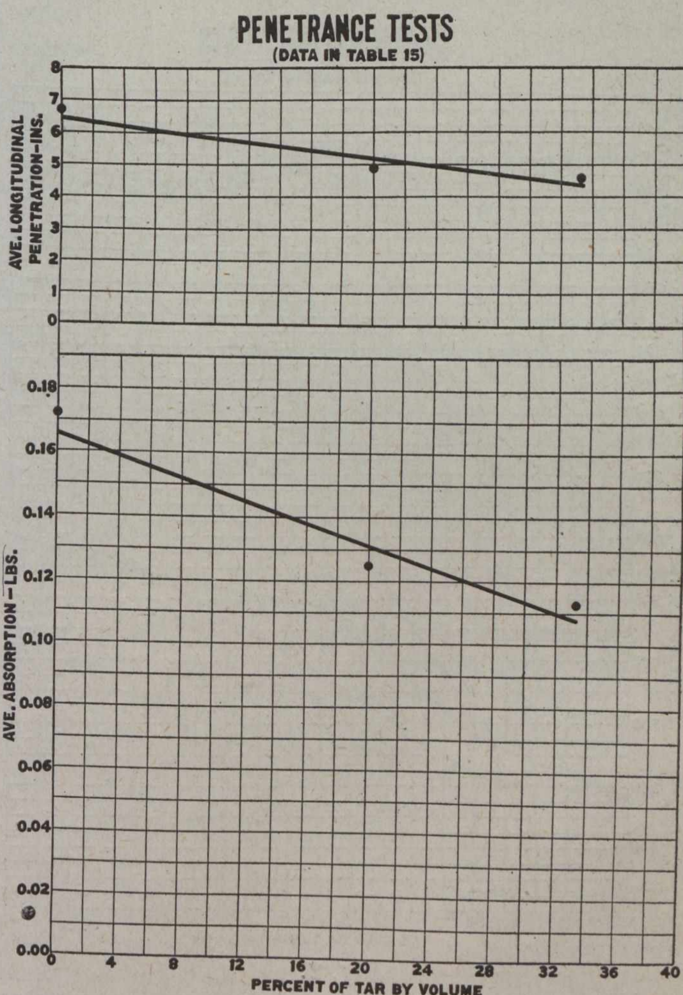


Fig. 1.

Absorptions and penetrations in heart longleaf pine using mixtures of tar No. 4 and creosote No. 6. Time of treatment, 2 hours; pressure, 80 lbs. per sq. inch; temperature of preservative, 180° F.

*Prepared for Convention of American Society of Municipal Improvements, October 9, 1916, Newark, New Jersey.

†"Some Tests to Determine the Effect on Absorption and Penetration of Mixing Tar with Creosote," by F. M. Bond, p. 216, Proc. American Wood Preservers' Association, 1913.

*The method of removing free carbon was the same as that followed in the tests publishel.

The essential feature to be noted in these experiments is that it was possible in the impregnation tests on paving blocks to obtain the required absorption of 16 pounds per cubic foot, even when the percent. of tar was greatly increased. In most cases this could be done by either increasing the time of treatment or the intensity of pressure. It was found in general that for a given absorption of oil better penetrations were obtained with lower pressures and longer treatments than with higher pressures and shorter treatments. Increasing the oil temperature was very effective for improving both penetrations and absorptions.

Summarizing the results, it can be stated that those tars produced at a low temperature and containing normally low amounts of free carbon retarded penetration the least. Removing the free carbon increased the penetrability of the oil. Good penetrations were obtained when tar was added to creosote by increasing the time and intensity of pressure. In such cases a given absorption could be quickly obtained by raising the pressure, but the best penetrations were secured by increasing the time of treatment. Raising the temperature of the oil assisted both penetration and absorption. In applying these results to treating plant practice, it may be said that the best penetrations are obtained with high oil temperatures and by using a long pressure period at low pressures rather than a short pressure period and high oil pressures.

The methods which are followed in handling paving blocks in the treating plant have a very important bearing on the subsequent development of bleeding and swelling troubles. Previous work on this subject was published in the 1914 proceedings of this association and with additional results was published in the 1916 proceedings of the American Wood Preservers' Association. It was found in this investigation that bleeding could be greatly reduced by using a vacuum before the oil pressure treatment and also after treatment, known technically as the preliminary and final vacuums. A reduction in bleeding could also be obtained by steaming the timber before treatment. This was more effective on tar and creosote mixtures than on creosote. Absorptions of oil of over 16 pounds per cubic foot tended to increase bleeding. It was also found that rapid growth loblolly pine blocks bled excessively. There was not a great difference in the bleeding obtained with creosote or with the tar and creosote mixtures. When the blocks were steamed and given a preliminary and final vacuum treatment the tar and creosote blocks had a tendency to bleed less than those treated with creosote. It was found that a final steam and vacuum treatment after the oil pressure period would clean tarry and carbonaceous matter from the blocks.

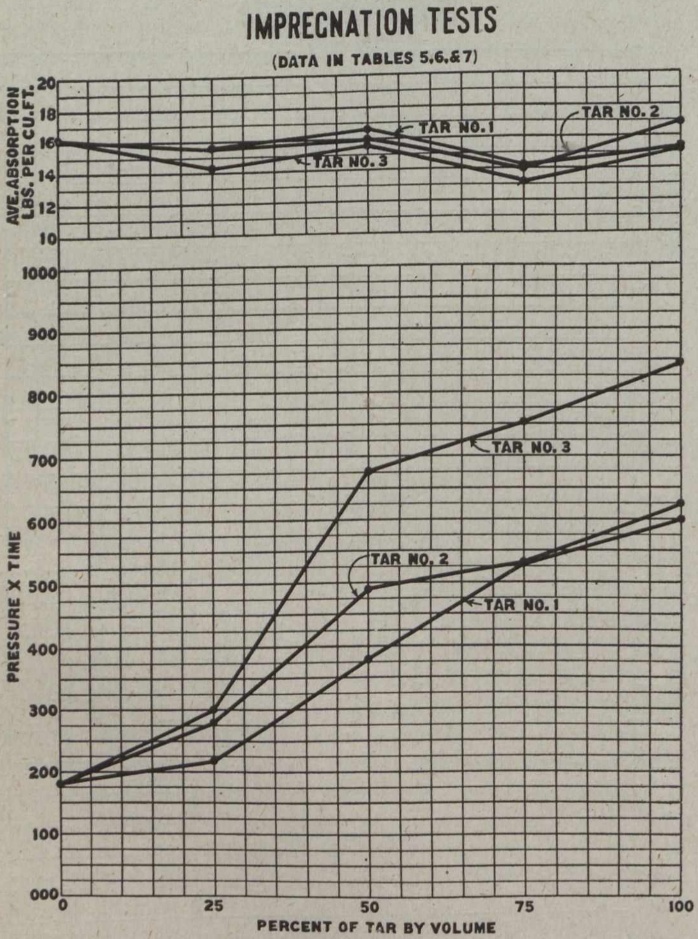


Fig. 2.

Variation in time of treatment and pressure necessary to secure a given absorption in paving blocks using mixtures of creosote No. 4 and tars Nos. 1, 2 and 3. In all runs blocks were treated at 80 lbs. pressure. If over 4 hours required, pressure was gradually raised to 150 lbs.

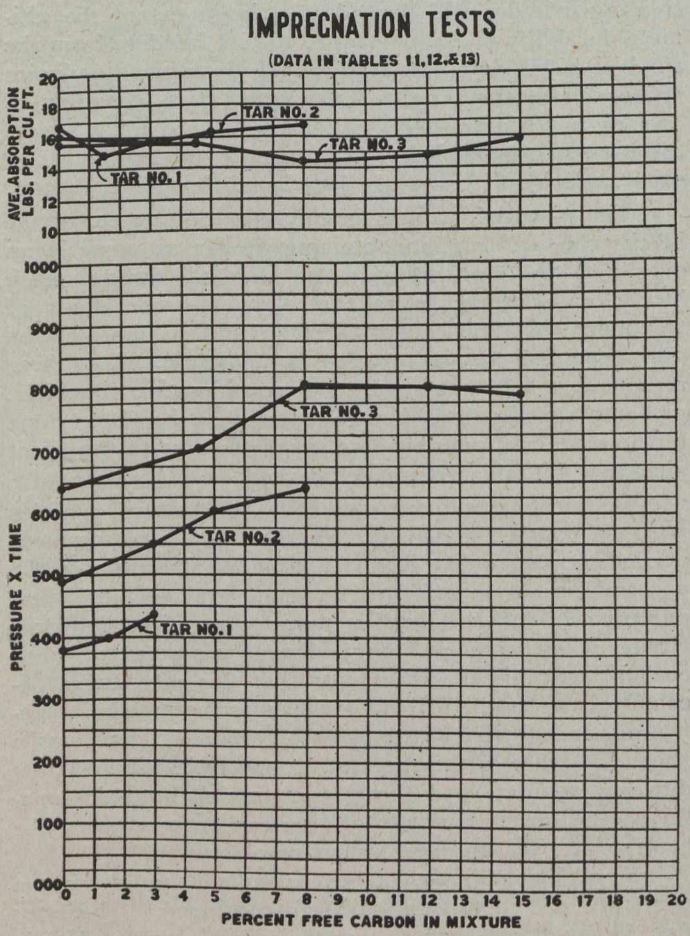


Fig. 3.

Variation in time of treatment and pressure necessary to secure a given absorption in paving blocks using mixtures of creosote No. 4 and tars Nos. 1, 2 and 3. In all runs blocks were treated at 80 lbs. pressure. If over 4 hours required, pressure was gradually raised to 150 lbs.

Subsequent to this work a further series of tests* was made in which the amount of bleeding obtained from a variety of oils was studied. These oils were injected into seasoned blocks by the steaming and vacuum method. The method of conducting the tests in this case was the same as that in the previous work.

*These experiments were conducted by Eugene ReQua in co-operation with the University of Wisconsin.

The data on absorption and bleeding are given in the following table. It will be noted that in no case was the bleeding over 5 per cent. of the absorption. In the previous work where no preliminary or final vacuum or steaming treatments were given, the total bleeding ranged from 9 to 23 per cent. It is also to be noted that coal-tar creosote and carbolineum bled more than those oils containing tars (3.8 per cent. and 4.3 per cent. respectively). The creosote and crude oil mixture bled 2.53 per cent., while all of the other mixtures showed less than 1½ per cent.

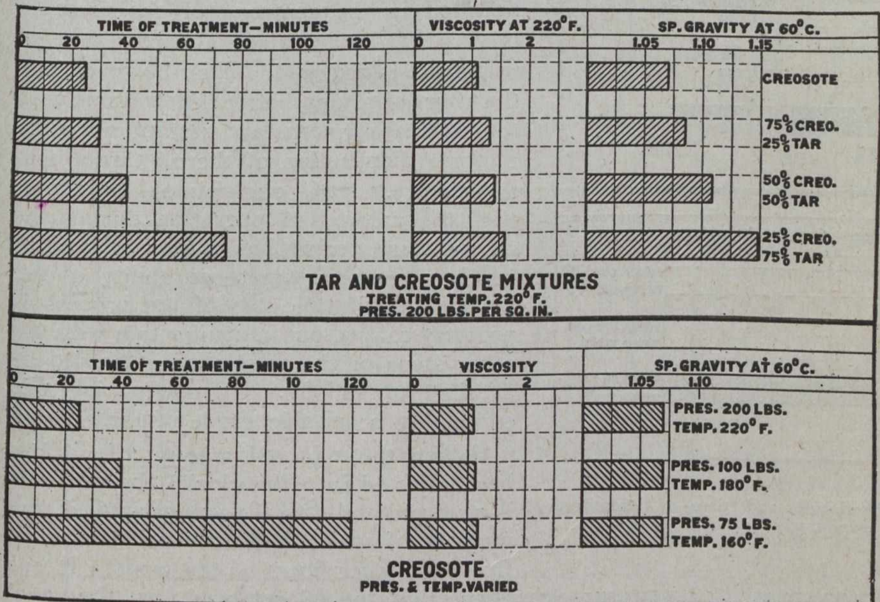


Fig. 4.

Diagram showing the time of treatment required to secure a given absorption (16 lbs. per cubic foot) in paving blocks using mixtures of creosote No. 4 and tar No. 5. Also the increase in time of treatment required to secure a given absorption of creosote when the pressure and temperature of preservative are lowered.

Results Obtained on Bleeding and Swelling Tests Using Various Grades of Oil.

Description.	Average absorption of oil by blocks, lbs. per cu. ft.	Total bleeding —per cent. of absorption.	Total selling—per cent. increase in area.
Coal-tar creosote	14.8	3.77	2.96
Coal-tar	14.2	1.43	2.85
Water-gas tar	17.5	1.15	2.14
Carbolineum	14.1	4.92	2.34
25% coal-tar .... 75% creosote	17.9	0.91	3.18
50% coal-tar .... 50% creosote	15.9	1.27	2.90
25% water-gas tar ... 75% creosote	17.0	1.31	2.48
50% water-gas tar ... 50% creosote	18.7	1.30	2.80
50% asphaltic crude oil 50% creosote	14.7	2.53	2.52

In the previously published work on the swelling of paving blocks the main features noted were that the rate of swelling was slower in treated blocks than in untreated ones, although in all cases treated blocks showed considerable swelling. Mixing tar with the oil retarded the rate of swelling. From 50 to 75 per cent. of tar was necessary, however, to appreciably retard or reduce the total amount. Free carbon apparently had no effect. Very heavy tars retarded swelling more than lighter ones. Increasing the absorption above 10 pounds had little influence.

At the time the additional work on bleeding was done, further tests on swelling with the same oils were carried on. These tests were made exactly as described in the previous work, which, in brief, consisted in placing the blocks in a tank of water and allowing them to soak until they ceased to increase in size. Measurements were made at suitable intervals of the length and breadth of the blocks. The results were given in the percent. increase in area of the transverse section of each set of blocks.

These blocks were treated with the same oils and at the same time as the ones described above for bleeding tests. Four seasoned blocks were used with each oil and those treated with different preservatives were so cut from the original stock that they were matched with each other as to moisture content and growth conditions. It will be noted that the results (see table) are all within 1 per cent. of each other, which indicates that the character of the oils used did not have a very great influence on the subsequent swelling.

The results of the experiments made at the Forest Products Laboratory have led to the following conclusions concerning the selection of timber, oil, treatment and laying of wood block paving. These conclusions must be considered tentative, at least for the present, until greater experience with these methods has been obtained.

1. Wood.—It is preferable to use green timber, although seasoned stock may be used by proper handling. The advantage of using green stock is the greater certainty of having the blocks expanded to their maximum size when they are laid in the street. Green timber also requires a thorough steaming before it is in a suitable condition for receiving the oil, and hence there is less incentive for omitting this portion of the treatment. Rapid growth blocks are undesirable, not only from the point of view of subsequent durability of the pavement but also because they take an inferior treatment and appear to bleed more than those which are of slow growth. Rapid growth heart pine takes good treatment in the summerwood bands, but the springwood bands are liable to have very poor penetrations. If the blocks are of very rapid growth this results in considerable areas which are untreated. This is not only undesirable because their durability is questioned but also because such blocks are more liable to take up water and expand.

2. Preservative.—Dry blocks treated with either creosote or with tar and creosote mixtures will take up water and expand. The main function of the oil, therefore, is not to waterproof the blocks but to preserve them from decay. Any fairly good grade of oil which will permanently accomplish this purpose and which can be thoroughly diffused through the wood should prove satisfactory. When tar mixtures are used the tars selected from those produced at low temperatures and containing small amounts of free carbon have given the best penetrations. Preferably the free carbon should be removed. Too much tar in the mixture is not desirable if the best penetrations are to be expected. It has been found that bleeding may occur with oils having widely differing properties of oil, and that by proper methods of treatment the bleeding may be greatly reduced. The method of treatment is, therefore, of greater importance than the oil when considering the bleeding problem, as this may

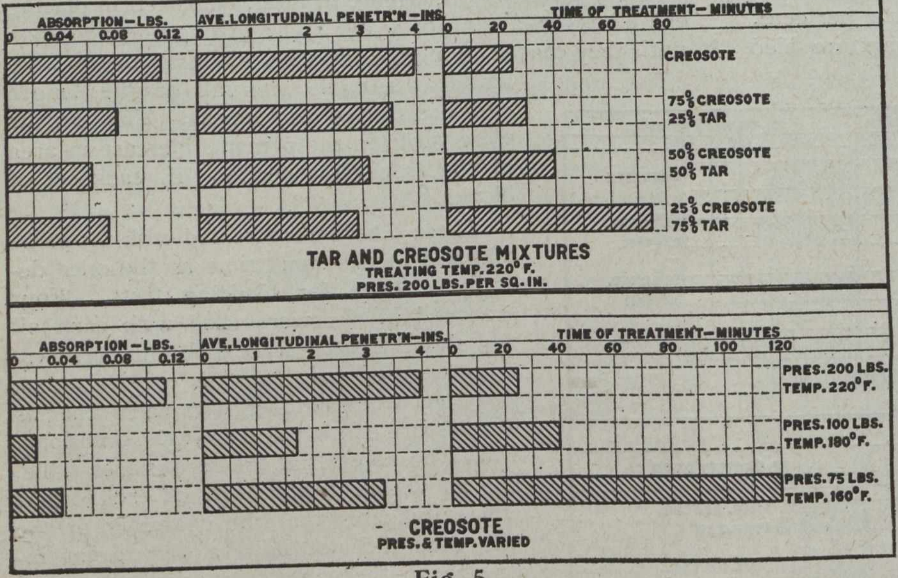


Fig. 5.

Diagram showing the relation between absorption, penetration and time of treatment using mixtures of creosote No. 4 and tar No. 5. Also the comparative effect of varying the pressure and time of treatment.

be handled in the treatment specification. However, it should be borne in mind that if any bleeding occurs, the presence of a tar paving oil on the pavement is more objectionable than an equal amount of creosote, because of its sticky and adhesive character.

3. Treatment.—A most important consideration in a paving block specification is the care which should be taken in treatment. The first step of treatment is to thoroughly steam the timber. This should be followed by a strong vacuum. If green timber is used the steaming and vacuum remove the excess moisture from the wood and prepare it for the oil. These steps also remove excess air from the cells, which is one of the principal causes of bleeding. When dry timber is used it is frequently easy to obtain the required amount of oil in the blocks without resorting to a preliminary vacuum. This is the simplest method of treating the blocks. If a vacuum is applied to thoroughly air-seasoned blocks it would sometimes be difficult to prevent the absorption of too much oil when the pressure is applied. Hence, the preliminary vacuum is not usually used in such cases. It is, therefore, desirable to steam the seasoned timber in order to permit the use of a preliminary vacuum. Steaming dry timber is also desirable because it adds moisture to wood and brings the blocks into the expanded condition, thus decreasing the possibility of swelling troubles. If the timber is not evenly seasoned the steaming will also tend to bring it to a more uniform moisture condition. Steaming and vacuum on dry timber, just as in the case of green stock, removes much of the air from the cells.

The oil should be admitted to the cylinder without breaking the vacuum, and the pressure gradually applied. It is important that the pressure should not be raised too rapidly. If high pressures and short pressure periods are used the tendency for blocks to receive much more than their share of oil, while others receive less, seems to be greatly increased. Furthermore, this has a tendency to give poorer penetrations, which results in much oil being near the outside of the blocks and little oil in the centres. If the pressure is very gradually raised a longer time of treatment is required. This, however, has the effect of giving better penetrations with the same absorptions and results in a more uniform distribution of the oil throughout the charge. It is our opinion, therefore, that the method of operation during the oil pressure period has a very important bearing on the ultimate durability of the blocks, and if this step of the process is properly carried out in conjunction with the other steps of the treatment, it should be possible to satisfactorily use paving oils containing a suitable grade of tar.

When the required amount of oil has been injected into the blocks the pressure is removed and a final vacuum applied, the purpose of which is to remove excess oil from the outer fibers of the wood. It has been our experience that the oil removed by the final vacuum would come out of the blocks in time even if this were not applied. Sufficient oil must be injected during pressure to allow for the loss during the final vacuum. More oil is, therefore, ultimately left in the blocks and

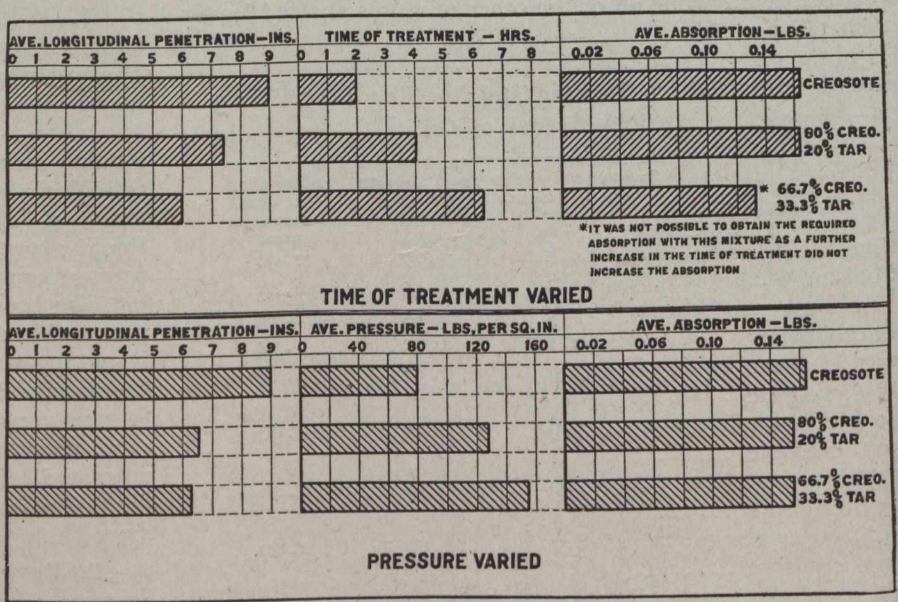


Fig. 6.

Diagram showing relative effect of varying 1—time of treatment and 2—pressure, in order to secure approximately the same absorption in longleaf pine using mixtures of creosote No. 6 and tar No. 4. With time varied the treating temperature was 160° F. and the pressure 80 lbs. per sq. in. With pressure varied the time of treatment was 2 hours and the temperature 160° F.

better penetrations (because of the greater amount injected) are secured than would be the case if the charge were removed without applying this vacuum.

If a preservative containing tar has been used it is often desirable to permit a final steaming and vacuum operation. This step removes dirt and tarry matter from the surface of the wood and makes the blocks bright and clean, even when oils containing much tar and carbon have been used. It also probably has considerable influence in retarding subsequent bleeding of tar mixtures.

Laying.—The moisture content of the treated blocks at the time they are laid is of great importance. Treated wood will lose or take up moisture quite readily, even though heavy paving oils have been used. If dry blocks are laid in the street, they may swell sufficiently to cause bulging or displacement of the curb. They may also squeeze the bituminous filler onto the surface and create

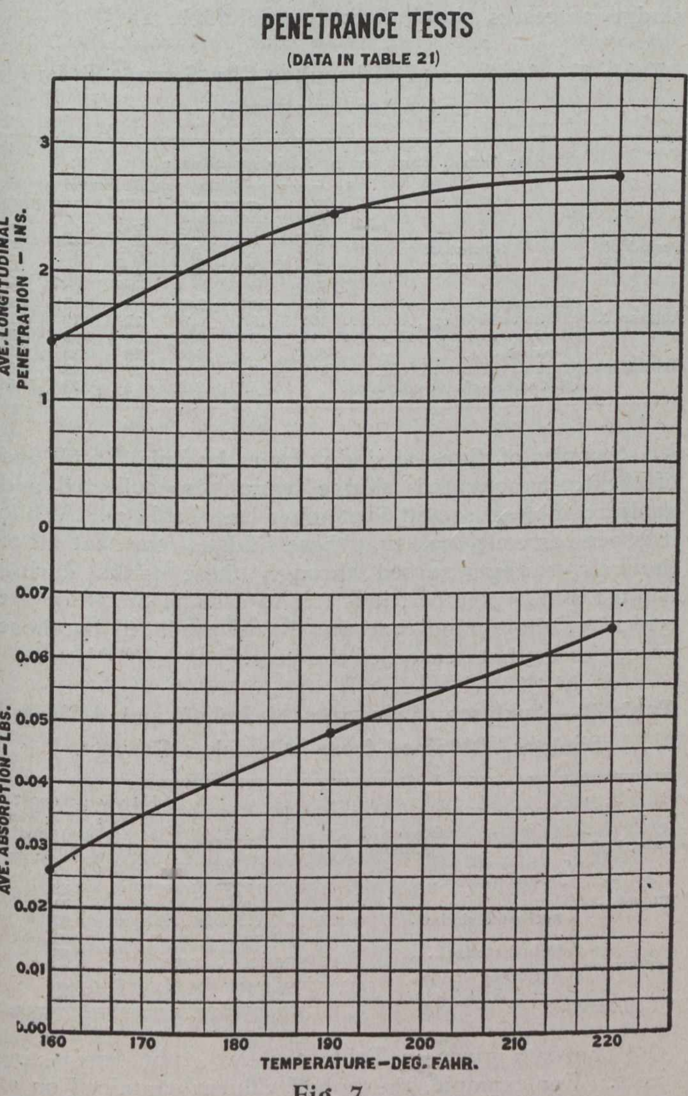


Fig. 7.

Relation between absorptions and penetrations in longleaf pine using a mixture of 25 per cent. creosote No. 4 and 75 per cent. tar No. 5 at different treating temperatures. Pressure, 200 lbs. per sq. in. Time of treatment, 1 hour.

a condition which is essentially as objectionable as bleeding.

It is important, therefore, to have the blocks expanded to their maximum size when laid. If green timber is used in treatment, this point can readily be taken care of. If well seasoned stock is used, the steaming treatment is depended upon to add water to the wood and expand it nearly to its maximum size. Care must be taken to have the blocks laid as soon as possible after treatment, or to so protect them during the meantime that they cannot dry out.

After laying, the blocks should be filled with suitable bituminous filler. This is depended upon to prevent water reaching the base of the blocks, which could cause expansion trouble, hence careful consideration should be given to the method adopted. Care should be taken to see that the blocks are not jammed too tightly together as it would then be difficult to thoroughly fill all of the spaces between them.

Poor results have been obtained so frequently where sand was used that this practice seems very inadvisable. Sand filler permits water to penetrate to the base of the blocks and consequent swelling.

CANADIAN SOCIETY OF CIVIL ENGINEERS.

At the meeting of the Canadian Society of Civil Engineers, Montreal, to be held November 2, Mr. L. M. Jones, city engineer of Port Arthur, Ont., will read a paper entitled "Water Supply of the City of Port Arthur." This paper had been scheduled for the meeting of October 19, but at the last moment it was found necessary to defer its presentation until the later date.

CANADIAN SOCIETY OF CIVIL ENGINEERS, MANITOBA BRANCH.

At the regular meeting of the above branch on October 5, 1916, Dr. R. C. Wallace, professor of geology, University of Manitoba, delivered an interesting address in which he dealt with the present stage of mining development in the province. Interest in metalliferous deposits was confined to three districts: (1) the Rice Lake area; (2) the district north of The Pas; (3) the Star Lake area.

The Rice Lake area now consists of four separate fields—the original Rice Lake area, the Gold Lake area, the Long Lake area, and the area north of the Hole River. The only development work is in the original Rice Lake area, where several shafts have been sunk to the 100-foot level, and some drifts have been run; and in the Gold Lake district where on the Gold Pan and Moose properties depths of 125 feet have been reached.

North of The Pas a belt extends over 120 miles from west to east, the centre of the belt being over 60 miles distant from The Pas. The deposits in this belt are of two kinds: (1) Sulphide bodies; (2) quartz veins with gold. The sulphide bodies have attracted widespread interest. They have been formed by impregnation in zones of weakness, and are consequently irregular in shape, and discontinuous.

In the Star Lake district a fahlband of conglomerate and quartzite has been extensively impregnated with pyrrhotite and arsenopyrite. Irregular veins and stringlets of quartz which traverse the fahlband, carry high values in gold; and into the whole fahlband gold has been introduced, but in low values. On one property there is a very complete set of buildings, but new mill machinery must be installed. The underground development is by no means extensive. Elsewhere development work has been confined to stripping and the sinking of shallow pits.

The lecturer emphasized the fact that mining operations were frequently retarded because the conditions of sale which prospectors demanded and those which mining companies were willing to offer were dissimilar in nature. He suggested that if development companies were organized to take over prospects and develop them to the stage where values could be approximately estimated, prospects of real value would have a much better chance of becoming producing mines.

NITROGEN FROM SEWER SLUDGE, PLAIN AND ACTIVATED.*

By William R. Copeland,
Chemist in Charge, Sewage Testing Station, Milwaukee, Wis.

THE answer to the question as to whether it is or is not practicable to recover the nitrogen in sewage and sewage sludge will depend upon three factors: (1) The amount of nitrogen contained; (2) the cost of recovering and disposing of the nitrogen; (3) the market value of the nitrogen.

Recovery of nitrogen, from the standpoint of this paper, had to do principally with the nitrogen in suspension, because that is the portion which appears in the greatest quantity in the sludge. The total obtained will vary both with the treatment process used and with the volume contained by the raw sewage (see Table 1).

Table 1.—Composition of Dry and 10% Moisture Sewage Sludge.

Source of Sample	Sludge Obtained from	% of Nitrogen
*On the Basis of Dry Sludge**		
Frankfurt-am-Main	Plain sedimentation	2.85
Columbus, Ohio	Septic tank	1.40
Essen	Imhoff tank	1.22
Philadelphia	Imhoff tank	1.20
Worcester, Mass	Chemical precipitation	2.77
Sludge Computed on Basis of 10% Moisture		
Brooklyn (Williamsburg)	Dickson (yeast) process	1.4
Columbus testing station	Grit-chamber sludge	1.2
	Plain sedimentation tank	1.6
Philadelphia testing station	Plain sedimentation tank	1.2
Cleveland testing station	Plain sedimentation	1.4
	Septic tank	1.3
	Imhoff tank	1.2
Gloversville testing station	Plain sedimentation	2.3
	Septic tank	2.2
Worcester, M. & E., Vol. III	Plain sedimentation	2.7
	Septic tank	2.7
Atlanta	Imhoff tank	1.5

*From Vol. 2, Metcalf & Eddy's "American Sewerage Practice."

The gist of the data given in these tables is that the sludge which has been obtained heretofore by the best known processes of sewage treatment contained from 1.2 to 3% of nitrogen. These figures are low and show that the sludge did not possess as much nitrogen as the amount contained by the raw sewage would lead us to expect. This condition may be explained by the fact that a large share of the colloidal matter carried by the sewage ran out in the tank effluent and took nitrogen with it; or, in the case of chemical precipitation works, the lime added drove nitrogen off in the form of ammonia and diluted the portion remaining by increasing the amount of inert mineral matter. Moreover, various authors state that from 10 to 60% of the volume of the solids deposited by sewage in the sludge-digestion chambers of Imhoff tanks and other forms of septic tanks is converted into soluble or gaseous form.

Much of the albuminoid ammonia is thus changed into free ammonia and free nitrogen, which escape in the liquor or bubble out at the gas vents.

Within the last two years, however, a new method of sewage purification by the so-called "activated sludge" process has been tried out in various cities of America and England. One of the distinctive features of this process is that the colloidal and suspended matters of the sewage are collected in the sludge. If this is not reaërated or overaërated, the solids are not liquefied to such a large degree as they are in septic tanks, and therefore the nitrogen does not escape.

*Slightly condensed from a paper entitled "Is the Recovery of the Nitrogen in Sewage Sludge Practicable?" read before the Division of Water, Sewage and Sanitation of the American Chemical Society.

For example, the digested sludge accumulates in Imhoff tanks at a rate of from 4 to 10 cu. yd. per million gallons of sewage treated, whereas by the activated-sludge process 20 to 80 yd. or more may be deposited in the settling tanks, varying widely, of course, with the strength of the sewage and the water content of the sludge.

The Milwaukee sewage-testing station carried on a series of experiments during the summer of 1915 where the city sewage was treated by Imhoff and activated-sludge processes simultaneously (see Table 2).

Table 2.—Analyses of Milwaukee City Sewage Before and After Treatment.

By Imhoff Tank and by Activated Sludge.

Period of Test, 1915	Source of Sample	Parts per Million					
			Nitrogen as				
			Ammonia				
		Suspended Matter	Free	Albuminoid	Organic Nitrogen	Nitrite	Nitrate
August	Sewage	253	14.6	7.88	29	0 15	0.13
	Imhoff effluent	105	16.2	6.10	27	0.19	0.13
	Activated-sludge effluent	14	3.8	3.19	6	0.29	6.00
September	Sewage	300	13.5	8.81	29	0.25	0.14
	Imhoff effluent	116	15.4	7.10	27	0.12	0.09
	Activated-sludge effluent	8	5.7	2.22	9	0.24	5.01

Samples of digested sludge from the Imhoff tank and of the fresh activated sludge were also collected and analyzed in August and September (see Table 3). While it is not correct to say that these sludges represent all of the raw sewage passed through these tanks during August and September, it is fair to assume that they are typical of the sludge that was being produced by those processes at that season of the year.

Table 3.—Analyses of Samples of Imhoff and Activated Sludges, Obtained from Milwaukee Sewage.

Date, 1915	Source of Sample	Nitrogen Reported as NH_3 on a Basis of Sludge Dried to 10% of Moisture
August	Imhoff sludge	2.87
		3.82
	Activated sludge	5.71
		4.97
		7.04
September	Imhoff sludge	3.88
	Activated sludge	8.69
		9.00

The data given in Table 2 show some interesting facts. For example, the Imhoff effluent contained on an average more than 100 parts per million of suspended matter, whereas the effluent from the activated-sludge process contained only about 10 parts per million; the Imhoff effluent contained more free ammonia than the raw sewage, whereas the activated-sludge effluent contained only one-third as much. The Imhoff effluent contained almost as much albuminoid ammonia as the raw sewage, whereas the activated-sludge effluent contained only about one-third as much. The Imhoff effluent contained almost as much organic nitrogen as the raw sewage, whereas the activated sludge contained only one-third as much.

What became of the nitrogen carried by the sewage? Evidently most of the nitrogen in the sewage treated by the Imhoff tank passed out in the suspended and colloidal matters carried by the effluent. The activated-sludge process, on the other hand, converted the free ammonia into nitrate and stored up the undissolved albuminoid ammonia and organic nitrogen, as indicated by the large amount of nitrate in the effluent and high nitrogen content of the activated sludge.

In short, analyses of this material when dry show that activated sludge contains from 4 to 4½% of nitrogen, and sludge from certain industrial plants, such as packing houses, may carry even more.

When it comes to recovering this nitrogen, however, we meet with a serious difficulty, because as the sludge gathers in the settling tanks it contains from 98 to 99% of moisture and the bulk of this water must be removed before the dry material can be sold for fertilizer.

The best information now available points to a combination of settling and decantation as a preliminary dewatering process. By this means the water will be cut down from about 99 to 96%. On passing the concentrated residue through a pressure filter the moisture can be cut down to 75%. The press cake can be dewatered in a drier to 10% of moisture or less. More than 30 samples of activated sludge have been dewatered by sedimentation, decantation and pressing at Milwaukee.

It is an interesting and notable fact that two different types of press can handle the settled sludge without requiring the addition of lime. The sludge is not as gummy as was expected, and it presses fairly easily down to 75% of moisture.

In order to try out the feasibility of further dewatering the sludge four samples of the press cake were sent to fertilizer plants and dried there on a commercial scale. Three of these tests were made in a steam-jacketed (indirect-heat) drier and one in a semi-direct-heat drier. In each case the tests proved to be successful from three standpoints: (1) The sludge dried readily to a satisfactory mechanical condition; (2) the processes did not require much power; (3) little nitrogen, if any, was driven off or lost by drying. From the mechanical standpoint, therefore, the recovery of nitrogen in sewage sludge is practicable.

With regard to the question of cost, however, the situation at the time of writing is not so clear. The pieces of apparatus used for settling the raw sludge and drying the press cake were not designed to handle activated sludge in the most economical manner, but were requisitioned as being the best commercial apparatus available at the time.

By comparing the behavior of activated sludge with such matters as packing-house tankage I estimate that this sludge can be dewatered so that the recovery of the nitrogen in it will probably cost, upon present evidence, about $8 to $12 per ton of material containing 10% of moisture, depending upon a variety of local factors. These figures are intended to cover interest charges, depreciation, repairs and renewals, and a liberal provision for labor and fuel, as well as the cost of resettling and decanting of the water of the original sludge, and expenses for handling, freighting and marketing the finished product. Obviously, the total cost per ton will be somewhat more in the case of a small plant than for a large one. For a very large plant, where fuel and labor are relatively cheap, it is possible that further experience will reduce the cost below the lower limit in the range here given.

Analyses of dried samples of sludge are given in Table 4. They indicate that dry activated sludge (basis of 10% moisture) will contain 4.6 to 5% of nitrogen figured as ammonia and 0.6 to 0.7% of available phosphoric acid. In addition to this our data show that the dry product contains about ¼ to ½% of potash and from 3 to 4% of fatty material. At present prices the nitrogen is worth $2.50 per unit (or per cent.). In normal times this nitrogen would be worth about $2 per unit. The phosphoric acid is worth about 50c.; and the potash may be worth something in the future, although the best that can be said of it at present is that it will assure for the fertilizer a more ready sale.

Table 4.—Analyses of Commercially Dried Activated Sludge, Milwaukee.

Basis of 10% Moisture*

Sample No.	Character of Drier	% of Nitrogen as Ammonia	% of Available Phosphoric Acid
1	Semi-direct heat	4.36	0.70
2	Indirect heat	4.76	0.81
3	Indirect heat	4.56	0 47
4	Indirect heat	5.06	0.39
	Average of four samples	4.68	0.57

*Additional analyses for percentage of nitrogen as ammonia on the 10% moisture basis showed the following results, the dates being dates samples were collected: May 3, 1916, 5.74; June 20, 1916, 4.65; June 13, 1916, 4.88; June 14, 1916, 4.92; June 16, 1916, 5.01.

The fat present in the Milwaukee sludge is negligible. It would not pay to recover the fat, nor will the fat injure the selling qualities of the dried sludge.

Summary.—Summing up the whole situation, then, we see that the dried sludge has a market value upon present figures of $9 to $15 per ton of material containing 10% moisture. The total cost of getting this product and placing it on the market will probably run from $8 to $12 commercially per dry ton, depending upon local conditions. For large plants this cost may possibly be reduced as a result of further experience.

The activated sludge containing 4% or more of nitrogen is much nearer a commercial possibility than the sludges obtained by the older methods of treatment, such as chemical precipitation, septic tanks, or the Imhoff process, which the data given in Table 1 indicate to contain only 1½ to 3% of nitrogen.

In case the question arises as to the possibility of finding a market for the dried activated sludge it should be added that raw materials containing nitrogen, phosphoric acid and potash are capable of being worked up readily as a base for making high-grade fertilizers; and as they are not very plentiful, they are in good demand.

Presumably, however, large cities, such as New York, Chicago and others, by installing this activated-sludge process, would produce so much raw material of this character that the product would have to be parceled out among a number of manufacturers. It is even possible that the production might be sufficient to reduce the price. However, the dried sludge is a good fertilizer just as it stands and contains enough value to pay for sale and distribution in quite a large local market.

COBALT ORE SHIPMENTS.

The following are the shipments of ore, in pounds, from Cobalt Station for the week ended October 13th:—

Alladin Cobalt Mine, 41,000; Nipissing Mining Company, 206,830; La Rose Mines, 166,826; Dominion Reduction Company, 176,000; McKinley-Darragh-Savage Mines, 254,625. Total, 845,281 pounds, or 422.6 tons.

From Elk Lake—

Miller Lake O'Brien Mine, 56,600 pounds.

The total shipments since January 1st, 1916, now amount to 24,723,551 pounds, or 12,361.7 tons.

The Engineer's Library

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

CONTENTS.

BOOK REVIEWS.

Arithmetic for Engineers. By Chas. B. Chapham, B.Sc. Published by Chapman and Hall, Limited, London, England. 436 pages, 149 figures, 4 tables, 6x9 ins., cloth. Price, $1.50 net. (Reviewed by Alfred S. L. Barnes, Ontario Hydro-Electric Power Commission.)

This book is published as one of the "D.U." or "directly useful" technical series. An editorial note explains that this series is being issued with the idea of including in each publication only such information, problems and exercises as are of a directly useful character, suitable explanations at the same time being furnished and it is hoped in this manner to appeal to all technical people, either students or those in actual practice. The title of the book hardly conveys a proper idea of its contents, because, besides ordinary arithmetic, there is included simple algebra, mensuration, logarithms, graphs and an explanation of how to use the slide rule. Many people will find the earlier portion of the book almost too simple, but it is evidently intended, by thus going into the subject right from the beginning in very gradual steps, to make the book of service to people whose arithmetical knowledge is almost nil. The aim of the book is to apply the knowledge which it is sought to impart to problems of a practical engineering nature from the start, and as early as page 17 an example of totalling up the dimensions of various parts of a spindle for a sluice valve is given, together with a sketch of the spindle referred to. This is a characteristic of the book, which is adhered to throughout. Vulgar and decimal fractions are first treated of, and these are followed by a chapter on symbols and their uses, thus introducing in a very gradual manner the subject of algebra. This is followed by a section on simple equations and transposition of formulas. A useful chapter on logarithms is given, which contains detailed instructions for using logarithmic tables. After this a good deal of space is devoted to mensuration with numerous practical examples illustrated by sketches. Chapter 9 explains how curves may be plotted and describes their uses. Chapter 10, on the sliding rule, brings to an end a book which should prove extremely useful to engineering students and, indeed, to many men who have left their student days behind them and are not daily in touch with calculations.

Examples in Alternating Currents—Vol. 1.—By Prof. F. E. Austin, B.S., E.E. Published by the author. Second edition, 1916. 223 pages, 4 tables, 70 illustrations, 5 x 7½ ins., flexible leather. (Reviewed by Prof. Robert W. Angus, Toronto University.)

This very nicely bound book deals with a number of problems which occur in connection with alternating current phenomena. The author recognizes the fact that the higher mathematics play an important part in such problems, and says in his preface: "No apology should ever be offered for introducing the methods of the calculus in the solution of engineering problems." Whether this is true or not, he has used the calculus freely, and the book is therefore of more value to the well-trained reader, although the results will be useful to others.

The first part of the book contains a number of relations from the calculus and trigonometry which are frequently used in the subject considered. Following this, a large number of examples and problems are worked out on such matters as "co-efficient of inductance of coils," "inductance of transmission lines," "capacity of condensers," "current in condensers," "current in any arrangement," and many other useful problems of value, more especially to electrical engineers.

At the end of the book there are tables of functions of various quantities, capacities, etc.

It is unfortunate that the book is printed in green ink, as its appearance is not improved thereby and a good deal of the small print is scarcely legible.

Railway Organization and Management. By James Peabody. Published by LaSalle Extension University, Chicago, Ill. 263 pages, 28 figures, 6 x 9 ins., cloth.

This is a most timely book as the subject of transportation is one which, at the moment, is receiving a great deal of attention in Canada. It is doubtful, as the author says in his introduction, whether any other one factor, with the exception of religion and the public school, has had more to do with the building up of our civilization than effective transportation. When one considers that with the exception of agriculture, transportation employs the greatest number of people on the North American continent, it is easy to understand just what an important part transportation plays in the life of the people. The book will be found of very great value to all those who have to do with the organization work of railroads, whether in the operating, the engineering or the supervisory departments. The book contains a number of charts showing the various organizations of different railroad systems, and in addition there are a number of test questions at the end of the book for the use of the student in testing his knowledge of the subject.

Principles of Oil and Gas Production. By Roswell H. Johnson and L. G. Huntley. Published by John Wiley and Sons, Inc., New York. First edition, 1916. 371 pages, illustrated, 6 x 9 ins., cloth. Price, $3.75 net.

This is a book which will fill a decided want on the part of those who have been anxious to secure a work that would deal adequately with the subject in hand, namely, the production of oil and gas. The book limits itself to a discussion of the subject, with particular reference, in fact, almost chief reference, to conditions as they exist in America.

The book has chapters on such subjects as the varieties of oil and gas, the origin of oil and gas, the locating of oil and gas wells, classification of the attitude of geologic surfaces, the valuation of oil properties. A most interesting chapter is that devoted to the oil and gas fields of North America, occupying nearly 100 pages of the book, in which a very complete account of the various fields both in the United States and Canada is given.

The Heat Treatment of Tool Steel. By Harry Brearley. Published by Longmans, Green & Co., London and New York. Second edition, 1916. 223 pages, illustrated, 6 x 9 ins., cloth. Price, $3.50 net.

Books on the treatment of steel for various purposes are not any too common and this latest book will be found of considerable value to the mechanic whose particular business it is to produce steel objects and tools for various purposes. The author deals with the structure and classification of steel, the properties of ingots, forging tool steel and the hardening of steel.

The Principles of Electrical Engineering and Their Application—Vol. I. By Gisbert Kapp, M.I.C.E. Published by Edward Arnold, London. 1916 edition. 356 pages, illustrated, 6 x 9 ins., cloth. Price, $3.75 net.

This is Volume I. of a series of two books on the subject, Volume II. dealing with the application of the principles which are referred to in the volume under review. Not only can it be used as a text book for all engineering students, but as a handbook for the general engineer. While the subjects which the books treat come, rightly speaking, into the domain of the electrical engineer, yet engineers in general will find a great deal of information in such a book as this and they are more or less likely in the pursuit of their work to be thrown into contact with problems which a book like this can help solve.

Pocket Book of Engineering Formulæ. By Sir Guilford L. Molesworth, K.C., I.E., and Henry Bridges Molesworth; Electrical Supplement by Walter H. Molesworth. Published by Spon and Chamberlain, New York. Twenty-seventh edition, 1916. 936 pages, illustrated, 3 x 4 ins., flexible leather. Price, $1.50 net. (Reviewed by Alfred S. L. Barnes, Ontario Hydro-Electric Power Commission.)

When a pocket book has reached its 27th edition, there is no need to refer to its probable usefulness. Molesworth's Pocket Book, for its size, probably contains more practical useful information than any other publication of the kind, and its small dimensions make it extremely handy for carrying about anywhere. Though for many years this pocket book was confined mainly to civil and mechanical engineering, there is now an electrical supplement of 180 pages, which considerably extends its scope.

How to Build Up Furnace Efficiency.—A handbook of fuel economy. By Jos. W. Hayes, combustion engineer, Rogers Park, Chicago, Ill. Published by the author. Tenth edition, 1916. 154 pages, illustrated by charts, diagrams and tables, 5 x 7 ins., paper. Price, $1.00.

This is a book that will be sure to appeal to those who are concerned with the generation of power by means of steam. The purpose of the book is to show how, why and where fuel is wasted in the boiler room. The first edition of this book was published in 1908 and since its initial appearance it has gone through ten separate editions. The subject is presented in a most interesting and attractive way, and the book will, undoubtedly, appeal to all those who are concerned with steam power operation.

Canadian Trade Index.—Issue of 1916-1918. Compiled and published by the Canadian Manufacturers' Association, Incorporated, 1404 Traders Bank Building, Toronto. 560 pages, 7 x 10½ ins., cloth. Price, $5.00.

This well-known index has made its re-appearance. It is in three parts. Part I. contains an alphabetical list of manufactures. Part II. is a directory of manufacturers of Canada classified according to the articles made. Part III. is an alphabetical index in French of the headings in Part II. with the parallel English. The aim of the book is to provide all buyers of Canadian manufactured goods with a dependable list of the articles made in Canada and the name of the manufacturers making them.

PUBLICATIONS RECEIVED.

Mining Operations.—Report on the mining operations in the province of Quebec for the year 1915.

County Roads.—Appendix to the Annual Report of the Department of Public Highways of Ontario, 1916.

Concreting in Cold Weather.—A 15-page illustrated pamphlet issued by the Portland Cement Association, Chicago, Ill.

Road Material Surveys in 1914.—By L. Reinecke. Memoir 85, No. 71, Geological Series, Department of Mines, Ottawa.

Civic Improvement.—Report of conference of the Civic Improvement League of Canada, 1916. Issued by the Commission of Conservation, Ottawa.

Concrete Houses and Why to Build Them.—A 7-page illustrated pamphlet published by the Portland Cement Association, 111 West Washington Street, Chicago, Ill.

Bulletin of the American Railway Engineering Association, August, 1916.—Published by the American Railway Engineering Association, at 900 So. Michigan Avenue, Chicago, Ill.

Specific Gravity Studies of Illinois Coal.—By Merle L. Nebel. Bulletin No. 89, Engineering Experiment Station. Published by the University of Illinois, Urbana, Ill. 44 pages, illustrated. Price, 30c.

The Quebec Streams Commission.—Fourth report, November, 1915, 109 pages, tables and maps. Also 19 plates to accompany the report. Secretary, L. H. Charlebois, 803 McGill Building, Montreal.

Engineering Education.—October, 1916, bulletin of the Society for the Promotion of Engineering Education, Lancaster, Pa. Published under the supervision of F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa.

That Alley of Yours; What Are You Going to Do About It?—A 23-page pamphlet issued by the Portland Cement Association, Chicago, Ill., containing illustrations of concrete alleys in various cities in the United States.

Rescue and Recovery Operations in Mines After Fires and Explosions.—By James W. Paul and H. M. Wolflin. Published by the Bureau of Mines, Department of the Interior, Washington, D.C. Franklin K. Lane, secretary.

Greater Winnipeg Water District.—Report on the aqueduct of the Greater Winnipeg Water District by the special board of consulting engineers—Brigadier-General H. N. Ruttan and J. G. Sullivan, of Winnipeg, and R. S. Lea, Montreal.

Railway Regulation and Locomotor Ataxia.—An address by Frank Trumbull, chairman, Railway Executives' Advisory Committee, before the twenty-third annual convention of the National Hay Association at Cedar Point, Ohio, July 12, 1916.

Coal Mines in Canada.—List of coal mine operators in Canada, arranged according to location of mine, by provinces and districts, to which is added a list of manufacturers of oven coke. Issued by the Department of Mines, Ottawa. Eugene Haanel, Ph.D., director.

Annual Report of the Board of Regents of the Smithsonian Institution, Washington, D.C., (Charles D. Walcott, secretary), showing the operations, expenditures and condition of the institution for the year ending June 30th, 1915. 544 pages, illustrated, 6 x 9 ins., cloth.

CANADIAN SOCIETY OF CIVIL ENGINEERS, ELECTION OF OFFICERS.

After a meeting of the council of the Canadian Society of Civil Engineers, held October 17th in Montreal, the following elections and transfers were announced:—

Associate Members—Donald T. Black, Welland, Ont.; Frederick Clarke, Victoria, B.C.; Arthur S. Clarson, Montreal, Que.; John B. D'Aeth, Montreal, Que.; Sidney C. Ells, Ottawa, Ont.; Charles R. Needs, Sudbury, Ont.

Associate—Charles C. Labrie, Montreal, Que.

Juniors—Horace Beaudoin, Montreal, Que.; Eric E. Wells, Toronto, Ont.

Transferred from Associate Members to Members—Albert H. Aldinger, Detroit, Mich.; William A. Davidson, Coleman, Alta.; William A. Duff, Winnipeg, Man.; Thomas M. Fyshe, Montreal, Que.; Albert C. Garner, Regina, Sask.; John A. Heaman, Winnipeg, Man.

From Junior to Associate Member—James Ferguson, Princeland, Coupar Angus, Scotland.

From Students to Juniors—John E. Caughey, Calgary, Alta.; J. Romeo Gauvreau, Montreal, Que.; F. I. C. Goodman, Montreal, Que.; Hector Grenier, Quebec, Que.; Donald F. MacIsaac, Antigonish, N.S.; Norman Wilson, Ottawa, Ont.

It will cost Australia about $25,000,000 to open the Murray River to navigation and to construct an irrigation system that will develop 1,500,000 acres of land.

STUDIES REGARDING CONCRETE MIXTURES EMPLOYED IN CONSTRUCTION OF SHOAL LAKE AQUEDUCT.

(Continued from page 334.)

which deposited the concrete in the forms while the second specimen was taken from a section half-way between the chutes. A pressure chamber 2 ins. in diameter and 2 ins. deep was made in each block and a 2-in. pipe grouted in above this chamber. Test was made at age of 84 days under 80 lbs. per square inch water pressure. Both specimens were tight.

Three 8-inch test cubes were made up from the materials on one of the contractor's platforms and in the contractor's cement store house. The mixture used was the standard 3 bags of cement to 16 cubic feet of aggregate. The specimens were mixed by hand and mixed to a consistency similar to that used on the work. At 27 days these cubes were tested at the University of Manitoba Laboratory.

Cube No.	Compressive strength in lbs. per sq. in.
1	1,849
2	1,955
3	2,023

These values have been reduced by use of the factor 0.73 to corresponding values for standard test cylinders.

The question of the proper grading of the aggregate for concrete is of more importance to the Canadian engineer than it is to the British or American engineer due to the much higher cost (some 45% to 50% more) of cement in Canada than in the United States or Great Britain. This higher cost of cement means that every effort should be put forward by the members of the society to prevent waste of cement in concrete work. "Concrete-making is essentially work for an expert and not for an ignoramus." This applies to the inspection of the cement, to the grading of the aggregate, to the mixing of the concrete, to the placing of the concrete and to the curing of the concrete. Lack of appreciation of any one factor results in poor work and generally in waste of cement.

PORTAGE AVENUE PAVEMENT, EDMONTON.

Portage Avenue, Edmonton, one of the most important paving jobs in Western Canada, is just about complete. The total length of the avenue is 9,911 feet, the width being 100 feet. The width of roadway is 66 feet, while the sidewalk is 16 feet wide. The street railway track occupies 22 feet 4 inches of the roadway.

The total cost of the work is $415,000, of which $350,000 was spent by the Hudson's Bay Company. There are 55,609 square yards of asphaltic concrete, 17,444 lineal feet of curb and gutter, 249,379 square feet of concrete walk, and 19,544 lineal feet of single track.

The contractors for fifteen blocks of pavement (from 106th to 121st Street) were the Crown Paving Company, while from 101st to 106th Street, the National Paving Company were the contractors. The concrete walks were constructed by Swanson & Kaline. The pavement has a 6-inch base, with 2-inch bituminous surface, and with an additional base of 6 inches under the street railway tracks.

Mr. A. G. Harrison, city commissioner of Edmonton, to whom we are indebted for the above information, states that Portage Avenue is probably the longest and widest paved street of its kind in Canada.

Editorial

HUMAN ENGINEERS.

Occasionally one who is regarded as a leader in the engineering profession will come out strongly and make claims that this or that cannot be done because it is opposed to good engineering practice. Frequently he will proceed to show why it cannot or should not be done in that particular way. Yet, where other engineers have a voice in the matter, this engineer's opinions may be overruled, and what he has previously claimed cannot be done, successfully accomplished. After the work has been completed and everything is in perfect running order, you will usually find this first engineer loyal to those whose judgment was chosen in preference to his own. At the time he used his best judgment, and his fellow-engineers knew it. He simply had to be shown.

Engineers are continually being confronted by something new—something on which data are unavailable. It is at this point where experts, who, to a large degree, draw their theories from past experiences, are often at variance, one with another. It cannot be avoided, and simply because an engineer errs in one connection is no reason why in the future his opinion should be tabooed.

It may be pointed out how many times our greatest judges render decisions that are diametrically opposed. It is, therefore, not illogical to assume that engineers will occasionally make mistakes. The fact that an engineer does so proves that he is human, and we all love human engineers.

THE ENGINEER AND HIS READING.

"Your account for another year's subscription is at hand. Will you kindly cancel the subscription, as I am arranging to receive *The Canadian Engineer* from another party after he has perused his weekly copy."

The above letter recently received from a subscriber gives us an opportunity of saying a few things on the subject of the engineer and his reading—a subject which, we are afraid, too many men give too little thought to.

If this particular reader has felt that owing to present conditions it would be better to read this paper, as it were, second-hand, then it is poor economy. It is more than likely that the real subscriber to the paper will take out of the issues as they come to him such portions as he feels are likely to be of service to him, and many times the "economical" subscriber will be handed a paper from which the best material has been removed.

In these days of keen competition it is essential that one keep at least abreast of the progress in the engineering profession. After graduation, the young engineer should not fall into the habit, altogether too common, of forgetting how and what to read. On the other hand, it is a habit which needs careful cultivation and the engineer who encourages it without making the mistake of trying to read too much, is sure to find it of real value in his work.

In his reading, it is not enough merely to read those articles in his technical paper that deal specifically with that phase of engineering work with which he is most concerned. He should endeavor to keep himself posted not only in that branch in which he is more particularly interested but in those lines of work which are in some degree related to it.

Too many men confine their reading too closely to the branch of the profession in which they are concerned, and to some extent are making specialists of themselves. That is well so far as it goes, but it is doubtful if he would not be a better engineer by adopting a broader programme so far as his reading is concerned.

The field of the technical journal is a fairly extensive one. It combines the text book plus the function of a newspaper. Let an engineer use his technical papers intelligently and he will find them a real investment and not an expense.

It will give him a complete summary of projected engineering work all over Canada which has, or ought to have, a commercial value for him. Furthermore, it will give him a presentation of articles on different phases of engineering work in which he is now, or may at some future time be, more particularly interested.

PRESIDENTIAL ADDRESS OF A. F. MACALLUM, BEFORE THE AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.

The American Society of Municipal Improvements has among its members the leading municipal engineers of the United States and Canada. For the year just ended the honor of presiding over this body fell to Mr. A. F. Macallum, M.Can.Soc.C.E., commissioner of works, Ottawa, Ont.

The following extracts from his presidential address delivered on the occasion of the annual convention, October 11-14, at Newark, N.J., will be of interest to Canadian municipal engineers generally:—

The society has now reached that position in its development that in most cities and in the latest text books upon municipal works the specifications as revised each year are considered as standard. This has been of considerable benefit to municipal engineers not always versed in the physical and chemical properties considered necessary in different materials. It has also eliminated the type of specification sent out by commercial institutions which were too often misleading inasmuch as clauses were in them that either limited competition or made it impossible. By continuing the policy that this society has always adopted in appointing to the different chairmanships of committees men recognized as authorities in their particular branch of engineering I have no doubt as to the success that will continue to follow their efforts.

In the majority of municipalities throughout the United States the engineers are voted in on a political ticket at each election. In the lack of continuity, different methods adopted, probable change of policy and lack of familiarity in municipal work, these municipalities must inevitably suffer. The fact that the man with the best qualifications politically may not be the best one from the standpoint of efficiency is, I believe, slowly but surely dawning upon municipalities, and attempts are being made in the appointments of commissioners, city managers, and other forms of civic government to get away from political domination.

It is a matter of common observation that many civic officials do not keep up their information as to what is being done in other cities and towns. Thus we see the same mistakes repeated time and again and the experience of others lost with consequent financial loss to their municipalities.

That membership in the American Society of Municipal Improvements will materially assist such men there is no doubt as, besides the information they obtain at the conventions and through their published proceedings, the discussion with others in their particular line of endeavor, will naturally quicken their interest and develop their reading faculty. One of the departments of this society which I believe should be developed further, is that with reference to the clearing house. This department could be broadened out to include research work so far as it is carried out in different cities which are represented by members of this society, and this would have the tendency of eliminating much useless preliminary experimental work. By the collection and distribution of the progress or results of experiments going on it would materially save both time and money.

PERSONAL.

HYNDMAN IRWIN, B.A.Sc., formerly editor of *The Canadian Engineer*, has sailed for England with a draft of the Canadian artillery. Mr. Irwin joined the staff of this journal in June, 1913, resigning in February, 1916, to enter the officers' training school at Toronto. Lieut. Irwin trained at the Niagara and Petawawa camps, where he was reconnaissance officer and acting captain of his battery. He spent a few days in Toronto a couple weeks ago upon his last leave, when he received the good wishes of a host of friends. Lieut. Irwin is well known and popular among the alumni of the University of Toronto, having been general secretary of the engineering society and editor of "Applied Science" for three years subsequent to his graduation at the university. He graduated with honors in electrical engineering with the class of 1909, but took a year's post-graduate work in mechanical and civil engineering. Before going to the university Mr. Irwin, who was born at Shelburne, Ont., had experience in teaching and, to a certain extent, in engineering. He spent a year in the Great Northern Railway shops at Havre, Montana, and was subsequently power engineer for the Cottonwood Coal Co. at Belt, Mont., and Stockett, Mont. For a time he acted as power engineer for the Graves, Bigwood Lumber Co. at Byng Inlet, Ont.

Hyndman Irwin, B.A.Sc.

Mr. Irwin's editorial work upon *The Canadian Engineer* was characterized by alertness and enterprise. His editorials were sound, well balanced and deliberated. He showed an accurate judgment of the comparative value of technical articles, and of what would 'appeal to the reader." *The Canadian Engineer* wishes him equal success in his new duties—and the more power to his arm when he meets the enemy!

R. E. CHADWICK, A.M.Can.Soc.C.E., assistant chief engineer of the Foundation Company, New York City, is visiting Toronto after an extended tour through Western Canada. Mr. Chadwick is a graduate of the University of Toronto and was formerly city engineer of bridges, Toronto. The Foundation Company is a rather unique United States concern, as it is composed almost entirely of Canadians and Englishmen, the general manager being Mr. John W. Doty, formerly of Toronto, Ont. Mr. Chadwick says that in the company's large staff there are only three or four Americans. An United States consular paper had to be signed in their office recently and they had the unique experience of not being able to find anybody in the office who was an American citizen and could sign the paper. The company has had a very successful year, having broadened out its field of activities very materially, and it is very satisfactory to note that these Canadian engineers are being so successful in this work in the United States.

JOS. McBRIDE has been engaged as engineer of the Halton Brick Company, Brampton, Ont.

J. T. HALLISEY has been appointed superintendent, District 6, Intercolonial Railway, Truro, N.S.

H. L. STEENBUCH, A.M.Can.Soc.C.E., has been appointed to succeed Carl J. Printz, Norwegian consul, in Toronto.

W. R. FITZMAURICE has been appointed superintendent, District 2, Intercolonial Railway, Campbellton, New Brunswick.

Capt. F. R. NEWMAN, late manager of the Canadian Fairbanks-Morse Company's sales office in Toronto, has been wounded in France.

A. S. CLARSON, formerly on the staff of the Montreal Electrical Commission, has been appointed city engineer of Verdun, P.Q.

A. A. McDIARMID has resigned his position as chief engineer on the Mattagami Pulp and Paper Co., Toronto, and is now engaged in special work at Sault Ste. Marie.

GOODWIN SHENTON has resigned his position with the Lyman Tube and Supply Company, Limited, Toronto, to take over the position of engineer to Messrs. Taylor & Arnold, Limited, Montreal.

Major A. G. NUTTER, now in the hospital at Boulogne severely wounded in the shoulder by gunshot, was formerly the representative of Mussens, Limited, Montreal, at the government terminals in Halifax, N.S.

Sir GEORGE PAISH, who was appointed as third member of the board which is investigating the railway situation in Canada, has resigned owing to ill-health. W. M. ACKWORTH, of London, England, will be appointed his successor.

Lieut. SIDNEY HAMILTON FELLOWES son of Mr. C. L. Fellowes, city waterworks engineer of Toronto, has been wounded in the head and leg. Lieut. Fellowes went overseas with the Canadian Engineers, and has been at the front eighteen months.

HARRY H. ANGUS, B.A.Sc., who has been in private practice at Toronto, has joined the firm of MacMullen, Riley & Durley, consulting engineers,