PAGES

MISSING

Volume 25 Toronto, Sept. 4, 1913 Contents of this issue on page 405

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

SPIRAL OR SCREW CONVEYERS

SPECIALLY REQUIRED FOR CONVEYANCE OF CERTAIN MATERIALS —GENERAL DESCRIPTION—CAPACITY UNDER VARIED LOADING HORSE-POWER REQUIRED—NET OPERATING COST.

By **REGINALD TRAUTSCHOLD, M.E.,**
Consulting Engineer, New York City.

In many industrial plants, whether power houses, cement mills, or of other types, certain operations frequently require the more or less continuous handling of materials that are often of such nature as not to permit efficient use of carriers of the flight conveyer type or of any type in which the load carried is exposed to possible disarrangement by air currents, etc. Then, too, the required capacity is frequently relatively small, making the installation of a system of large capacity of questionable economy, owing to the intermittent service that would be required from such apparatus. In such cases, a popular and sometimes very desirable equipment is the screw or spiral conveyer, a conveyer that possesses the advantages of relatively low first cost and of extreme compactness. This type of carrier consists of a suitable metal ribbon wound spirally about a shaft to form a screw which, enclosed in a box or trough, pushes the material handled forward as the screw is revolved. At intervals, gates or openings may be made in the bottom of the trough through which the material conveyed is discharged or else the material may be carried to the end of the trough, which is invariably left open, and there dumped out. The diameter of the trough may be only slightly larger than that of the screw, in which case practically all material fed to the conveyer is propelled forward as the screw revolves, or the trough may consist of a relatively large box surrounding the screw, which gradually fills with material until the screw forms its own trough and pushes forward the additional material fed to the conveyer. The first type of trough is usually found in installations for carrying fine coal, grain, small cement clinkers and other "fines," while the latter is almost always limited to installations for handling ashes, etc., which may be temporarily stored in the conveyer trough or box and subsequently removed through gates in the bottom of the storage box. Naturally only fine materials can be efficiently handled by such a conveyer, and while these materials need not be necessarily homogeneous in character they should contain no lumps more than a few inches in size, the maximum allowable size of lump depending somewhat upon the diameter of screw, i.e., size of conveyer. The screw conveyer is at its best when handling fine and light substances, materials that could not be carried by any other type of conveyer without a great deal of spill. This is particularly noticeable in cement mills where screw conveyers are often employed to handle fine cement clinker containing a great deal of air. In such installations the squeezing action of the helical ribbon of the conveyer also tends to compress the clinker and displace much of the air contained on its receipt from the kilns. The efficient length of screw conveyers is also limited for, though the flight is interrupted every few feet to accommodate supporting bearings for the screw shaft, the torsional strain on the screw shaft becomes unduly severe if the conveyer is more than about 100 feet in length, unless the material handled is very light and has a small angle of repose—such as grain.

The size of screw conveyers (diameter of screw) is usually limited to about 24 inches, though conveyers have been built and successfully operated that were upward of 3 feet in diameter, and, as the speed at which they can be efficiently operated is also limited to about 250 revolutions per minute, their carrying capacity must therefore be relatively small. Actually three conditions govern the capacity of screw conveyers; 1st, the diameter of the screw; 2nd, the pitch of the screw; and 3rd, the speed at which it is run, i.e., revolutions of the screw; but the question of mechanical efficiency of the apparatus—the mechanical efficiency being at a maximum with a screw pitch of 45 degrees—has led to the universal practice of making the pitch of the screw about the same as its diameter, so that only speed and size of conveyer need be considered for a standard equipment. The speeds usually employed are from 100 to 250 revolutions per minute, the higher speeds for conveyers of small size, irrespective of either character or weight of material conveyed. Table III. gives the average capacity of various standard sizes of screw conveyers when operated at their respectively most economic speeds, expressed in terms of bushels handled per hour. Table IV. gives similar data expressed in terms of tons of material weighing 100 pounds per cubic foot handled per hour. Material of other weight or carried at different conveyer speeds vary directly proportionally as the weight and speed. The carrying capacity of screw conveyers is further dependent upon the depth of material in the trough, or rather the proportion of the screw that would be submerged in the material should it be possible to push the material forward with no agitation, and this is limited to a depth equivalent to about one-third the diameter of the screw, so it is possible to evolve a formula for the derivation of carrying capacity of any size of screw conveyer at any speed, expressed in terms of the square of the diameter of the screw, the pitch of the screw and the revolutions made by the screw in a given time. As the pitch and diameter of the screw are usually equal, the variable quantities are simply those of size of conveyer (diameter of screw) and speed of conveyer (revolutions of screw). Such relationship is expressed in Formulæ VI. and VII., the former giving the capacity in terms of bushels per hour and the latter in terms of tons per hour.

Table III.

Capacity of Screw Conveyers, Continuously and Uniformly Loaded.

Diameter of Screw	Speed R.P.M.	Bushels per hour	Diameter of Screw	Speed R.P.M.	Bushels per hour
4″	220	125	12″	150	2,250
5″	205	220	14″	140	3,400
6″	195	370	16″	130	4,700
7″	185	550	18″	120	6,000
8″	175	800	20″	115	8,000
9″	170	1,100	24″	100	12,000
10″	160	1,400			

Table IV.

Capacity of Screw Conveyers, Continuously and Uniformly Loaded.

Handling material weighing 100 lbs. per cu. ft.

Diameter of Screw	Speed R.P.M.	Tons per hour	Diameter of Screw	Speed R.P.M.	Tons per hour.
4″	220	4.5	12″	150	83.3
5″	205	8.3	14″	140	123.5
6″	195	13.5	16″	130	171.0
7″	185	20.4	18″	120	225.0
8″	175	28.8	20″	115	295.0
9″	170	40.0	24″	100	444.0
10″	160	51.4			

$$B = 0.0088022\ d^3R \qquad \text{Formula VI.}$$
$$W = 0.000003213\ d^3w'R \qquad \text{Formula VII.}$$

Where :—
B = Capacity in bushels per hour.
W = Capacity in tons per hour.
d = Diameter of screw in inches—size of Conveyer.
w′ = Weight of material conveyed in pounds per cubic foot.
R = Revolutions of screw per minute.

The consumption of power by screw conveyers is naturally relatively high on account of the low mechanical efficiency of the screw; that is, the power requirements are similar to those of an ordinary flight or scraper conveyer corrected for the inclined plane action of the screw construction to which must be added the loss of power or thrust due to the mechanical inefficiency of the screw. The power consumed in running the empty conveyer is not affected by the pitch of the screw, of course, being virtually that required to revolve the screw at the required speed, but the greater power requirements for propelling the load depend directly upon the pitch of the screw and must be corrected accordingly. Theoretically there is also a difference in power consumption by screw conveyers depending upon the nature of the material handled, its weight, angle of repose, etc. Practically, however, no great variations are found in power requirements of screw conveyers handling different materials as ordinarily installed and subjected to the abuse to which such apparatus is invariably submitted. Though formulæ have been derived which provide for varying power requirements by the substitution of various constants for conveyers destined to carry specific materials, the following formula (Formula VIII.) gives approximately accurate results for ascertaining the power requirements of practically any screw conveyer handling suitable material at advisable speeds. This formula allows for an inclination to the conveyer (elevating the material) which allowance is about equal to the amount that would be required to simply raise the specified weight through a vertical distance equal to the difference in elevation between the two ends of the conveyer. Actually, some additional power might be required, owing to appreciable increase in thrust on conveyer bearings, but the capacity of the conveyer is also somewhat reduced by any inclination so that the derived horse-power is practically accurate for the load actually conveyed. As much of the material that is frequently handled by screw conveyers is customarily measured in bushels rather than in tons, Formula IX. will be found to be of convenience when such unit is the base of measure. Chart II., giving the power requirements for screw conveyers in both terms of tonnage capacity and of capacity in bushels, will also be found to be of decided assistance. The accuracy of chart reading is not as great, of course, as is attainable when relying upon formulæ, but, for all practical purposes, such readings are sufficiently accurate.

Horse-power:

W = Weight of load conveyed in tons per hour = $0.00015065\ d^3R$ (aver.)
V = Velocity (speed) of Conveyer in feet per minute = $0.2618\ dR$
d = Diameter of Conveyer (screw) in inches.
L = Length of Conveyer in feet.
H = Height to which load is elevated in feet.
R = Revolutions of screw per minute.
W_s = Weight of moving parts per foot of Conveyer in pounds.
= $0.1\ d^2$—average value.
W′ = Weight of load conveyed per foot of Conveyer in pounds per minute.

$$= \frac{33\ W}{V}$$

f_s = speed factor = 0.09—from experiment.
f_l = load factor = 0.70—from experiment.
d′ = diameter of screw shaft in inches = 0.15d—average value.
V′ = Velocity of screw shaft in feet per minute = 0.03927 dR.

Work in foot pounds per minute required to run Conveyer empty.
$= W_s \times f_s \times V' \times L = 0.00035303\ d^3RL = 2.343\ WL$—av. value.

Work in foot pounds per minute required to convey load.
$= W' \times f_l \times V \times L \times 0.3183 = 7.35\ WL$ (neglecting inefficiency).
$= 20.1\ WL$ (correcting for inefficiency of screw).

Horsepower required to elevate load (inclined conveyer).

$$= \frac{WH}{1000}$$

Then :—
Total horsepower required.

$$HP = \frac{0.68\ WL + WH}{1000} \qquad \text{Formula VIII.}$$

$$HP = \frac{0.017\ BL + 0.025\ BH}{1000} \qquad \text{Formula IX.}$$

B = Load conveyed in bushels per hour.

The standardization of screw conveyers in the matter of pitch and the large factor of safety that must be used in proportioning the various parts of the screw, etc., in order to permit economical manufacture, has created a close relationship between the weight of the screw, hangers, bearings, driving mechanism, etc., and the size of the conveyer and correspondingly a close relationship between the average cost of such parts and the diameter of the screw, size of conveyer. Likewise, the trough is usually a comparatively heavy casing slightly larger than the screw or a relatively large box with a correspondingly light lining, so that the cost of the stationary parts of a screw conveyer also vary closely with the size of the conveyer. For rough approximations, sufficiently accurate for conservative estimates of the average burden of interest on investment, depreciation, renewals, insurance, taxes, etc., an equation can be derived for ascertaining the average cost of equipment in which the only variable quantities are those of length of conveyer and diameter of screw, the various items constituting a complete equipment varying directly with the diameter of the screw, except for the ends of the conveyer which vary closely with the square of the diameter of the screw. Such an equation is given as Formula X., and its use gives a fairly accurate estimate of the initial cost of any screw conveyer, including an average allowance for covering cost of erec-

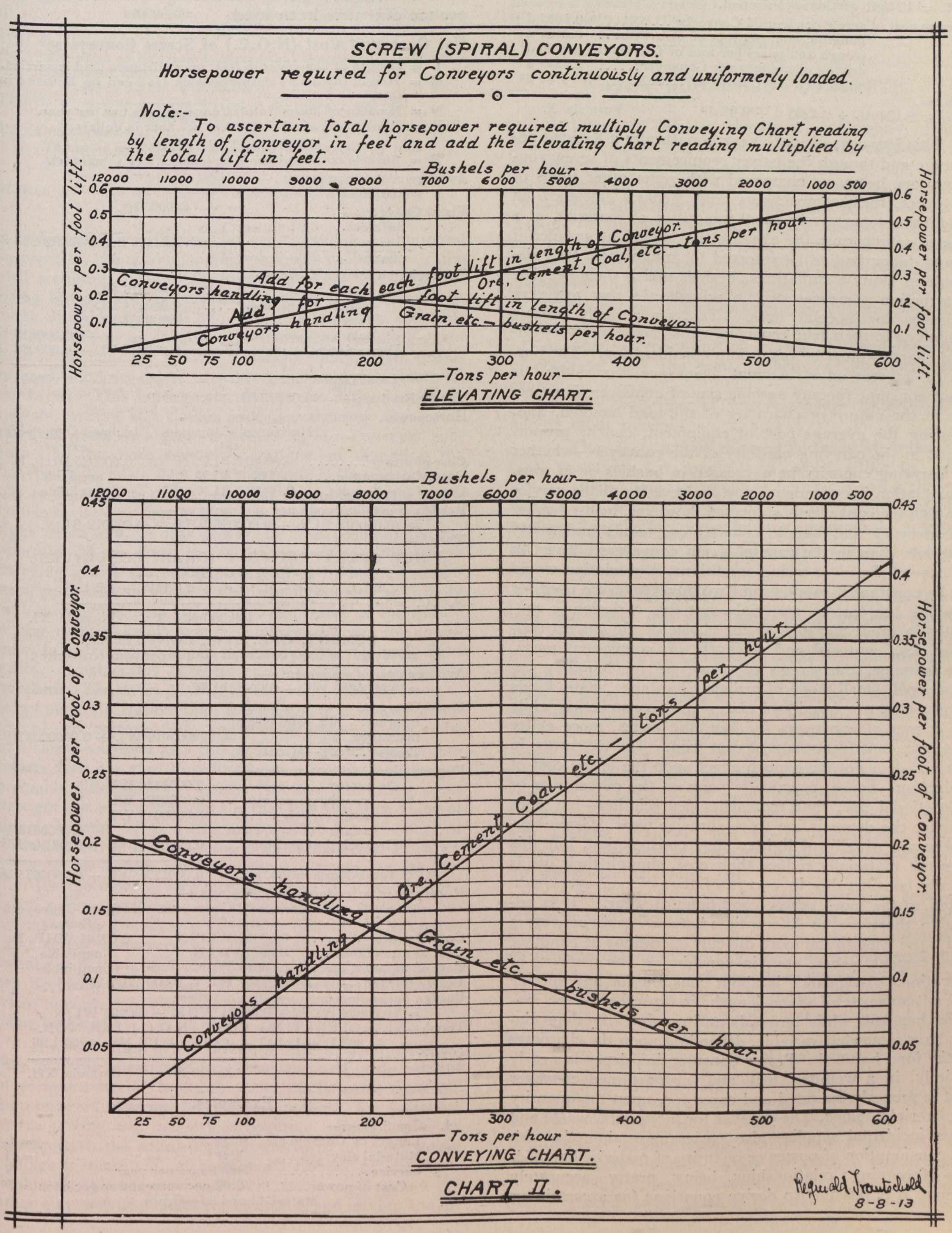


CHART II.

tion and of the ordinary supporting structures required—items which should be rightfully charged against initial cost of equipment.

Cost of Equipment:

C = Cost of Screw Conveyer equipment in dollars.
d = diameter of Conveyer (screw) in inches.
L = Length of Conveyer in feet.

Average cost of screw per foot of Conveyer	0.1653 d
hangers, etc., per foot of Conveyer...	0.0107 d
trough and gates per foot of Conveyer	0.0200 d
driving machinery per Conveyer......	2.3233 d
ends, etc., per Conveyer	$0.0700\ d^2$

Then:—

$$C = 0.196\ dL + 2.3233\ d + 0.07\ d^2 \qquad \text{Formula X.}$$

This low cost of machinery is naturally a decided advantage and though the power requirements of screw conveyers are heavy as compared with some other types of conveyers, their compactness and general efficiency in handling comparatively small quantities of material, at a decided saving over the expense that would be entailed if manual labor had to be resorted to, make them very desirable in many installations, besides which their peculiar construction possesses certain advantages that are very desirable for special uses. To form a really reliable opinion as to their true economic value, however, the overhead charges must be taken into consideration. The burden of interest on investment, insurance, taxes, etc., is about constant for any specific size of conveyer, irrespective of the nature or character of the load handled, and, knowing the average cost of equipment, can be proportioned to the carrying capacity of the conveyer—whether the carrying capacity be expressed in bushels or in tons. Depreciation is dependent upon the severity of the service to which the conveyer is subjected, however, being greater in conveyers that handle cement, ore, coals and gritty materials than in the case of grain conveyers. Even in the case of the more trying conditions, depreciation would not be constant if exactly similar conveyers were used for handling the various materials, but this variation is controlled in great measure by the choice of the correct conveyer, i.e., material and strength of component parts. For instance, the screws of conveyers for handling cement, coal, small stone of ordinary hardness, many kinds of ore, etc., are usually of heavy steel construction while the screws of conveyers for handling ashes, more gritty ores, etc., are frequently of cast iron. The difference in material does not have much effect upon the initial cost of equipment—hence, practically none on the percentage or proportional part that represents depreciation—but does equalize the depreciation from abrasive wear. Grain conveyers are usually of lighter steel construction, but this does not materially reduce their cost, though their life is usually considerably in excess of that of conveyers subjected to the more severe conditions of wear. It is advisable, therefore, to differentiate between grain conveyers and those used in the more difficult operations of handling ores, cement, ashes, etc., in considering the net cost of operation. Attendance is about constant for any specific size of conveyer of given length, irrespective of the material handled, while renewals and repairs, like depreciation, are somewhat variable, depending upon the character of the load handled. Power consumption depends nearly entirely, in a well-designed and proportioned conveyer that is properly operated and cared for, upon the quantity of material handled. The expense for lubricants, waste and other incidental supplies also varies approximately with the consumption of power or quantity of material handled. The foregoing relationships being pretty accurately known, it is possible to derive equations for ascertaining the average net cost of operation of screw conveyers upon which a reliable opinion of their economic value can be based. Such equations are given as Formulæ XI. and XII., the former applying to grain conveyers and giving the net operating cost per bushel handled and the latter applicable to screw conveyers handling ores, coal, ashes, cement, etc., etc., giving the average net operating cost per ton of material conveyed.

Net Operating Cost (N.O.C.) of Screw Conveyers:

L = Length of Conveyer in feet, max. distance load is carried.
H = Height (distance) through which load can be elevated in feet.
N = Number of hours (total) Conveyer is in use per year.
P_c = Price (cost) of a horsepower per hour in dollars.

GRAIN CONVEYERS.

B = Bushels conveyed per hour (capacity of Conveyer).

Average cost of equipment:—
= 0.01703 BL + 0.02458 B.

Fixed Charges:—
Interest.. 6% total cost; Insurance 1%; Taxes .. 2%—¾ cost } = 0.0014426 BL + 0.0020893 B

Depreciation renewals, etc.:—

On screw	0.001915 BL
trough, gates, etc.	0.000174 BL
hangers, etc.............	0.000062 BL
balance of equipment	+ 0.000819 B
Depreciation account	0.000215 BL + 0.000082 B
Total Depreciation, etc. =	0.002366 BL + 0.000901 B

Yearly Burden:— = 0.00381 BL + 0.00299 B.

Horsepower, attendance, supplies, etc.:—

	Horizontal Conveyers (total)	Inclined Conveyers (extra)
Cost of power	$0.000017\ BLP_c\ N$	$0.000025\ BHP_c\ N$
Cost of attendance....	0.000002 BLN	negliable
Cost of supplies, etc...	0.000010 BLN	negliable

Burden depending upon use of Conveyer:—
= $(0.000017\ BLP_c + 0.000025\ BHP_c + 0.000012\ BL)N$.

Then:—

NET OPERATING COST (GRAIN CONVEYERS) PER BUSHEL.

$$\text{N.O.C.} = \frac{381\ L + 299 + (1.7\ LP_c + 2.5\ HP_c + 1.2\ L)N.}{100{,}000\ N} \qquad \text{Formula XI.}$$

CEMENT, ORE, ETC., CONVEYERS.

W = Weight of load conveyed in tons per hour (capacity).

Average cost of equipment:—
= 0.0005255 WL + 0.0006161 W

Fixed Charges:—
Interest.. 6% total cost; Insurance 1%; Taxes .. 2%—¾ cost } = 0.00003617 WL + 0.00006237 W

Depreciations, renewals, etc.:—

On screw	0.0001436 WL
trough, gates, etc. ..	0.0000131 WL
hangers, etc.	0.0000047 WL
balance of equipment.	0.0000616 W
Depreciation account ...	0.0000161 WL + 0.0000062 W
Total depreciation, etc. =	0.0001775 WL + 0.0000678 W

Horsepower, attendance, supplies, etc.:—

	Horizontal Conveyers (total)	Inclined Conveyers (extra)
Cost of power	$0.00068\ WLP_c\ N$	$0.00101\ WHP_c\ N$
Cost of attendance	0.00010 WLN	negliable
Cost of supplies, etc...	0.00040 WLN	negliable

Yearly Burden:— = 0.00021367 WL + 0.00012017 W

Burden depending upon use of Conveyer:—
= $(0.00068\ WLP_c + 0.00101\ WHP_c + 0.0005\ WL)N$

Then:—NET OPERATING COST (N.O.C.) PER TON.

$$\text{N.O.C.} = \frac{21.367\ L + 12.017 + (68\ LP_c + 101\ HP_c + 50\ L)N}{100{,}000\ N} \qquad \text{Formula XII.}$$

Examples.

I. Conditions:—

Length of Conveyer..	30′ 0″	= L
Material elevated	8′ 0″	= H
Service...............	2400 hours per year	= N
Cost of power.... .	$0.02 per horsepower per hour	= P^c

Material handled—Grain

$$\text{N.O.C.} = \frac{11430 + 299 + 89808}{240000000} = \$0.000423 \text{ per bushel.}$$
$= 42.3$ cents per thousand bushels.
Equivalent to about $0.01692 per ton.

II. Conditions:—
The same as Example I, except that service is 12000 hours per year.

$$\text{N.O.C.} = \frac{11430 + 299 + 44904}{120000000} = \$0.000472 \text{ per bushel.}$$
$= 47.2$ cents per thousand bushels.
Equivalent to about $0.01888 per ton.

III. Conditions:—
The same as Example I, except that the material handled is fine (small size) coal.

$$\text{N.O.C.} = \frac{641 + 12.017 + 3736704}{240000000} = \$0.01557 + \text{ per ton}$$

IV. Conditions:—
The same as Example III, except that service is 1200 hours per year.

$$\text{N.O.C.} = \frac{641 + 12.017 + 1868352}{120000000} = 0.01558\text{—per ton}$$

Assuming conditions that are commonly encountered in practice, the accompanying examples well illustrate the real economic value of the screw conveyer and they also bring out apparently surprising facts. Under the conditions considered, it will be noted that the screw conveyer is not relatively as economical a method of handling grain as it is for handling heavier materials such as coal, ore or cement—that is, when measured by weight of material conveyed. This is true even though the depreciation, renewals, repairs and similar expenses are only about one-third as great in a grain conveyer as in a conveyer subjected to the more severe operations of handling the heavier materials. The reason for this is that proportionally to the weights of the materials the capacity of a screw conveyer is very much less when handling the relative light grain and, as less power is also required for the operation of any given size of conveyer of specified length carrying grain, the burden represented by interest on investment, insurance and taxes, which amounts to a more or less constant sum per year, irrespective of the nature of the material handled or the number of hours the equipment is in operation, is, in the case of the relatively light grain, considerably greater per weight of material handled. The average weight of grain, etc., is from 25 to 50 per cent. lighter than the weight of a similar quantity of ore, cement, etc., and though the economic value of a screw conveyer as a carrier for the two classes of materials does not vary to quite such an extent, still, an appreciable difference does exist. Another interesting point brought out by the examples is that the economic value of the equipment is not affected as much by the hours of operation when handling the heavier materials as when carrying the lighter grains. This is also due to the fact that for the more severe work the item of power is very much greater proportionally than when the working conditions of the conveyer present less difficulty. Nevertheless, screw conveyers are frequently employed in the handling of grain and of materials of similar nature and are decidedly economical at such service; particularly when they are long, as then the overhead burden is somewhat lessened.

A modification of the standard type of screw conveyer that has been considered is extensively used in the mixing of several materials while they are, at the same time, being conveyed from one location to another. For instance, in the mixing and delivery of concrete. Such conveyers usually have the spiral flight in the form of succeeding paddles in place of a continuous ribbon, or else have double flights, one a ribbon flight for conveying and the other a system of paddles for agitating and mixing the ingredients. These adaptations, however, although they are examples of apparatus for mechanically handling materials, should not be classed with standard types of conveying machinery, the principal subject of the present discussion.

[NOTE.—This is the second of a series of articles bearing upon the Mechanical Handling of Materials written for *The Canadian Engineer*. A third article will follow in an early issue.—Ed.]

WATERPROOFING OF CONCRETE.

Although it did not arrive at sufficiently definite conclusions to enable it to formulate specifications for the making of concrete structures waterproof, or for materials to be used in such work, the Committee on Waterproofing Materials, of the American Society of Testing Materials, reached certain conclusions which will be of assistance in securing impermeable concrete. These formed the basis of the committee's report at the convention in Atlantic City in June.

The work was found to subdivide naturally into three branches:

1. The determination of causes of the permeability of concrete, and the best methods of avoiding these causes.

2. The rendering of concrete more waterproof by adding other substances.

3. The treatment of exposed surfaces after the concrete or mortar has been put in place, either by penetrative, void-filling or repellent liquids, making the concrete itself less permeable; or by extraneous protective coatings, preventing water having access to the concrete.

These several subdivisions were considered separately:

Causes of Permeability of Concrete.—In the laboratory and under test conditions using properly graded and sized coarse and fine aggregates, in mixtures ranging from 1 cement, 2 sand and 4 stone to 1 cement, 3 sand and 6 stone, impermeable concrete can invariably be produced. Even with sand of poor granulometric composition, with mixtures as rich as 1 cement, 2 sand and 4 stone, permeable concrete is seldom, if ever, found and is a rare occurrence with mixtures of 1 cement, 3 sand and 6 stone. But the fact remains, nevertheless, that the reverse often obtains in actual construction, permeable concretes being encountered even with 1 cement, 2 sand and 4 stone mixtures, and are of frequent occurrence where the quantity of the aggregate is increased. This the committee attributed to:

(a) Defective workmanship, resulting from improper proportioning, lack of thorough mixing, separation of the coarse aggregate from the fine aggregate and cement in transporting and placing the mixed concrete, lack of density through insufficient tamping or spading, and improper bonding of the work joints, etc.

(b) The use of imperfectly sized and graded aggregates.

(c) The use of excessive water, causing shrinkage cracks and formation of laitance seams.

(d) The lack of proper provision to take care of expansion and contraction, causing subsequent cracking.

Properly graded sands and coarse aggregates are rarely, if ever, found in nature in sufficient quantities to be available for large construction, and the effect of poorly graded aggregates in producing permeable concrete is aggravated by poor and inefficient field work. Even if the added expense could be afforded of screening and remixing the aggregates so as to secure proper granulometric composition to give the density required to make untreated concretes impermeable, it is seemingly often a commercial impossibility on large construction to obtain workmanship even approximating that found in laboratory work.

Addition of Foreign Substances.—The committee found that, in consequence of the conditions outlined above, substances calculated to make the concrete more impermeable, either incorporated in the cement or added to the concrete during mixing, are often used.

The committee had investigated a sufficient number of the special waterproofing compounds on the market, as well as the use of certain very finely divided mineral products, such as finely ground sand, colloidal clays, hydrated lime, etc., to form a general idea of the value of the different types. It reported that:

(a) The majority of patented and proprietory integral compounds tested have little or no immediate or permanent effect on the permeability of concrete and that some of these even have an injurious effect on the strength of mortar and concrete in which they are incorporated.

(b) The permanent effect of such integral waterproofiing additions, if dependent on the action of organic compounds, is very doubtful.

(c) In view of their possible effect, not only upon the early strength, but also upon the durability of concrete after considerable periods, no integral waterproofing material should be used unless it has been subjected to long-time practical tests under proper observation to demonstrate its value, and unless its ingredients and the proportion in which they are present are known.

(d) In general more desirable results are obtainable from inert compounds acting mechanically than from active chemical compounds whose efficiency depends on change of form through chemical action after addition to the concrete.

(e) Void-filling substances are more to be relied upon than those whose value depends on repellent action.

(f) Assuming average quality as to size of aggregates and reasonably good workmanship in the mixing and placing of the concretes, the addition of from 10 to 20 per cent. of very finely divided void-filling mineral substances may be expected to result in the production of concrete which under ordinary conditions of exposure will be found impermeable, provided the work joints are properly bonded, and cracks do not develop on drying, or through change in volume due to atmospheric changes, or by settlement.

External Treatment.—While external treatment of concrete would be necessary if the concrete itself, either naturally or by the addition of waterproofing material, was impermeable, it was found in practice that in large construction, no matter how carefully the concrete itself has been made, cracks are apt to develop, due to shrinking in drying out, expansion and contraction under change of temperature and moisture content, and through settlement.

It is, therefore, often advisable on important construction to anticipate and provide for the possible occurrence of such cracks by external treatment with protective coatings. Such coating must be sufficiently elastic and cohesive to prevent the cracks extending through the coating itself. The application of merely penetrative void-filling liquid washes will not prevent the passage of water due to cracking of the concrete. The committee therefore, divided surface treatment into two heads:

(a) Penetrative void-filling liquid washes.

(b) Protective coatings, including all surface applications intended to prevent water from coming in contact with the concrete.

While some penetrative washes may be efficient in rendering concrete waterproof for limited periods, their efficiency may decrease with time, and it may be necessary to repeat such treatment. The committee, expressed its belief that the first effort should be made to secure a concrete that is impermeable in itself and that penetrative, void-filling washes should only be resorted to as a corrective measure.

While protective extraneous bituminous or asphaltic coatings are unnecessary, so far as the major portion of the concrete surface is concerned, provided the concrete is impermeable, they are valuable as a protection where cracks develop in a structure. It therefore recommended that combination of inert void-filling substances and extraneous waterproofing be adopted in especially difficult or important work.

Bituminous or Asphaltic Coatings.—Considering the use of bituminous or asphaltic coatings, the committee found that:

(a) Such protective coatings are often subject to more or less deterioration with time, and may be attacked by injurious vapors, or deleterious substances in solution in the water, coming in contact with them.

(b) The most effective method for applying such protection is either the setting of a course of impervious brick dipped in bituminous material into a solid bed of bituminous material or the application of a sufficient number of layers of satisfactory membranous material cemented together with hot bitumen.

(c) Their durability and efficiency are very largely dependent on the care with which they are applied.

Such care refers particularly to proper cleaning and preparation of the concrete to insure as dry a surface as possible before application of the protective covering, the lapping of all joints of the membranous layers, and their thorough coating with the protective material. The use of this method of protection is further desirable because proper bituminous coverings offer resistance to stray electrical currents.

Richer Mixtures.—So far the committee had considered only concretes of the usual proportions, namely, those ranging from 1 cement, 2 sand and 4 stone, to 1 cement, 3 sand and 6 stone. It was suggested that impermeable concretes could be assured by using mixtures considerably richer in cement. While such practice would probably result in an immediate impermeable concrete, the advantage is believed to be only temporary, as richer concretes are more subject to check cracking and are less constant in volume under changes of conditions of temperature, moisture, etc. Therefore, the use of more cement in mass concrete would cause increased cracking, unless some means of controlling the expansion and contraction be discovered. With reinforced concretes the objection is not so great, as the tendency to cracking is more or less counteracted by the reinforcement.

It was also suggested that the presence in the cement of a larger percentage of very fine flour might result in the production of a denser and more impermeable concrete, through the formation of a larger amount of colloidal cells.

Neither of these suggestion was especially investigated by the committee. Both appealed, however, for the reason that they substitute active cementitious substances for the largely inactive void-filling materials previously recommended, thus increasing the strength of the concrete.

In conclusion, the committee pointed out that no addition of waterproofing compounds or substances could be relied upon to counteract completely the effect of bad workmanship, and that the production of impermeable concrete could only be hoped for where there is determined insistence at all times on good workmanship.

The production of impermeable concrete has assumed greater importance since the appointment of the committee, owing to the well-known injurious action of saline or alkaline waters, and to the suggested possible effect of the moisture in concrete occasioning or aggravating electrical action from stray currents.

Originally the question of waterproofing involved mainly the physical troubles resulting from water passing through the concrete, without any special consideration of its effect on its durability, other than a gradual leaching out of the cement. Recent developments suggest the possibility that owing to the increased conductivity of damp concrete to electrical currents, such currents, if present, may so effect damp concrete as to lessen its integrity seriously, and this possibility further emphasizes the importance of the recommendation that no waterproofing compound of unknown chemical composition be added to concrete, as recent tests seem to show that the action of electrical currents is aggravated by the presence of certain solutions.

THE CANADIAN PUBLIC HEALTH CONGRESS.

The third annual Congress of the Canadian Public Health Association will be held in Regina, September 18th, 19th and 20th. The city hall has been placed at the disposal of the members for the general sessions, while sectional meetings will be held in Regina College, the Board of Governors having granted the use of its buildings for this purpose.

The social functions of the Congress will include a luncheon at the Parliament Buildings on September 18th, tendered by the Government of Saskatchewan, the annual dinner of the Association to take place that evening, when the members will be the guests of the city of Regina; a visit to the city sewage disposal works on the following day, and on the last day of the Convention a trip to Fort Qu'Appelle, one of Saskatchewan's summer resorts, where the new sanitorium buildings are under construction.

The programme for the general session includes seventeen papers. Section I., for Medical Officers of Health; Section II., Medical Inspection of Schools; Section III., Military Hygiene; Section IV., Veterinary Hygiene and Food Inspection; Section V., Sanitary Inspectors; Section VI., Engineers and Architects; Section VII., Laboratory Workers; Section VIII., Social Workers. All have individual lists of papers bearing directly upon the science of public health.

Arrangements have been made with the Eastern and Western Passengers' Association whereby a standard certificate can be obtained at any railway station entitling the holder to reduced return fair, the advice of the committee being to purchase a one-way ticket to Regina, securing at the same time the standard certificate.

THE DETERMINATION OF THE MAGNETIC MERIDIAN.

By J. A. MacDonald.

THERE had not been much done in the way of determination of the magnetic meridian at various points throughout Canada until a short time ago, when the Topographical Surveys Department of which Dr. Deville is at the head, took up this work in connection with Dominion land surveys in the Western provinces. Nothing of much account has yet been done in the older provinces by the Canadian Government, although the United States geogetic surveys branch has done considerable work in various parts of the Dominion in the way of determining magnetic declinations. The writer, a few years ago, determined the magnetic declination, at a point in one of the Maritime Provinces where no observation for magnetic declination had ever been made for the United States Geogetic Surveys. Data has, of course, been furnished by the Marine Department at the various harbors in Canada, for the information of navigators, but this data is of no value to those using compasses on land.

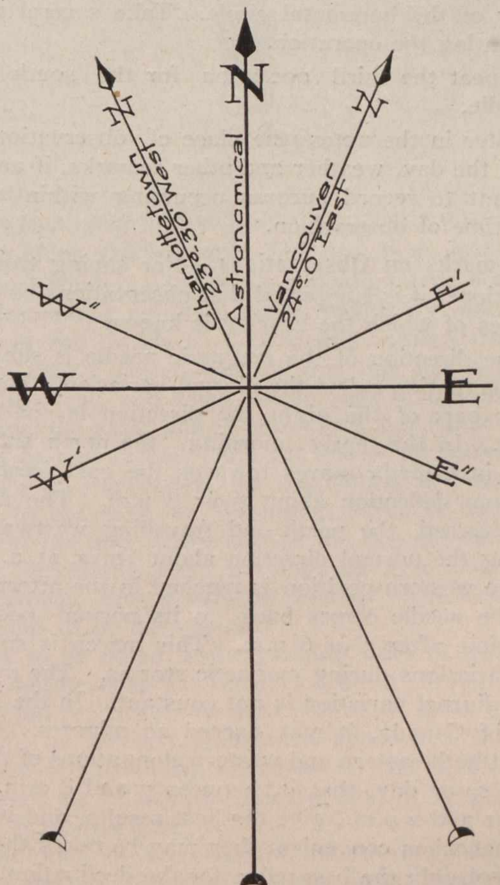


Fig. 1.—Magnetic Declinations.

The Magnetic Needle Still Used for Establishing Lines.—Although the compass is not allowed for establishing lines of Dominion land surveys, it is employed by most of the older provinces, and a knowledge of the direction of the magnetic meridian or of the magnetic declination is of absolute importance. The directions given for obtaining magnetic declinations in the Manual for Dominion Land Surveyors is very explicit.

For the determination of this direction, transit theodolites of the D.L.S. pattern are fitted with especially sensitive needles. As the observation can be made in a few minutes and with very little trouble, it is desirable that all surveyors should observe when they can do so without inconvenience.

The observation and recording forms are arranged for the determination of the bearing of the magnetic needle instead of the magnetic declination. The arrangement is made for the sake of simplicity in observing and recording, the bearing in question being, subject to instrumental corrections, the angle read on the horizontal circle of the transit. Moreover, it is not liable to errors of sign, as in adding or subtracting the declination.

Directions for Observing.—Place the instrument on a section or other line, defined astronomically, and after adjustment, set the vernier to read the astronomical bearing of the line.

Release the lower clamp, direct the telescope on the line, and fasten the lower clamp.

Release the vernier clamp, and turn the vernier plate until the north end of the magnetic needle observed with a magnifying glass, is seen exactly opposite the zero mark. Tap the trough lightly with the pencil to be sure that the needle has taken the position of rest. Note the reading of the horizontal circle. Take several readings by repeating the operation.

Repeat the third operation for the south end of the needle.

Enter in the notes the place of observation, date, hour of the day, weather and other remarks, if any. It is important to record auroras occurring within 24 hours of the time of observation.

Remarks on Observations.—For saving trouble and calculations, it is suggested that observations be made on any lines of which the bearing is known.

The direction of the magnetic needle is subject to a daily fluctuation called the diurnal variation. During the greater part of the night the direction is not far from normal. In the early morning, the north end of the needle in Canada moves towards the east, reaching its maximum deflection about 7 or 8 a.m. The motion is now reversed, the north end travelling westwards, and crossing the normal direction about 10 or 11 a.m. The extreme western position is reached in the afternoon and then the needle comes back to its normal position at some time after 5 or 6 p.m. This march is subject to wide variations during magnetic storms. The magnitude of the diurnal variation is not constant. In the inhabited parts of Canada, it may exceed 20 minutes. Observations at both eastern and western elongations of the needle on the same day, that is, between 7 and 8 a.m. and between 1 and 2 p.m., give the best results, and it is desirable that when convenient they may be taken then. This gives not only the best value for the declination, but also the diurnal variation which it is most useful to know. Failing this, however, the best time to observe is after 5 p.m., when the needle is about in its normal position. It is true that the normal position is crossed generally between 10 and 11 a.m., but the motion being very rapid and the time of crossing uncertain, the afternoon observation is preferable.

When an instrument is brought from England, where many of the transits and compasses are made, it is usually found that the north end of the needle is dropping. To balance it without injuring the pivot point or cap, proceed as follows:—

Raise the needle with the lifter, unscrew the end of the trough, withdraw the cover glass, take out the needle and shift the small brass counterweight. Then the lifter being still raised, place the needle upon it and lower the lifter gently. If the needle is not yet balanced, raise the lifter again and repeat the operation. The greatest care must be taken not to bend the needle in the slightest degree while shifting the counterweight, because the bending would change the direction of the magnetic axis.

If the needle is sluggish, the observation cannot be accurate. The sluggishness is generally due to a dull pivot or a scratched cap. To keep both in proper condition, the needle must always be lowered gently on its pivot and never be allowed to play, except when actually in use.

OBSERVATION FOR MAGNETIC DECLINATION

Date 19th July 1908 Observer G. J. Lonergan D.L.S.

Place 40 Chs. E of the S.E. Cor. of Sec. 5

Tp. 50 Rge. 20 W. of 4th Mer.

Time 7 15 P.M. Instrument Watts #2216 (Give No.)

Bearing of reference line 89° - 59'

H. C. R. FOR DIRECTION OF MAGNETIC NEEDLE.

	NORTH END.	SOUTH END.
(1)	27 - 15'	27 17
(2)	11	16
(3)	12	10
(4)	11	10
(5)	10	12
Mean	*Mean of North End.* 27 - 11·8	*Mean of South End.* 27° - 13.0'

(a) H. C. R. of compass north	27 - 12.4'
(b) Corr. for convergence	− 1.2
(c) Bearing of compass north	27 - 11.2
(d) Index error	5.8
(e) Bearing of magnetic north	27 - 05.4

REMARKS.

A few clouds Windy

No aurora.

Fig. 2.

Explanation of Specimen Observation.

1. The H.C.R. of compass north is the average of the mean north and south end readings. The transit was adjusted to read correctly the bearing of the section line, so that the horizontal circle reading of compass north is the bearing of compass north referred to the astronomical meridian through the centre of the township. If the transit had not been so adjusted a correction to this reading would have been required.

2. The correction for convergence has for object to refer the bearing read on the horizontal circle to the astronomical meridian of the point of observation. The value of the correction is taken from the diagram in the

Astronomical Field Tables. It is added when the point of observation is in the east half of the township, and subtracted in the other half. The rule of clause 69 of the Manual is inverted, the object in this case being to refer the bearing to the meridian of the point of observation.

3. The bearing of compass north has now been referred to the meridian of the point of observation.

4. The index error is furnished with each instrument after comparison with the unifilar magnetometer.

5. The bearing of magnetic north is the angle formed by the astronomical and magnetic meridians.

There are instances of the polarity of the needle being reversed by transporting an instrument on an electric car. It is difficult to conceive that a needle may be brought into such an intense magnetic field as that of an electric car without its magnetism being effected in some way, therefore, it is preferable to avoid this mode of transportation.

The place of observation must be at least three or four hundred yards away from electric wires carrying direct current. The observer must scrutinize his clothing and make sure that he has no iron or nickel on his person, as there must be no iron near the instrument. Iron is found in buttons, as wire in hat brims, in some forms of neckties, in watches, chains and other articles of jewelry. The pivot in folding reading glasses is frequently made of iron. In case of doubt, the object may be tried close to the compass, measuring the distance at which an appreciable deflection is first produced. If the object during the observation for declination is not brought closer than 15 or twenty times the above distance, the effect on the needle is negligible in observations of this kind.

The needle may be deflected by static electricity developed in cleaning the glass cover of the compass trough or the rubber frame of the reading glass; this electricity is dissipated by breathing on the glass or rubber frame.

There is an index correction for each instrument. This is ascertained by comparison with a standard unafilar magnetometer at the Magnetic Observatory. When possible, it is well to determine the index error both at the beginning and at the end of a survey.

Setting a Transit by Means of the Compass.—In connection with surveys of Dominion lands, the most frequent use of the compass is for checking the courses of a traverse or for setting up the transit to read astronomical bearings.

In the first case, it is sufficient to make sure that there is no abnormal change in the reading of compass north: any sudden change indicates a probable mistake in some of the last courses.

The second case arises when it is desired to observe the pole star in day time at a place where there is no line of known bearing. The problem consists in setting up the transit so that it shall read astronomical bearings. If the surveyor has already ascertained the bearing of compass north with his instrument, he merely sets his vernier to read this bearing, releases the lower clamp, turns the whole instrument till the needle is exactly opposite the zero mark, fastens the lower clamp and releases the vernier clamp. With the instrument used for the specimen observation and anywhere near the place where the observation was taken, the vernier would be set to read 25°, or rather $25^\circ\ 07'$.

It may be, however, that the surveyor has not ascertained the bearing of the compass north with his own instrument and has to resort to the bearing of magnetic north taken from a map or determined by another surveyor. Then the surveyor must, from the bearing of magnetic north, deduce the bearing of compass north by applying the index error of his own instrument after changing the sign. Starting with $25^\circ\ 01'.1$, for bearing of magnetic north in the case already cited, and the index error being—$51'.8$, the surveyor would add $5'.8$ to $25^\circ\ 01'.1$, which would give him $25^\circ\ 06'.9$ for the bearing of the compass north. He would then proceed as already explained.

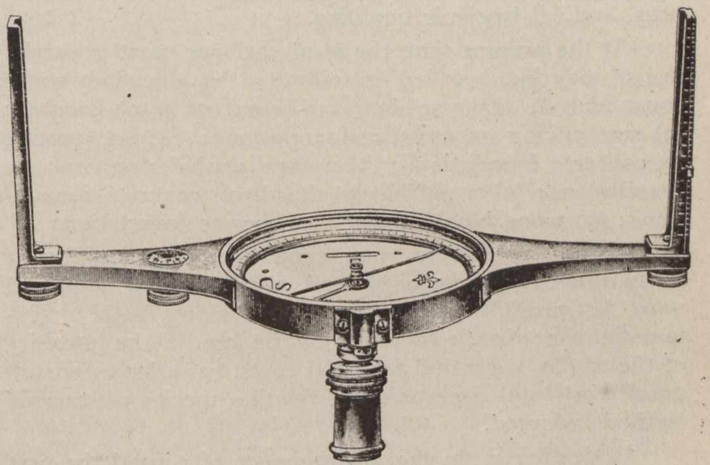


Fig. 3.

All these corrections, it may be observed, are generally small and in practice are frequently disregarded.

Line of no Declination.—The line of no declination, or the line which a needle will indicate a true north and south direction is situated in any imaginary line drawn from Sault Ste. Marie to Charleston, South Carolina. A magnetic needle placed east of this line has a declination to the west, and when placed west of the line a declination to the east; and in both cases it increases as the needle is carried farther from the line of no declination.

Thus, in Vancouver, the declination is twenty-four degrees to the east, at Winnipeg eleven to twelve, to nothing at the Soo; while east of the Soo the declination is west, increasing from nothing, to 23½ degrees, at Charlottetown, Prince Edward Island. The declination is now said to be decreasing.

It is to be noted in determining lines of declination that the needle does not remain constant through an entire day, but reaches its farthest point east about 8 o'clock a.m., and its farthest point west about 2 o'clock p.m. The cause of this daily variation of the needle is not understood, as observations show that it is greater in summer than in winter.

Conditions of temperature, magnetic storms and other causes at times affect the needle and different needles observed at the same time and under the same conditions differ in their directions, but show nearly the same daily change.

Gaspe Bay district has high hopes of oil-producing possibilities. In view of the increasing attention being given to the adoption of oil in the Royal Navy and the decision of the Imperial Government to secure supplies so far as possible within the Empire, there opens up the prospect of another large Canadian industry. The admirable shipping facilities which the district possesses are receiving attention.

ROAD MAINTENANCE AND COST.

By Hector F. Gullan, M. Inst. C.E.,
Superintendent to the Works Department of the City and County Borough of Belfast.

SCIENTIFIC road maintenance is not only the mere continuance of an existing form of road surface by the most approved methods, but should mean the providing of a road surface which is best suited for the traffic it is called upon to bear having regard to (*a*) cost of maintenance and cleansing, (*b*) economy in regard to wear and tear on the traffic using same, (*c*) noiselessness, and (*d*) hygienic qualities.

At the present time the road surfaces most generally in use may be classified as follows: (1) Macadam water consolidated; (2) macadam tar-bound or pitch-grouted; (3) sett paving on existing foundations; (4) sett paving on concrete foundations; (5) natural asphalts on concrete foundations; (6) wood blocks (hard) on concrete foundations; (7) wood blocks (soft) on concrete foundations.

To secure efficient road maintenance the quality of the various materials used and workmanship employed must be carefully determined, and, along with a systematic inspection, records should be kept of the intensity of the traffic, wear and tear and costs, in order to ensure good work and ascertain the relative merits of various methods adopted.

In dealing with the maintenance of a road the first essential is that the road, including the foundation, shall be sufficiently substantial to support the traffic passing over it, and where such is not the case, either in patches or over considerable lengths, it will be found to tend to ultimate economy to go to considerable expense, either in strengthening the roadway generally or renewing the foundations.

Water-consolidated macadam roads, which, at the present time, form by far the greater percentage of the road surfaces of the country, have, on account of the growth of motor traffic of all kinds, proved themselves to be, in spite of the greatest care being exercised in the selection of the material and skilful workmanship, in many cases altogether unsuitable. In several cases the cost of maintenance has increased during the last eight years as much as 100 per cent., and along with this increase the nuisance arising from dust has become almost intolerable.

In selecting the stone for repair work the greatest care must be taken to obtain a thoroughly hard and tough material, and it has been the practice of the author for some years to test mechanically the stone from various quarries in a form of "rattles" machine. The stone submitted for testing, after being broken to a standard size, is carefully weighed and placed inside the machine. The number of revolutions per minute is uniformly regulated, and an automatic recorder indicates the number of revolutions during the period of the test. The stone is afterwards removed from the cylinder and again weighed, and the percentage of loss due to wear and tear ascertained. This machine has been found to be of the greatest value in determining the wearing qualities of various stones.

After every care has been taken to determine the wearing quality of the stone to be used in the maintenance of roads, there is yet one condition which must be carefully observed, especially in the case of road surfacing, in order to obtain entirely satisfactory results—it is, ensuring that the material used over a given surface is of a uniform quality. The indiscriminate use of two or more stones of different qualities, even when relatively good, both in paved streets and macadam roads, will be found to produce very disastrous results. On macadam roads in particular the traffic will very soon find out the spots where the softer material is situated. Where the surface begins to wear down below the harder material surface water will gather, slightly at first and gradually increasing, with the result that the crust of the road is softened, and the less hard material is subjected to the disintegrating effects of the weather to a far greater degree than the other parts of the road, thereby causing further damage, and, in combination with the traffic, the wear goes on daily in an increasing ratio, and the general surface of the road rapidly becomes a series of hills and hollows.

Before recoating a macadam road the custom is to scarify the surface of the old road crust. After gathering all loose material to the side, a coat of about 3 in. of new metal is carefully spread, and before being rolled the old material from the side of the road is uniformly scattered over the new stone. This coat is rolled dry until all the stones are firmly bedded in position, and is then lightly sprinkled with water. A coating of ½-in. screenings or chippings is then spread, the screenings having been first damped. This coat is then watered sufficiently to allow the roller to work over the same without picking up the material, and from time to time additional water is sprinkled until the binding material has gradually worked its way into the interstices. Two men are employed in front of each roller lightly brushing the ½-in. chippings so that the surface is uniformly fed with the fine stone. It is found that the screenings being damped before use find their way more uniformly between the stones, and that the fine material is not washed through the new stone, but helps to close the road crust along with the coarser chippings.

The author is of opinion that in many cases the quantity of water used in consolidating a macadam road is considerably overdone. In wet weather on flat roads little or no water is necessary. In Ireland in the dryest of summer weather not more than 3½ gallons of water per square yard of road surface is required. The average quantity of water used last year on upwards of 220,000 sq. yds. was somewhat over 400,000 gallons, and works out at 1.84 gallons per square yard. A final coat of gravel, about ⅛ in. in depth, greatly assists in finishing the road surface, and protects a new road from the effects of traffic.

In the North of Ireland, on account of the variable climate, tar-spraying has not met with any considerable success. The greatest difficulty has been found in carrying out the work during suitable weather, and in many cases the mud arising in the winter from roads which have been thus tarred has given a great amount of trouble.

Except where very heavy traffic exists, on a properly maintained ordinary macadam road a general patching of the surface should never be necessary, and where, owing to exceptional circumstances, such repairs have to be undertaken, the work should only be done during wet weather. The method found most satisfactory has been to slightly rough the surface of the road requiring such repair, and to make use of stone of 1½-in. gauge, blinding the new surface with a sufficient coating of ½-in. chippings from which the stone dust has not been extracted. These are carefully packed by the surfaceman, and

---

*Extracted from a paper presented to the "Surveyor," of London.

all such patches are tightened up twice or three times daily with a brush. In ordinary wet weather, with proper attention, such patches will consolidate under the traffic and become an integral part of the road surface in about three days.

Tar-Macadam Roads, Etc.—A very large number of methods are in operation in the preparation of a tar-macadam or pitch-grouted surface, and the author, in submitting his remarks under this heading, wishes it to be understood that he in no way dogmatizes as to the best form of construction, but rather desires to convey the principles which have guided him in arriving at his present method.

In the manufacture of tar-macadam it is essential that all moisture should be expelled from the stone, and that after it has become absolutely dry the heated stone should be thoroughly mixed with the boiling tar preparation. The heat used for the drying of the stone should be duly regulated, and the proper proportion of boiling tar applied to thoroughly coat all the particles of stone.

In Belfast an entirely novel tar-macadam plant has been devised by the author by which the resources of a refuse destructor have been availed of for drying and heating the stone and boiling the tar mixture, which, if required, can deal with an output of 10,000 tons per annum, and has been working with entire satisfaction from June, 1910.

The general features are as follows: The stone supplied from the quarries is delivered at a high level to the drying towers. In its passage, by gravity, through the towers the stone is thoroughly dried and heated, and passes out at the lower end into a revolving mixer. Boiling tar, of sufficient quantity to thoroughly coat the stone, is also fed into the mixer, and the whole discharged at the outlet, thoroughly mixed, in the form of tar-macadam.

To obtain the heat from the furnace gases before passing up the destructor chimney a by-pass or loop has been built alongside the main flue, and two dampers or doors (one on the main flue and the other on the by-pass) have been built in at either end to regulate the passage of these gases. Into the by-pass a tubular air heater has been built through which, by means of a fan, fresh air is drawn and driven forward at a high temperature into the drying towers, where, after passing through the stone, it finds its way out at the top of the towers. The temperature of the hot air delivered to the drying towers is recorded by a pyrometer, and the heat required is regulated by the opening and closing of the dampers in the flues, and a cold-air inlet valve situated between the heater and the fan.

A cylindrical revolving mixer receives the stone from the outlets of the drying towers, and as the stone passes into the mixer it is treated with boiling tar delivered from one of a pair of tar-boilers on either side.

The power to drive the shafting and belting is derived from the destructor engine.

Twin towers are provided to secure a continuous supply of stone, the stone from one tower being drawn while the other is drying and heating. This arrangement also applies in the case of tar-boiling, and should it be required, there would be no difficulty in working continuously night and day.

Tar-macadam may be laid upon an existing roadway provided the levels of footpaths or abutting buildings will allow. If this is not the case, the surface of the existing roadway must be cut away to provide a sufficient depth for the new coating of tar-macadam, the formation being left to correspond with the finished camber of the tar-macadam. The camber generally adopted on a level tar-macadam road is 1 in 30, while on an incline this may be reduced to 1 in 40, or even 1 in 45. In the case of a tar-macadam road the foundation must be sufficient to support the road traffic independent of the road crust for at least twelve months after the tar-macadam has been laid; there is, in warm weather, a certain amount of "give" in the crust, which, if the road is not to disintegrate as a consequence of the traffic, must be entirely supported by the foundation.

Difficulty has been found in securing uniformity in the distribution of the various sizes of stone in the mass where the aggregate is prepared with mixed sizes, with the result that the road surface wears unequally. It has therefore been found desirable to lay the material in three separate layers, the utmost care being taken that all material shall be uniformly spread and rolled. The bottom layer, being of 1½-in. material, is first spread to a depth of 4 in. and compacted by light rolling, the intermediate coat of 1-in. material being then laid 2 in. in depth, and the two coats thoroughly combined by careful rolling. A top coat of ½-in. material is finally added and the surface rolled until the whole crust is thoroughly compacted. No advantage is obtained by an excessive amount of rolling. Only sufficient material is used in the top coat to thoroughly key the surface, and when finally consolidated the whole forms a tar-macadam crust 4 in. in thickness. After the road has been laid from six to nine months the surface is thoroughly cleansed, dressed with boiling tar, the surplus tar being absorbed and retained by covering off with a coating of fine stone dust. This tar painting may be repeated every two years, and greatly adds to the life of the surface crust.

In regard to repairs, it is of the utmost importance that any patching should be carried out as soon as the surface shows undue indications of wear, always providing that the work is done in dry weather. In executing such repairs the openings are carefully trimmed down plumb from the surface to an even depth, the whole is then thoroughly cleaned and given a light coating of a mixture of hot pitch and creosote oil and filled with 1-in. material, sufficient ½-in. being used to key the surface. The patch is then either rolled or well punned solid. In renewing surfaces it is well to deal with as long lengths as possible, the method adopted being the same as used in patching. In no case should the wear be allowed to extend below the finishing coats.

The life of a tar-macadam road varies in ratio to the intensity of the traffic, and has given best results in suburban roads. In the centre of the city, where subjected to heavy traffic, the results have not proved satisfactory. The author is, however, doubtful whether this is not due to defects in foundation rather than to failure in the wear of the tar-macadam surface crust.

Sett Paving on Existing Foundations.—The author has a considerable mileage of what may be termed second-class streets, through which a large amount of heavy traffic passes, paved with setts upon existing foundations. These setts are usually 6 in. deep, 3 in. broad, and from 5 in. to 7 in. in length, either of granite or whinstone. In most cases these streets were originally either ordinary macadam or boulder paving, and in consequence of the development of the district have been converted as indicated. In the case of a macadam road, sufficient depth is obtained for the new paving, and the old roadway trimmed off to the required contour. The setts are paved on a ¾-

in. bed of compo. formed of 4 parts of sea gravel to 1 of cement, and joined with a grout of 3 parts of sharp sand to 1 of cement. In the case of replacing boulder paving with setts the same method is adopted, with the exception that the setts are frequently bedded in the sand from which the boulders are taken, and grouted in cement. This class of carriageway forms a very serviceable and economical roadway, and although not having the appearance of better-class paving, provided the foundations are suitable, will withstand very considerable traffic. This paving, however, suffers considerably under traction engine traffic.

Sett Paving on Concrete Foundations.—In main thoroughfares and important streets traversed by heavy traffic of all descriptions, sett paving on concrete foundations is found the most serviceable. The concrete bed should be from 6 in. to 9 in. in depth, varying according to the subsoil; and having regard to the development of heavy self-propelled traffic, the author is inclined to advise that in no case should the concrete be less than 9 in. in depth. As mentioned before, the stone for sett paving is specially tested and selected, the requirements being a tough stone which at the same time will not become unduly slippery under horse traffic.

The standard size of setts used in Belfast is 4 in. square on head and 6 in. in depth, truly dressed on all surfaces, so that the setts can be paved on either end; the setts must be squared and dressed to the exact measurement (4 in. by 4 in.), and the variations in depth must not exceed ¼ in. The 4-in. sett on the surface affords greater foothold for horses, while, as compared with cubes, the extra 2 in. depth in the sett secures greater power of resistance to the rolling action of the traffic and breaking of the bond. The setts are paved upon a 1-in. bed of compo. formed of 4 parts of gravel and 1 part of cement, and again grouted with compo. of the same strength. Seven days are allowed for the jointing to set before the traffic is permitted to pass over the new paving.

The camber of a sett-paved roadway should not be greater than 1 in 50. In some cases the sett paving is grouted with a mixture of pitch and tar. This has the advantage of allowing the traffic to pass over the roadway as soon as the jointing has become thoroughly hardened. With properly selected stone this form of pavement will last under the heaviest traffic for fifty years, the setts during that period being once repaved with the lower ends upwards. At the present time there are in Belfast several heavy-trafficked streets near the quays which have been laid between forty and fifty years. Beyond this repaving, such repairs as are necessary cost on an average slightly less than one cent per square yard per annum.

Natural Asphalt, Hardwood and Softwood Paving.—Where sett paving is found undesirable owing to the noise caused by the traffic, natural asphalt, hardwood or softwood paving may be found suitable.

For heavy traffic a coating of 2-in. asphalt should be laid, and care taken in spreading where jointing up to asphalt already hardened to thoroughly make good the jointing in order to prevent fractures appearing in the road after the work has been finished. This form of roadway is usually laid and maintained by various companies who specialize in this material. The camber of an asphalt road should not exceed 1 in 50.

Wood paving, like sett paving, is laid upon a bed of concrete, and, like asphalt, the surface of the concrete is truly floated in cement to correspond with the finished contour of the roadway and the wood blocks directly laid on the cement surface.

The sizes of wood blocks as laid in Belfast are 9 in. by 4½ in. by 3 in. All blocks must be of thoroughly well-

Table No. 1.

Table Showing the Comparative Cost of Various Classes of Road Surfacing, Having Regard to First Cost, Capital Charges, Where Such May be Included, and Cost of Maintenance, Cleansing, and Renewals per Square Yard per Annum for a Period of 20 Years.

Surface Material	Average Life Years	First Cost per sq. yd.	Capital Charges per annum	Maintenance per sq. yd. per annum	Cleansing per sq. yd. per annum	Renewals: Average cost per sq. yd per annum	Renewals: Total Cost per sq. yd. for 20 years	Total Cost per sq. yd.: Per Annum	Total Cost per sq. yd.: For 20 years	Remarks
Water-consolidated Macadam (on existing foundations)	Variable	See Maintenance	Nil	4c. to 24c.	2c. to 18c.	See Maintenance		6c. to 42c.	$1.25 to $8.75	All charges paid for out of revenue
Tar Macadam (on existing foundations)	6	$ .50 to $1.12	Nil	2c. to 6c.	2c. to 7c.	2·8c. to 6·3c.	$ .58 to $1.30	9·2c. to 29⅔c.	$1.90 to $5.15	(All charges paid for out of revenue)
Sett Paving (on existing foundations)	15	$1.87	Nil	4c.	6c.	3·2c.	$ .62	22c.	$4.58	(All charges paid for out of revenue)
Sett Paving (exclusive of concrete foundations)†	*40	$2.25	15c.	1	7c.	—	—	23.2c.	$4.83	*The first cost is entirely paid out of capital in 20 years' period, remaining 20 years free of all capital charges
Natural Asphalte (exclusive of concrete foundations)†	10	$2.25	26c.	12c.	4c.	—	—	42c.	$8.73	First cost and renewals paid out of capital
Hardwood (exclusive of concrete foundations)†	15	$3.00	25c.	6c.	8c.	—	—	39c.	$8.12	Do.
Softwood (exclusive of concrete foundations)†	12	$2.25	22⅓c.	8c.	9c.	—	—	39⅓c.	$8.20	Do.

†9in. concrete foundation, including excavation, &c., costs $1.50 per square yard.

To repay capital charges in 20 years means an additional 11 7/10c. per square yard per annum.

seasoned wood, free from shakes or other defects, and cut to exact sizes by machinery. In the case of softwood blocks creosote oil is forced into the blocks under pressure. Not less than 10 lb. of creosote oil per cubic foot of timber must be absorbed during the process. All blocks are examined and passed by the corporation inspector before being creosoted, and the inspector must also satisfy himself that the specified amount of creosote oil has been absorbed by the timber. Hardwood blocks, before being laid, are dipped to a depth of ½ in. in a mixture of pitch and tar or creosote oil, and an expansion joint left on either side alongside the curb to allow for the expansion of the wood when the roadway becomes moist. The width of expansion joint allowed is approximately one-ninetieth the width of the paving. To prevent the space being filled with dirt the joint is loosely closed in with puddled clay.

The author's experience in the case of hardwood paving block has been that the expansion and contraction is greater and more difficult to deal with than in the case of softwood.

Both cement and pitch have been used for grouting wood pavement, and in spite of the great advantage that pitch has over cement in allowing the immediate use of the road as soon as the surface has been thoroughly grouted, the author believes, especially in regard to hardwood, that cement grouting gives a very much more satisfactory result as regards the smooth wearing of the surface, particularly after some years' wear, than does wood pavement grouted with pitch. In some instances the pitch mixture, probably owing to its not having been sufficiently hard, with the vibration of the traffic in hot weather, has worked downwards and found its way under the lower surfaces of the blocks, thereby raising individual blocks above the normal surface level.

To finally determine the relative merits, a roadway in which the traffic is uniform from one end to the other was selected and paved with Jarrah wood blocks in May, 1907, one half with pitch grout, the second half with cement grout, and careful observations have been made since. For the first three years no difference was noticeable. At the end of the fourth the difference was so extremely slight that a person would not have noticed the change without having his attention called to the difference. At the end of the fifth year the change was more apparent. At the present time, although the section of the roadway grouted with pitch is in very good order, it is distinctly more uneven than the cement-grouted section on which the youngsters of the neighborhood disport themselves on roller skates when they are able to avoid the attention of the police.

As regards repairs, hollows appearing in the surface are mainly due to defective or soft blocks; these are cut out and sound blocks inserted with as little delay as possible. A stock of old blocks is kept for this purpose gauged to various depths, so as to fit in with the actual depth of the wood paving at the time that the repairs are required. No very serious difficulty has been experienced in Belfast in summer weather in regard to open joints, but on hot days a special water service is given to all wood-paved roadways. The gravel used for gritting the surface is specified to pass a ½-in. screen, the stones being rounded and about the size of peas.

Statistics.—A large amount of care is taken in the compilation of records as to the qualities of materials used in the construction and maintenance of roads, and also as to the maintenance cost of each road individually.

Every water-consolidated macadam road in the city is scheduled in a macadam road journal, and all charges, both in regard to materials and workmanship, are returned weekly from each district and posted in this journal against the respective roads on which the work has been done. By this means an accurate record is maintained which proves of the greatest importance and use in determining, not only the merits of any special materials or methods that may be employed, but also if the cost of the maintenance of the existing surfaces is the most suitable and economical having regard to the traffic each road is called upon to bear.

With regard to the construction of tar-macadam roads, for some years a register has been kept in which is recorded:—

(1) The date when the tar-macadam road was first laid.

(2) Particulars of the original roadway.

(3) Superficial area dealt with.

(4) Thickness of tar-macadam surface.

(5) Tonnage of materials delivered.

(6) Number of square yards per ton of each size of tar-macadam used.

(7) Cost of scarifying and preparing foundations, including removal of materials.

(8) Value of old materials.

(9) Total net cost of preparing foundations, with cost per square yard.

(10) Cost of laying tar-macadam under the following heads: (*a*) Labor, (*b*) cartage, (*c*) materials, (*d*) miscellaneous charges.

(11) Total net cost of the work.

These items are again worked out to cost per square yard. The condition of the weather during the progress of the work is also recorded, and any special remarks entered that may be of future value. Reference to this register from time to time has been found of the greatest value in investigating and analyzing the behavior of the various road surfaces. A careful record is also made of all repairs done to each road, so that the actual maintenance charge in each case may readily be ascertained.

Cleansing.—In connection with road maintenance, it must be emphasized that it is of the utmost importance that every care and attention should be given to the cleansing of road surfaces, as, if cleansing is not done with due regard to the proper requirements of the road, a very large amount of waste and damage will accrue. This especially applies to water-consolidated macadam roads. All surplus mud should be removed without delay. An undue amount of sweeping, especially in dry or frosty weather, or on a newly made road, causes serious damage by the removal of the binding material in the road surface.

The greatest care should also be exercised in the cleansing of a newly paved street so that the jointing material is not disturbed by the operation; also in the case of wood pavement it is of great importance that a thorough and systematic cleansing should be maintained, the refuse being removed either to orderly bins or in barrows. It will be found necessary at times to wash the surface of the roadway, this being usually done at night, and, as has already been mentioned, the wood pavement should be thoroughly watered during hot or windy weather to protect it from the effects of shrinkage.

In order to indicate the most suitable form of road surface from an economic standpoint, Table No. 1 gives the comparative cost of various classes of road surfacing, having regard to first cost, capital charges, where such may be included, and cost of maintenance, cleansing and renewals per square yard per annum for a period of twenty years.

Owing to fluctuations in the price of materials and wages due to local conditions, maximum and minimum figures are given for water-consolidated macadam and tar-macadam roads. Should, in exceptional cases, the range provided not be found sufficient, other figures may be supplemented and conditions ascertained.

In comparing these figures, which represent present-day costs, with those of road surfaces of a more permanent nature, allowance should also be made for the advance in price of materials and wages which must take place during the period under consideration. Table No. 2 gives the cost per mile per annum of a road 18 ft. wide, surfaced with the materials scheduled in Table No. 1, and more clearly indicates the comparative maintenance expenditure involved.

Having carefully considered the question of road maintenance in respect to various surfacing materials from a purely economic standpoint, it becomes necessary to consider the probable future developments, not only in respect to a particular road, but also to the district through which it passes, and the requirements in regard to same. One factor which the author feels at times hardly receives the attention it deserves is the direct saving of wear and tear on all classes of vehicular traffic due to the substitution of a suitable road surface in the place of one that has become effete, and also to the saving on adjoining road surfaces by the diversion of traffic on to the new road. Again, the hygienic qualities and noiselessness of the materials selected, in relation to the traffic and needs of the locality, must be carefully weighed. The values of these factors cannot be expressed by any mathematical formulæ, but nevertheless on the accuracy of the conclusions arrived at largely depends the success or failure of a general system of road maintenance.

Table No. 2.

Table Showing Cost of Maintenance per Square Yard and Cost per Mile per Annum of a Roadway 18 Feet in Width.

Surface material.	Cost per sq. yd. per annum.	Cost per mile per annum of roadway 18 ft. in width.
Water-consolidated macadam on existing foundations	6 to 42c.	$642 to $4,497.00
Tar macadam on existing foundations	9.2 to 24.7c.	$985 to $2,642.60
Sett paving on existing foundations	22c.	$2,355.00
Sett paving exclusive of concrete foundations..	23.2c.	$2,484.00
Natural Asphalte, exclusive of concrete foundations	41.8c.	$4,493.50
Hardwood, exclusive of concrete foundations..	39c.	$4,173.50
Softwood, exclusive of concrete foundations..	39⅓c.	$4,212.00

9 in. concrete foundation, including excavation, etc., at 12 cents per square yard (first cost), repayable in 20 years = $1,080.40 per mile.

Table Showing Relative Merits of Various Road Surfacing Materials in Respect to Ease of Haulage, Noiselessness and Hygienic Qualities.

Ease of haulage.	Surface material.	Noiselessness.	Hygienic qualities.
6	Water-consolidated macadam	1	5
3	Tar macadam	3	2
5	Sett paving on existing foundation	5	4
2	Sett paving on concrete foundation	6	3
1	Natural Asphalte	4	1
4	Hardwood and softwood	2	6

FUNCTIONS OF THE NON-BACTERIAL POPULATION OF THE BACTERIA BED.*

By James Crabtree, B.Sc., A.I.C.

EXPERIMENTS on the part played by protozoa in soils, have been extended to sewage disposal beds, and have shown the decided effect which removal of the fauna of the bacteria bed has upon its capacity, a bed with no (or very little) animal population "making up" much quicker than a bed with a normal fauna.

This absence of fauna can be the only cause of this observed difference in capacity, as any effect caused by bacteria would be in the opposite direction; for, since the number of putrefying bacteria (those growing on nutrient gelatine) was generally greater in the partially sterilized bed than in the control, the tendency would be for a greater resolution of solid matter in the toluened bed than in the control, with a corresponding increase in the capacity compared with the control. This is quite contrary to the observed results, which showed a decrease in the toluened bed compared with the control. The difference can, therefore, only be assigned to the animal population, which in some way keeps the bed "open."

Exactly how this is caused can not yet be said—whether the organisms actually digest the particles of solid matter, or whether the material is taken up to form the tests or shells of rhizopods, etc., thus modifying the nature of the deposit and allowing the water to run off more freely. There is probably a good deal of actual digestion taking place—at any rate, of the more easily resolvable precipitated colloidal matter. To the eye, however, the most striking difference in the deposits on the bed media is in the physical character rather than the amount, the deposit in the toluened bed being, as before stated, much more spongy and less granular than in the normal bed. That there is a difference in amount is shown by the following estimation made at the end of the experiment, on a control bed, A, and two beds B and C, partially sterilized by toluene.

Amount of deposit per 1,000 c.c. bed medium (obtained by brushing off into water the deposit from 50 c.c. medium, taking an aliquot portion and evaporating dry): A bed, 19.2 gs.; B bed, 20.2 gs.

According to these figures there is more deposit per unit capacity of bed in the bed deprived of its animal population.

How much of the difference in capacity is caused by difference in character and difference in amount of de-

*From a paper read at the Exeter Congress of the Royal Sanitary Institute.

posit must be left to the future to decide. The fact remains, however, that the animal population does a good work in keeping the bed medium "open," and, from this standpoint, are very desirable inhabitants of the bacteria bed.

Outside the effect caused by difference in capacity, what is their connection with the actual purification processes taking place in the soluble constituents of the sewage? A consideration of the results obtained leads us to say that it is probably very little.

The improvement in the effluent on a toluened piece of soil, and a similar improvement in a toluened bed outlined in the above experiments may, in our opinion, be explained away by the difference in capacities produced in the beds. The fact that in a toluened bed we get a greater number of bacteria capable of growing on gelatine seems to indicate that we should get a greater purification in that bed. The experiments with beds A and C (which did not differ in amount and nature of surface deposit, but where C contained a greater number of bacteria than A) do not support this idea, for C gave a worse effluent than A. For, after all, a comparison of the counts on nutrient gelatine does not of necessity indicate the relative proportions of those bacteria bringing about the purification in the respective beds. Bacteria growing on gelatine are largely putrefactive, while the processes going on in the bacteria bed are largely processes of oxidation.

Müller, investigating the reduction of bacteria in water samples due to protozoa, finds that although a reduction takes place among the bacteria capable of growing on gelatine, those growing on Heyden agar are practically unaffected. His conclusions are that the protozoa prey only on bacteria foreign to the water (e.g., B. coli, B. Typhosus, and many putrefying bacteria), while the normal population goes untouched.

STEEL VS. WOODEN SIDEWALK FORMS.

BEFORE the advent of steel forms, concrete for sidewalks, curb, and curb and gutter was molded by means of wooden forms. The contact of wet concrete, however, tends to warp the wood out of shape, besides the nailing and staking necessary in setting them up makes moving difficult without danger of breaking or splitting, which shortened the life of the forms. The skilled labor necessary, time required in setting, and cost of lumber for this work, make these items enter largely into the cost of the job. Metal forms of various types have been designed to overcome this difficulty by securing greater durability of forms, more uniform work, besides saving labor, cost and time required to complete the work.

In Municipal Engineering, Mr. Chas. H. Allison, describes their successful use and gives a number of pointers gained from his own experience with them.

No type of concrete construction is better adapted for the use of steel forms than concrete sidewalk, curb and combined curb and gutter. Although steel forms are more expensive than wood in first cost, their advantages are so many that they are now being used to a large extent in the work of this sort.

Sidewalk side rails are used in constructing crosswalks by having 6 or 8 division plates shaped to suit the cross sectional crown of the walk. By the use of two adjustable rigid side-rails, these forms can be set to build a crosswalk for any width of street. The all-steel curb forms are built for a curb 20 inches deep, 6 inches wide on top and 8 inches on the base, in 12-foot sections, with provision for templates at intervals of 6 feet. The side rails are similar to those used for sidewalks. Templates can be made to conform to any desired specifications.

The all-steel curb and gutter forms are made similar to the combination sidewalk and curb forms, with 3-inch flanges. One wide side rail is used to form the back and a narrow one on the front. With these forms a steel side rail is used to mold the face of the curb and is held in position by a metal arm or brace attachment. These forms are also made for curved sections. Division plates are made to be used with plank side rails for curb and combination curb and gutter.

The division plates used in the forms which the writer has been using are entirely different from those found in other systems as they can be removed by one man without disturbing the side rails and without the use of a hammer. They are connected by merely dropping them in their proper places and no wedges, keys, bolts or moving pivots are required. These division plates are to be had in all lengths up to and including 6 feet and in the construction of a 12-foot walk it is only necessary to double the 6-foot plates and in the building a 10-foot walk it is only necessary to double the 5-foot plates.

These division plates do not project or extend above the top or beyond the outside of the side rails. They are perfectly smooth between the side rails and have tapering slots which will not bind when the plate is drawn from the concrete. One of the particular advantages of this system of forms is that there are no intermediate slots in the division plates to corrode and tear up the concrete when the plates are withdrawn.

The side rails, which are connected together without the use of keys, wedges or bolts, are 12 feet in length and are made of a special shape, comprising three right-angle bends, thus making the construction most rigid and durable. These rails are so made that the top surface is free of any obstruction which would interfere with the free passage of rodding-off tools. They are easily adjustable, thus enabling the workmen to place the forms in any odd space without using wood to fill in. These side rails are so made that it is a simple matter to make a block of any desired size.

It is a very simple matter to so adjust 100 feet of these sidewalk forms to be used as 100 feet of curb and gutter forms; all that is necessary is an additional use of 16 curb and gutter templates.

It is a very easy matter to construct 350 feet of sidewalk per day with the use of but 100 feet of these forms. They are simple to place and there is no toggle arrangement to oil and the division plates can be removed before or after finish is applied.

September 15th and 16th are the days of the sixth general Annual Assembly in Calgary of the Royal Architectural Institute of Canada. According to the programme, the two days are well filled, and several of the papers to be presented deserve special mention. A lecture on Ferro-Concrete will be given by Mr. F. Goldie Engholm, A.M.I.C.E., of Vancouver. Prof. E. Brydone-Jack, Department of Civil Engineering, Manitoba University, will also present a paper. The headquarters of the Institute during the assembly will be at the Public Library, Calgary.

STEEL PRODUCTION IN THE UNITED STATES.

The Bureau of Statistics of the American Iron & Steel Institute has received from the manufacturers statistics of the production of all kinds of steel ingots and castings in the United States in 1912. The production of ingots and castings by all processes reached the remarkable total of 31,251,303 gross tons, against 23,676,106 tons in 1911, an increase of 7,575,197 tons, or almost 32%. The remarkable point is that while the production of steel in 1911 exceeded that of pig iron by a small amount—26,559 tons—in 1912, the excess was no less than 1,524,166 tons. As there were no large stocks of pig iron on hand at the beginning of 1912, it is evident that the openhearth furnaces must have used a large proportion of scrap in making steel last year.

The total production of steel of all kinds in 1912 is given below:

	1911, Total.	1912, Ingots.	Castings.	Total.	%
Bessemer	7,947,854	10,259,151	68,750	10,327,901	33.0
Acid openhearth .	912,718	712,371	426,850	1,139,221	3.6
Basic openhearth .	14,685,932	19,197,504	443,998	19,641,502	62.9
Crucible	97,653	100,967	20,550	121,517	0.4
Electric	29,105	14,147	4,162	18,309	0.1
Miscellaneous ..	2,844	542	2,311	2,853	...
Total	23,676,106	30,284,682	966,621	31,251,303	100.0

The total increase in 1912, as compared with 1911, was 7,575,197 tons, or 32%. The increase in basic openhearth steel in 1912 was 4,955,570 tons, or 33.7%; in acid openhearth, 226,503 tons, or 24.8%. The gain in bessemer steel was 2,380,047 tons, or 29.9%. The production of bessemer-steel ingots was practically all in standard converters; that of castings was from tropenas and other modified forms of converters. No basic converters are in use in the United States. The make of openhearth steel in 1912 was over twice that of converter.

Included in the 19,641,502 tons of basic openhearth-steel ingots and castings produced in 1912 are 1,438,654 tons of duplex steel ingots and castings which were made from metal partly purified in bessemer converters and finally purified in basic openhearth steel furnaces. This steel was produced by seven works, four being in Pennsylvania, one each in Maryland, Alabama and Illinois.

The production of crucible steel showed a gain of 24% over 1911; that of electric steel, however, was considerably less than in 1911 and 1910. The make of crucible steel was exceeded in two previous years.

Steel Production for Ten Years.—The total make of steel of all kinds in the United States for 10 years past is given in the following table:

	Bessemer, Tons.	%	Openhearth, Tons.	%	Crucible, etc., Tons.	%	Total, Tons.
1903 ...	8,592,829	59.1	5,829,511	40.1	112,238	0.8	14,534,978
1904 ...	7,859,140	56.7	5,908,166	42.6	92,581	0.7	13,859,887
1905 ...	10,941,375	54.6	8,971,376	44.3	111,196	1.1	20,023,542
1906 ...	12,275,830	52.5	10,980,413	46.9	141,893	0.6	23,398,136
1907 ...	11,667,549	49.9	11,549,736	49.5	145,309	0.6	23,362,594
1908 ...	6,116,755	43.6	7,836,729	55.9	69,463	0.5	14,023,247
1909 ...	9,330,783	38.9	14,493,936	60.5	130,302	0.6	23,955,021
1910 ...	9,412,772	36.1	16,504,509	63.3	177,638	0.6	26,094,919
1911 ...	7,947,854	33.5	15,598,650	65.9	129,602	0.6	23,676,106
1912 ...	10,327,901	33.0	20,780,723	66.5	142,679	0.5	31,251,303

The growth of production in the 10 years has been almost wholly in openhearth steel. Bessemer or converter steel reached its maximum in 1906 and has declined since then, its proportion of the total falling from 59.1 to 33%. Openhearth steel ran bessemer closely in 1907; exceeded it in every year since that, and in 1912 its output was more than twice that of bessemer steel.

Alloy Steel.—The following table gives the approximate production by processes of steel treated with ferro-vanadium, ferro-titanium, ferro-chrome, nickel and other alloys:

	Ingots.	Castings.	Total.
Bessemer	159,427	18,814	178,241
Acid openhearth	85,188	75,590	160,778
Basic openhearth	408,007	5,095	413,102
Crucible	27,553	3,208	30,761
Electric, etc.	9,217	402	9,619
Total	689,392	103,109	792,501

In 1912 there were 143 works which made some form of alloy steel. This alloy steel constituted 2.5% of the total make. A large part of this steel was used in the manufacture of rails.

Number of Steel Plants.—At the close of 1912, there were 30 plants equipped to make steel by the standard bessemer process, 35 plants by the tropenas process, and 37 plants by other modifications of the standard bessemer process, while at the close of 1911, 29 plants were equipped to make steel by the standard bessemer process, 29 by the tropenas process, and 31 by other modifications of the standard bessemer process. There were no bessemer plants building at the close of 1912, but 13 plants were projected.

At the close of 1912, there were 182 complete openhearth-steel plants, of which 157 were active during the year and 25 were idle. Of the total 113 were equipped to make basic steel, of which 101 were active during the year and 12 were idle, and 96 were equipped to make acid steel, of which 77 were active and 19 were idle. Some of the plants were equipped to make both basic and acid steel. Six plants were being build on December 31, 1912. On the same date work had been suspended upon three partly erected plants. In addition, five plants were projected. In 1912 four plants made steel by the cementation and other minor processes; in 1911 five plants were active. On December 31, 1912, one plant for the manufacture of steel by a special process was being built in the State of Washington.

The total number of steel plants of all kinds in existence at the close of 1912 was 306, which includes one openhearth plant in the Panama Canal Zone. This total is an increase of 24 during the year.

In connection with the 1912 production, Engineering News published an interesting table a few weeks ago comparing the acid and basic outputs of Germany and the United States, which is given below:

	—United States— Acid.	Basic.	—Germany— Acid.	Basic.
Converter ...	10,327,901	....	28,511	10,015,631
Openhearth ..	1,139,221	19,641,502	194,924	6,650,565
Crucible	121,517	....	79,190	....
Electric, etc. .	21,162	....	74,177	....
Totals	11,609,801	19,641,502	535,802	16,666,196
T'l all kinds.		31,251,303	......	17,301,998
Proportion of steel to pig iron		105.1	......	96.8

The Canadian Engineer

ESTABLISHED 1893.

ISSUED WEEKLY in the interests of
CIVIL, MECHANICAL, STRUCTURAL, ELECTRICAL, RAILROAD, MINING, MUNICIPAL HYDRAULIC, HIGHWAY AND CONSULTING ENGINEERS, SURVEYORS, WATERWORKS SUPERINTENDENTS AND ENGINEERING-CONTRACTORS.

Present Terms of Subscription, payable in advance
Postpaid to any address in the Postal Union:

One Year	Six Months	Three Months
$3.00 (12s.)	**$1.75** (7s.)	**$1.00** (4s.)

Copies Antedating This Issue by More Than One Month, **25** Cents Each.
Copies Antedating This Issue by More Than Six Months, **50** Cents Each.
ADVERTISING RATES ON APPLICATION.

JAMES J. SALMOND—MANAGING DIRECTOR.
H. IRWIN, B.A.Sc., EDITOR.
A. E. JENNINGS, ADVERTISING MANAGER.

HEAD OFFICE: 62 Church Street, and Court Street, Toronto, Ont. Telephone Main **7404**, **7405** or **7406**, branch exchange connecting all departments. Cable Address: "ENGINEER, Toronto."

Montreal Office: Rooms 617 and 628 Transportation Building, T. C. Allum, Editorial Representative, Phone Main 8436.

Winnipeg Office: Room 820, Union Bank Building. Phone M. 2914. G. W. Goodall, Western Manager.

Address all communications to the Company and not to individuals.
Everything affecting the editorial department should be directed to the Editor

The Canadian Engineer absorbed The Canadian Cement and Concrete Review in 1910

NOTICE TO ADVERTISERS:
Changes of advertisement copy should reach the Head Office two weeks before the date of publication, except in cases where proofs are to be submitted, for which the necessary extra time should be allowed.

NOTICE TO SUBSCRIBERS
When changing your mailing instructions be sure and give your old address in full as well as your new address.

Printed at the Office of The Monetary Times Printing Company Limited, Toronto, Canada

Vol. 25. TORONTO, CANADA, SEPT. 4, 1913. No. 10

CONTENTS OF THIS ISSUE.

THE LONG SAULT RAPIDS POWER SCHEME.

One would imagine that the history of the project of the Long Sault Development Company, in so far as it pertains to Canada, has reached its closing chapter. The company's proposal involves the erection of a 3,800-foot dam between Barnhart Island and the north-easterly end of Long Sault Island in the St. Lawrence River, and another, 1,450 feet in length, adjacent to lock 20 of the Cornwall Canal, on the Canadian side, thus requiring the construction of a new channel with a new canal at that point. Its proposal includes the generation of 500,000 h.p. of electrical energy on the American side and of 100,000 h.p. on the Canadian side. The company's many and varied assurances that the development was just what Eastern Ontario needs, were commented upon in *The Canadian Engineer* of October 24, 1912, and were accompanied by a note of caution, toward the safeguarding of Canada's interests.

It is now six years since the company obtained a charter in New York State authorizing it to construct dams and other works at Long Sault Island for the development of electrical energy and the improvement of navigation, but not across the international boundary "unless consented to by the Dominion of Canada." In the meantime a Canadian charter has been diligently and persistently sought, for the widening of the whole project. The granting of it has been pending a report, after most thorough investigation, from the Commission of Conservation. Meanwhile the New York charter was repealed a few months ago, and a special application was presented to the United States Congress, also pending.

The Commission of Conservation has just issued its report, expressing strong disapproval of the scheme. The report is a complete review of the question, and presents no vague impressions. The outcome of it should be a discountenancing of the power scheme by the Dominion Government. It is not for the reason that the company resorted to improper tactics in endeavoring to create an impression in Ontario favorable to the granting of a Canadian charter; or that the company is a small part of a strong financial and commercial organization included in which is the St. Lawrence Securities Company, and back of it the Aluminum Trust. Nor it is because the United States franchise has been discontinued. The commission's report places its finger on the vital point when it emphasizes the likelihood of the proposed development placing enormous difficulties in the way of the imminent enlargement of Canadian navigation facilities. Deeper navigation upon the St. Lawrence will forthwith command the attention of the Dominion Government, and a free hand in the undertaking of such an enterprise must be maintained.

The proposed diversion of water by the dam between the Long Sault Island and Barnhart Island would take from the main navigable channel over one-third of its water. The effect of such a diversion of water from the navigable channel is impossible to estimate. It can, however, be stated with centainty that the navigability of the channel would not be improved by such diversion. The construction of the dams in question would result in compelling navigation (other than by the Cornwall Canal) to follow a new route known as the South Sault Channel. Experienced navigators are of the opinion that this route would be much inferior to that now followed.

From the point of view of benefits accruing to Canada from the proposed power development, the report dispenses with the alleged advantages in the following way:—

"Looking at the whole scheme, it does not appear that any serious attempt can be made to show that Canadian requirements or Canadian interests are an appreciable factor in the plans of the company. The plans contemplate the absolute monopolization of the whole power available from the rapids with a minimum consideration of Canadian interests.

"No market exists at the present time on the Canadian side for the power proposed to be developed, or for any appreciable portion thereof. When any large quantity of power is required in the territory tributary to the proposed works it can be otherwise provided. Should the time come when further power is required by Canadian interests, and the placing of a dam across the St. Lawrence River is determined upon, one-half of the power to be generated thereby will belong by right to Canada and should be permanently retained for Canadian use without exception or qualification."

HAMILTON'S RAILWAY PROBLEM.

Readers will remember our recent reference to the plan which the city of Hamilton is working out in an endeavor to have the railways adopt a common route through the city, and to the dissenting stand which the Toronto, Hamilton and Buffalo Railway is taking. An article beginning on page 411 of this issue goes into interesting detail concerning the whole situation.

It is quite clear that the solution of this problem is going to play an important part in the future expansion of Hamilton. The city is destined to increase in size by reason of its peculiar geographical situation and in spite of the same. Its present population may double in the next 25 years. At any rate, the expansion is well under way, and no more appropriate time than now is likely to present itself for the complete straightening out of the question of railway right-of-way.

Conditions have changed since the T. H. & B. was first granted its right-of-way over the streets of the city. Public opinion against level crossings has developed generally, and the local trend of residential growth toward that section of the city would render it impossible if the railway were seeking to-day the right-of-way it secured twenty years ago. To what extent should further development of its present system, in the matter of a station and trackage extensions, be permitted, is a live factor with which the civic authorities, bent as they are upon an entire revision, must contend.

The refusal of the T. H. & B. to consider the city's plan to unite the railways on a common right-of-way, and in a union station, is largely based upon the adaptability of the location of its present station for passenger traffic. Granting this, alternative plans have been forwarded, dealing with elevation or depression of tracks. Of the two plans, as outlined in the article, while cost and questions of operation are in favor of the elevation project, the depression plan is more consistent with the present condition of entrance from the west, as the tracks are already depressed from the city limits to Park Street. The advantages which the city will thereby derive are beyond question, and the plan should be vigorously pushed forward.

CANADIAN NATIONAL EXHIBITION

Since its inception in 1879, the Canadian National Exhibition has grown—wonderfully. It has kept well in step with the Dominion's march of progress, and the inter-relation between the two has been close. Through its park of 264 acres, its buildings of stone, brick, concrete and steel, costing $2,225,000, its half a million feet of exhibit floor space, and its "million mark," the value of the Exhibition to Canada may be estimated.

President Kent has announced a proposed expenditure of $50,000 in improving the agricultural department of the Fair. This will incite a keener interest in the live stock exhibits, and will be money well spent.

An inspection of the marked indications of the rapid development of Canadian industries, particularly of machinery and processes, creates the impression that the above extension should shortly be followed by added accommodation in this department as well. The great Fair is built up by the co-operation of innumerable units, many of which are each the result of large annual expenditure. Many concerns have cheerfully spent thousands of dollars annually on exhibits that have not seen the inside of these great buildings, but are tented in some necessarily obscure location. This should be remedied. Machinery Hall should be duplicated, in order that these exhibits receive the housing they deserve. Otherwise, firms cannot be expected to retain their co-operative spirit in making the Exhibition what is is.

The Canadian National Exhibition is very deserving of attaining the million mark in attendance. The achievement, considering weather conditions at this time of year, and also the pre-occupation of farmers in harvesting, shows that it is receiving world-wide recognition and that Canada is unknown nowhere on the globe. But to fulfil its function, as an Exhibition, it should have more accommodation for the machinery men.

EDITORIAL COMMENT.

It is anticipated that about 1,100 miles of colonization roads will represent Ontario's progress in this respect this season. The north country is being webbed with good roads at a rapid rate and by another season the work of construction will have so far advanced that a settlement campaign on a large scale may be carried on. Mr. G. W. Bennett, Provincial Superintendent of Colonization Roads, states that the number of men employed ranges between 4,500 and 6,000. Satisfaction is being derived from doing the work by day labor, and no part of it is under contract this year.

* * * *

The navigability of the Saskatchewan River is being investigated by the Dominion Government, and the engineer in charge of operations, Mr. L. A. Voligny, reports that the river will greatly enhance the shipping facilities in conjunction with the Hudson Bay Railway from Le Pas. In many parts of the river the channel is sufficiently deep and for miles little extra work will be necessary to put it into shape. Eventually the waterway may extend from Edmonton to Winnipeg, which, if accomplished, will go a long way to reduce shipping rates.

STREET AND PAVEMENT CONSTRUCTION

ESSENTIAL TO PREMISE NATURE OF FUTURE WEAR—VARIOUS PAVEMENTS IN USE FOR URBAN TRAFFIC, AND THEIR CHARACTERISTICS —THE STREET RAILWAY SYSTEM AND THE RAIL IT SHOULD USE

By **A. F. MACALLUM, C.E., A.M. Can. Soc. C.E.,**
City Engineer, Hamilton, Ont.

THE first necessary function of a paved roadway is to supply a hard, smooth, and durable surface upon which the vehicular traffic of the town may be conducted with the least expenditure of energy; other considerations being cheapness, and low maintenance. It should also be sanitary, and not slippery in any kind of weather. This would give an ideal pavement that at present does not exist, for a pavement ideal in one location would not be in another, although it has been suggested that the general requirements in all cases would be the same. This does not naturally follow, for in one case low first cost and low maintenance cost may be the first consideration, while in another case ease of hauling and lack of slipperiness may govern, and a third case noiselessness and sanitariness may overbalance all other considerations.

In the following table different authorities give relative values of the various qualities of an ideal pavement:—

	U. S. Bulletin.	Tilson.	Baker.
First cost—Cheapness .... / Maintenance cost—Cheapness.	14	14	15
Durability	20	21	..
Ease of Maintenance	10	10	20
Ease of Cleaning	14	15	10
Low Tractive Resistance	14	15	10
Non-slipperiness	7	7	5
Sanitariness	13	13	25
Noiselessness / Acceptability	4	..	15
Favorableness to travel	4	5	..
	100	100	100

It will be noted that while the United States Bulletin and Tilson agree closely, a considerable variation exists between them and Baker. Apparently they had in view pavements subject to heavy travel, while Baker considered a residential type of pavement.

Using values for this from the present costs of different pavements under conditions where the pavement proposed will exist, it is possible for the engineer to select the proper pavement for any particular case without bringing in the personal equation.

The first question that arises when a street is to be paved is what will be the probable quantity and character of the traffic to which it will be subjected. Although it is an obvious fact that a street in a business section should be treated differently from one in a residential section, yet, it is not done so in many cases. In the first case the paved portion of the roadway should be made as wide as the boundaries of the street will permit, while in the second a width of twenty-four feet (24′) is quite sufficient. Any additional width is more than wasted because this additional width of paved roadway will increase in the ratio of its width the cost of maintenance, cleaning, sprinkling, and cuts for house services. It may be objected that carriages and other vehicles could not turn around in a street twenty-four feet (24′) wide. While many could not, yet with blocks of the usual length such vehicles could go around the block. It is a very moderate statement to say that many thousands of dollars have been wasted in this country by making the pavements and roadways in residential districts unnecessarily wide.

Where street railway tracks exist through paved streets they are a serious menace to the durability of the pavement. Unless the paved area outside the tracks is of considerable width (say 18 feet) the traffic is so concentrated in narrow strips on each side of the tracks as to many times increase the traffic per foot of width on these strips with the consequent wear and tear to the pavement. It is also impossible to maintain any kind of a pavement alongside a poorly constructed railway track.

When a street is about to be paved it is not always possible to keep to the existing grade of the roadway to obtain the best grade for the desired pavement. It is doubtful if there is any other municipal improvement that will raise a louder howl of indignation from property-holders than the grading of a street for a pavement. The average property-holder considers only the street directly in front of his property, and believes firmly that the rest of the street should be made to conform with that regardless of drainage, ease of traction, and appearance. The stranger visiting a city for the first time may not remember the handsome buildings, but if the streets are bad he will never forget it.

Preliminary Works.—As water is the enemy of all pavements provision should be made in clay soils for proper drainage.

Every writer on pavements from Macadam to the present has referred to sub-drainage as the first essential to successful pavement construction. Where the sub-drainage is insufficient the underside of the pavement is always damp with the inevitable result of deterioration, and a tendency of the pavement to settle from its normal shape and grade. It may be assumed that any of the modern and practically waterproof forms of pavement now in use will have the sub-soil beneath it dry providing no water percolates from back of the curb which can be prevented by means of small tile drains beneath the curb. If the sub-soil be gravel, or sand, giving natural drainage no artificial drainage is required.

Macadam.—This is not a pavement, but as it is low in first cost, quiet and satisfactory if properly constructed, and used only upon residential streets where the traffic is not heavy. It is a good first pavement in a district not fully built up where there will be considerable tearing up of the roadway for house services.

*Read at the fifteenth annual meeting of the Ontario Municipal Association, Toronto, August 28th and 29th.

The usual method adopted for constructing macadam roads is to dump the broken stone on the road and roll to the form of the road, putting a certain amount of binder on top and wetting. The result is generally an uneven surface and rapid erosion after traffic has been upon it for a short time. Very seldom are large stones placed on edge on a proper camber of foundation, as brought out by Telford, although by so doing it will stand heavier traffic. As in all pavements the roadway should be rolled before the stone is placed upon it to the proper camber, and not more than ten inches (10″) of stone placed before rolling with a fifteen (15) ton roller. This stone should be hard and not all of one size, although such a clause will be found in many specifications. Sufficient small limestone binder should be added and flushed and rolled until the voids are filled and the surface in the proper form. After two or three days the street may be opened for traffic. If it be desired to provide a practically waterproof and dustless macadam then after about ten days' time the roadway should be swept to remove loose material, and a distilled coal tar heated to a temperature of about 250 degrees Fahrenheit should be sprayed using about ¾ of gallon per yard, and immediately covering with about ¼-inch of sand, or stone screenings. After rolling once upon the following day a second coating of about ½-gallon per yard should be applied cold and again sanded. In about ten days' time the roadway will have the general appearance of an asphalt pavement, the penetration of the tar being from one to two inches.

The advent of the automobile has made necessary the protection of the macadam surface from unravelling, and removing of the binding material in the form of dust. Oils of various kinds have been in use for several years—more or less successfully. Crude petroleums which contain the largest proportion of pure asphaltum give the best results. The petroleums having a paraffin or naphtha base are useless as they will not bind besides making a greasy slime and having an ill odor. It has been a common thing for an official to whom all oils look alike to purchase carloads of oil of unknown quality, sprinkle it from watering cars instead of spraying in unrestricted quantity regardless of the road condition, or weather. As a consequence slimy mud has been caused by sudden rainfalls which forms an emulsion with the oil, and the oil has pooled in depression in the roadway. It is necessary for the roadway to be first swept clean, be thoroughly dry, and have the oil heated and applied upon warm days.

From plain macadam roads to oil and tar painted, and on to tar macadam is but a step. Some years ago in Hamilton tar macadam pavements were extensively laid and these were successful in some cases, but not in others. The failures were partly due to using a limestone which was not tough or hard enough, and partly through the variable nature of the coal tar supplied. If tar used be not sufficiently refined the light oils and ammoniacal liquors will disintegrate. If it be heated too much it becomes brittle and forms black dust. There are now tar preparations on the market which give a reliable uniform product. In every city having a gas works using various grades of coal the quality of crude tar from a given tank will vary. Even with the coal constant the tar drawn from the bottom of a full tank will often differ materially from that taken from the same tank when nearly empty. Most failures in using crude tar may thus be traced to the variable nature of the tar which would not have occurred by using tar refined to the proper uniformity.

The tar macadam pavements which failed as such in Hamilton were not, however, total failures. The pavements were levelled up with concrete and asphalt binder, and a sheet asphalt top placed on it at very small comparative cost and with excellent results. These tar macadam pavements cost from 97 cents to $1.06 per square yard.

By the use of asphalt instead of tar a suitable pavement may be secured. The asphalt is applied in either of two ways, by penetration or pouring, or by mixing, as in the case of the tar macadam just mentioned. Using the penetration method, and after the foundation course has been rolled, there is placed a wearing surface of two inches thick (after compression with a road roller) of stone passing a two-inch ring. If there is already a foundation of concrete, old brick, block or macadam of sufficient strength no other foundation course will be necessary. On this wearing surface of compressed stone no water should be used but with suitable distributors from one and a half to two gallons per square yard of an approved asphalt binder should be poured depending upon the character of the broken stone. This binder should have a temperature ranging from 300 to 350 degrees Fahrenheit, and applied when stone is dry. Stone screenings are placed then on top sufficient to fill all surface voids, and the surface again rolled until smooth and true to cross section. Approximately one cubic yard of this material will cover 50 yards of roadway surface. A squeegee coat of approved asphalt from ½ to ¾ gallons per yard is then applied, and again sufficient screenings and rolling when the roadway is open for traffic.

In the mixing method the 1½-inch stone is dried and mixed with asphalt at the plant at a temperature not less than 300 degrees Fahrenheit, and spread on the prepared foundation to a depth of three inches after compression with a roller while the mixture is still hot, however, and before rolling stone chips, or sharp coarse sand free from dust should be spread over the surface. It is important that the rolling be thorough, especially about manholes, etc. As for the penetration a squeegee coat is spread and re-rolled as in the previous method. By this latter method an asphalt plant either portable or stationary is necessary. The crown of these bituminous pavements should be flatter then for macadam; in fact should be about ½-inch per foot of width where the grade will allow as in cold weather, it is apt to be somewhat slippery. The average cost of macadam in Hamilton was 60 cents, and for bituminous pavements as described, the cost would be from 25 to 40 cents more.

From bituminous macadam we naturally drift into bituminous concrete, where the stone is varied in size from sand to stone one inch in size graded to have as few voids as possible. Under this head come proprietary pavements, as Westrumite Bitulithic, and Warrenite. The ingredients are combined and mixed at the plant and spread about two inches thick upon the foundation which is usually of concrete roughened on the surface. The following mortar has been used successfully in Chicago:—

Bitumen		18.8%
Passing	200 mesh	11.0%
"	80 "	10.6%
"	40 "	36.6%
"	10 "	23.0%
		100.0%

In proper grading of the smaller constituents about as above a close firm pavement is secured, less care being necessary for the larger sizes, provided also, of course, that a good asphaltic cement is used.

These bituminous pavements will cost from 95 to 90 cents per square yard, not including the concrete base, and are not intended for streets upon which the traffic is heavy. It may be intense that in having a large amount of light or rapidly moving vehicles with occasional teaming of coal or building material, and still be an excellent pavement, but it will not stand the traffic on business streets in cities.

Street asphalt pavements are laid only in the larger cities in Ontario on account of the skill required in properly mixing at the plant. Another reason is that such a plant is necessary. The refined asphalt is softened with a heavy mineral oil in the proportions of about eighty-one to eighty-six parts by weight to nineteen to fourteen parts of flux, and this forms the asphaltic cement. This cement forms from 9½ to 11½ parts by weight of the asphaltic mixture which forms the wearing surface. Between the wearing surface and the concrete base is placed a binder of ½ to 1″ stone which holds the surface to the base.

A few years ago several cities in the United States, and one or two cities here, including Hamilton, laid pavements without the binder course, roughening the concrete base instead. While it was successful on some streets with very little traffic it failed on well-travelled streets by rolling on the base. It was found almost impossible to get a roughened base without projecting stones too deeply into the surface mixture, and as a consequence much of the base was made too smooth with the resultant rolling under traffic. In earlier pavements an open binder was used, but recently a binder much closer is used.

The asphalt surface is principally graded sand; in fact about 90 per cent. of the surface mixture with a small percentage of stone dust and mixed with the asphalt somewhat less than will fill the voids to prevent rolling. The surface must be hard enough to prevent caulking by horses, and soft enough to prevent cracking in winter which is between comparatively small limits in this climate. For about two years the asphalt surface becomes about 5 per cent. harder each year so that in repairing a penetration much less should be used for the new material.

In grading the sand we have followed the following standard as closely as possible usually by mixing sand from two or more different places:—

Passing 200 mesh	....	0%
" 100 "	....	12%
" 80 "	....	12%
" 50 "	....	26%
" 40 "	....	11%
" 30 "	....	16%
" 20 "	....	12%
" 10 "	....	8%
" 8 "	....	3%
		100%

200 mesh sand does not pack well, and is therefore, not so desirable as 200 mesh limestone dust, as it tends to make the pavement mush in hot weather.

The grading given above is somewhat coarser than usual, but it has been found that this mixture gives a richer mixture with the same amount of bitumen, and will also lessen the drying out of the pavement.

The mixture should reach the work at a temperature not less than 28 per cent., and spread with hot rakes for a depth of 3″ to give a compressed surface of 2″. This requires also some skill and care to obtain good results.

The asphalt pavements will cost, including binder, but not the base from 65 to 80 cents per square yard. It will stand up under heavy traffic better than any of the asphalt concrete mixtures (including the proprietary ones). It requires a certain amount of traffic to keep in condition, and for business streets it is better than the asphalt concrete mixtures that depend on the stone in them for their strength, which on account of the size is apt to move about losing the inherent stability of the pavement.

Asphalt block is composed generally of 77 per cent. crushed gneiss, 10 per cent. limestone dust, and 13 per cent. asphaltic cement put in moulds, subjected to a pressure of from two to three tons per square inch, after which it is slowly cooled in water, all of which is done at the factory. Their only advantage over sheet asphalt is that the blocks can be laid by unskilled labor, but there are few cases where sheet or concrete asphalt is not preferable, especially on account of its high cost of about 2.70 per square yard without the base.

Vitrified brick pavements have been used extensively in some of the larger cities in Ontario, but in the case of Hamilton it is no longer used for pavements, except alleyways, where it replaced concrete. A vitrified brick pavement is not so slippery as asphalt, is durable under moderate traffic, and requires no special plant for laying. The reason for the re-action against the brick pavements in some of the cities is that the people prefer wooden block as being much quieter and lacking the peculiar roaring noise produced by the passage of light wagons. Much credit has also been thrown upon the use of brick by the careless and ill-judged manner in which some manufacturers have sent out irregular or imperfectly burned brick, along with the laying by inexperienced city foremen; a brick that is too hard being just as bad as one too soft upon the bricks surrounding. One drawback is that a street paved with brick and grouted cannot be travelled upon for a week or two after being laid without injuring the joints, and this is almost impossible to prevent upon some streets with the consequence that the flushers afterwards take it out and leave the edges of the brick unprotected, which under traffic causes the edges to chip off. The pavement is laid on a concrete foundation usually with a two-inch cushion of sand to take up an unevenness of the brick and to spread the pressure on the base.

The brick pavement is well laid under good specifications will give as good satisfaction under moderate traffic as asphalt block, while the cost is much less, being about $1.55 without the base.

Stone block pavements are only desirable for steep grades on streets of large cities where the heaviest traffic exists. There is no such traffic in any city of moderate size, so that in Ontario there are very few places where it would be necessary. It is a difficult pavement to keep clean, is extremely noisy, and about the most expensive pavement that can be laid.

Treated wooden blocks have come into use in the past few years, and each year shows a large increase in the amount being laid. It is practically noiseless, free from dust, and will withstand the heaviest traffic. The writer examined pavements in New York wholesale district where the traffic was of the heaviest, and after eight years' use these pavements were in excellent condition. In Hamilton at the intersection of James and King Streets, where there is the heaviest traffic in the city, the wooden blocks show no indications of wear after four years.

Although some engineers call for less the consensus of opinion is that the blocks should be treated with twenty pounds of creosote oil per cubic foot, and even then there will be a certain amount of swelling of the pavement, as a small percentage of water can still be absorbed. There will be a little bleeding of the oil from the blocks during the first summer after being laid, but it generally disappears by the second season. Longleaf Georgia pine has been the wood usually specified, but good results have also been obtained from Norway pine, tamarac and birch when properly treated. The joints may be filled either with grout, or pitch, the latter being the better, increasing the cost of the pavement. The blocks are laid with the grain vertical, and laid in a one-inch bed of cement and sand upon a concrete foundation, blocks being driven together, but having expansion joints at each curb of 2″ and every 10′ across the pavement.

In Hamilton this pavement has become so popular that some residential streets have petitioned for it on account of its quietness, although it is a costly pavement running from $2.25 to $2.65 per square yard, according to the kind of block, whether plain or grooved for heavy grades. All of these pavements have assumed a concrete base 6″ thick at least on business streets, with a mixture not less than 1-3-6, which will cost from 50 cents to 60 cents per square yard.

Pavements of concrete and reinforced concrete are now being built, but it should be remembered that the hardest concrete is less durable and softer than the average brick pavement, hence the hardest obtainable surface should be constructed. Two-course and one-course pavements have been built, and successful pavements have been built under either specification on residential streets. It is now entering into competition with brick and asphalt on business streets, and its use under such conditions is doomed to failure, as streets where such pavements ought to be laid cannot be successfully paved with concrete. While there is a wide field for its use on highways, and many streets in cities, yet it is the duty of the engineer to recognize that concrete has its limitations like other paving materials. Its proper use, however, under proper specifications, will prove a profitable investment for property owners on many streets where low first cost is a consideration, as it can be laid at a cost of from $1 to $1.20 per square yard, including the base. Unfortunately commercial interests have sent forth a lot of literature booming this pavement under all conditions which will work to the injury of such pavements if carried out under such advice. The success of this pavement depends greatly upon the way it is laid and some of its failures may be traced directly to the poor workmanship even with good specifications. Other causes will be improper materials, lack of screening, improper mixing, careless placing of materials, faulty joints, neglect of protection and curing. These pavements are sometimes reinforced with wire mesh two inches beneath the surface to eliminate cracks and have successfully done so where otherwise under the existing conditions cracks would have appeared from settlement, freezing, or contraction.

Grades.—Much misleading information is given out as to the grades upon which pavements can be laid. It is misleading because the conditions are not named and while the grade may be satisfactory under conditions of light traffic, yet be far from it where heavy teaming exists. The writer has found that in the condition existing in Hamilton that macadam, or asphalt-macadam can be used safely to 8 per cent. bitulithic to 4 per cent. brick, 3½ per cent. asphalt to 3 per cent. wood 2½ per cent., or where grooved or spaced with both 4 per cent. for heavy teaming. For general traffic 1 per cent. may be added.

Street Railway Tracks.—While the street or suburban railways always want tee rails because of cheapness and deeper flanges, it is the policy of the city to insist upon girder rails. No pavement will last alongside the inside of the tee rail as long as the steel protecting lip of the girder rail and sooner or later there is a groove worn out alongside the inner face of the rail where loaded vehicles will pull off wheels and which will become dangerous to general traffic.

The rails should be at least 80 pounds per yard, preferably fastened to steel ties with clips spaced ten-foot centres, with one tie at each rail end. A poorer construction is with wooden ties fastened to the rails with spikes which are apt to work loose allowing the rail to move. Even with the heaviest construction there is a certain amount of vibration which has a tendency to loosen the blocks of the pavement adjacent to the rail, especially at the joints.

In conclusion I would say that where a small city or town is about to spend large sums on paving, that it is money well spent to retain a consulting paving engineer to work out the proper pavement for each street. Infinitely better results would be obtained than at present where the councils are pulled about by representatives of different paving interests, or where deputations from such councils are steered to other cities to look over carefully selected pavements by these same commercial interests.

THE MINER'S INCH.

On the Pacific coast, the unit for measuring water in mining is known as the miner's inch. This varies greatly in different localities, and is now generally defined by legislative enactment. The statute inch of Colorado, for example, is defined as "an inch square orifice, which shall be under a five-inch pressure measured from the top of the orifice to the surface of the water, in a box set in the banks of the ditch. This orifice shall in all cases be six inches perpendicular inside measurement, and all slides closing the same shall move horizontally, while from the water in the ditch the box shall have a descent greater than one-eighth of an inch to the foot."

In British Columbia, under the Water Clauses Consolidation Act, 1897, Section 143, a miner's inch is declared to be a flow of water equal to 1.68 cubic feet per minute. Therefore, a miner's inch is equal to .028 cubic feet per second, and 1 cubic foot per second is equal to 35.71 miner's inches, approximately. One cubic foot per second would be equal to 38.4 Colorado miner's inches.

THE RAILWAY SITUATION IN HAMILTON

PECULIAR LOCATION OF CITY CREATES PROBLEM—SOLUTION IS SPEEDILY NEEDED—CO-OPERATION OF LINES NECESSARY—FUTURE DEVELOPMENT WILL NECESSITATE CHANGES NOW CONTEMPLATED

By E. H. DARLING, M.E., A.M. Can. Soc. C.E.

SEVERAL very important questions are involved in Hamilton's railway problem, some of which are of recent origin, while others date back many years. First of all there is the growing need for better station accommodation for the existing steam roads. This is a chronic trouble in a rapidly growing city. There is the question of grade separation,—the elimination of grade crossings with their dangers and delays. There is the smoke and noise nuisance which gradually grows as the railway traffic increases. All this, but principally the fact that another steam railway is seeking right-of-way through the city, has impressed upon the minds of the city officials, and many citizens in general, that now is the time to consider the railway problem as a whole, and, if possible, to find some solution which will not only answer present needs, but will provide for the future growth of the city.

The location of Hamilton is such that it is extremely difficult to bring a railroad into it, quite apart from the thousand and one obstacles which are always encountered in locating a right-of-way through a thickly populated district. To the north lies Burlington Bay. On the south abruptly rises the Niagara escarpment or "mountain" to a height of over 320 feet above the centre of the city, and 400 feet above the bay. On the west lies the "marsh" and the broken irregular Dundas valley. Between the marsh and the bay is a narrow ridge of land or "Hog's Back," a hundred feet in height, extending diagonally across the city. On the east, the level flats of the Niagara fruit district, permit an easy access, but this only for a line from Niagara Falls.

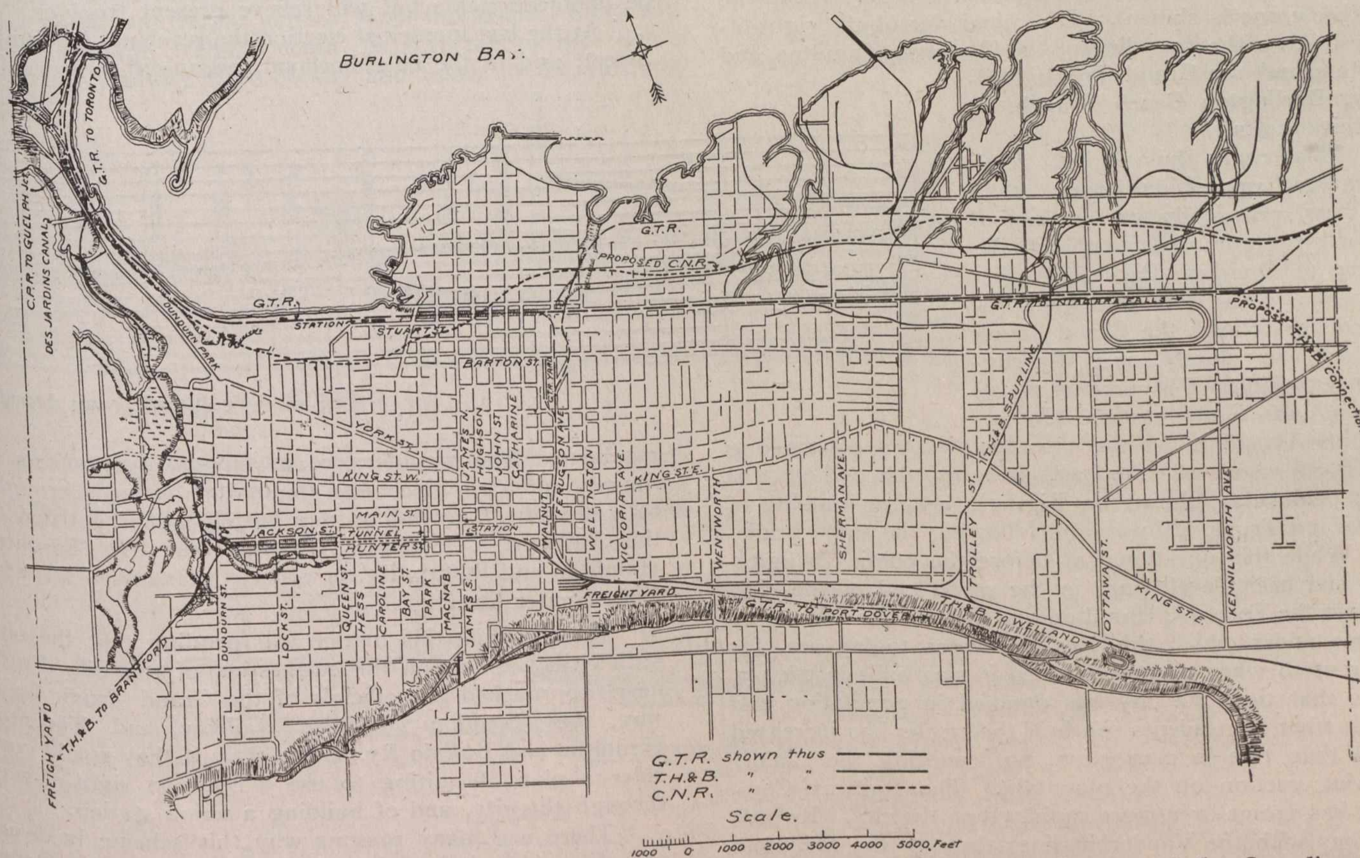


Fig 1.—Diagram of the city of Hamilton Showing existing railroads and proposed route of the Canadian Northern Railway.

Over fifty years ago the Great Western Railway, (now the Grand Trunk), occupied the bay shore. Its Port Dover branch (the old Northwestern Railway) cuts across the city and climbs the mountain to the eastward. In 1894-5 the Toronto, Hamilton and Buffalo Railway tunnelled the "Hog's Back" and entered between the centre of the city and the mountain. Last year the Canadian Pacific Railway, Guelph Junction branch, connected with the Toronto, Hamilton and Buffalo outside the city at the Des. Jardine Canal, (See Fig. 1). Besides these steam roads there are five suburban electric roads each with its independent entrance. These, with the street railway system, occupy most of the main streets.

About two years ago the Canadian Northern Railway began buying land for a right-of-way through the city, and filed their plans with the Railway Commission. Their plan is to follow the Grand Trunk Railway around the

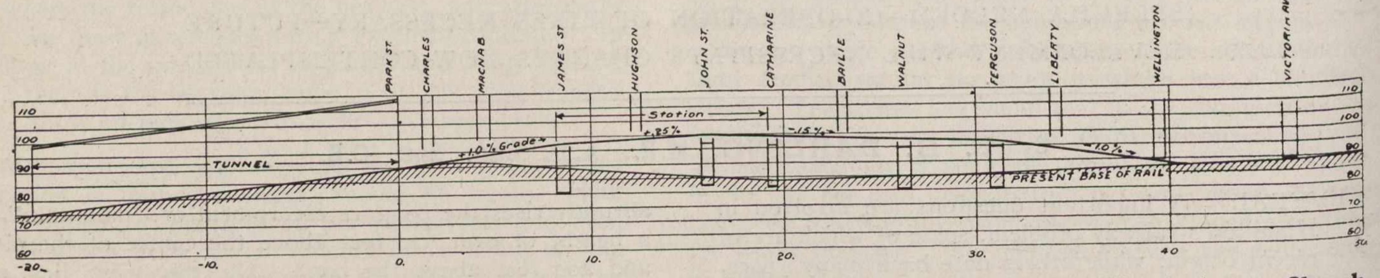


Fig. 2.—Profile of track elevation plan for the Toronto, Hamilton and Buffalo Railway, by Westinghouse, Church, Kerr and Company.

end of the bay, keeping at a higher level, cutting through Dundurn Park and striking the grade of the city streets about Bay Street. (See Fig. 1). From here there are three alternative routes to Ferguson Avenue. (Only the southerly one is shown). The remainder of the right-of-way follows the spur line of the Toronto, Hamilton and Buffalo and the Grand Trunk Railway, Burlington Beach Branch, to the city limits.

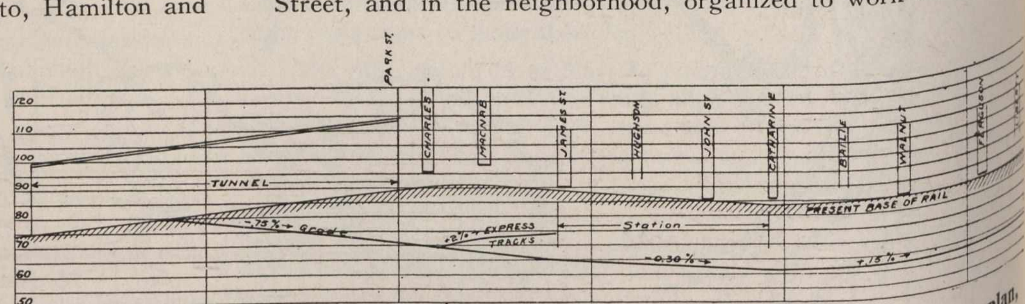


Fig. 3.—Profile of track depression plan, by

This route has called forth strenuous opposition from many quarters, principally on account of the many grade crossings and the injury to Dundurn Park and other property. The fact that the proposed line follows the Grand Trunk Railway so closely, naturally suggested the idea of a common right-of-way and a union station. In this case the Canadian Northern Railway would come along the north shore of the bay, bridging the end at the long peninsula, (shown on Fig. 1), keeping outside of the Grand Trunk Railway and following the same grade.

While this question was before the public an agitation had been developing, in the south end of the city, against the Toronto, Hamilton and Buffalo Ry. The conditions under which this road operates to-day are far different to what they were when it was built in 1894-5. Since that time the city has doubled in population and the number of residents south of the tracks has increased more than this in proportion, not counting the rapidly growing section on the mountain. The Railway Company has grown even more rapidly than the city. Its connections with the Vanderbilt lines through the Michigan Central and the Canadian Pacific Railway to Guelph and Toronto, make it the entrance of these two great systems.

The number of trains per day has greatly increased. Also, they have become heavier, longer, and operate day and night. As the station platform is only a short city block in length,—(about three hundred feet)—it is impossible to handle this heavy traffic without more or less blocking of streets. This, with the noise and smoke, is what the residents in the neighborhood are complaining about.

For some time it is believed that the Toronto, Hamilton & Buffalo Ry. has been buying lands on either side of its right-of-way for the purpose of adding tracks and increasing the station accommodation. There is also a probability that the Canadian Pacific Railway will build a line to Niagara Falls, using the Toronto, Hamilton and Buffalo Ry. right-of-way through the city and station. The fear of some such step has done more to arouse those interested to action than the other things they complain of. Their hope is to forestall the Railway Company, so that when the time comes to extend their station they (the company) will be committed to a plan that will not only be unobjectionable but will relieve present troubles.

At the last municipal election the residents on Hunter Street, and in the neighborhood, organized to work for candidates who would agree to support their efforts in the city council. Since then the matter has been brought to a head by the sending of a largely-signed petition to the Railway Commission, asking that the Toronto, Hamilton and Buffalo Ry. be ordered to remove its tracks from Hunter Street.

It was while this matter was pending that the city authorities, acting on the suggestion of the City Engineer, approached the officials of the Grand Trunk Railway, the Canadian Northern Railway, and Toronto, Hamilton and Buffalo Ry. to ascertain if they would consider a plan of uniting to use a common right-of-way through the city, and of building a union station.

There are many reasons why this scheme is desirable from the city's point of view. In the first place, Hamilton is so confined between the mountain and the bay that an independent right-of-way through it effects as much as 10 per cent. of the city. The granting of another right-of-way is therefore a serious proposition.

(2) It would be a decided convenience to have all the steam roads use a union station just as do the electric lines, and thus do away with awkward transferring from station to station. If the union station were placed somewhere near the corner of James and Barton Streets it would be more convenient for a large majority of the citizens than at any other point for it would be within easy walking distance from the centre of the city and every street car line, with one exception, passes through that point without transfer.

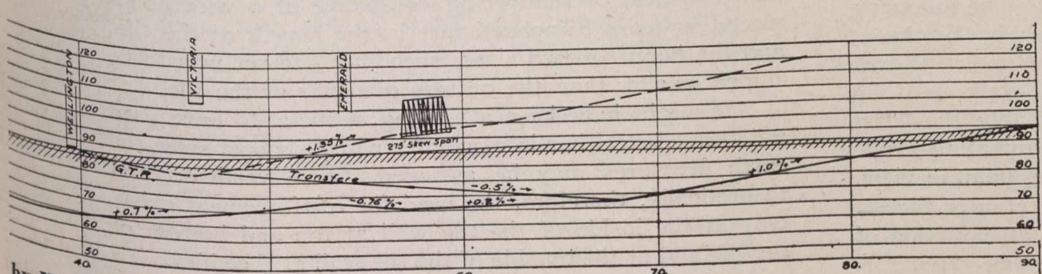
(3) The land along and adjacent to Hunter Street, on account of the rapid growth of the city is becoming

very valuable (or would be if the railway were not there) and will be needed for the future growth of the business section. The land in the north end, as pointed out by the City Engineer, has reached its limit in value for residential purposes, and is more suitable for manufacturers and railroads.

(4) The proposed improvement to Hamilton harbor by the Dominion Government will make it all the more desirable to concentrate the transportation companies in the north end.

(5) The street traffic in the centre of the city has already become so congested that it requires special regulation, and as the city grows it will become more and more important to clear the streets now more or less obstructed by the Toronto, Hamilton and Buffalo Ry.

(6) At present the Toronto, Hamilton and Buffalo Ry. has a spur line across the city into the manufacturing district. A glance at (Fig. 1) shows a regular network of switches, and only the main ones are indicated. From these are collected every day several train-loads of freight, which are now transferred across the city, up heavy grades, the most of it travelling along Hunter Street to the west end freight yards. If all this traffic, along with the through freight, could be diverted to the Grand Trunk Railway right-of-way and taken to the yards by way of the Des Jardines Canal, practically every objection of the Hunter Street residents would be done away with. Besides it would not only bring the Railway Company within reach of new customers, but it would apparently be a convenience in handling freight.



by Westinghouse, Church, Kerr and Company.

Taking everything into consideration the common right-of-way scheme would seem to be a very satisfactory solution to the railway problem from the city's point of view, and the officials were correspondingly disappointed when, after the Grand Trunk Railway and Canadian Northern Railway had signified their willingness to confer on the question, the Toronto, Hamilton and Buffalo Ry. recently absolutely refused to consider it. However, the city decided to go ahead with the preparation of plans and of an estimate of the cost of connecting the Toronto, Hamilton and Buffalo with the Grand Trunk Railway, and will also ascertain if the Railway Commission has power to order the railway to make the change. The plans are now ready but have not yet been made public.

The attitude of the Toronto, Hamilton & Buffalo Ry. on this question is hardly to be wondered at. The company has very little to gain directly, even if it has nothing to lose. Its franchise through the city is of great value, quite apart from the actual value of the property it holds. This value increases every year as the city grows. The present location of its station affords an advantage in passenger traffic that is estimated at four to one. This, however, would be very materially effected should the Grand Trunk Railway build a proper station near James and Stuart Streets. There is one thing, however, that might make it worth while for the Toronto, Hamilton and Buffalo Ry. to consider the union station scheme and that is the outcome of the petition to the Railway Commission mentioned above, which might be an order to depress or elevate its tracks through the city.

Coming back to this petition. In replying to it the Toronto, Hamilton & Buffalo Ry. submitted a report, prepared by Westinghouse, Church, Kerr and Company, of New York, in which plans for both elevating and depressing the tracks through the city were worked out, with an estimate of the cost. These plans are both on the basis that the present alignment is to be maintained. At the session of the Railway Commission held in Hamilton, on April 28th, 1913, at which the case came up, the city submitted a third plan showing the tracks depressed and swung entirely off Hunter Street,

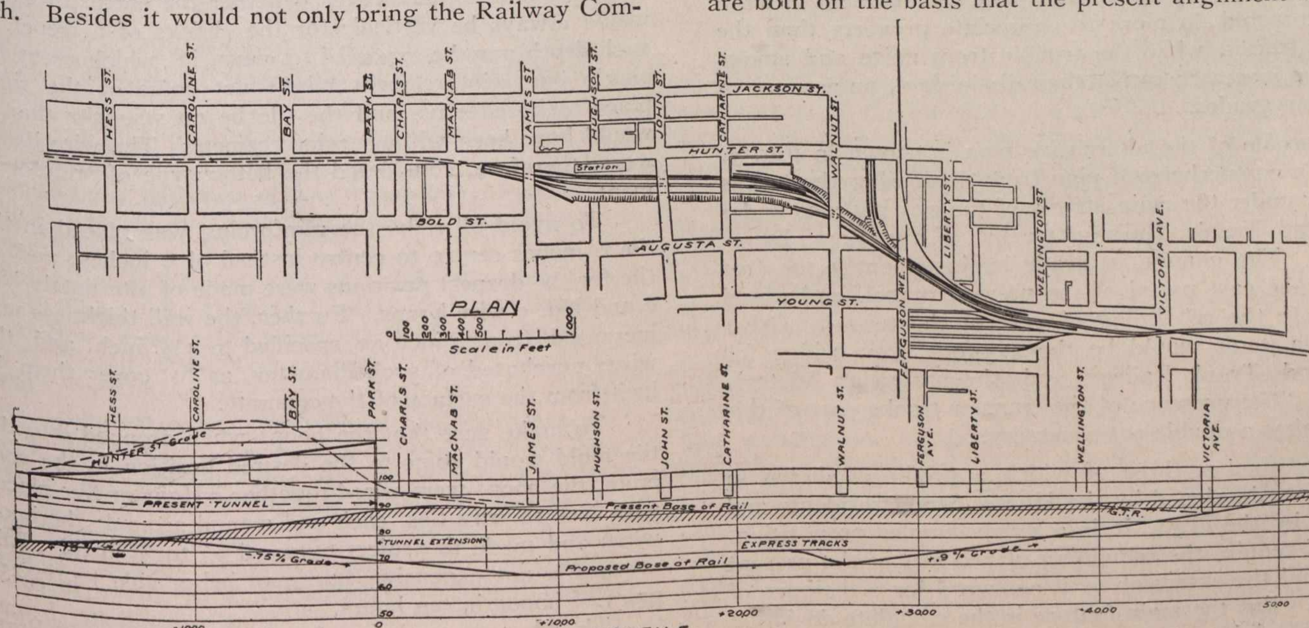


Fig. 4.—Plan and profile of track depression, city's plan.

or covered in a tunnel.

A rough estimate of the cost of the three plans is as follows:—

Plan No. 1.—For elevating the tracks......	$760,000
Plan No. 2.—For depressing tracks	2,940,000
Plan No. 3.—For depressing tracks, city's plan	1,200,000

These figures do not include land damages. For plan 3 in which this item is larger than for the other plans, it is estimated that these would amount to $310,000, allowing for salvage on property owned by the Toronto, Hamilton and Buffalo Ry.

All these plans include extensive additions to the station platforms, tracks, etc., which are much needed at present, and the cost of which should not be included in the actual cost of grade separation.

Fig. 2 shows the profile of the track elevation plan as worked out by Westinghouse, Church, Kerr and Company. Beginning at the mouth of the present tunnel the track rises on a 1 per cent. grade to James Street, where the station platform begins. James Street is depressed about nine feet and John, Catharine, Walnut and Ferguson Avenues, are depressed from three to six feet. The maximum street grade is 5 per cent. The following streets are closed entirely; Charles Macnab, Hughson, Bailie and Liberty Streets, while Hunter Street would be diverted and only one side-walk left on the present street. This plan is probably the least expensive and most satisfactory way of eliminating grade crossings from a construction and operating point of view, but to the city it would mean the loss of Hunter Street, the closing of five other streets and the introduction of long heavy grades in some of the main business streets. A glance at Fig. 1 will show that every north and south street from James to Bay Streets,—a distance of a quarter of a mile, would be practically closed as the grade on Park Street, over the portal of the present tunnel, makes it useless except for very light traffic. The embankment through the city would do more to depreciate property than the present tracks, while the trouble from noise and smoke would be increased rather than diminished, on account of the heavy grades.

A profile of the alternative plan is shown in Fig. 3. This is a comprehensive plan from depressing the tracks not only under the main streets of the city but also under the Grand Trunk Railway tracks of the Port Dover Branch. The change in grade begins about 1,200 feet west of the east portal of the present tunnel, and would necessitate the rebuilding of part of the tunnel. Other expensive items would be the 275-foot skew-bridge for the Grand Trunk Railway and the bridge at Victoria Avenue. The presence of the transfer tracks east of this point makes a double cut necessary.

Plan number three of which a profile is shown in Fig. 4 was developed by the Hunter Street residents and adopted by the city. It is a much simpler proposition. It would require the rebuilding of 700 feet of the present tunnel and the extension of it eastward for a distance of 600 feet. But the main feature is the complete deviation of the line off Hunter Street. This would restore Hunter, Park, Charles and Macnab Streets to their original grade and free them from obstruction. On the east the present grade is reached at Victoria Avenue. East of this street the railroad is practically out of the city as there is no land of much value between it and the mountain.

There will probably be a joint meeting of the engineers of the parties interested early this fall to go over the plans and reduce the estimates to a common basis. The Railway Commission will then be in a position to consider the question.

REINFORCED CEMENT DRAIN TILE.

MR. CHARLES E. SIMS, writing in "The Iowa Engineer," refers to a contract which he secured in the spring of 1912, for the 30 to 42-inch cement drain tile for Rock County, Minn. The contract called for 3,700 feet of 42-inch tile, 1,500 feet of 34-inch, 1,300 feet of 32-inch and 2,200 feet of 30-inch. The 42's were to be laid at an average depth of 17 feet 9 inches and a maximum of 22 feet and 6 inches; the 34's at a maximum depth of 13 feet 6 inches, the 32's at a maximum of 11 feet 4 inches and the 30's at 9 feet 7 inches.

The earth pressure at the greatest depth of the 42's, figuring the trench 62 inches wide, was estimated at 5 tons per foot, or 15 tons on a tile 3 feet long. The engineer, in charge, specified a wall thickness of 4 inches and a system of reinforcing consisting of 6 wire hoops placed in pairs 8 inches apart in the length of the tile, and the hoops of two sizes, such that one set was to be 1 inch smaller than the outside diameter of the tile.

It might have been a saving of metal to have used a deformed steel bar in place of a pair of hoops, since the earth pressures may be assumed to be vertical, and theoretically, therefore, the need for reinforcement exists only at the inside of the tile wall at top and bottom of the tile and at the outside of the tile wall at the sides. To make this clear let us imagine a tile failing from the load upon it. As the tile fails, cracks open on the inside at top and bottom and on the outside at the sides, hence reinforcing is needed where the cracks can first be seen. It was a question, however, whether the earth pressures would always be vertical; for the banks of a trench of such depth may be expected to cave, in which event the single bar reinforcement might not come at the right place to be effective and the tile be no stronger than it would have been without reinforcement. The wire hoops were, therefore, considered the better type of reinforcement.

To avoid all risks the reinforcing was placed in the tile 6 inches centre to centre instead of 8 inches, and all tile for the deepest positions were made of alternately No. 6 and No. 3 wire hoops. Further, the wall thickness was increased from 4 inch as specified to 4½ inch and the wires purchased of such diameter as to cover them ¾ inch from the surface of the concrete.

To make sure that the hoops when dropped into the tile mold would come to the desired position in the concrete, the hoops were wired together in four or five places with No. 16 wire ties, each end wound around the hoop wires and made to project outward ⅝ to ¾ inch. This process is not expensive, one man being able to tie 250 pairs of hoops in ten hours.

The tile were made in 3 foot lengths. One part Portland cement to 3 parts of sand and gravel was used for the concrete, and as much water as possible, with the result that the tile made have watertight walls, and it is believed that the bond between the reinforcing and the concrete is all that is necessary for strength and preservation of the metal.

The smaller sizes of tile were made of wall thickness equal to one-tenth the inside diameter of the tile and reinforced 8 inch centre to centre with No. 7 wire hoop placed 5/8 inch from the surface of the concrete, except the 30 inch, which were made with the walls one-twelfth the diameter of the tile, as they would not be used for six months after manufacture and the thinner wall was deemed sufficient, with good materials, mixed wet and tamped densely.

The 42's have been shipped 45 miles without breakage, and hauled seven miles frequently when but ten days old, thus demonstrating the quality of material and the effectiveness of the reinforcing in reducing breakage. A thousand feet of the tile are now in place, some under a fill of two-thirds the maximum due to tamping the fill at the sides of the tile.

PROGRAMME OF THE AMERICAN ROAD CONGRESS.

The American Road Congress, which is held under the auspices of the American Highway Association, the American Automobile Association, and the Michigan State Good Roads Association, and in which some twenty-five Road Associations will participate, is being held in Detroit, September 29th to October 4th.

The following is a list of papers to be presented. They will be read by title only, advance proofs being previously circulated and the sessions of the Congress given over to prepared discussion.

"The Labor Problem in Road Construction," by Captain P. St. J. Wilson, State Highway Commissioner of Virginia. Discussion to be opened by Mr. W. E. Atkinson, State Highway Engineer of Louisiana.

"Systematizing the Purchase of Road Materials and Equipment," by Mr. Henry G. Shirley, Chief Engineer, State Roads Commission of Maryland. Discussion to be opened by ——.

"Unsurfaced Roads," by Mr. W. S. Keller, State Highway Engineer of Alabama. Discussion to be opened by Mr. George W. Cooley, State Highway Engineer of Minnesota.

"Gravel Roads: Their Construction, Maintenance, Cost and Special Treatment," by Hon. S. Percy Hooker, State Superintendent of Highways of New Hampshire. Discussion to be opened by Mr. H. L. Bowlby, State Highway Engineer of Oregon.

"Treatment of Worn-out and Ravelled Macadam Surfaces," by Colonel E. A. Stevens, State Highway Commissioner of New Jersey. Discussion to be opened by Hon. Robert C. Terrell, State Commission of Public Roads of Kentucky.

"Bituminous Macadam Construction and Maintenance," by Mr. S. D. Foster, Chief Engineer, State Highway Department of Pennsylvania. Discussion to be opened by Mr. W. A. McLean, Provincial Engineer of Ontario, Canada.

"Brick Roads," by Mr. James M. McCleary, County Engineer of Cuyahoga County, Cleveland, Ohio. Discussion to be opened by Mr. R. Keith Compton, chairman Paving Commission, Baltimore, Md.

"Concrete Roads," by Hon. Frank F. Rogers, State Highway Commissioner of Michigan. Discussion to be opened by Mr. Paul D. Sargent, State Highway Engineer of Maine.

"Selection of Road Materials," by Hon. Logan Waller Page, Director, United States Office of Public Roads. Discussion to be opened by ——.

"Dust Prevention," by ——.

"Drainage Structures," by Mr. A. R. Hirst, State Highway Engineer of Wisconsin. Discussion to be opened by Professor T. H. MacDonald, State Highway Engineer of Iowa.

"California's $18,000,000 State Highway System," by Mr. A. B. Fletcher, State Highway Engineer of California.

"Highway Accounting, with Special Reference to Maintenance," by Mr. Halbert P. Gillette, Editor-in-Chief, Engineering and Contracting.

"The Organization and Management of Working Forces," by Mr. A. N. Johnson, State Highway Engineer of Illinois.

"Contract Law," by Mr. William Bowman, of New York.

"The Protection and Upkeep of Road Equipment," by Mr. Daniel J. Hauer, of New York.

"The Merit System in Road Management," by Hon. J. A. McIlhenny, President United States Civil Service Commission.

"Financing Road Improvements," by Mr. Wm. G. Edens, President Illinois Highway Improvement Association.

"Bond Issues for Road Improvement," by Mr. S. E. Bradt, Vice-President First National Bank, DeKalb, Ill.

"The International Congress and the Roads of England, France and Germany," by Col. Wm. D. Sohier, chairman, Massachusetts State Highway Commission.

"Economics of Road Improvement," by Mr. J. E. Pennybacker, Secretary, American Highway Association.

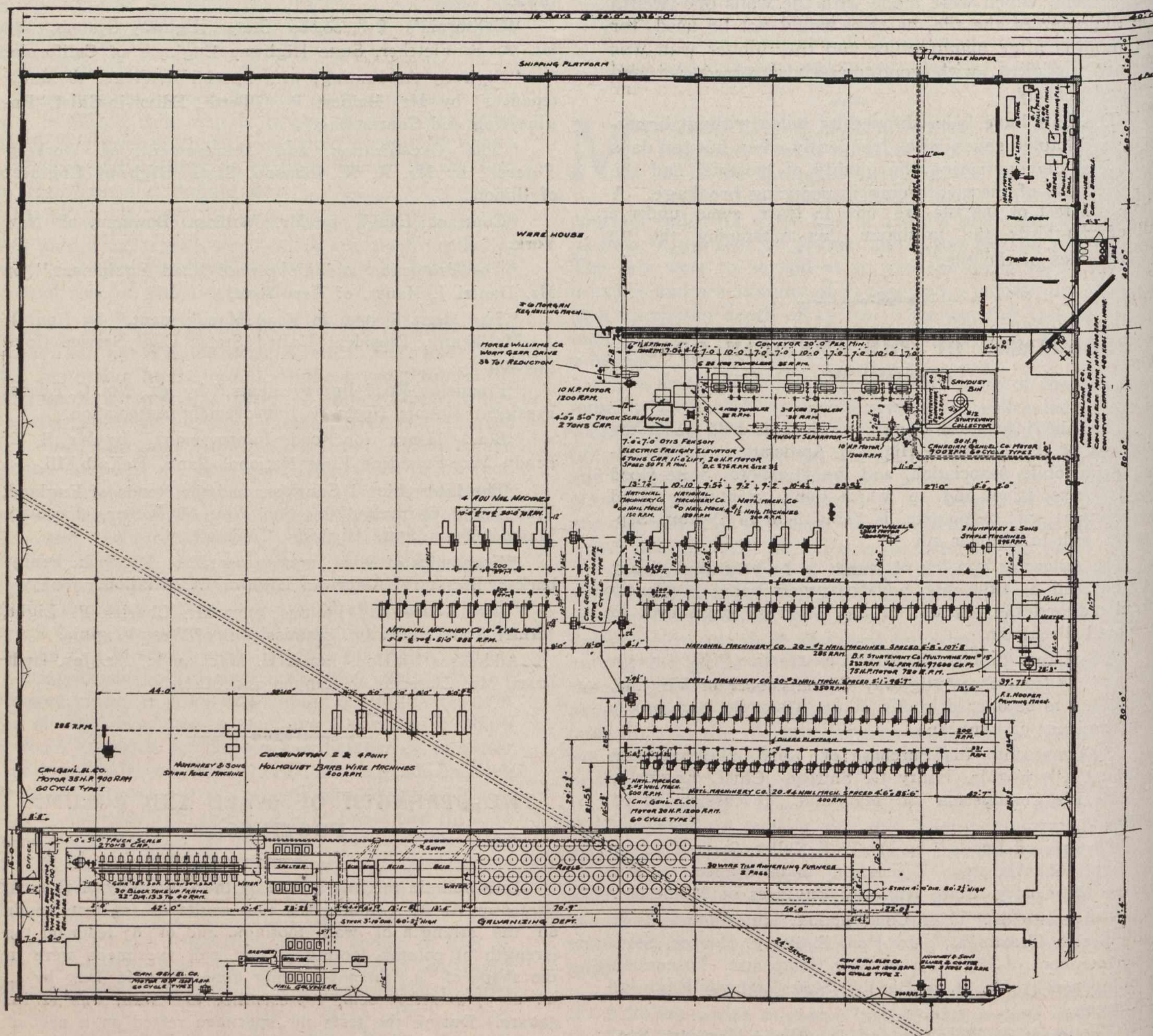
"Dirt Roads and Politics," by Mr. Charles P. Light, former State Highway Commissioner of West Virginia.

Addresses by Hon. James H. MacDonald, Dr. Jos. Hyde Pratt, Mr. Clarence A. Kenyon and others.

THE STRENGTH OF WALL AND COLUMN FOOTINGS.

In a bulletin recently issued by the University of Illinois, Professor A. N. Talbot gives the results of 114 tests made on the strength of wall footings, and of 83 tests on the strength of column footings. The wall specimens were in the shape of ⊥, the table being generally 5 ft. long by 12 in. deep, and the stem, representing the wall, was 12 in. square. During the tests the specimen rested on a nest of helical car-springs, of which as many as 225 were used in some tests. The load was applied to the top of the stem, and failure occurred generally by bending about a section parallel to one face of the "wall." The tests included footings of brick and of plain concrete, as well as of reinforced concrete, but the latter only gave fairly consistent results. The unreinforced specimens showed great irregularities. With the reinforced footings, on the other hand, the results were in fair accord with the ordinary theory of the reinforced concrete beam. The reinforced column footings were 5 ft. square and 12 in. deep, and the column was represented by a stem 12 in. square. As in the experiments with the wall footings, the specimen was supported during the test on car-springs. The general question of the distribution of stresses in slabs is discussed by Professor Talbot on a qualitative rather than a quantitative basis, the problem being, of course, of a very complicated character. This fact makes it difficult to give any really useful summary of the results, of which, however, full particulars, with illustrations of characteristic cases of failure, will be found in the bulletin.

THE WIRE AND NAIL MILLS OF THE DOMINION IRON AND STEEL COMPANY, LIMITED.



General Arrangement of Nail and Wire Mill, Dominion Iron and Steel Company, Sydney, Cape Breton.

Like almost all the large and successful enterprises, the works of the Steel Company at Sydney, N.S., have grown by a process of evolution. In the earliest days the output was confined to pig iron and steel in its primary forms, the manufacture of which is not always profitable, but without which there can be no permanent or satisfactory development of the secondary industries producing more highly finished materials. Later, when the expanding trade of the country seemed to warrant a forward movement, mills were erected to produce rails, billets and wire rods. During the past year a third stage of development was reached by the completion of the Merchant Mill, described in *The Canadian Engineer* of July 31st, and the establishment of a department for the manufacture of a large scale of all kinds of wire and wire products, including not only various sorts of wire nails required for the home market, but others specially adapted for export.

An indication of the importance of this latest development of the works is given by the fact that the buildings in which the various processes are carried on for the conversion of rods into wire and nails cover no less than four acres of ground and that the tracks serving these buildings and connecting them with the company's general railroad system take up nearly as much more.

Briefly stated, the course of operations is as follows: Rods, coming direct by hook conveyer from the rod mill, are prepared for drawing by cleaning and coating, they are then drawn into wire which may be finished for sale plain as it comes from the drawing blocks, or as annealed or galvanized wire. Part of the galvanized wire is put through machines which convert it into fencing of one sort or another. A large part of the plain wire is sent to the nail mill where it is made into nails of all patterns and sizes from a quarter of an inch to twelve inches in length, bright, coated, blued or galvanized.

For convenience, the departments in which these various processes are carried on may be described separately.

Cleaning and Coating Department.—The cleaning house occupies a space 94 ft. by 160 ft. with a lean-to on the west side for storage of acid and lime. It contains acid and water rinsing tubs, lime coating tank, measuring tank, two jib cranes and a baker with ten tracks and capacity for ninety trucks.

Rods in bundles are delivered to cleaning house by hook conveyer direct from the mill. They are first placed in the acid tubs to remove scale and rinsed in the water tub. They are then thoroughly coated in the lime tank and heated in the baker until the lime coating is firmly set and the rods are ready for drawing.

Wire Drawing Department.—This immediately adjoins the cleaning house, covers a space of 94 ft. by 192 ft., and contains seven wire-drawing benches equipped with 83 twenty-six-inch blocks of the most modern types. The benches are separately driven by six 100 h.p. and one 150 h.p. motors, through Morse silent chain drivers. Provision is made for making and annealing and tempering the steel plates through which the wire is drawn.

Annealing is done either in a muffle furnace set near the baker in the cleaning house, or in four coal-fired annealing pots housed in a building 33 ft. by 80 ft., served by a five-ton overhead electric crane.

Nail Department.—This occupies a space 240 ft. by 336 ft., and is equipped with eighty-two nail machines designed to make a great variety of sizes and patterns of nails, including some that have not been previously made in Canada. There is a full equipment of tumblers and other accessories, including a package printing press and automatic nailing machines, and a tool-room fitted up for making the dies required for the nail machines.

A space 80 ft. wide and running the whole length of the building is reserved for storage and has capacity for 80,000 kegs.

Galvanizing Department.—This is under the same roof as the nail mill on the west side, but is separated from it by a brick wall. The whole floor space, 53 ft. by 336 ft., is occupied by apparatus required for galvanizing wire and wire nails.

In the wire galvanizing process the wire is given two passes through a tile annealing furnace and afterwards goes in succession through water and acid baths, a pan of molten spelter and a water tank. It is then wound on electrically driven take-up blocks or reels, of which there are thirty in all, forming coils 22 inches in diameter inside.

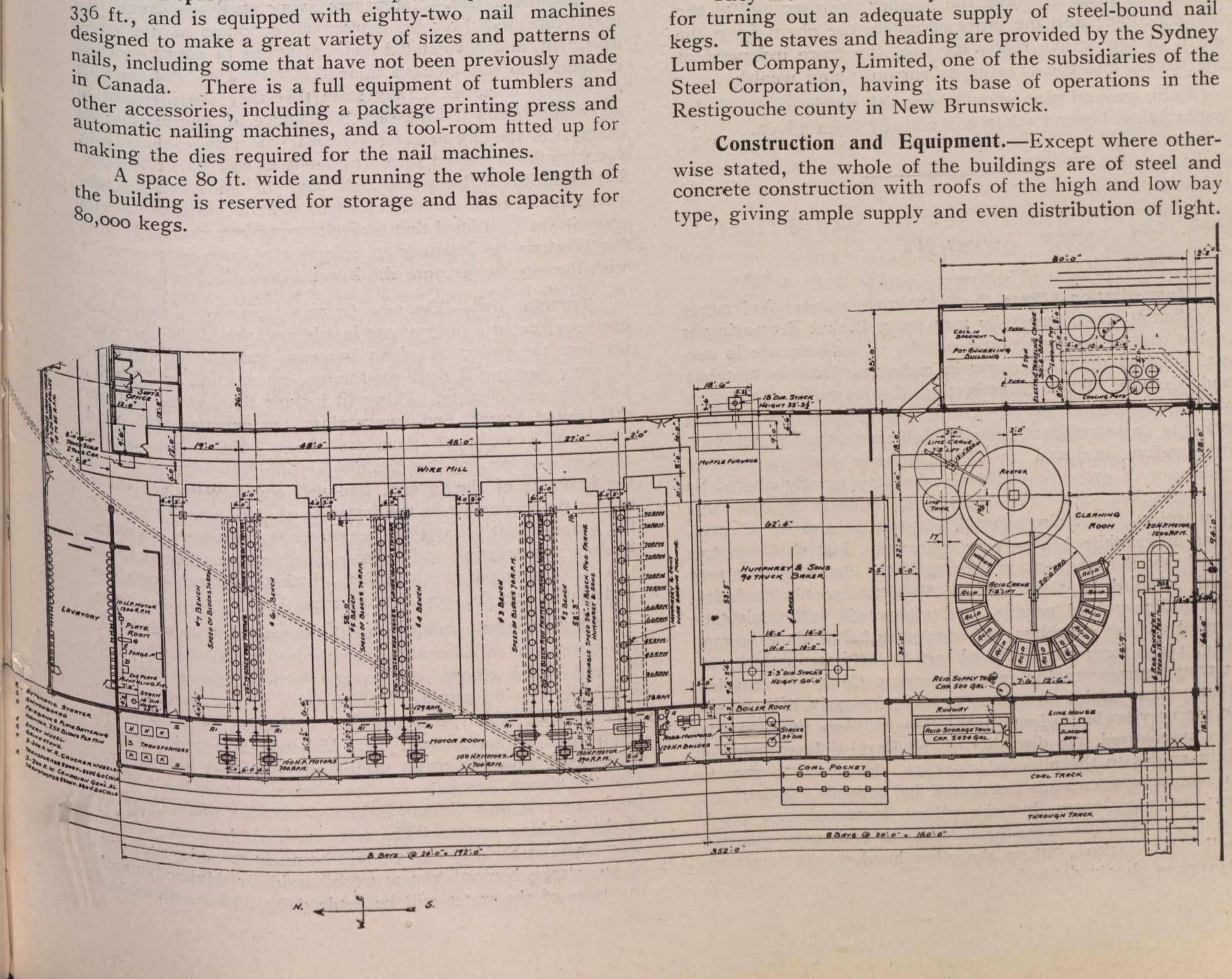
Coming from these reels the wire is ready to be bundled for shipment or to be put through the fence machines, of which there are six in the main building. This branch of the business might be largely increased, but at the present time conditions are such that there is little inducement for expansion.

The nail galvanizing unit consists practically of a tank for holding melted spelter into which the nails, previously cleaned, are dipped in steel baskets and a shaker and conveyer upon which they are kept in motion until the coating of spelter has cooled and set and there is no longer any danger that they will stick together.

Cooperage.—The cooper shops are housed in a two-story brick building, 40 ft. by 80 ft., with a single-story frame and corrugated iron extension the same size for storage of shooks.

They are fitted with dry kilns and suitable machinery for turning out an adequate supply of steel-bound nail kegs. The staves and heading are provided by the Sydney Lumber Company, Limited, one of the subsidiaries of the Steel Corporation, having its base of operations in the Restigouche county in New Brunswick.

Construction and Equipment.—Except where otherwise stated, the whole of the buildings are of steel and concrete construction with roofs of the high and low bay type, giving ample supply and even distribution of light.



Motive power throughout is electric. Steam for dry kilns, cleaning house and heating is furnished by 500 h.p., W.T. boilers. The buildings throughout are served by a Sturtevant heating and ventilating system. Lavatories and toilet rooms equipped with all modern conveniences are provided for the use of the employees.

Self-Dependence.—In this latest development of its varied activities there is a striking illustration of the ability of the Steel Corporation to carry on its business independently of aid or opposition. It wins the ore, coal and flux from its own mines and quarries, smelts the ore in its own furnaces, carries the resulting pig iron in its own works through the various processes that are necessary to convert it into the finished article that is required by the consumer, puts it in a package made in its own shops from lumber cut in its own mill from timber taken from its own lands, and delivers it to the user in the heart of the Dominion by means of its own ships.

What this really means is, that practically every cent of the value of a cargo of rails, or nails, or wire laid down at Port Arthur or Winnipeg, manufactured and transported under conditions such as are described above has been paid to our own people—and that not one cent has gone abroad.

The same statement could not be made if the pig iron were imported and made into steel, if steel billets were imported and made into rails or rods, or if rods were imported and made into wire and nails. The fewer the operations done at home the smaller the earnings of the home people; and the more complete the chain from the earth to the article ready for use, the more independent the nation and the greater its earnings and wealth.

The ground plan shown herewith needs no particular explanation beyond what has already been given.

ELECTRIC RESISTANCE OF MAGNETIZED GRAPHITE.

Magnetization affects the electric resistance of elements in different ways, generally increasing it, but decreasing it in the case of ferro-magnetic metals. This influence is several hundred times stronger in cadmium than in tantalum and bismuth. When investigating the magnetic properties of the elements, Morris Owen, Amsterdam, found that graphite possessed exceptionally high magnetic susceptibility. It, therefore, occurred to D. E. Roberts that the electric resistance of graphite would also be very greatly altered by magnetization, and his experiments entirely confirm this assumption. They also showed, however, that different specimens of graphite behave very differently, just as Owen had found that the magnetic properties of the elements were very much affected by their purity. Roberts experimented first with ordinary lead pencils, and afterwards with prismatic bars of various graphites, the specimens being about 10 mm. long, 1 mm. or 2 mm. in width, up to 0.5 mm. in thickness, at temperatures ranging from —200 deg. Cent. to + 200 deg. Cent. Some of his graphites conducted nearly half as well as mercury under ordinary conditions. When the graphite was magnetized, the direction of the lines of force being at right angles to the plane of cleavage, the electric resistance for continuous currents increased by several hundred per cent. in many cases, but the values fluctuated very much. As the temperature rose, the increase in resistance was generally less marked, but on the other hand it was sometimes also more clearly defined.

COAST TO COAST.

Vancouver, B.C.—The city has under consideration the expansion of the water system by the purchase of the watershed of Seymour Creek and the construction of a large reservoir or storage basin therein, a project which will involve much engineering.

St. Boniface, Man.—About two weeks ago the formal opening took place of the new stock yards at St. Boniface, Man. The function brought together a representative gathering of public men, and after Premier Roblin had declared the yards open, the party inspected the yards, which possess considerable interest for the engineer and the contractor. The contract for the laying of the sewers, water mains, together with all the concrete work, constitutes a problem that is quite interesting in itself when it is remembered that the pavements alone cover an area of 65,000 square yards. The paving consists of a concrete base 5½ inches thick, the mixture being 1:3:5. On top of this there is a one-inch thickness of finish, one part cement to 1½ parts coarse sand. The base and topping took 12,000 cubic yards of mixture. The runways for the cattle from the landing platforms to the level of the pens are all built of concrete. Altogether, it is an interesting piece of concrete construction. The contract for laying the sewers, water mains, laterals and concrete paving was carried out by the Hurst Engineering and Construction Company, of Winnipeg.

Brantford, Ont.—Ratepayers living on Brant Avenue became incensed over the deplorable condition of the street pavement, and have stated their intentions to the city council of refusal to pay charges upon the work when the tax bills are due in October. They state that they are prepared to go to the courts if necessary in defiance of any attempt on the part of the city to exact payment. Meanwhile, the paving company has received several ultimatums to repair the street, but nothing has been done, although the nuisance has prevailed for several months. Latest report has it that the city council has instructed that proceedings be commenced against the Westrumite Company to enforce the company's contract with the city for keeping the Brant Avenue in good repair.

Toronto, Ont.—The new Ontario Highway Commission has constructed a programme for the balance of the year that involves the collection of an immense quantity of statistics covering provincial road conditions, expenditure, and traffic, for each municipality. This will include data gathered from the United States, and concerning the experimental road work which many of them are doing. From the course adopted it is evident that the new system will primarily serve the interests of the farmer, and will endeavor to achieve a proper proportioning in the interests of the agriculturist and the automobilist. Laws and regulations, economic features, finance, construction and maintenance, and educational facilities is a summary of the work which the commission has undertaken for the next few months.

Calgary, Alta.—Analyses of the sample of Calgary drinking water sent to Edmonton recently by Dr. Stanley Mahood, medical health officer, show that the water from the Bow River, now being pumped into the city mains, is free from colon bacilli, which is a practical indication that there are no typhoid germs present. Dr. Mahood expressed himself as pleased with the result of the analyses, but pointed out that the city will soon be in a position to protect itself absolutely against possible contamination through daily analyses of the drinking water. "The new municipal laboratory, with City Chemist Field in charge, will be ready to make analyses of our water, beginning next week," said Dr. Mahood, "and the tests of the water will be made daily. This will enable us to keep a constant check on our water supply, and will be of the greatest assistance to the health department." At the present time the water that is being pumped into the mains from the Bow River is chlorinated to destroy harmful germicidal life. The chlorine, however, to a certain extent favors the propagation of harmless bacilli, as shown by the Edmonton test. The water taken direct from the Bow showed 7,400 bacilli to the cubic centimeter, while that treated with chlorine showed 8,800 of the harmless bacilli to the cubic centimeter. The fact that the water samples have to be sent to Edmonton by train also permits the water to stand for a time, with the result that the propagation of bacilli is favored. The complete result of the analyses of water taken direct from the Bow River and the chlorinated water is as follows:—

	Direct from Bow River.	Chlorinated.
Hardness	120	114.2
Total solids	215	243
Loss on ignition	82	120
Alkalinity	132	120
Ammonia, free	.008	.026
Ammonia, albuminized	.032	.006
Nitrites	None	None
Nitrates	.04	.04
Chlorine	1.8	2.7
Sulphate	None	None
Colon bacillus	Negative	Negative

Edmonton, Alta.—City Engineer Latornell has submitted to the Commissioners blue prints showing the proposed sewage purification works to be erected on Ross Flats. As he pointed out, for some time past it has been proposed to erect a disposal plant there to purify the sewage from that portion of the city, which, roughly speaking, lies south of Jasper Avenue, between First and Twelfth Streets. In 1912 an appropriation of $30,000 was set apart for the construction of such a plant. But further study of the question has led Mr. Latornell to the conclusion that it would be an advantage if the city could bring across to this side of the river the sewage from that part of the South Side, which is already provided with drainage, and treat this South Side sewage in the plant located on Ross Flats. The new drawings are for that plant. A larger plant is in consequence required than was originally intended, but the ultimate economy in having one plant instead of two will be considerable, in the opinion of the city engineer, even though the new arrangement will necessitate one very expensive item, namely, a syphon under the river.

Ottawa, Ont.—On the suggestion of City Engineer Currie, a recommendation will be made to the city council by the board of control with a view to improving the manner of laying pavements. The main point aimed at is to prevent pavements sinking over where water or sewer pipes have been laid, and also to avoid having public services companies cut up a pavement the next day or so after it is laid. The proposition is that no permanent pavement be laid on any street till six months after the work has been passed by the city council. This will give the city time to do its underground work on the street and allow the earth used for filling in to settle. The public service companies will also be notified to do their work under the same conditions. The board discussed the matter, and all were agreed that the suggestion of the city engineer is a good one. So far, the Ottawa Gas Company has been cutting up pavements whenever it wished, claiming that under its charter it has a right to do so without asking the permission of the city. The board is of the opinion that recent legislation by the Dominion Parliament gives the municipality more control over the streets and prevents future work without the sanction of the city. At any rate, if the board's report is approved, the companies will be so notified.

Montreal, Que.—Chairman Drayton, of the Canadian Board of Railway Commissioners, and a small party recently witnessed a demonstration in London by the South Western Railway at Hamilton Court Station of the Prentice system of automatic wireless traffic control. It was invented by a young Canadian telegraphist, and is claimed to be an ideal scheme. The essential factor is that if any obstructive vehicle is on the track it interrupts wireless operations. A highly insulated wire is laid in the casing of the middle track. Normally, electric waves are constantly discharged, but the green and red signal lights are automatically shown when there is any danger on the track. The demonstration was entirely successful. A special train automatically was brought to a stop when a light engine was on the track some distance ahead. The cost of installation has not yet been indicated.

Vancouver, B.C.—An instrument that is expected to save the city of Spokane, Wash., $1,000 every day in the year by preventing a daily loss of 15,000,000 gallons of water from the system of mains, is being set up under direction of Water Superintendent Alexander Lindsay. It is a new leak detector, purchased by the department after a thorough investigation by Mr. Lindsay showed that 15,000,000 gallons of water was being lost each day by defects hard to locate in the complex system of underground mains. "We have just received the instructions for setting up the rather complicated piece of apparatus," Mr. Lindsay said. "The meter is attached to a single lead running into a given district, and all other inlets are cut off. It records every gallon of water sent into the pipes at the hour pumped. Then we trace the flow, and if it is found that much water is going into the district between the hours of 1 a.m. and 3 a.m., when the use of water is at the minimum stage, we can tell that there is a leakage. Then the district is made smaller, parts of it being cut off, until by a process of elimination we find just where the section is that is causing the waste. It will take some time to test out all of the mains in a city of 120,000 population, but our regular force will start the work immediately, and we hope to be able to reduce a great amount of waste in the very near future."

Quebec, Que.—Interesting forecasts of the business to be brought up at the next session of the Provincial Legislature, when a further loan for the good roads work, aid for the Canadian Northern Railway, in the Province of Quebec, and the question of a new court house for Montreal will be dealt with, were made by the Hon. Mr. L. P. Berard, Legislative Councillor, of Quebec, in an interview recently. The Highways Bill, passed in the early part of the year, authorized a loan of $10,000,000 for the improvement and building of roads in the province. About $3,000,000 of this has already been secured. So much work is in progress, however, says Mr. Berard, that more funds will be needed before long, and an additional loan floated towards the end of this year. Another important measure for consideration at the next session will be financial aid for the Canadian Northern Quebec lines. Mr. Berard does not anticipate any serious opposition in this matter, as he believes it to be generally recognized that the railway is entitled to the same benefits received by other great systems in the Dominion. Such assistance on the part of the Provincial Government will, of course, only provide for lines in the province. A proposition for the erection of Montreal's new court house, so long the subject of discussion, Mr. Berard states, will be introduced at the next session. The bench and bar of the city are practically unanimous on the question, and Sir Lomer Gouin is in favor of a new building also. Consequently, there is a good prospect of definite action being taken before the spring of 1914.

PERSONAL.

Geo. A. JANIN, city engineer of Montreal, is at present in Europe on a short vacation.

P. J. MITCHELL, of London, England, who organized The Canadian P. J. Mitchell Company about two years ago, is spending a few weeks at Banff, Alta.

C. A. MEADOWS, B.A.Sc., has acquired the management of the newly-opened Toronto branch of the Dominion Engineering and Inspection Company, of Montreal.

R. C. HARRIS, commissioner of works for Toronto recently received an offer from Vancouver, B.C., to a similar position there at a salary of $10,000 a year. Mr. Harris will likely remain with Toronto, however.

R. G. FINCH, of the State engineer and surveyor's staff, New York Barge Canal, has been spending a few days in Ontario acquainting himself with Canadian canal developments.

W. F. TELTZEL, provincial government agent at Nelson, B.C., has resigned his present position to accept the position of selecting and recommending sites for all public buildings throughout Western Canada. He will make his headquarters at Victoria.

OAKLEY T. BROWN, M. E., formerly combustion engineer on the Camden, N.J., engineering staff of R. D. Wood and Company, of Philadelphia, has been appointed chief engineer of The Mechanical Engineering Company, Limited, Montreal.

J. L. CHAMBERS, of Chambers, Limited, Toronto, has just returned from a business trip to Great Britain, while abroad Mr. Chambers visited the works of John Fowler and Company, Leeds, Manlove, Alliott and Company, Nottingham, Bertrams, Limited, Edinburgh and others of his principals over there.

HON. W. F. ALYMER, Dominion public works engineer at present in Vancouver, will go north shortly for the purpose of examining the Fraser River between Soda Creek and Lillooet with regard to the feasibility of navigation along this part of the river, and also to report regarding the channel in the south fork of the Fraser near Tete Jaune Cache.

FRANCIS A. JACOBS, the Montreal mechanical engineer who invented the Jacobs shop furnaces and oil burning equipment, has sold his patents and business to the Mechanical Engineering Company Limited, of Montreal. Mr. Jacobs becomes president of the new company. Mr. Graham being secretary-treasurer. The company has a well-equipped shop on Mill Street, Montreal. They are building furnaces and burners under the trade name of "Mecol," and are also agents for Canada for R. D. Wood and Company, of Philadelphia, and Mesta Machine Company, of Pittsburgh.

OBITUARY.

E. M. STOREY, a prominent architect residing in Regina, Sask., died on August 24th. Mr. Storey was formerly a resident of Kingston, Ont.

ALEXANDER MACFARLANE, D.Sc., LL.D., whose prominence as an educationalist in mathematical and physical research grew to be universal, died at his home in Chatham, Ont., on August 28th.

Dr. Macfarlane was born at Blairgowrie, Scotland, April 21st, 1851. He was a pupil-teacher at the age of thirteen, and in 1869 entered the University of Edinburgh, where he won many scholarships. In 1875 he finished an unusually extensive course in undergraduate study by taking the degree of M.A., with honors in mathematics and physics.

After graduation he won the MacLaren fellowship, and in 1878 he obtained the doctorate, after one year spent on botany, chemistry and natural history. His thesis was a remarkable experimental research into the conditions governing the electric spark. This brought him to the attention of the celebrated electrician and philosopher, Clerk Maxwell. In 1879 he was elected to the Royal Society of Edinburgh.

In 1885 he was called to the chair of physics in the University of Texas, and in 1887 received the honorary title of LL.D., from the University of Michigan. In 1891 he was actively engaged in organizing the Texas Academy of Science, and for two years acted as honorary secretary.

About fifteen years ago Dr. Macfarlane moved to this country, and since that time he has been actively engaged in mathematical research. A few months ago Dr. Macfarlane read a paper before the Royal Society of Britain that elicited much praise from its members. At a special invitation from President Falconer he gave, last spring, a series of five lectures on Vector Algebra at the University of Toronto. A brief of these lectures, written by Dr. Macfarlane, appeared in "Applied Science" for July.

Dr. Macfarlane lived in Chatham for the past nine years, during which time he took great interest in educational matters.

COMING MEETINGS.

THE NEW ENGLAND WATERWORKS ASSOCIATION.—Annual Convention to be held in Philadelphia, Pa., September 10th, 11th and 12th, 1913. Secretary, William Kent, Narragansett Pier, R.I.

THE ROYAL ARCHITECTURAL INSTITUTE OF CANADA.—Sixth General Annual Assembly will be held at Calgary, Alberta, September 15th and 16th. President, J. H. G. Russell, Winnipeg, Man.; Hon. Secretary, Alcide Chaussé, 5 Beaver Hall Square, Montreal, Que.

NATIONAL PAVING BRICK MANUFACTURERS' ASSOCIATION.—Tenth Annual Meeting will be held at Cleveland, Ohio, September 17th and 18th. Secretary, W. P. Blair, 824 Engineers' Building, Cleveland, Ohio.

CANADIAN PUBLIC HEALTH ASSOCIATION.—Third Annual Meeting in Regina, September 18th, 19th and 20th. General Secretary, Major Lorne Drum, Ottawa; Local Secretary, R. H. Murray, C.E., Regina.

ILLUMINATING ENGINEERING SOCIETY.—Annual Convention to be held at Pittsburg, Pa., September 22nd to the 26th. Secretary, I. D. Israel, 29 West 39th Street, New York City.

AMERICAN ROAD CONGRESS.—Annual Session will be held in Detroit, Michigan, from September 29th to October 4th. Secretary, J. E. Pennybacker, Colorado Building, Washington, D.C.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—Twentieth Annual Meeting to be held in Wilmington, Del., October 7th to 10th. Secretary, A. Prescott Folwell, 15 Union Square, New York.

UNITED STATES GOOD ROADS ASSOCIATION.—Convention will be held at St. Louis, Mo., November 10th to 15th. Secretary, J. A. Rountree, L021 Brown-Marx Building, Birmingham, Ala.

AMERICAN ROAD BUILDERS' ASSOCIATION.—Tenth Annual Convention to be held in First Regiment Armory Building, Philadelphia, Pa., December 9th to 12th. Secretary, E. L. Powers, 150 Nassau Street, New York, N.Y.

AMERICAN CONCRETE INSTITUTE.—Tenth Annual Convention to be held in Chicago, February 16th to 20th, 1914. Secretary, E. E. Krauss, Harrison Building, Philadelphia, Pa.