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IMPACT FORMULAS FOR HIGHWAY BRIDGE DESIGN

PART II.

A DISCUSSION OF THE DOMINION GOVERNMENT AND ONTARIO GOVERNMENT IMPACT FORMULAS WITH SUGGESTIONS AS TO SIMPLIFICATION.

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

IN Ontario, most highway bridges are now built under the Ontario Government specifications, but a few, for various reasons, are designed according to the Dominion Government specifications. In the latter, the impact formula used is the Prichard formula, for all spans.

$$I = \frac{L^2}{L + D}$$

I = impact increment to be added to the live load stress.
L = live load stress.
D = dead load stress.

The maximum unit tensile stress allowed for medium steel is 20,000 lbs. per square inch.

In the Ontario Government specifications the same formula is used but it is reduced by a factor depending on s, the length of span, or the loaded length that produces the maximum stress, thus

$$I = \left(.4 - \frac{s}{500}\right)\frac{L^2}{L + D}$$

The maximum unit tensile stress allowed for medium steel is 16,000 lbs. per square inch. (For the sake of brevity only the formulas for stresses of the same kind are discussed.) This formula has been plotted on Diagram II., being for dead load = zero and for dead load equal live load. The Dominion Government formula is also shown by the two horizontal lines, for dead load equal to zero and for dead load equal to live load.

Now, consider how these formulas work out in practice, but before doing so it is only fair to state that both the above-mentioned specifications will probably be revised in the near future and the following discussion is more of an attempt to suggest improvement than to criticize what most bridge engineers agree in condemning.

Nearly all highway bridges now built are designed for concrete floors and for all spans, say, from 30 feet to 100 feet the dead load is approximately equal to the uniform live load of 100 lbs. per square foot. For longer spans, as this live load is reduced at the rate of one pound per square foot for every five feet increase in length until a minimum of 80 pounds for a 200-foot span is reached, and as at the same time the dead load increases very rapidly, the impact increment soon becomes so small that it may be neglected. But for spans of from 30 to 100 feet it may be seen from the diagram that the impact increment by the Ontario specifications will be approximately from 10 to 20 per cent. of the live load, or only 5 to 10 per cent. of the total load.

By the Dominion Government specifications the percentage of impact increment for the same assumptions would be, for all spans from 30 to 100 feet, about 25 per cent. of the total stress, but as the unit stress allowed is 25 per cent. higher than that allowed by the Ontario specifications, it works out that the former, with impact added, gives the same result as the latter without impact. For all practical purposes the Ontario impact formula might just as well be neglected for all spans over 100 feet.

For spans under 30 feet the concentrated live load usually controls in the design. The impact stresses produced by this load are probably of greater magnitude and therefore of more importance than those of the uniform load. With light wood floors and short spans or stringers and floor beams of long spans the dead load will be small compared with the live load and the impact increment will accordingly approach 40 per cent. of the live load for the Ontario specifications and 100 per cent. for the Dominion specifications, or reducing to the same unit stresses the actual increases are 40 and 60 per cent. respectively. For short spans with concrete floors, which is the usual construction, the dead load is approximately equal to half the live load. The corresponding values for the impact increment are consequently somewhere around 26.6 per cent. of the live load for the Ontario specifications and 33.3 per cent. for the Dominion, and reducing these as before to the same unit stresses we have in percentage of the total stress 17.7 per cent. for the former and 15.2 per cent. for the latter.

The use of s = loaded length, in a formula for concentrated loads produces very inconsistent results. After the distribution of the wheel loads has been figured the load is treated exactly the same as if it passed over the bridge like the uniform load. Take, for instance, in the design of floor beams or the hip vertical of a bridge, s is always taken as two panel lengths. Then, while the rear wheel of a road roller will produce exactly the same static stresses in these members, yet by the Ontario formula the impact increment will be 20 per cent. less for 30-foot panels than for 10-foot ones, even if the dead load were exactly the same in both cases. For stringers the difference is 10 per cent. Is there any logical reason why stringers and floor beams for long panel bridges should be relatively lighter than for short panel bridges when they both are to carry the same road roller?

Another thing that impresses one in examining these formulas is that 25 or 30 per cent. is not much to allow for impact for the concentrated load. A practical example will bring out this fact.

Assume a bridge having 16-foot stringers resting on solid abutments and having a 6-inch concrete floor. The stringers will be spaced at 3 feet centres and each will be assumed to take half of the concentrated wheel load of 10,000 lbs. The Ontario specifications will require a 10-inch I-beam weighing 25 lbs. per foot.

The deflection under dead load will be .1041 inch.

The deflection under the live load of 5,000 lbs. applied gradually at the centre of the span will be .2082 inch.

The maximum allowable deflection by the live load for a stress of 16,000 lbs. per square inch is .2499 inch, which would be produced by a concentrated load of 6,000 lbs. gradually applied. The total resilience of the stringer available for the live load is therefore

$$6{,}000 \times \frac{.2499}{2} = 749.58 \text{ inch-lbs.}$$

This amount of work will be done by the live load of 5,000 lbs. if it is dropped onto the floor from a height of .025 inch, thus

$$5{,}000 \times .025 = 125.0 \text{ in.-lbs. kinetic energy}$$

$$5{,}000 \times \frac{.2499}{2} = 624.7 \text{ in.-lbs. work in deflecting beam}$$

$$749.7 \text{ total work}$$

In the same way it can be shown that if the live load were dropped more than .15 inch the elastic limit of 32,000 lbs. per square inch would be exceeded.

Fortunately, in actual construction there are many "mitigating circumstances" which greatly modify the theoretical result. The concrete floor slab absorbs work and distributes the load. If the stringer rests on floor beams of a truss span the total drop of the stringer when the live load is applied will be many times its own deflection and the resilience of the truss is thus added to it. This is doubtless one of the reasons why so many shaky old bridges stand up apparently in spite of all theory. Their very flimsiness makes them good shock absorbers. It is not safe, however, to count on this resilience by any means, for if the stringer or floor beam in its vertical vibration is moving upward when the live load strikes it, it is brought to rest and the effect is the same as if it were rigidly supported.

So, while the above illustration must not be taken too seriously, yet it will serve to indicate how little provision is made for rough usage by the average impact formula.

Summing up the preceding discussion, the following conclusions stand out:

1. That these impact formulas are not based on any mechanical law or on practical experiment that would warrant them being accepted as expressing even approximately the true action of live loads on highway bridges. (See *The Canadian Engineer* April 6 for Part I. of this paper.)

2. That the Dominion specifications for the uniform live load with impact added only reduces the stresses to about what the best modern practice demands for static loads.

3. That in practical results there is very little difference which specification is used in spite of the apparent wide difference in unit stress and impact allowance.

4. That by the Ontario specification the impact increment for uniform loads is a very small percentage of the total load and that for spans over 50 feet it soon becomes so small that it might as well be neglected. The uncertainty regarding internal stresses of the materials, secondary stresses, and faulty workmanship, to say nothing of the impact stresses for which it is supposed to provide, are of an order of magnitude greater than the few per cent. added by the elaborate formula. Its use is therefore an unnecessary refinement, even if it gave absolutely accurate results for impact.

5. With reference to the application of these formulas to the concentrated load, no difference is made between it and the uniform distributed load, although their action is very different. The use of s = loaded length, is objectionable in a formula for slow-moving concentrated loads.

6. To provide for the possible impact from the concentrated load and to make an allowance for future increase or an emergency load the percentage of impact increment given by these formulas (the Ontario one in particular) cannot be considered adequate.

Only by an elaborate series of carefully conducted experiments and tests can any final conclusion be reached as to the effects of impact in highway bridges. But the difficulty of getting anything like satisfactory results from even the most carefully conducted experiments would hardly warrant the time and expense required for them. As related above (Part I.) the committee of the American Railway Engineering Association, after making many thousands of measurements and tests, finally recommended the formula for railway bridges that was developed by C. C. Schneider, who had little more than his judgment to guide him. It should be possible for highway bridge engineers to derive from their experience some formula or method which would be accurate enough for all practical purposes and at least be more logical and satisfactory than present methods. It is with this end in view that the following suggestions are made.

In the first place, it is necessary to make certain assumptions regarding unit stresses and loading. The use of high unit stresses make it necessary to provide a more liberal allowance for impact to insure against overstressing the materials. For many reasons it seems desirable to adopt what is now standard for medium steel, namely, 16,000 lbs. per square inch for tensile stresses due to static loads and the corresponding values for bearing, shear, etc.

The choice of loads is more of a matter of judgment and should be carefully considered for each individual bridge. As a large part of the impact increment is expected to provide for uncertainties in the loading and for future increases or emergencies, the choice of a fairly heavy loading will therefore make a large impact increment unnecessary. Fifteen years ago about the heaviest load that the rural highway bridge ever had to carry was the 6-ton traction engine. To-day, road rollers of 15 tons are coming into use all over the country. A new source of trouble is the motor truck which is now made with a capacity up to 20 tons. The chances are that their number will constantly increase and should some substitute be found for the soft rubber tires and roads continue to improve, even heavier loads may be expected. Whereas the traction engine used to make its trip through the country only once or twice a year and could almost be considered as an emergency load for bridges, there is a possibility that the motor truck will become a very important percentage of the traffic along some roads at least. Then, also, the rate of speed of 10 or 12 miles an hour means increased vibration and more wear and tear on the bridges. Some main-road bridges will have to be designed for two motor trucks passing on them, especially if they are long spans with 16-foot roadway or more.

The uniform distributed load, on the contrary, has no tendency to increase. The heaviest concentration of a crowd of people never exceeds 150 lbs. per square foot, while a crowd in motion does not weigh more than 80 lbs. per square foot. True impact from this load need not be considered.

On account of the great difference between the nature and effects of the concentrated and uniform loads the writer believes they should be considered separately, in allowing for impact, and would suggest the following method:—

1. Concentrated Live Loads.—In fixing on a maximum concentrated load for a particular bridge one should be selected which is not only probable but that is reasonably possible. It is unnecessary to design a bridge for an emergency load which there is no likelihood of it ever having to carry. To the estimated static stresses produced by the chosen load the writer would add 50 per cent. as the allowance for everything usually covered by the impact increment. The stresses so obtained will control in the design of all spans up to about 30 feet, and it is just as necessary to provide for them in a 30-foot span as a 10-foot span or in a section of a 300-foot span.

2. Uniform Distributed Live Load.—If a reasonably heavy concentrated load is used a comparatively light uniform load can be assumed, for rural bridges. Furthermore, the practice of decreasing the uniform load in proportion to the span for spans over 100 feet seems reasonable and has proven satisfactory in the past. Why not extend this practice and increase the load in the same proportion for spans under 100 feet? This is virtually what is done by the use of any of the straight-line impact formulas, but why waste time over a tedious, meaningless formula when the same result can be accomplished by this simple method? Assume a uniform live load of 80 lbs. per square foot for all spans 200 feet and over. For spans under 200 feet, increase the live load three pounds for every 10 feet decrease in length. This would give us as designing loads to be used without any other impact allowance, 110 lbs. per square foot for a 100-foot span, 125 lbs. for a 50-foot span, 137 lbs. for a 10-foot span, etc. These loads would provide ample strength for congested crowds on sidewalks and for trusses they would give practically the same stresses that have been found satisfactory in the past.

A bridge designed by the above rules, with proper details, will be capable of carrying, without danger, a 100 per cent. overload in its floor system and all parts affected by it, and yet have a light, economical truss, and these are the main requisites for efficiency and long life, as far as they are influenced by design.

While the discussion has been limited to highway bridges not carrying electric railways there is no reason why these rules could not be used for city or town bridges where the speed of loaded cars is restricted to 10 miles an hour.

Excessive allowance for impact is sometimes excused on the grounds that the extra metal adds to the rigidity and leaves a margin for rust, etc. But there are ways of obtaining better results by a more intelligent use of the material, as, for example, the following:—

The usual requirement found in all specifications fixing the minimum size and thickness of material might be extended by requiring that all members be increased 1/16 inch beyond what the figured stresses call for.

More attention should be given to the question of vibration of long members. It would be advisable under some circumstances to use diagonal lacing on all long tension members instead of small tie plates, as now allowed.

All members, and the span as a whole should be designed so that the moment of inertia of a cross-section divided by the length of the member should not be less than a certain ratio. In other words, the members should be designed to resist lateral deflection and vibration.

The lateral bracing should be designed not merely for strength to resist the wind but its deflection as a horizontal truss should be limited to a certain amount under full load. The use of high unit stresses for laterals may be quite safe and economical, but it means greater elongation when loaded and consequently more deflection. Laterals placed at too small an angle with the chords permit deflection.

Attention to a few such minor points would greatly increase the stiffness of a bridge and at less expense than by a wholesale increase of 10 per cent. or 20 per cent. of material in the main members.

Formula *1: $I = \frac{L^2}{L+D}$

Formula *2. $I = \left(0.40 - \frac{S}{500}\right)\frac{L^2}{L+D}$

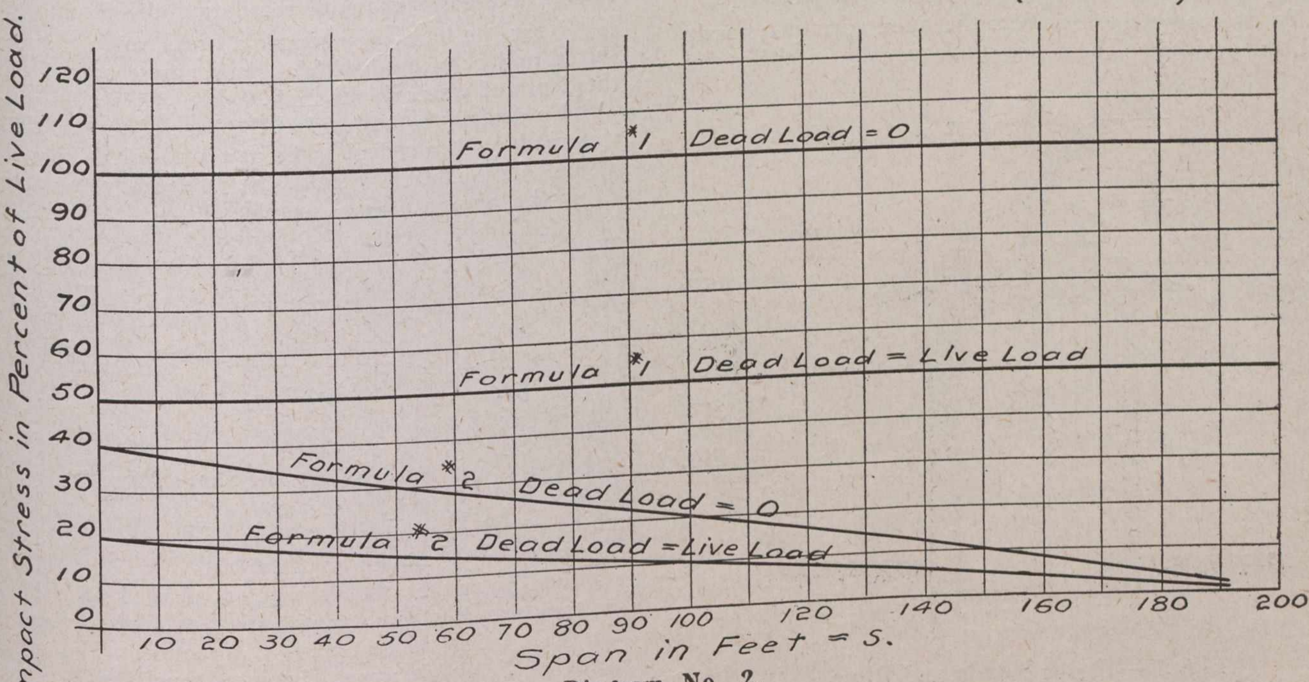


Diagram No. 2.

A METHOD OF TESTING THE EFFICIENCY OF DISTRIBUTION OF SEWAGE SPRINKLER NOZZLES.*

By Edward R. Stapley, C.E.

At the present time, when designs of sewage disposal plants so often include systems of sprinkling filters, the question of obtaining an even distribution over the filter beds is of more than average importance. It is the purpose of this article to bring forth some revised methods by which the efficiency of distribution of various types of fixed nozzles may be determined.

The best possible distribution of sewage so far obtainable is given by moving distributors. These involve either a rotary or a rectilinear motion over the bed. Such types, however, have the disadvantage of being very costly, and difficult to keep in order; and in a very cold climate they cannot be used unless covered because of the complicated parts that freeze readily when wetted.

To overcome these defects the fixed sprinkler nozzle has been devised. These are made usually in either the circular, square, or hexagonal form covering areas corresponding to their respective names.

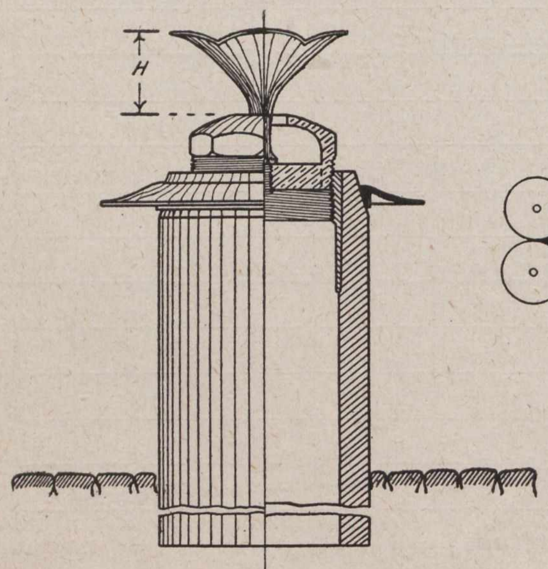


Fig. 1.—Taylor Nozzle and Riser.

By reference to Fig. 2 it is readily seen that, if they do not overlap, circular nozzles placed at the corners of squares can cover only about 78% of the ground.

By staggering, the area of surface covered can be increased to 90%. In the case of the square and hexagonal nozzles, however, it is quite apparent that the whole area can be utilized. For this reason the tests made in the thesis aforementioned were confined to the two latter types.

No matter what form may be adopted it can readily be seen that the higher the head in the dosing chamber the farther the sewage will be thrown as it comes from the nozzle. It has been the customary practice to operate the nozzles in cycles of about ten minutes each, depending on the rate of flow. The total amount of sewage for each cycle is discharged in two or three minutes out of the ten. The best distribution will, of course, be obtained by a varying head. For example, at the beginning of a cycle the tank may operate under its highest head. As the sewage is discharged it will drop to the lowest head and stop. The collecting tank is then allowed to fill up until the highest head is reached when the cycle is repeated.

The length of time that the nozzles are to operate at each head is adjusted by building a dosing tank of irregular cross-section or by means of undulating or butterfly valves in the feed pipes, automatically operated by cams. While the latter may perhaps furnish better regulation, they have the obvious disadvantage of necessitating moving parts.

A photograph showing a general view of the apparatus used by Mr. Field and the writer in their experimental work is shown in Fig. 3.

The apparatus was essentially as follows: A cylindrical galvanized iron tank served as an equalizing reservoir. From the bottom of this tank a 1½-inch pipe fitted with elbows so as to be easy of adjustment led to a point about 30 feet away. Here it was turned up and connected to a 2½-inch bituminized fibre riser in which rested the nozzle. Both inlet and outlet pipes were fitted with valves to give prompt and easy means of regulating the discharge.

Near the base of the tank a brass valve tap was inserted and connected with a glass gauge so as to show the depth of water in the tank.

To determine the head at the base of the nozzle a tap was made with a reducing tee and a hose led from this to a glass gauge fitted beside the stationary tank gauge. After the apparatus was in place, a scale graduated in tenths of a foot to show the elevation above the orifice of the nozzle, was painted on the tank.

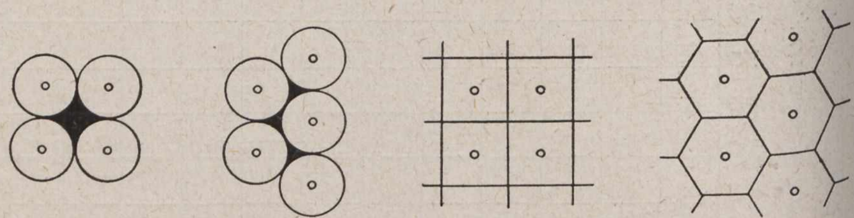


Fig. 2.—Areas Covered by the Different Shaped Nozzles.

The apparatus as constructed allowed of a head at the tank varying from four to nine feet, higher heads than nine feet being seldom used in practice. The effective heads at the nozzle were, of course, much less.

Around the nozzle two lines of rails were built circumferentially and at the same level. Placed radially on these were planks which supported the collecting pans, the whole being so arranged that the upper surfaces of the pans were six inches below the nozzle orifice.

In the experimental work actual measurements were made at points opposite the lobes and notches of the nozzles. The centres of the collecting pans in these lines were placed at points one foot, two feet, three feet, and so on out from the nozzle. In order to facilitate the replacement of the pans after emptying, nails were driven in the radial planks at these points and the centres of the pans marked with paint.

However, in order that a fairly correct idea of the average depth of discharge on different portions of the area served might be known it seemed advisable to have readings at as many as five lines radiating from one side of the square or hexagonal nozzle. These points were distributed as follows, the latter two in this case being interpolated. Two points were taken opposite the notches, one opposite the lobe, and the remaining two at the quarter points. This was done by placing the radial planks in the desired positions.

Due to the method of computation which was devised after the experimental work was finished, it was necessary

*In "The Cornell Civil Engineer."

to convert the readings taken in the lines opposite the notches to corresponding intermediate values. In the case of the four-lobed nozzle, depths at points 1.414 feet, 2.828 feet, 4.242 feet, and so on out from the nozzle in the lines opposite the notches were picked from curves plotted from the actual measurements made at the foot points. From this it is evident that the work would have been facilitated and the accuracy increased somewhat by arranging the pans at the desired distances from the nozzle when the run was being made, and also to have had actual readings taken in lines intermediate between the lobes and notches. The reasons for this arrangement of the points at which depths of discharge are desired is shown in the explanation of the method of computation.

As would be readily inferred, the factor of wind has considerable effect on the spray from the nozzle. Such conditions, however, are not at all uncommon in actual practice. If readings are taken at different compass directions from the nozzle, the effect of the wind may be seen and also a fair average depth of discharge obtained. This method was therefore adopted.

Owing to the fact that sewage is not always available for use, experiments may be carried out with water, the results being fairly comparable for all practical purposes.

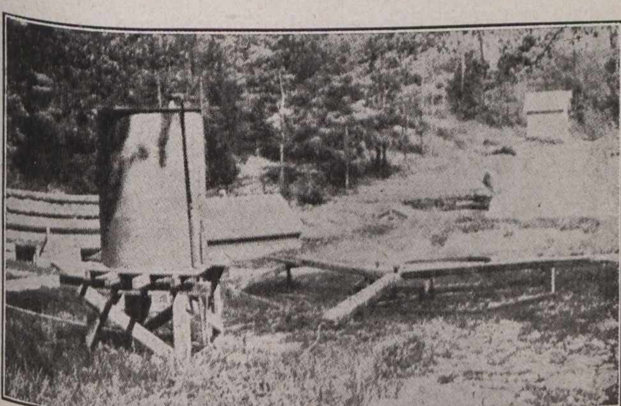


Fig. 3.—Arrangement of Apparatus Used in the Experiment.

In any preliminary investigation it is best to make all runs with constant heads. If thought desirable in order to obtain a better average more than one run may be made at each head. In the tests made constant heads were used, one run being made at each head.

The method of making a run was as follows: The collecting pans being empty and placed in their correct positions and the water in the equalizing reservoir at a certain head, the discharge valve was suddenly opened. The time of opening the valve was noted on a stop watch. By opening the supply valve at the same time, the head in the tank was kept constant. The total head at the tank and the effective head at the base of the nozzle were then noted. At the end of two or three minutes, depending on the depth of water in the pans, the control valve was closed and the depth of water in each pan measured and recorded.

Since the distribution was measured in actual depths at different distances from the nozzle, the measured depths were taken in the convenient unit of thousands of a foot. As it is not always convenient or economical to obtain pans whose sides are vertical, those with slanting sides may be used by making the necessary corrections. The latter type were used in this experiment and the corrections made by means of conversion curves. The pans used, however, should be of a uniform size and shape.

The rate of discharge of the nozzle at any head was obtained by noting the period of time necessary for the water surface in the tank to drop one-tenth of a foot, the supply valve being closed.

The results obtained in the experimental work were arranged according to the following form:

Original Data for Taylor Four-lobed Nozzle.

*Nozzle Setting, H = 0.177 Feet.

Time of Run	Position	Gage Readings Tank	Gage Readings Nozzle	Depth in Pans in 0.001 Feet 1	2	3	4	5	6	7	8	Direction	Rate of Flow
3′	Lobe	5.98′	4.15′	0	6	170	232	51	2	0		West	0.1′ in 37″

At the start of the computation work the readings giving the depths of discharge in the various parts of the bed were converted to corresponding average values for one minute of time. As the numbers became rather small, the unit depth was decreased to ten-thousands of a foot. These values were then arranged according to the following form:

Average of Three Directions for One Minute Flow for Four-lobed Nozzle.

Nozzle Setting, H = 0.177 Feet.

Position	Velocity in Riser Ft./Sec.	Effective Head At Nozzle Feet	Depths in Pans in 0.0001 Feet 1	2	3	4	5	6	7	8
Lobe	2.72	4.275	1	32	404	631	218	9	0	

In testing the efficiency of the nozzles, and as a means of comparison of the distribution under varying conditions, some method by which the relative efficiency of distribution can be measured is necessary. The best method so far devised seems to be that of Phelps, who makes use of a "coefficient of distribution." As originally developed, this idea of a numerical expression of efficiency was applied to tests on circular nozzles only. This was not applicable to the case of four-lobed or six-lobed nozzles, designed to cover respectively square and hexagonal areas. For this reason some new means of expressing the evenness of distribution which would apply to these cases seemed necessary.

To meet this need and also to make it possible to take into account the factor of overlap, which is not considered in the method aforementioned, a modification of the Phelps' method was devised. This modified method, while following the same general theory as the other with respect to the manner of stating the evenness of distribution, differs in that it allows the shape of the area served to be taken into account. The method as devised is given below. In order to make the explanation perfectly clear, a sample computation is given for a four-lobed nozzle.

Calculation of Coefficient of Distribution for Taylor Four-lobed Nozzle by Modified Phelps' Method.—For the purpose of description a 12-foot spacing of nozzles will be assumed, although in the actual computation this does not enter into the work until later and may be varied at will according to the conditions of the case in hand.

The diagram in Fig. 4 shows two nozzles spaced 12 feet apart and placed with the lobes opposite and in line. lines drawn parallel to the common side of the areas served, and midway between the foot points divide the triangular area, forming one-fourth of the total area served by one nozzle, into trapezoidal strips one foot wide with the exception of the outer one which is one-half foot wide and the inner one which contains only one-fourth square foot and may be neglected. The letters *a*, *b*, *c*, *d*, etc., indicate the depths of liquid at points 1, 2, 3 and 4 feet from the nozzle. Letters *a′*, *b′*, *c′*, *d′*, etc., indicate the depths at points 1.414, 2.828, 4.242 and 5.656 feet

*See Fig. 1 for explanation of "H."

from the nozzle. Letters a'', b'', c'', d'', etc., indicate depths at the corresponding quarter points. These depths are the average of the values read in the experimental work reduced to one unit of time.

The average depth on any strip as $D = 1/5\ (d + 2d' + 2d'')$. The average depth multiplied by the area of the strip gives the discharge on that strip. In the computations all depths or quantities, since the latter may be stated in terms of the depths, are in ten-thousands of a foot.

Average depths on strips for a one-minute flow in 0.0001 feet, using a nozzle setting, H = 0.131 feet.

Effective head.	A	B	C	D	E	F	G
5.622′	2	21	171	374	391	122	6
4.939	6	33	242	491	317	40	3
4.149	6	36	268	539	168	23	1
4.039	5	56	344	619	62	4	
3.355	5	54	579	275	11		
2.683	7	251	863	51	2		

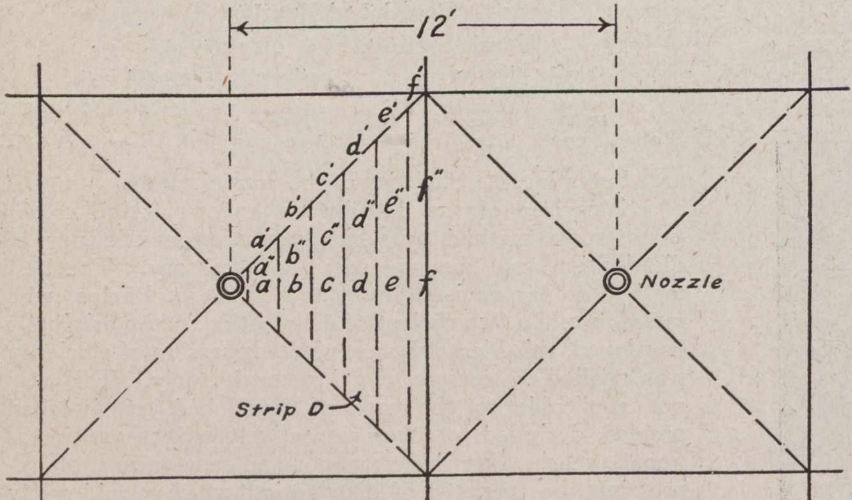


Fig. 4.—Spacing of Nozzles with Lobes Opposite and in Line.

If the nozzle is operated 1½ minutes at 5.622′ head and ½ minute at 2.683′ head, we have:

A	B	C	D	E	F	G
3	31	256	561	586	183	9
3	126	432	26	1		
6	157	688	587	587	183	9

Adopting a 12-foot spacing of nozzles and taking into account the overlap, we have as the average depths on the various strips:

A	B	C	D	E	F	G
6	157	688	587	587	183	
				9	183	
6	157	688	587	596	366	

Discharge T = (average depths on strips) × (area of strips).

$$6 \times 2 = 12$$
$$157 \times 4 = 628$$
$$688 \times 6 = 4{,}128$$
$$587 \times 8 = 4{,}696$$
$$596 \times 10 = 5{,}960$$
$$366 \times 5.75 = 2{,}105$$
$$17{,}529 = T$$

Total area of triangular strip = 2+4+6+8+10+5.75 = 35.75 sq. in.

Average depth over whole area = 17,529/35.75 = 490.

This value of 0.0490 feet being the average depth of discharge during ten minutes of time, corresponds to a rate of approximately 2,300,000 gallons per acre per day, which is slightly in excess of the 2,000,000-gallon rate commonly employed.

The excess depth on any strip equals the depth on that strip minus the average depth on the area served.

	A	B	C	D	E	F
	6	157	688	587	596	366
			490	490	490	
Excess depth ...			198	97	106	

$$198 \times 6 = 1{,}188$$
$$97 \times 8 = 776$$
$$106 \times 10 = 1{,}060$$
$$3{,}024 \text{ excessive discharge } E$$

Coefficient of distribution = $(T - E)/T = (17{,}529 - 3{,}024)\ /\ 17{,}529 = 0.827$.

In this case the method of operation tending to give the most even distribution seemed to be that of using only the high and low heads.

A similar method of procedure was followed in the case of the six-lobed nozzle, except that the positions of the collecting pans in the rows opposite the notches and in the intermediate rows were changed to correspond to the six-sided area which was now covered.

Results of Tests.—In the experiments carried on by Mr. Field and the writer, the tests were limited to the Taylor nozzles of the four and six-lobed type. Either one or the other of these two types has been adopted in a large number of modern plants. The reason for confining the tests to these nozzles was that they seemed to cover the ground better than any other type.

The tabulated results of the tests are given in the following table:

Type of Nozzle	Setting	Spacing	Maximum Head	Time	Intermediate Head	Time	Minimum Head	Time	Coefficient of Distribution
4 Lobed	0.131′	12′	5.622′	1.5′			2.683′	0.5′	0.827
4 "	0.155	12	5.586	1.3			2.709	0.7	0.827
4 "	0.177	12	5.975	1.25			2.851	0.6	0.881
4 "	0.200	12	7.554	1.75			3.265	0.75	0.863
6 "	0.135	14	6.018	1.5			2.635	0.75	0.884
6 "	0.160	14	5.964	0.9	3.962	0.4′	2.613	0.5	0.869
6 "	0.185	14	6.214	1.0	4.122	0.5	2.741	0.5	0.838
6 "	0.210	15	7.257	1.25	5.638	0.75	3.340	1.5	0.903

From a study of the above table it would appear that within the limits of the effective heads used in the experiments with the two types, the six-lobed nozzle with a setting, H = 0.210 feet, would appear to be the best model to use, if the best distribution possible is desired. The area served by the four-lobed nozzle, however, is about 9.6% greater than that served by the six-lobed type, so that the resulting gain in economy of the installation may overbalance the difference of 2% in the distribution effected. In either case the degree of perfection of distribution is fairly high and the choice would probably go to the one giving the lowest first cost.

In conclusion, therefore, it would appear that it is important not only to choose the best type of nozzle, but also to operate the same under the conditions of spacing and pressure which will allow of its operating at its highest efficiency. In the majority of cases in actual practice the maximum available head is usually fixed, so that the chief problem for the engineer to solve is to properly adjust the distribution of this head, the length of cycle, and the spacing of the nozzle, so as to give the maximum efficiency, at the same time not neglecting to consider the factor of relative economy of installation. It is believed that the first three of these points may be met to advantage and with a fair degree of ease by the method illustrated.

BITUMINOUS PAVING PLANTS.

By L. Kirschbraun, Ch.E.,
Consulting and Testing Engineer, Chicago, Ill.

ENGINEERING literature of the past few years has been prolific with discussion of various features in the production of bituminous pavements—with types of pavement, methods of construction, qualities of materials and other considerations. Little has been said, however, in regard to the factor of plant equipment used in the manufacture of bituminous paving compositions, and as to the effect, in a general way, upon paving work, of the efficiency of various types of plants in producing good or poor pavement mixtures. The writer proposes to discuss somewhat, the practical effect of this factor of paving plant upon the finished pavement.

Conditions Encountered.—During the writer's experience, situations have been frequently encountered in which contracts have been let for paving work under well-drawn specifications calling for good type of construction, good materials, etc., but when actual construction was commenced, there was found a contractor on the job with a contraption for turning out a pavement, ranging anywhere in character from a "peanut roaster" to a converted concrete mixer. The problem then presented to the engineer, when faced with such conditions, is to produce a good pavement under most disadvantageous and most adverse conditions with reference to plant facilities.

The writer is able to trace a number of instances of bad construction to nothing but this particular factor of inadequate and improper plant equipment, resulting in the production of uneven and frequently totally defective mixture. In fact, this condition has appeared so frequently on account of the large increase in the amount of asphalt construction, and the large number of new and inexperienced contractors entering upon this work, that in the latest specifications, a description has been included covering, so far as possible, the essential requirements for plant equipment. This requirement, as included in the writer's specifications, is given as follows:—

"**Minimum Plant Requirements.**—The paving plant shall be of an approved type, properly adapted for producing the character of mixture hereinafter described. It shall consist of separate units for melting and preparing asphaltic cement, a dryer for heating mineral aggregate, a screen and storage bin, having at least two compartments whereby the mineral aggregate may be separated by means of a 6 or 8-mesh screen into two sizes, that passing through the screen being collected in one compartment, while the rejection is collected in another compartment. Plant shall further be equipped with the necessary devices for weighing separately the fine and coarse aggregate from each compartment of the storage bin. An asphalt cement bucket shall be provided with scales attached in order that the amount of asphaltic cement which is put into the mixture may be properly gauged. The mixing unit shall consist of a twin pugmill mixer or its equivalent with blades so spaced as to produce a thoroughly homogeneous mixture."

This description is intended to eliminate certain types of equipment which are favorably regarded by the inexperienced contractor undertaking asphalt construction, with the idea of simple work and large profits. Plants which fail to meet the above description should not be allowed on a paving job.

It is believed that the formulation and preparation of a good bituminous mixture, capable of withstanding modern conditions of traffic is a matter of sufficient difficulty and involves a sufficiently high degree of judgment and care, to at least call for the best of facilities in preparing such mixtures, and certainly the engineer engaged in such work should not be harassed and handicapped by plant facilities which frequently vitiate and certainly make most burdensome, the successful production of a well-planned mixture.

Changed Conditions.—In the manufacture of paving plants in years past, it is apparent that the producers of such plants were concerned much more with those mechanical features which tended to greater capacity, and ease of mechanical operation, rather than to ease of controlling product. It is only within the very recent years that some attention has been paid to this latter factor, and while this tendency is a matter of encouragement to those engaged in controlling paving mixtures, yet it is apparent that there is much room for further improvement in this direction.

Conditions with respect to plant requirements have changed greatly within the last few years. Asphalt paving construction is being called for by cities of much smaller size than heretofore, and a large amount of road work of mechanically mixed type is being laid throughout the country.

As a result of this wider spread use of asphalt surface, the demand for portable plants, either of railway or road type, has been greatly increased. The permanent plant which was maintained in the larger cities could be set up with facilities for handling materials which are not generally available in connection with the portable plants.

Again, prior to ten years ago, very little asphalt work was done excepting sheet asphalt pavements, whereas in more recent years, types of bituminous pavements have been developed of more complexity, containing stone as well as sand aggregate, thereby necessitating improvement in plant facilities over those available before. It is therefore apparent that as the complexity of our mixtures has been increased and the factor of portability has become so important, more is being demanded of the paving plant to make it adaptable to the latest conditions.

Need of Greater Accuracy.—It is unnecessary to point out the need for accuracy and uniformity in preparing bituminous paving mixture. This is particularly true in the newer forms of construction which include a wider range of aggregates than heretofore. It is well known that variations in uniformity permissible in a sheet asphalt mixture, are frequently disastrous in connection with asphaltic concrete mixtures. These latter mixtures are much more susceptible to variations in content of asphalt cement than are sheet asphalt mixtures, and not only is this true with respect to the mixtures themselves, but conditions of traffic make it necessary to observe finer points in their preparation than has been the case heretofore.

For example, an asphaltic concrete mixture under heavy automobile traffic must be regulated to narrower limits in composition and within different limits than is the case in a mixture exposed to light traffic of mixed character. These conditions make it more and more necessary to have plant equipment capable of the most accurate work and susceptible of at least as much control as is required for similar manufacture in other branches of chemical technology. These conditions are being met with by the more progressive manufacturers of paving plants.

Lack of Skilled Labor.—Generally speaking, the labor available for the operation of asphalt plants is of very unsatisfactory character, and is not to be entrusted with carrying out any important operation without the closest supervision. This statement does not, of course, apply to the operations of those concerns who continuously carry and carefully break-in the labor controlling the more important portions of the mixture manufacture.

Generally, however, the labor available at the asphalt plant is the kind which is picked up locally, and most frequently such plants come upon the work with scarcely anyone but a foreman having any idea as to operation. These conditions make it essential that the important operations in turning out these mixtures be so arranged as to be subject to almost automatic control, so that the labor available need not be depended upon for the success of the work.

In other words, the paving plant should be made foolproof, or as nearly so as is possible with reference to those features which enter into the control of product.

The result of crude facilities and poor labor is that with the best of intentions, and frequently with the best of efforts, inferior results follow simply because, in the final analysis, the pavement mixture, however well planned or however well set, is dependent for its accurate proportioning upon the man at the mixer, who frequently holds his job because no one else will stand the dust, dirt and heat of this portion of the work.

The writer has been often amused when visiting paving plants to find, upon asking the plant foreman as to his mix, a ready response in odd and exact figures of different materials used, and then to climb up on the mixer and find the gentleman of color presiding there, overdrawing his A.C. bucket ten or more pounds, the bucket carrying a choice accumulation of dirt, its tare a matter of ancient history, the amount of filler dependent upon half-filled buckets of variable number, and a general promiscuous intermingling and wandering of various aggregates from their respective bins.

The box weights given by the foreman with so much assurance and emphasis on the ground become a matter of chance and purest guesswork at the mixer. Without an inspector almost continuously at the mixer, the well-planned proportions and the careful judgment used in making the mix become a theory, subject to the vagaries of totally unskilled and unreliable laborers.

The Requirements.—The important operations of a paving plant, from the point of view of the engineer, may be briefly stated as follows:—

(1) Melting of refined asphalt and fluxing to produce asphaltic cement.

(2) The proportioning and feed of cold aggregate into the dryers.

(3) Control of temperature of aggregate and of asphalt cement.

(4) The separation of complex aggregates and distribution into various bins.

(5) The weighing out and combination at the mixer of the components of the paving composition.

The ideal paving plant will approach the maximum of efficiency in proportion to the extent that these operations may be controlled automatically or with the least possible dependence upon the labor employed.

If the attention of the manufacturer of paving plants be directed towards these features rather than to further improvement in capacity, a great deal will have been accomplished for the benefit of the paving industry. As a matter of fact, the later types of standard plants on the market have generally little to be desired as to mechanical reliability or capacity of output. There is even a tendency for some of these plants to turn out more material than can be given proper attention in laying, so that the time is ripe for more important development in the way of control of product.

How to Meet Requirements.—The writer desires to point out somewhat generally the character of mechanical devices which he has in mind with reference to accomplishing the above-mentioned important operations. In doing so, however, he desires to disclaim any mechanical ability or knowledge of details by which these rough ideas might be carried out.

Asphalt Cement.—With reference to preparation of asphalt cement, there is nothing wanting in the best types of present plants. The refined asphalt is melted by steam or indirect fire, and the fluxing operation is sufficiently well regulated by weighing out the required proportions of materials and agitating them mechanically by air or steam until homogeneous. Generally, there is very little danger of overheating. The temperature of the asphalt cement can be subject to very considerable ranges without injury.

Feeding Aggregates.—The proportioning of cold aggregates into the dryers, as now carried on, is accomplished generally by bringing up to the cold elevator, and piling there, the individual elements of the aggregate. From these piles, one or more men feed the material into the elevator by means of shovels or hoes, regulating the proportioning by the number of shovelfuls of material from each pile. Sometimes this is also done by bringing up the material in wheelbarrows and piling the different portions in one pile, the proportion being regulated by the number of wheelbarrows operating from the stock piles of individual aggregates.

In either case, the labor employed in accomplishing this result cannot be depended upon to maintain correct proportions with measuring units which are, to say the least, crude at best. Very frequently, the wheelers drop out of line or out of order, leaving the other feeders or wheelers working, regardless, at their respective materials. Sometimes the cold elevator will be carrying one element of the aggregate almost entirely, and again, some other element will be carried in preponderating proportion.

This lack of uniformity produces a constantly varying temperature, in the heating drums. It would seem possible that this operation of feeding aggregates could be accomplished by separate conveying devices, bringing each component from its pile at predetermined rates of feed regulated by interchangeable gears or other simple speed-governing device.

By some such arrangement, the proportions of the aggregates could be regulated accurately and uniformly. Even the filling of hoppers or buckets attached to the conveyers operating from each pile of materials might be simply effected.

Temperature.—The temperature of mineral aggregate leaving the dryers must be controlled within fairly close limits. If the aggregate is too cold, it will not mix

(Continued on page 446).

THE AIR LIFT.*

By Arthur H. Ford.

SINCE the cost of pumping is one of the principal items in the cost of supplying water to the residents of a municipality, every waterworks manager is interested in discussions regarding the relative costs of pumping by different methods. Of late years, the air lift, as a means for raising water from deep wells, has become of such great importance that the writer deems a short discussion of the subject worthy of your attention.

Though air lifts have been used for the past fifty years for pumping water from wells of all depths, the theory of their operation has defied mathematical analysis, with the result that their design is almost wholly dependent on the use of empirical formulæ. This has led to the improper design and operation of many lifts, to the detriment of their efficiency.

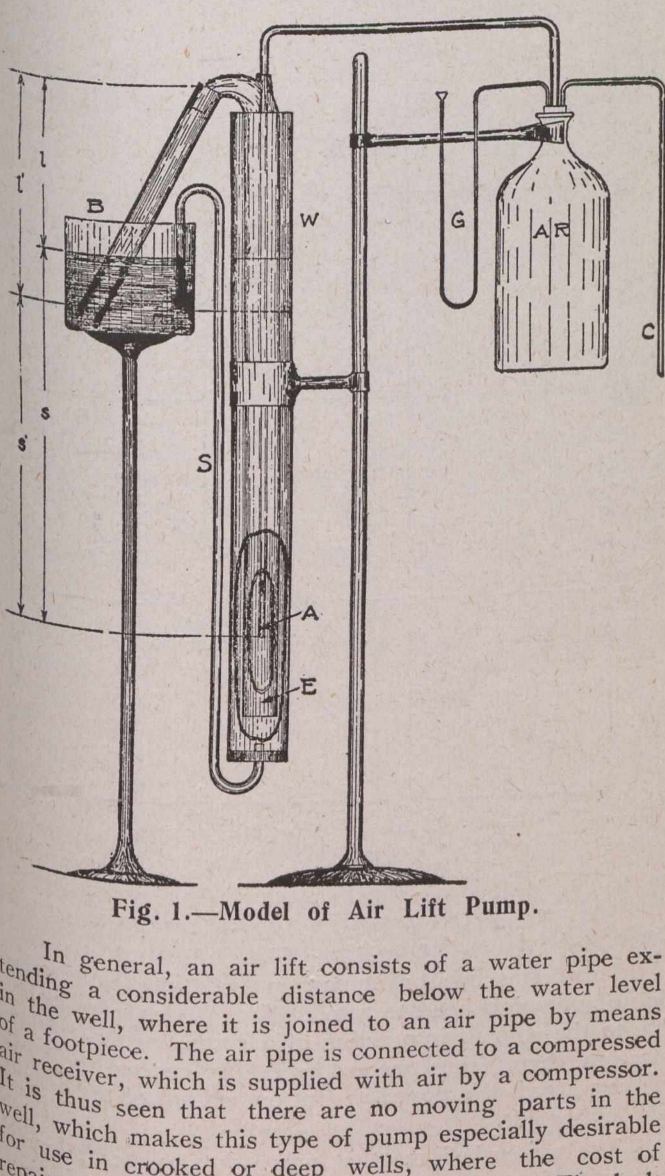


Fig. 1.—Model of Air Lift Pump.

In general, an air lift consists of a water pipe extending a considerable distance below the water level in the well, where it is joined to an air pipe by means of a footpiece. The air pipe is connected to a compressed air receiver, which is supplied with air by a compressor. It is thus seen that there are no moving parts in the well, which makes this type of pump especially desirable for use in crooked or deep wells, where the cost of repairs on pump rods and cylinders is large. The lack of moving parts in the well also increases the reliability, which is a great advantage in those cases where one well only is depended on for the water supply; it also makes it possible to handle water containing so much grit that reciprocating pumps will not answer, because of the excessive wear of the cylinders. Air lifts can pump water faster than any other type of pump, and are, therefore, frequently used for the purpose of testing new wells. The rapid rate of pumping water is such a desirable feature that this alone may lead to the use of an air lift in preference to a pump of some other form.

*Read at the first annual meeting Iowa Section, American Waterworks Association.

A picture of a working model of the simplest form of air lift is shown in Fig. 1. The outer tube (W) represents the well; connected to the catchment basin (B) by means of the siphon (S), which represents the water passages in the rock. Inside the well is suspended the eduction tube (E), having the air tube (A) suspended in it, but not reaching quite to its bottom. The air tube is connected to the air receiver (AR), which is supplied with a pressure gauge (G) and a connection (C) to the air compressor (not shown).

When the compressor is started, the pressure in the air receiver gradually increases and the water is forced out of the air pipe until it is entirely empty, at which time the air pressure is at a maximum. The air now bubbles out of the end of the air pipe into the eduction pipe, which causes the level of the water in this pipe to rise an amount proportional to the volume of the air in the bubbles. As long as this does not bring the top of the column of air and water above the discharge opening in the eduction pipe, no water will be pumped and the air will merely bubble through the column of water. This condition obtains when the quantity of air supplied is insufficient to operate the lift.

The supply of a larger quantity of air will cause a larger proportion of the mixture in the eduction pipe to consist of air, with the result that the column will be higher, and when the air supply is sufficient the top will be above the discharge opening and the pump will begin to operate. The manner of operation will depend on the relation of the rate at which air is supplied to the area of the eduction pipe. When the rate of air flow is small, the air bubbles will be small in comparison with the size of the eduction pipe and the flow will be steady. Such a flow can be attained only when the pumping head (l) is small in comparison with the submergence (s) of the air pipe.

When the rate of air supply is increased, the size of the air bubbles increases until they entirely fill the eduction pipe and form air pistons, enclosing slugs of water between them. The flow now becomes pulsating; discharges of water and air alternating. Every time that a slug of water is thrown out, the pressure at the lower end of the air pipe is slightly reduced and a quantity of air is emitted. This lifts the column of air and water in the eduction pipe, and at the same time stops the flow of water into the lower end, with the result that the level of the water in the well rises, increasing the water pressure at the end of the air pipe. As soon as the water pressure exceeds the air pressure the air flow stops until the pressure is again reduced by a slug of water being thrown out of the eduction pipe.

The maximum air pressure required to start a lift operating is equal to 2.31 times the submergence (s) of the air pipe, in feet. As soon as the lift begins to operate, the pressure is reduced, because of the drawing down of the water in the well, thus reducing the submergence to s', and increasing the head to l'. (See Fig. 1.) This lowering of the water level may be considerable, and is the determining factor in fixing the economical rate of pumping.

A number of the factors which enter into the efficiency of an air lift must of necessity be determined by experiment on the particular well in question; but some of them admit of generally applicable determinations being made. Among these is the best form of footpiece, as the connection between the air pipe and the eduction pipe is called. There are a number of forms of footpieces on the market, for some of which extravagant claims of efficiency are made; but as wide variations in the efficiency are due to slight changes in the proportions of other parts of the system or the method of operation, such claims are to be looked on askance, unless they are backed up by adequate guarantees. Tests have shown that the effect of a change in footpiece may be to increase the efficiency as much as 50 per cent. when the head is high, with a much smaller increase when the head is low.

The efficiency of even a well-designed air lift is low, varying from 20 per cent. for a lift of 600 feet to 45 per cent. for a lift of 50 feet; and is greatly influenced by the ratio of the submergence of the air pipe to the lift, the best ratio being about 2. This is clearly shown by a test of a well at Hattiesburg, Mississippi. In this test the speed of the air compressor was adjusted so as to keep the rate of flow of water constant, while the length

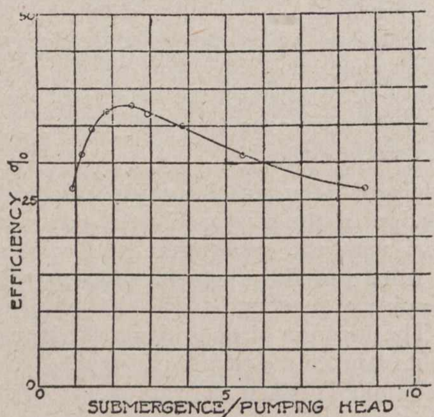


Fig. 2.

of the air pipe was varied. The data are given in the following table and shown in Fig. 2.

Total depth of well	453.5 feet.
Inside diameter of casing	9⅝ inches.
Inside diameter of air pipe.........	2½ inches.
Inside diameter of eduction pipe...	9⅝ inches.
Static lift (l)	4.0 feet.

Effect of Submergence on Efficiency Pumping Head.

Submergence.	Efficiency.	Submergence.	Efficiency. Per cent.
8.70	26.5	1.86	36.8
5.46	31.0	1.45	34.5
3.86	35.0	1.19	31.0
2.91	36.6	0.96	26.5
2.25	37.7	....	....

Flow, about 1,100 gallons per minute; pumping head, about 37 feet.

These results show that the maximum efficiency is secured when the submergence is 2.5 times the lift, and that the efficiency falls off more rapidly for a reduction in the submergence than for an increase. It is a good plan, therefore, to have the submergence more than that calculated for the best efficiency rather than less. This allows for the usual occurrence, *viz.*, that the pumping lift increases as more wells are sunk or during a dry season.

Previous to this test the length of the air pipe in this well had been varied with a view to finding out the best flow at which to operate the well. The important data are given below and plotted in Fig. 3:—

Length of Air Pipe. Feet.	Flow. Gal. per min.	Pumping Head. Feet.	Efficiency. Per cent.	Duty. Gal. per h.p. hr.
224	1,495	47.5	32.6	1,630
208	1,459	45.8	31.5	1,640
184	1,419	44.3	31.1	1,670
162	1,359	39.4	30.0	1,790
142	1,299	37.7	30.6	1,920
124	1,219	37.5	32.8	2,070
105	1,106	37.1	36.7	2,340
86	1,008	32.5	33.4	2,450
79	904	29.3	31.3	2,530
67	802	26.0	30.5	2,750
43	690	21.2	29.8	3,240

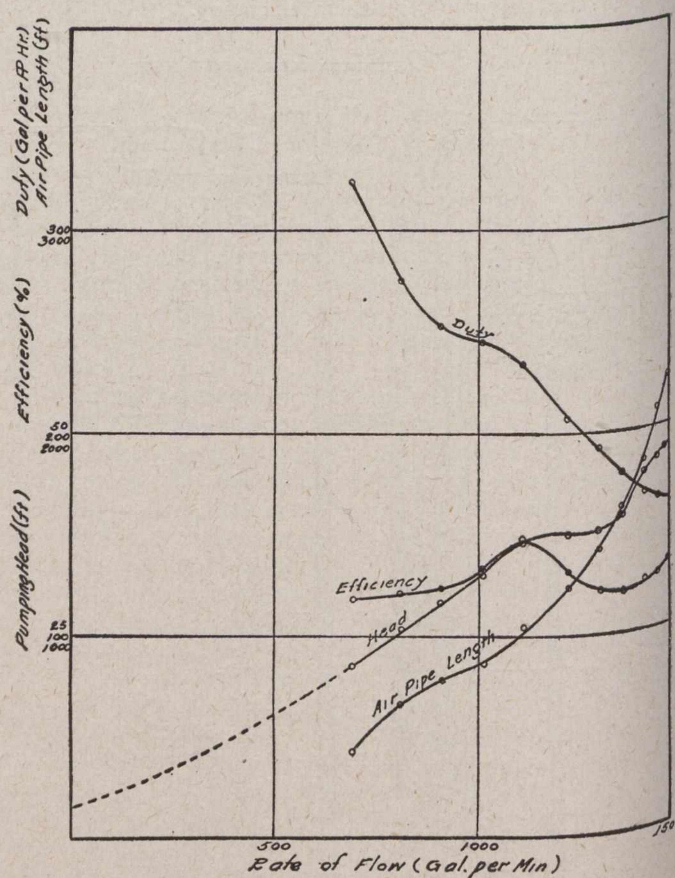


Fig. 3.

The air supply was apparently adjusted so as to get the best efficiency for each submergence.

This test shows an anomalous variation of the relation of pumping head to rate of flow, which is probably due to the coming into action of a second water-bearing stratum, there being two cut by the well, when the level of the water had dropped 33 feet on account of the operation of the lift.

The writer believes that pump duty, water pumped per unit of energy supply, should be made the criterion of operation rather than mechanical efficiency. He has, therefore, calculated the last column.

This shows that the duty of the lift increases as the rate of pumping is decreased, which is due primarily to the decrease in the pumping head. The variation will be small for a free-flowing well, or one in which the drop due to pumping is small in comparison with the pumping head. This dictates that the well should be pumped at the minimum rate at which the desired quantity of water will be furnished.

When the well under discussion is operated at a flow of 1,106 gallons per minute, at which flow the maximum efficiency was obtained, the pump duty was 2,340 gallons per horse-power hour; while, if the pumping rate had been reduced to 690 gallons per minute, the duty would have been 3,240 gallons per horse-power hour—an increase of 38 per cent. This would reduce the pumping expense 28 per cent.

The present status of the air lift is such that it can be considered as a thoroughly reliable piece of apparatus; but one should not be installed without the advice of an engineer who has made a special study of the subject, and he should be given opportunity to make trials with various lengths of air pipe and various speeds of compressor operation after the lift has been installed, so as to find the conditions for best operation.

A VISIT TO THE MOUNTAINS OF NORTHERN LABRADOR.*

By Prof. A. P. Coleman, Ph.D.

THE Torngap Mountains in northern Labrador are only 1,300 miles northeast of Toronto, but to get there cost me nearly 4,000 miles of travel. After the rail journey to Sydney, N.S., I took the ice-breaker "Bruce" to Port aux Basques, in Newfoundland. It was her last voyage on the route and she left soon after for Archangel, in the White Sea, where she was to help in keeping open navigation. A crooked railway of 3½ feet gauge took me, in 28 hours, to St. Johns, from which a steamer leaves for the Labrador coast, usually reaching Nain, the central Moravian mission to the Eskimos. From Nain I travelled partly by motor boat, partly on the little whaling steamer "Hump," and partly by schooner, to Hebron, the last settlement of the Moravians on the Atlantic coast. From this point I made my way north in a fishing skiff, with two Eskimos, to Komaktorvik Bay, in latitude 59° 30′, about 80 miles south of Cape Chidley, the turning point to Hudson Straits.

In this chilly, foggy bay I was right among the mountains and did some climbing and exploring in quite unknown territory. The highest mountain climbed reached 4,700 feet above the sea and had three small glaciers on its flanks.

As Komaktorvik is north of the timberline, where hardly even bushes grow, the fuel question was serious. We used partly a little driftwood found on the shore and partly a small oil stove. My Eskimos killed a number of seals and a fine caribou, so that there was plenty of fresh meat when we had fire enough to cook it.

After mapping the surroundings at Komaktorvik we went south in the skiff to Nakvak Fiord and had a wild and stormy voyage. Nakvak Fiord is one of the grandest in the world, to be compared with those of Norway, though its beauty is of a more desolate kind since no trees grow on its wild shores, which rise from the water into mountains of 3,000 or 4,000 feet.

*Abstract, prepared for *The Canadian Engineer* by Prof. Coleman, of his illustrated address to be given to-night before the monthly meeting of the Toronto Branch of the Canadian Society of Civil Engineers, in the Chemistry and Mining Building of the University of Toronto.

Here, again, I explored and climbed, reaching one summit above 5,000 feet, giving a magnificent view of the fiord and of a sea of barren mountains with many small glaciers and snowfields as well as beautiful lakes.

The finest trout I have seen run up the river here; golden and copper colored and more than two feet long.

On August 25th, we had a snowstorm and I decided to go south. We had a very rough passage to Hebron, where I waited in the mission till the "Hump" came with the mails, and went south on this comfortless little ship as far as Hopedale, the last mission in that direction. Here there was a delay of eleven days, waiting for the "Sagona," which had been held up by storms and fog.

Thousands of Newfoundland fishermen go to Labrador in their schooners every summer, scattering in all the little coves and harbors along the coast and spending two or three months in cod fishing. Their catch was very small last summer, and there must have been poverty in some of the Newfoundland villages in consequence.

Icebergs are very common all the way along the coast and early in the season great fields of floe ice come down from Davis Strait with the Arctic current. I was twice halted by these floes on my way north and found the harbor at Hebron, the most northerly inhabited point, filled with loose blocks and pans of ice when I arrived on July 23rd. Ice conditions will, no doubt, have a very important bearing on the navigability of Hudson Straits.

INFLUENCE OF TEMPERATURE ON THE STRENGTH OF CONCRETE.

In *The Canadian Engineer* for March 9th, 1916, there appeared an article by H. S. Van Scoyoc on "Concrete Highways Subjected to Extremes of Temperature." Further information relating to this subject is contained in a paper by Prof. A. B. McDaniel, read before the American Concrete Institute. The conclusions drawn by Prof. McDaniel are briefly:

(1) Under uniform temperature conditions there was an increase in strength with age within the time limits of the tests.

(2) It is evident that if the concrete is to acquire a reasonable self-sustaining or a load-bearing strength in a short time (conditions which ordinarily obtain in building work), it is necessary to place the concrete under the most favorable conditions and maintain these conditions during the first few days. Concrete which is protected and maintained at a temperature of from 60° F. to 70° F. will at the age of one week have practically double the strength of the same material which is kept unprotected at a low temperature of from 32° F. to 40° F. Under freezing temperature conditions the materials should be heated so that the concrete will have an average temperature of from 60° F. to 70° F. and the concrete in place kept under an air temperature of not less than 45° F. by artificial heat during the first week. This provision for favorable temperature conditions avoids the well-known injurious effect of the freezing of the water in the concrete, and also the deteriorating effect of the alternate freezing and thawing of the concrete.

Columbia University will hereafter confer the degree of Master of Science upon graduate engineering students who satisfactorily complete the Graduate Course in Highway Engineering. From 1911 to 1915, the graduate engineering students who have specialized in highway engineering have been candidates for the degree of Master of Arts.

BUILDING AND MAINTAINING ROADS WITH REFINED TAR.*

By John S. Crandell, C.E.,
Engineering Department, The Barrett Co., New York.

Of the various binders used for road purposes in the last decade only the bitumens have been successful. There are two classes of bitumens so used, and they may be divided into asphalts and tars. The former are found native or may be produced by the distillation of asphaltic oils. Tars are obtained from a number of sources, but those made during the destructive distillation of bituminous coal have given the best service and most satisfaction.

Refined tars for surface treatment of roads have been used during the past fifteen years. With the advent of the automobile came the dust nuisance, and it was in great measure to alleviate this that experiments with refined tars were begun in Europe by Dr. Guglielminetti at the beginning of the twentieth century. These experiments were very successful and led to the tremendous development of the road tar industries of to-day.

Tars are refined for roads and pavements so as to obtain materials suitable for cold application surface treatment, blanket-coat (hot application), the construction of tar-bound macadam and paving pitch filler.

Bituminous roads may be constructed either by the penetration or the mixed methods. By the penetration method is meant spreading and rolling crushed stone to the proper depth, crown and grade, after which hot, refined tar is sprayed over the surface of the broken stone, then the voids are filled with chips and a second or seal coat of refined tar is applied. By the mixed method is meant mixing the heated aggregate and binder together before placing in the road. Both methods give satisfactory results when the construction is properly done, and it is a matter of judgment on the part of the engineer which he selects. Mixed work costs about 25 per cent. more than penetration and requires greater skill and care.

The construction of a tar macadam built by the penetration method will first be taken up. This will be followed by a description of mixed work, and a discussion of maintenance by using a cold surface treatment, which can also be used on water-bound macadam, will conclude the paper.

It is assumed that the drainage problem has been solved and adequately taken care of before the construction of the pavement is begun. The purpose of a pavement of any kind is to distribute the load over the foundation, as well as to provide a waterproof wearing course. The foundation is the earth on which the pavement rests, and it should be thoroughly compacted by rolling; all soft spots should be made firm and unyielding, and the surface of the foundation after rolling should be parallel to that of the finished road.

Base Course.—On such a well-compacted foundation broken stone is spread to a depth of from four to eight inches, depending on the kind of stone and the character of traffic the road is to carry. This is large-sized stone, such as will pass a 3½-inch ring and be retained on a 2¼-inch ring. The harder the stone, the smaller the size that may be used. This base course should be thoroughly rolled so that no movement takes place when the roller passes. A 10 or 12-ton roller is best.

*Abstract from address at the International Road Congress, Montreal, March, 1916.

In order to make the base course more stable; to keep the foundation from working up; and to prevent the refined tar, that is applied later on to the next course above, from leaking through, and thus being wasted, the spaces between the stones should be filled with fine, clean gravel, coarse sand or stone screenings. Rolling should be continued, always beginning at the side and working up to the centre. The rolled surface of the base course should resemble a water-bound macadam free from dust.

On this base course either a penetration or a mixed top may be placed.

Penetration Method.—The wearing course is made up of stone, 2¼ to 1¼ inches, and after rolling it should be 2½ inches in depth. The stone is carefully spread, and rolled so that the surface is smooth and firm. This course is to be filled with tar, so that great care must be taken when soft stone is used to avoid crushing, and thus sealing the surface with rock dust, which would prevent the penetration of the bitumen.

Refined tar will not stick to dirty or wet surfaces. Therefore, the wearing-course stone must be clean and dry.

Refined Tar for Binder.—Not less than 1¼ imperial gallons nor more than 1½ imperial gallons of refined tar at a temperature of from 200° F. to 275° F. are then spread uniformly over each square yard of the wearing course. The tar is best applied by pressure distributors, but hand-pouring pots may be used if it is impossible to secure suitable apparatus.

It is very important that the tar be uniformly applied so that the resulting pavement has neither lean nor fat spots in it.

Filling and Sealing.—The spaces between the stones of the wearing course are now filled with ¾-inch clean stone. This should merely fill the voids and not form another course.

Roll again, sweep off any excess stone, and the road is ready to receive the seal coat, which consists of ⅓ to ½ imperial gallon of tar at 200° to 275° F. temperature and is covered with sand or peastone.

Roll for the last time, and the road is then ready for traffic.

Mixed Method.—On the base course, constructed as previously described, can be placed a wearing course made by the mixed method, or such a wearing course may be placed on a concrete base or on a Telford base.

It is necessary to have a mechanical power mixer to properly mix stone and bitumen. There are many such mixers on the market. Some of them heat up the drum with an open flame. The flame should never be allowed in the mixer after the bitumen has been introduced. Portable plants can be had as well as stationary plants, and it is important to choose one that has a capacity suitable to the job.

The advantages claimed for refined coal tar over other bitumens are that it is easily used in the cold-mix type, in which the stone is not heated; that it requires less heat, since the tars have a lower melting point than asphalts, and that the same number of men can turn out a greater yardage per day.

The greatest care must be exercised to see that the temperature is right and that no batch is burned. A burned batch means a bad spot in the pavement that is bound to show up in time.

About 2½ inches of wearing course material is placed on the base course and rolled until it is compacted to two inches, judgment being exercised as to time and amount of rolling necessary.

Maintenance.—There is no such thing as a permanent road. There is nothing permanent in the universe. The sooner that fact is realized and given due thought by our taxpayers, the sooner grumbling over unmaintained roads will cease. The most enduring structures in the world, whether natural or erected by man, are not proof against the elements, and a roadway, exposed as it is at all seasons of the year to the weather, needs and should receive the best of care.

Just why it is so difficult to make the average man realize that a road needs more maintenance than his house or his office or his barn or his farm machinery is impossible to say. Yet the popular notion still obtains, even among officials who should know better, that once a road is built it is there forever, although their common sense and observation should tell them otherwise.

Maintenance of a tar macadam is such a simple matter that there is little or no excuse for failure to keep the road, once properly constructed, in excellent condition for years to come. All that is necessary is the patching of such few depressions as may need it and the cold application of a light tar yearly, or bi-yearly, as the traffic may dictate or the condition of the surface may indicate.

The amount of tar necessary to maintain a tar macadam varies from ⅛ gallon per yard to ½ gallon per yard. It is seldom that the latter amount is needed, and where maintenance is the rule, the former figure is nearer the average amount used. In order to get such a small amount as a pint to the yard, a pressure distributor is absolutely necessary. Such a distributor may be made by attaching a system of gearing onto the rear wheels of a horse-drawn sprinkler and connecting this to a pump, which forces the tar out under pressure. Or an auto truck may be used, or even a man-driven pump attached to a barrel may be employed.

The means of application are so many, and the cost is so slight, that it is wasteful economy not to treat bituminous-bound roads when they need it.

Water-bound macadam may be treated and maintained in the same way.

Maintenance of Water-Bound Macadam.—As noted elsewhere, refined tar will not stick to dirty or wet surfaces, so that it is absolutely necessary to sweep and thoroughly clean a water-bound macadam before treating it with refined tar. The sweeping is most economically done with horse-drawn sweepers, followed by men with push-brooms, who remove any crust or scale that may have formed on the surface. It is most essential that the sweeping and cleaning be thoroughly well done, for if any dirt is left on the surface it is to be expected that the tar will peel off at such places. Ruts and pot-holes should be scarified and repaired in advance of the cleaning.

When the road is dry, ¼ imperial gallon of refined tar, liquid at ordinary temperatures, is applied cold, and, if necessary, broomed in with fibre push-brooms. The application of the tar may be done with pressure distributors or with hand-sprinklers. The former give a more uniform distribution.

Whenever it is possible, traffic should be kept off a newly-treated highway for twenty-four hours or more, after which the surface should be covered with screenings or sand and traffic admitted. In any event, the treated surface should be closed to traffic for at least two hours. Always cover the treated surface with screenings or sand to prevent the tar from being tracked into houses and on to sidewalks. The covering acts like a blotter, taking up the excess tar not absorbed by the road.

This film of tar, which penetrates about ½ inch of the surface, prevents ravelling, prevents the formation of dust, and keeps the road intact. When traffic is heavy, a second and lighter treatment should be given the first year, after which one light application a year should be sufficient to keep the road in excellent condition.

Surface Treatment of Gravel Roads.—Good gravel roads may be maintained in a similar way. In case the road is rutted or pitted it should be scarified and rolled. Two light coats, about 3/16 imperial gallons each, are applied after the road has been swept. The first coat is applied in the morning, followed by the second in the afternoon. Sand or stone chips are then spread, as noted above. Sometimes it is necessary to give the centre of the road a third light coat of tar.

A few barrels of tar should be kept on hand for patching purposes. With surface-treated gravel roads it is very essential that the surface be kept intact, and patching in time saves much annoyance later on, as well as keeping the road in constant good condition.

Tar is not recommended for treating dirt roads.

STEEL COMPANY OF CANADA.

The profits of the Steel Company of Canada for the past year at $3,230,452 were double those of the best previous twelve months' period. Equally gratifying is the fact that 55 per cent. of the company's output during 1915 represents domestic trade. The company manufactures a very wide range of steel products, mines its own ore and finishes its products to the last stages, all of which factors help materially to obtain a good share of business offering at home.

Deducting a sum of $400,000 on account of depreciation, $88,500 set aside for bond sinking fund, $531,000 for bond interest, and $454,741 for preferred stock dividends, surplus profits, after all fixed charges, amount to $1,756,211, equal to 15.2 per cent. on the common stock. Adding this latter to the previous surplus, the amount carried forward at the end of the year is $3,014,641, the largest balance in the company's history, comparing as it does with $1,258,430 in 1914, $1,571,603 in 1913 and $1,060,571 in 1912. The depreciation allowance is substantial, providing as it does for the extra wear and tear entailed by the working of extra shifts. The sinking fund provision of $88,500 is on account of the first payment in this respect, which is due July 1st, 1916, as under the terms of the security a cash sinking fund of 2 per cent. per year becomes operative on that date. The amount now being set aside, therefore, takes care of the six months up to the end of last year. The preferred stock dividend allowance covers two quarters of arrears and two quarters of 1915. The remaining 3½ per cent. arrears, covering two quarters, which were unpaid at the end of the year, have since been arranged for.

The company has materially improved its liquid position. An increase of over 50 per cent. is shown in current assets, these now totalling $9,796,200 as against $6,479,770 at the end of 1914. Cash on hand has grown from $99,407 at the end of 1914 to $182,691 at the end of 1915, an increase of 85 per cent. The company's financial statement generally shows an excellent position.

RAILROAD DEVELOPMENT IN CANADA.

By J. L. Payne, Ottawa.

THE first impression created by a glance at official data relating to the operations of Canadian railways for the year ended 30th June, 1915, is that our transportation interests were hit rather hard by conditions which grew out of the war. On further consideration, however, that impression is somewhat modified. A heavy blow was given to traffic and resultant earnings. There can be no doubt of that; but any depression which might be developed by that fact alone, gives place to relief when the whole situation is carefully analyzed. It is then realized that the railways were able in large measure to meet adversity by adjustment. That is to say, while receipts fell off, there was a proportionate reduction of operating cost. Hence net earnings were fairly maintained. To the intelligent student the results of the past year will be accepted as revealing first-class executive and administrative capacity by our railways. It is stress of weather which tests seamanship, and it is assuring to know that the strength and soundness of our railway situation stood up against the hurricane of 1914-15.

A special feature of the year was the quite unprecedented addition to operative mileage. Everyone familiar with what was going on in the country knew that since 1910 a very large amount of construction work had been under way. Some of the heavier undertakings, such as the National Transcontinental and Grand Trunk Pacific, had actually been started ten years ago. During the four years following 1910 there were 6,063 miles of new line brought upon an operating basis. That was really a significant betterment of transportation facilities—more significant than the unthinking onlooker would suspect. It meant that we had built railway lines beyond the actual need created by swelling population. Nor had such enlargement of carrying facilities been demanded by the pressure of traffic upon existing lines. When the movement began, Canada stood in first place among the nations on the basis of railway mileage per capita. She is still at the top. The tremendous activity in railway building—for by every fair standard of railway measurement it was tremendous—which had been in evidence for years past was an expression of faith in the future of Canada rather than an attempt to meet immediate and urgent needs. Like the charge of the Light Brigade, this faith was no doubt superb; but there are not a few who regard it as, on the whole, imprudent. Time will tell.

An increment of 4,788 miles to operating mileage in 1915 broke all records. Added to the 6,063 miles, to which allusion has just been made, it meant that within the past five years railway mileage in Canada had been expanded by 10,852 miles, or an average of 2,170 per annum. The United States did not do as much during the same period. It is doubtful if the whole of Europe did. This addition was greater than the mileage of the Dominion in 1885—the year the Canadian Pacific was completed—and it brought the total up to 35,582. That total pushed Canada up to fourth place among the nations of the world, only the United States, Russia and Germany being ahead of her. Let us now see how the 10,852 miles of new line put in operation since 1910 were distributed. The following little table will show:—

	Added since 1910.	Present mileage.
Ontario	2,472	10,702
Quebec	882	4,677
Manitoba	1,277	4,498
Saskatchewan	2,395	5,327
Alberta	1,686	3,174
British Columbia	1,268	3,100
New Brunswick	440	1,962
Nova Scotia	16	1,367
Prince Edward Island	6	275
Yukon	11	102
In United States	398	398
Total	10,852	35,582

It should be explained that the mileage assigned to the United States consists merely of sections of Canadian lines which, for purely geographical reasons, cross American territory—such as the well-known Short Line of the Canadian Pacific connecting Quebec with New Brunswick. Look, however, at the table, and see that 6,626 of the 10,852 miles were located west of Lake Superior, or nearly 62 per cent. of the whole. That is where the facilities are most needed, in the area of settlement. It was confidence in the future of our vast and fertile West which impelled this striking construction work.

It will now be in place to see what all this development of carrying power since 1910 has cost; for railways are not built on faith alone. They not only cost a great deal of money, but on a rapidly rising scale. Assuming that the actual cost is closely identified with capitalization, we find that the bill reaches the respectable total of $665,513,201. That is to say, whereas the capitalization of Canadian railways was $1,210,297,687 (as revised) in 1910, it stood at $1,875,810,888 in 1915. But that is not the whole cost. Aid was given in cash by the Dominion, the provinces and municipalities, to the extent of $38,147,848.20, in addition to which the Dominion built the eastern section of the Transcontinental at a cost of $152,802,746. These sums added together make a total of $856,463,795 as the probable cost of railway lines built since 1910; and, to make financing easy, the federal and provincial governments have guaranteed the bonds of railway operations to the amount of $409,869,165 during that period. These are all large and impressive figures, and the outstanding problem at this moment turns upon our ability as a nation of 8,000,000 to carry the liability involved without serious inconvenience. In the last analysis it becomes a matter of earning power. If the railways concerned in this vast capital outlay can meet fixed charges until post-bellum reconstruction has taken place, there is every probability that rising receipts thereafter will remove all ground for anxiety. Meanwhile, the western provinces are in the position of a man who has endorsed the promissory note of a friend, and sees that friend struggling to make both ends meet. To be absolutely candid, we have been just a trifle too optimistic in railway building, and have gone ahead a little faster than Scotch prudence would approve. But the world will witness other grave disasters of a monetary character before Canada, having regard to her resources, finds herself in real trouble because of the faith she has shown in respect of railways.

In 1915 railway gross earnings fell off, as compared with 1914, by $43,240,457. This was largely because freight traffic declined during the year from 101,393,989 to 87,204,838 tons. Gross earnings, however, had been steadily on the ascendant for twenty years. In 1895 they were $46,785,486. Ten years later they stood at

$106,467,198. In 1913 they reached high-water mark—$256,702,703. Not another country under the sun had done relatively as well. Is it any wonder we grew sanguine? A setback had really begun before the war broke out; but with Europe in arms the decline gained momentum month after month. It was under such circumstances that the test of management occurred to which reference has been made. Operating expenses, which had been $178,975,259 in 1914, were pulled down to $147,731,099. Earnings shrank by 17.8, and operating cost by 17.5. The result was that net earnings were brought up to $52,111,973, as against $64,108,280 in 1914. This was a fine achievement, all things considered; but it involved drastic and courageous action. The number of employees was cut down from 159,142 to 124,142. Retrenchments took place in many directions. It was a very trying year. Yet the high standard set for operating conditions was maintained. Roadbed and equipment were not neglected. Our railway managers did not lose their heads and do wasteful things.

The decline in traffic, as has been said, began a few months before the outbreak of war. Ere the people at large knew that a period of contraction in trade had begun the railways knew it. They are always the first to know whether commerce is moving upward or downward. They hold the barometer, and an unfailing, trustworthy barometer it is. Commerce has no particular centre. Foreign trade is registered at the Customs Department; but domestic trade has no point of registration. Railway earnings will always show the trend of both foreign and domestic commerce. These earnings are recorded weekly, and the man who watches them really has his finger on the pulse of national business life. For trade and traffic are synonymous terms. So, let it be repeated, the railways had primary warning of the slump which started early in 1914. It continued until September last. Then the pendulum began to swing in the other direction. War orders and the harvest combined to bring about the change. Instead of one day of thanksgiving, the people of Canada should have been on their knees for a week last autumn. That unprecedented harvest saved Canada from very serious trouble; saved them in a far broader sense than did the demand for munitions.

The upward movement in railway earnings has continued with more or less steadiness since last September. Therefore, without any corroboration from the banks or any other quarter, we know beyond a peradventure that the commerce of Canada has been actively growing. A very substantial part of the losses in gross receipts incurred between March, 1914, and September, 1915, have already been retrieved. This recovery is not wholly attributable to the movement of grain and war materials. Trade in general has answered to the impulse of confidence —that subtle, yet potent, force beneath all enterprise. It is well this change took place. It concerns us all. When earnings are pouring into the coffers of the railways, everybody should rejoice; for railway earnings are invariably and necessarily the reflex of trade. Let nobody grumble when the railways are doing well; the people at large are also doing well. Of course, the fall in earnings last year smashed practically all the nice looking and encouraging averages which had been built up in railway statistics year by year since 1895. It looks at this moment, however, as if many of them would soon be restored to former levels. All the conditions are favorable.

There is another aspect to the decline of last year, and the circumstances which produced it, that cannot be ignored. There will inevitably be a lull in railway building for a time. Caution has succeeded to daring. Nobody knows what adjustments will be necessary when the war is over. Canada is in the best position of any country affected by the war to stand the strain, and Canada, too, is in the best position to receive the immediate benefits of peace. Immigration has been the parent of our railway expansion since the early nineties, and the outflow of population from Europe, when fighting ceases, must come in large measure to our shores. We hold the land available for settlement on attractive terms. But capital will be at too high a premium for some years to make financing easy, and we must not forget that railways are constructed on borrowed money. On 30th June last there were barely 1,600 miles of new line under contract, as compared with many times that mileage two years ago. Not a single new line has been started since 1914. We are therefore facing a period of comparative inactivity. This will afford time for much-needed digestion of the ten thousand miles of railway put into operation since 1910. New mileage is invariably low in density of traffic for quite a period of years. Whatever may be said on the score of prudence respecting our rapid railway building, there is satisfaction in the reflection that we at least have the transportation facilities to make enormous development of our resources practicable. To bring about that development is one of the great problems to which the people of Canada are now called upon to address their energies. They have the power to win.

FUEL-OILS FROM COAL.

Advocating the use of raw tar as engine fuel, and, further, low-temperature carbonization, in a paper on "Fuel-Oils from Coal," read before the Manchester Association of Engineers on February 26, Mr. Harold Moore, M.Sc.Tech., stated that shale oil was a satisfactory substitute for petroleum, but that Scotland produced only 300,000 tons of crude oil per year, whilst the petroleum output of the United States had amounted to 33 million tons in 1913. Ordinary horizontal coal-gas retorts gave from 9 to 13 gallons of tar per ton of coal (about 5 per cent. by weight), while low-temperature carbonization yielded from 10 to 20 per cent. of tar. These figures fall within those quite recently given by Professor Bone. The lighter fractions of the tar distillate were known as creosote, and served both for timber preservation and as fuel for Diesel motors. Tar-oils from low-temperature carbonization being hardly on the market yet, the possibilities of raw tar as engine fuel had to be studied. Raw tars cost about 25s. or 30s. per ton now, which was half the price of the distillate; heavy tars yielded about 25 per cent. of their weight as tar oils, so that the direct utilization as fuel of raw tar, which was made all over the country, and not in special works only, would make four times the material available for power purposes. In calorific power tars were 16 per cent. lower than average petroleum oils. This consumption of tars, like that of heavy petroleum oils, in internal-combustion engines required, however, the use of an ignition oil and a special fuel-pump and atomizer for that oil. These problems had been investigated on the Continent, and Constam and Schläpper had found out that Diesel engines could be run on vertical-retort tars, on chamber-oven tars, water-gas and oil-gas tars, certain coke-oven tars, as well as on lignite tars, but not on tars from horizontal and inclined retorts. Mr. Moore entirely agreed with this conclusion. Requisites for fuel tars were: High hydrogen contents; low contents of "free carbon" (which would wear out cylinders and valves); high calorific power; moderately low viscosity; less than 2 per cent. of water (to prevent irregular running); low coking value (not over 15 per cent.); and low ash content (not exceeding 0.15 per cent.). The Premier Tarless Fuel Company avoided decomposition of the tar in the retort by working annular retorts with outlets at both ends, under a high vacuum of 25 ins. of mercury at 900 deg. or 1,000 deg. Fahr., and obtained from slack 20 to 25 gallons of tar per ton; from poor cannel coal, 52 to 60 gallons; and from good cannel, 60 to 80 gallons. When dehydrated this tar made an excellent Diesel-engine fuel. Mr. Moore finally suggested to submit the hot gases to fractional condensation by cold in three successive stages; the first stage would yield pitch and free carbon, the second oils, the third the volatile benzene, toluene, etc.; the oils (carbolic, anthracene) of the second stage should give a good engine fuel, which, if too rich in naphthalene, could be preheated in tanks.

EXPERIMENTS IN WATER SOFTENING WITH A ZEOLITE-LIKE SUBSTANCE.*

By Robert N. Kinnaird.

THE application of the chemical exchange properties of zeolites to the art of water softening indicates an important step in the evolution of the art. The peculiar ability of zeolites to exchange their alkaline bases has been known for a number of years. Dr. Robert Gans, of the Royal Prussian Geological Institute, has been the foremost investigator of this group of minerals, and is probably the first to conceive of their applicability to water purification. Dr. Gans and others have measured the exchange capacity of a large variety of natural zeolites, and concluded that the natural deposits were either too rare or too greatly associated with impurities to be of commercial value in themselves. He therefore sought to develop a synthetic product having as large an exchange capacity as possible. His product is beginning to be fairly well known in this country and is coming into extensive commercial use abroad.

You are probably acquainted with the general nature of the process. The synthetic product, in chemical composition, is a hydrous aluminum silicate in combination with sodium. A hard water containing calcium and magnesium salts in contact with this material exchanges its calcium and magnesium ions for the sodium ions in the silicate, the result being that the medium is transformed to a calcium silicate, and the salts carried by the water become sodium salts in combination with the original acid radicals. After the silicate has absorbed its capacity of lime and magnesia, it is restored to its original sodium condition by forcing the action in the opposite direction through the agency of a solution of salt or sodium chloride. Under such conditions as are favorable this artificial product is the basis of an ideal process. Salt is cheap. The chemical application is automatic in so far that fluctuating hardness is self-adjusting. No precipitation of insoluble salts is involved, consequently there is no insoluble sludge of which to dispose. Sedimentation and filtration are eliminated.

The natural substance, which the writer has been investigating, is a hydrous aluminum silicate in combination with calcium, which is capable of exchange for sodium in the raw state at a high rate and to at least as high a capacity as the synthetic product. The writer has succeeded in evolving a method of measurement of the rates of exchange in both directions of the reaction with considerable reliability and accuracy.

Des Moines city water, which has a total carbonate and sulphate hardness of over 300 parts per million, has been softened in experimental filters. In the laboratory of Dr. Edward Bartow, of the Illinois State Water Survey, these Des Moines experiments have been duplicated with the University of Illinois water having a total carbonate hardness of 300 parts per million.

With a filter layer 2 feet in thickness, rates of filtration of 2 gallons per minute per square foot and upwards have been obtained with water of 300 parts per million hardness. This is equal to the rapid sand filtration rates and suggests the substitution of this natural medium either in gravity or pressure filters for municipal use. The requirements for containers and drainage and washing systems would not be unlike the arrangement for rapid sand filtration. More idle time would be involved in the regenerating process than is at present consumed in washing the filters which would increase somewhat the bulk of the equipment. The cost per unit capacity would therefore be somewhat more than the cost of rapid sand filters. The other items of expense would be in the cost of the medium as compared with sand, its life and the cost of salt for regeneration. It is not unlikely that the medium can be produced very cheaply, as compared with a synthetic product. The material with which the writer has experimented requires some refining and hardening to give it mechanical form. The process is not involved and if handled in large quantities can be made to meet a heavy demand at an easily practicable figure.

Present information indicates that 4 pounds of salt can be counted upon to completely convert 1 pound of equivalent calcium carbonate to sodium carbonate, and the writer feels justified in saying that the indications are that this can be reduced. Assuming a ratio of 4 to 1, and 300 parts per million hardness, 10 pounds of salt would be required to treat 1,000 gallons of water. Salt is marketed in car-load lots at $3 and upwards per ton. Assuming $5 per ton, the chemical cost would be 2½ cents per 1,000 gallons, which is easily competitive with lime and soda.

The two processes, however, are not strictly comparable. The zeolite process gives a completely softened water without reducing the total solids. The lime process reduces the hardness by the amount of bicarbonates, while the soda process is only useful in that it converts calcium and magnesium sulphates to the sodium sulphates, which is exactly the same chemical substitution as is made by the zeolite. Either alone or in combination with lime, the zeolite process will be a most valuable finishing process. For waters harder or softer than 300 parts per million the cost figures would vary about in proportion to the hardness. Complete softening would probably be neither necessary nor desirable for municipal use, which would reduce the cost proportionately. For harder waters, the depth of the medium layer could be somewhat increased, sufficient probably to maintain rates of flow nearer the usual rates, without increasing the equipment except as to depth of the containers.

*Read before the Iowa Section of the American Waterworks Association, Iowa City, Iowa.

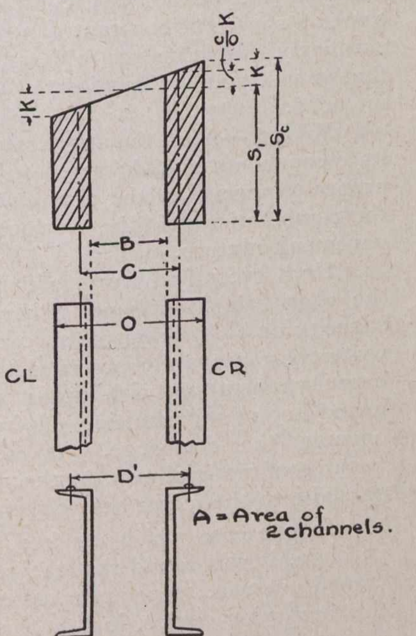
"America's Electrical Week" has been selected by the Campaign Executive Committee as the official name for the great electrical celebration, December 2 to 9, 1916. A start has already been made on the nation-wide campaign which from every indication will surpass even the wonderful results accomplished by the 1915 "Electrical Prosperity Week."

Letters to the Editor

Stresses in Lattice Bars of Channel Columns.

Sir,—In fulfilment of a promise made to you in my letter of March 14th, I enclose herewith a few notes upon Mr. Pearse's paper on "Lattice Bars," published in *The Canadian Engineer* of February 24, 1916.

(1) Fig. 3, page 274, which is intended to show the variation of stress in the two channels, is a bit misleading. The enclosed sketch gives a somewhat better idea of how the stress is distributed.



Let C represent the distance between the centre of gravity lines of the two channels, which are a distance B back to back and distance O out to out. Then the total stress due to bending in channel marked "C R" is $\frac{A}{2}\frac{C}{O}k$ instead of $2k\frac{A}{2}$

(2) The distance D' (Fig. 4) appears to represent not only the distance between rivet lines but also the distance between gravity lines and the distance between the resultant total stresses in the two channels as well.

(3) Euler's *long column* formula, Equation 7, for hinged ends, applies to columns for which the ratio $\frac{l}{r}$ is greater than 200, and is of little use for practical investigation. "Column 1," which the author uses to test the soundness of his theory, has an $\frac{l}{r}$ of 37.8, and the greatest $\frac{l}{r}$ of any column in his table (page 275) is 92.

(4) The coefficient of $\frac{l^2}{r^2}$ of Rankin's column formula, given in Equation 3, is the same as is used in the Dominion Government Specifications, 1908, for a column with one fixed end and one pin end.

(5) It may not be out of place to say that any column formula which contains the factor $\frac{l}{r}$ as a measure of the slenderness of a column should be viewed with some suspicion, for it can easily be proved, either mathematically or empirically that a rectangular column with free ends will not bend in the plane of its least dimension.

(6) The testing laboratory is the only source from which we may ever hope for the solution of the column; and any prophecy eminating from such a source should be given its just weight.

In the laboratory the loads are artificial, the conditions are ideal, and the material and fabrication are usually above the average. Such tests stand much in the same relation to the real problem as the sample packages left at the back door resemble the article produced over the counter.

(7) Since the memorable date of August 29, 1907, over a hundred monographs on compression members have been published, and the conclusions have not always been satisfying. The problem has created as much mathematical discussion as did perpetual motion a generation or more ago.

(8) The structural engineer will be greatly encouraged by Mr. Pearse's paper since it is an indication that architects in some localities at least are in sympathy with the problems of the engineer.

CHARLES A. ELLIS,
Professor of Structural Engineering,
Urbana, Ill. University of Illinois,

Oil-Tar Creosotes.

Sir,—Referring to your editorial of December 30th, 1915, and to Dr. John S. Bates' letter in your issue of February 24th, 1916.

Dr. Bates' letter is an outline of the methods usually employed for distinguishing between coal-tar creosotes and water gas tar creosotes. These *are* the methods usually employed for this purpose, and, as a rule, are very satisfactory in determining the character of *unmixed* oils.

However, as Dr. Bates says, it is not so easy to detect *mixtures*, and, sometimes when the mixtures are made with the intention of deception, it is practically impossible to detect them. The recent introduction of tars produced in vertical retorts and at low temperatures (which are exceedingly good tars) has further complicated this matter of detecting the presence of water gas tar, since these tars sometimes contain a considerable proportion of paraffine compounds.

The whole matter, then, gets back to what the writer has maintained several times; that is, that the detection of addition of water gas oils to creosote is exceedingly difficult and requires a great deal of experience.

AMERICAN TAR PRODUCTS COMPANY,
Per E. B. Fulks, Vice-president.
Chicago, Ill., March 8th, 1916.

Through traffic over the line now being built from Petrograd to the Arctic port of Kola is now possible as far as the rail head at the south-western corner of the White Sea at Soroka, but traffic along this line will be light until it is in full working order. The Port of Soroka is not large, having had heretofore merely local fishing and lumbering importance. It has been subject to all the difficulties suffered by Archangel and caused by the ice conditions prevalent in the "neck" of the White Sea, where it opens through a strait into the Arctic Ocean. In 1913 only 45 vessels put into this port, with a tonnage of 45,389, and the departures were 71 vessels, with a tonnage of 47,061. The vessels were extremely small, many being mere barges constructed roughly to carry lumber and intended to be knocked down at the end of the voyage to other White Sea ports.

BITUMINOUS PAVING PLANTS.

(Continued from page 336).

properly, and cannot be handled properly on the street. If too hot, the asphalt cement is injured when tossed about in the mixer in thin films upon the overheated aggregate.

In the present plants, change of temperature will occur most frequently through variations in rate of feed or through delays in turning out the material which necessitates shutting off the feed and allows the drum to become overheated. The most common cause of temperature change would be removed by the regular mechanical feed of aggregates as described above.

In any case, it would be comparatively simple to apply to the control of temperature of the dryers, the principle of the electric thermostat which is attached to the draughts of the ordinary house furnace. This thermostat could be so set that when the predetermined upper limits are reached at the boot of the hot elevator, an electric motor would come into operation which would open a trap at the discharge chute from the drum, allowing the mineral aggregate to drop into a screw conveyer, discharging onto the ground.

This conveyer would be interposed between the end of the drum and the hot elevator, so as to remove the overheated material before entering the elevator. Simultaneously, the motor should open the fire doors of the drum, allowing the cold air to enter. When the temperature has dropped sufficiently, and the electric contact is broken, the motor should operate and close the trap, permitting the aggregate again to enter the elevator.

A similar operation could be adjusted for predetermined minimum temperatures.

Present arrangements for control of temperature necessitate taking a sample of aggregate from the boot of the hot elevator and testing it there or at the mixer, and if the temperature is not right, either discharging the aggregate from the top of the hot elevator or from the storage bin. This latter operation is always attended with confusion in shifting teams beneath the mixer or in changing the rate of feed of aggregate. The uniformity of temperature and general satisfactory operation of a plant depends very largely upon the continuity, and anything which interferes to shut down or disturb the mixing operation immediately throws the entire work out of gear, and leads to other disturbances.

Screen and Bins.—Generally, in handling complex mineral aggregates, the proportions are approximately determined at the cold elevator, but in order to avoid segregation in bins or drums, the best practice requires the screening of the aggregate into several compartments and sizes, the number of operations depending upon the complexity of the aggregate.

In most plants, this is not accomplished with sufficient accuracy or with sufficient provision against contingencies which arise during plant operation. Frequently, the storage bins upon these plants are small, and when subdivided into compartments, the operating screen is too short to make a clean separation. Sometimes the partitions are light and do not come up sufficiently around the screens, and when one bin becomes filled, while the adjoining one is nearly empty, there is enough deflection in the partitions to move them beyond the line of division of the screen, permitting one bin to catch aggregate which should drop into the other. Frequently, also, if the plant is not taking material as fast as it might, or if the feed has been varied, one bin will fill up and in the absence of an overflow spout from each individual compartment, material from one bin will crowd over into the next.

It follows, in any case, that in weighing out aggregate from different bins, the proportions set are departed from, and variable aggregate discharges into the mixer, for which the amount of asphalt cement may be entirely unsuited. To correct this condition, it is necessary, when this occurs, to stop the work, empty out the bins, thereby interrupting the smooth operation of the plant and causing disturbances in other directions.

This occurrence is a most frequent one at paving plants, and is the cause of much unnecessary trouble and irregular mixture. In fact, it sometimes becomes so troublesome that it is often advisable not to make a screen separation of aggregate, but to regulate it as closely as possible at the cold elevator. Unless this screen device is so constructed as to operate without causing contamination of the various aggregates with each other, it becomes a source of constant danger. It should be a comparatively simple matter to design this separating unit so that it will actually perform the work for which it is intended.

Mixing.—After the aggregate has been separated into its components and delivered to the storage bins at the proper temperature, the next and most important step is the combination of the various elements into the final pavement mixture.

Until recently, it was common practice to measure the aggregate by volume, either in a box of constant capacity or by striking off an open measuring box. The writer has frequently observed these boxes of constant capacity operating with upper and lower slides, which would not permit shutting off from the bin without first opening the discharge. As a result, a considerable quantity of material over the theoretical capacity frequently passed into the mixer before the upper slide was shut off.

In one case which resulted in a dispute of binder yardage, it was found that the amount of binder actually turned out was 20 per cent. in excess of the capacity of the measuring device, just on this account.

The use of open boxes for measuring is liable to the objection that it requires striking off by the laborer, and this in the long run is slighted. Measuring devices of this kind, as well as volume measurements of asphalt cement, are fortunately almost a thing of the past. It is now customary upon the most modern plants to weigh these various ingredients. Unfortunately, however, the class of labor available for this purpose cannot generally be depended upon for accuracy, even in so simple a matter as weighing, and the result frequently is in error, owing to overdrawing of weights, changes of tare, and errors in handling weights.

The automatic scales on the asphalt concrete bucket should be of a kind which would operate somewhat differently. This should be devised in such a manner that the given amount of asphalt cement will be discharged from the bucket regardless of its tare. This would eliminate the greatest source of error at the mixer, and would result in uniformity of the product of the plant.

It is believed that the foregoing accounts for a very considerable amount of defective or partially defective work which sometimes results in spite of the best of intentions on the part of the paving contractor and his employees. It is further believed that the manufacture of paving mixtures should be facilitated by applications at least equally effective as those available for processes of similar importance. The plant manufacturer who devotes attention to such details will do much toward forwarding the interests of the asphalt paving industry, and his efforts will be appreciated by all responsible for the success of the product of these paving plants.

UNIT CONCRETE CONSTRUCTION FOR MANHOLES, VAULTS AND CATCH BASINS AT ST. JOHN, N.B.

By R. Fraser Armstrong, A.M.Can.Soc.C.E.
Engineer and Superintendent, Department of Water and Sewage, St. John, N.B.

SEVERAL new departures have been made recently by the city of St. John, N.B., in which concrete has played a large part as an economical material of construction. The use of unit concrete blocks in the construction of manholes, catch basins, gate valves, vaults, etc., has effected a saving of from 10 to 40 per cent. of the original brick construction cost, besides making a better and more durable piece of work.

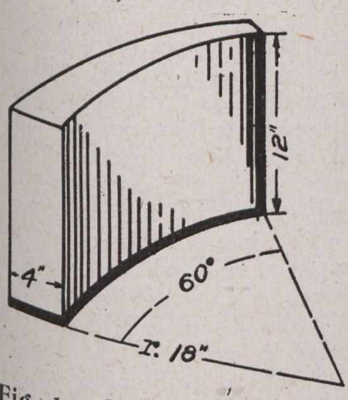


Fig. 1.—Concrete Block, Unit of Construction.

The standard unit adopted is circular in section, 3 ft. diameter on the inside and consists of a concrete block 4 ins. thick by 12 ins. high and forming one-sixth of the circumference of the circle. Each block weighs 96 pounds and is cast in special moulds made for this purpose. A smaller number of blocks are made of different heights, so as to be able to have the top of the finished work conform to the surface elevation of the ground. Each 12-in. block, including material and all labor of casting and cleaning moulds costs 20 cents. (Cement, $2.30 per bbl.; ½-in. broken stone, $1.60 per cubic yard; sand, $1.25 per cubic yard, and labor, $2.25 per day.)

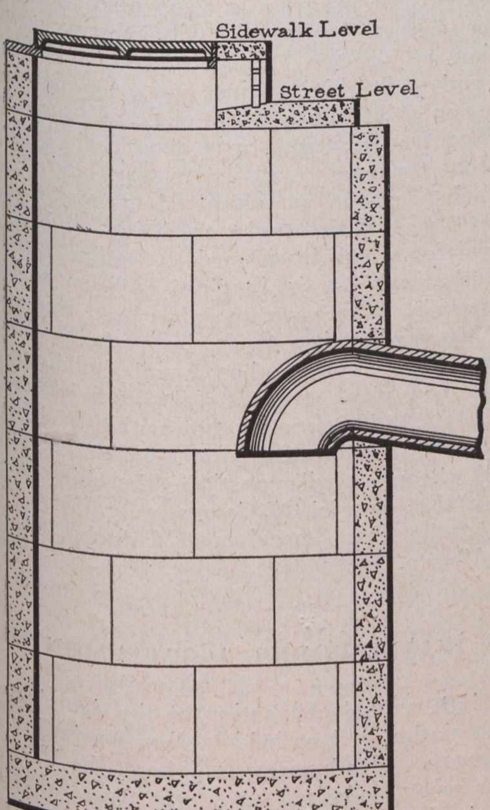


Fig. 2.—Catch Basin Built of Concrete Block Units.

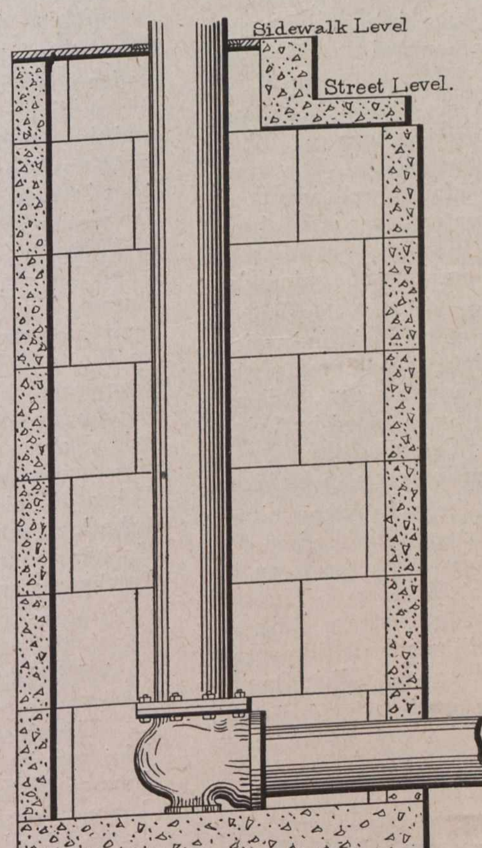


Fig. 3.—Unit-built Fire Hydrant Vault.

In the construction of the catch basins a concrete curb is cast having the inlet opening, fitted with a cast iron grating, in its face. Access to the catch basin is obtained by removing a neat cast iron cover placed in the sidewalk and flush with the asphalt surface finish. These curbs cost 50 cents, including both labor and material, and are similar in design and dimensions to the standard curbs adopted by the street department.

Costs kept upon both the brick and the unit concrete manholes are given below. These costs include all labor and material, but not excavation costs.

Depth of manhole.	Brick construction.	Unit concrete block.
10 feet	$37.00	$27.00
12 feet	43.00	30.00
14 feet	52.00	36.00
16 feet	60.00	39.00

The net saving to the department is greater than indicated above, as these itemized costs allow for the actual labor in each type of construction and make no allowance for the fact that the concrete blocks are all cast by our regular mason and yard laborers in their spare time. It is necessary to keep these men around for emergency work and where formerly all their time was not occupied at necessary work, now all their time is employed to advantage and the portion formerly charged to general maintenance is now charged to concrete block construction.

Another very good use to which concrete has been put is in the construction of a tunnel under the Intercolonial Railway tracks. The nature of the soil at this point is such that a distinct vibrating motion is imparted to the ground as each heavy train passes. Ever since the water pipe was placed, in 1899, it has been necessary to dig down to the pipe several times each year to repair leaking joints, and the total cost of construction was less than cost of repairs during the last few years. This work was completed in May, 1915, and since that time no repairs have been necessary. The pipe passed under three main tracks so that five joints were exposed to the vibration of passing trains.

Between each line of tracks a concrete foundation was built and, resting on these foundations, reinforced concrete beams were cast, forming the walls of the culvert. At each end of the culvert, manholes were built, giving access to workmen who were engaged in repair work. The water pipe is suspended by rods fitted with turnbuckles. The total cost of the culvert was $773.

COAST TO COAST

Welland, Ont.—Work has commenced on the extension of the Niagara, Welland & Lake Erie Railway line.

Winnipeg, Man.—Further damage from electrolysis to sewers and pipes has been reported to the board of control by the city engineer's department.

Alberta Province.—In 1910 there were 1,060 miles of railway in Alberta, and in 1915 it had increased to 4,473 miles, according to figures recently issued by the government.

Kingston, Ont.—The Utilities Commission is entering into an agreement with J. M. Campbell, whereby the latter will furnish it with 300 horse-power of electrical energy from his waterfall at Kingston Mills, as auxiliary power for the Kingston steam plant.

St. John, N.B.—At a public meeting held at Armstrong's Corner, Queen's County, a resolution was passed approving of the proposal to change the route of the St. John Valley Railway from the so-called east side route, and urging that the line be constructed so as to make connection with the C.P.R. at Welsford, and thus reach St. John.

Chatham, Ont.—Building operations in this city during the three months ended March 31st show a great depreciation as compared to the same period of last year. Building permits for the past three months amount to $16,050, or $23,150 less than last year during the same period. Last month's permits amounted to $2,850, against $11,050 for last year.

Markham, Ont.—Markham village, which is installing a water system into the newly annexed suburb of Mount Joy, expects to have it completed about June 1. The work of putting down the new pipes was fairly well advanced in the fall, and the handsome steel water tower is finished. It is 160 feet high, and takes six hours to fill. It will hold 60,000 gallons, and will have a pressure of 70 pounds.

Medicine Hat, Alta.—It is reported that the cement plant south of Medicine Hat, partly completed, and which has been lying in its present state since the collapse of the building trades business some few years ago, will recommence construction. This plant was started by Leigh Hunt, of Kansas City, well known in Canadian circles, and he was employed by the Max Aiken interests to build it.

Ottawa, Ont.—On March 30th the railway committee of the Commons reported a bill extending the time for the construction of the Atlin Railway from the town of Atlin southward to the international boundary. The bill to incorporate the Edmonton and Southwestern Railway was reported. The projected line will run from Edmonton to a point on the Saskatchewan River, near Blue Rapid.

Prince Rupert, B.C.—The new floating dry dock and ship repairing plant, which the Grand Trunk Pacific Railway has built at Prince Rupert, is now open for business. The dock is in three units, with a total lifting capacity of 20,000 tons. All the units are interchangeable, and each is complete in itself. When all three are joined together the dock will be capable of raising a vessel 600 feet long of 20,000 tons. The dock has an over-all length of 604 feet 4 inches on the keel blocks, a clear width of 100 feet, and a width over all of 130 feet.

Toronto, Ont.—Seven hundred thousand dollars worth of work will be done on the new harbor development by the Toronto Harbor Commission itself this summer. The development east and west in Ashbridge's Bay and at the Humber has been almost entirely government work. This will be continued this summer, and, in addition, the Harbor Commissioners will start in on their transformation of the old harbor. The commissioners' plans provide for establishing at the foot of Bathurst Street a dock and industrial area of 17 acres north of the new channel. This area will be served with 800 feet of dock with 20 feet of water. At this point will be constructed modern freight sheds and a factory building. The proposed bulkhead line at the city waterworks dock lies 330 feet south of the new windmill line, while the proposed pierhead line is 920 feet southerly from the windmill line, the distance increasing as the line is projected easterly.

Winnipeg, Man.—With a view to providing a network of better roads all over the province, Hon. T. H. Johnson, Provincial Minister of Public Works, will appoint an organizer to form new districts throughout Manitoba in connection with the split-log drag competitions. An instructor will be named, and additional grants given. According to A. McGillivray, highways commissioner, there are only 15 districts out of 110 that have taken advantage of these competitions to date. These 15 are adjacent to Winnipeg. A new set of rules will be drawn up and more encouragement given. Municipalities desiring to take up the work in an organized manner will have the expenses in connection thereof defrayed by the government. The government will make a grant of $2.50 per mile of road entered in a competition and dragged during the entire season, besides the usual grant of $250 to the Manitoba Good Roads Association.

Regina, Sask.—Good progress is being made on the new million-dollar plant of the Imperial Oil Company now under construction in this city. One large oil tank 115 feet in diameter and 35 feet high, is just about completed, and there remains only the roof to put in place. A second large tank over 90 feet in diameter is about half completed; two 25-foot tanks are well under way, and the foundations are being laid for two additional 93-foot tanks and three 75-foot ones. These tanks are being made of steel, the material for which is shipped to Regina from Sarnia, Ont. It is ready to set in place as soon as it arrives on the grounds. One warehouse has been erected 50 ft. by 50 ft, a machine shop 25 ft. by 35 ft., and a temporary boiler house, and other small buildings. Machinery for the new plant and materials are being received almost daily. It is expected that within a short time work will commence on the permanent buildings. When completed, the plant will constitute the chief distributing centre of the Imperial Oil Company for Western Canada, covering the three provinces, Manitoba, Saskatchewan and Alberta.

AMERICAN WATERWORKS ASSOCIATION.

The thirty-sixth annual convention of the American Waterworks Association will be held in New York City, June 5th to 9th, 1916. Headquarters will be at the Hotel Astor. Overflow accommodations have been arranged for at the Woodstock Hotel, 43rd Street, east of Broadway, a short block from the Astor. The Waterworks Manufacturers' Association promises an exhibit of waterworks appliances much ahead of any previous convention. Thursday will again be set aside as superintendents' day and devoted to short practical papers by waterworks superintendents; answering questions and discussing everyday waterworks problems.

Editorial

PREPARING FOR THE FUTURE.

Sir George Foster, addressing the Toronto board of trade recently, showed, as minister of trade and commerce, a keen appreciation of the national and international trade position as it is likely to appear after the war. He predicted that unless we now plan and act for the period to follow the war, we shall pay a heavy penalty for commercial unpreparedness. He gave a clear outline of the position and the first question which must have arisen in the minds of his audience, was "What is Canada doing in this connection?"

Sir George answered this question only to an extent which would seem to show that the department of trade is hampered by politics, by lack of sufficient appropriations for the work of the department, by insufficient assistance or by other factors. The department has the proper conception of the situation but has it enough machinery for its materialization? Here we are, after nearly two years of war, listening to the first proposal of its character that an advisory council of Canada's financial, industrial, commercial and transportation leaders should be appointed to co-operate with the department of trade at Ottawa. It is an excellent suggestion and one which has constantly been made in these columns. It comes, with official backing, a year behind time, but it is a good omen. Great Britain not only appointed such a committee long ago, but the committee has met and presented a report of considerable value.

Those who heard Sir George Foster's speech, know that he is working on right lines, but is the government as a whole and the country at large giving the proper support to what is at present one of the most important departments of state, its commerce department? We think they are not.

AN ENGINEERING COUNCIL.

Mr. C. H. Rust, who was for many years city engineer of Toronto, and who has been city engineer of Victoria, B.C., for the past few years, is probably one of Canada's best-known engineers, and is a man of wide experience. It must be a great comfort to Mr. Rust, however, to have so many valued engineering assistants in the city council of Victoria this year.

Despite Mr. Rust's strong objections, the council insisted recently in calling for tenders for untreated wood paving blocks. Mr. Rust advised them that they were taking a retrograde step, not conducive to the best interests of the city, explaining that the lifetime of the treated wood block is from 50 per cent. to 75 per cent. longer than that of untreated block, and that, moreover, the treatment tends to make the block waterproof.

Mr. Rust said that the first cost of the block is not the only matter to be considered, and told of the advantages of the treated block which are so generally recognized by all engineers. Three of the aldermen, however, had ideas of their own about block paving work. One of them wished to lay a tar base, then to place the untreated block against the rails in a diagonal position, and then to cover the whole over with tar. Another alderman favored the untreated block, because he said that it would keep the moisture from sinking to the tar cushion underneath, where it would linger and perhaps disintegrate the block. The third alderman said he favored treatment in "crude oil instead of in tar."

However, we are taking a daily newspaper report as our authority concerning these suggestions of the aldermen, and perhaps we may be doing them an injustice, as daily newspaper reports on technical matters are not always absolutely correct. But if this report was correct, City Engineer Rust must certainly greatly appreciate the council's assistance. Having in their employ a man of the ability of Mr. Rust, it seems to us that the Victoria council would do well to leave purely technical matters of this sort entirely in Mr. Rust's hands.

ESCHER-WYSS FIRM INVESTIGATED.

For more than a year there has been considerable doubt as to whether or not the firm of Escher-Wyss & Co., of Zurich, Switzerland, is a German concern.

Zurich is near the German border, the firm name sounds Teutonic, the company admittedly owned a branch factory in Wurttemberg, and their managing engineer in Canada was a German subject.

Superficially the combination looked suspicious. In fact it looked so suspicious to the British War Office that many months ago the firm was put on the enemy trader list. This action brought forth strong protest from the Swiss Consul-General at London, but nothing was done pending the result of a thorough investigation into the firm's affairs by representatives of the British Government.

The directors of the firm requested full examination. They claimed that they were strictly neutral; that about as many Englishmen and Frenchmen worked at their shops as did Germans; that their stock was held in Belgium, France, England and Switzerland, as well as in Germany; that stock-control was in Switzerland and not in Germany; that the shares held by Swiss banks were not held in trust for the Allgemeine firm, as had been alleged; that the German government had taken over their Wurttemberg factory, and that they no longer had control over it; that their firm had made no munitions of war; and that since the war they had sold more goods to the countries of the Allies than they had to Germany or Austria.

These claims were fully investigated, and as a result the Canadian customs commissioner has been officially informed by London that the name of the company has been entirely removed from the Black List and that the Imperial Government is satisfied that the firm is genuinely Swiss.

The Canadian Engineer is very pleased to hear that this firm, which has done much good hydraulic and steam turbine work throughout Canada, is not an enemy trader. It may appear to them that they have not been justly treated in this country during the past year, but they must surely recognize that no part of the British Empire can afford to run the slightest risk of English money finding its way to Germany.

PERSONAL.

R. H. LEE has been offered the position of city engineer at Kamloops, B.C.

A. T. ARNOLD has been appointed supervisor of public works at Chatham, Ont.

D. ANSCOLD, for eleven years road superintendent of North Vancouver, B.C., has resigned.

J. D. McMILLAN has been appointed acting superintendent of Districts 5 to 10, Belleville Division, Grand Trunk Railway.

T. C. DUNCAN, for three years superintendent of the light and telephone department at Prince Rupert, B.C., has resigned.

H. M. WILLIAMS has been appointed head of the publicity department of the Montreal Light, Heat and Power Company, with offices at 301 Power Building, Montreal.

J. W. ADAMS has been appointed city engineer of Chatham, Ont., to succeed his brother, F. P. Adams, who has been granted leave of absence, and has enlisted for overseas service.

ALONZO B. SEE, president of the A. B. See Electric Elevator Co., Montreal and New York, has been elected vice-president of the Machinery Club of New York City, to succeed the late John A. Hill, publisher of the American Machinist.

N. BRUCE McKELVIE, of the firm of Hayden & Stone, Boston and New York, has been appointed a director of the Nova Scotia Steel & Coal Co., Halifax, N.S. Mr. McKelvie is a native of Prince Edward Island. This appointment completes the board of directors.

JOHN D. McBEATH, C.E., of Moncton, N.B., has been given a commission with the Canadian Engineers for overseas service. Mr. McBeath is a graduate of the University of New Brunswick, and was for a time assistant engineer in Moncton and later assistant engineer in Medicine Hat, returning to Moncton last spring.

A. E. WRIGHT, of the Dominion Steel Foundries, Hamilton, Ont., has been promoted to the position of secretary-treasurer, and FRED W. SHERMAN will assume the duties of purchasing agent. MR. HAMMON, who was formerly secretary-treasurer, has severed his connection with the company, and has taken up his residence in California.

Ex-Alderman GEORGE McKNIGHT has been appointed city engineer of Fredericton, N.B., and will take over his new duties about April 15th. At present Mr. McKnight is engaged as an engineer with the St. John and Quebec Railway Company, having been engaged in the construction work on the St. John Valley Railway from the start of that project.

W. H. ROBINSON, of Granby, Que., has been elected president of the Canadian Consolidated Rubber Company, Limited, Montreal, to succeed Mr. J. H. McKechnie, deceased. Mr. Robinson is already identified with a number of large corporations, being vice-president of the Granby Consolidated Mining & Smelting Company, and a director of the Crow's Nest Pass Coal Company.

NORMAN K. HAY, city engineer of Sydney, N.S., has enlisted for overseas service in the 224th (forestry) battalion, and has been granted leave of absence while at the front. Mr. Hay was graduated from McGill University in 1907 and went to Sydney the same year. He took a position at the street works as street engineer under W. C. Risley and remained there until June, 1913, when he became city engineer. Private Hay is a native of Ottawa.

OBITUARY.

HENRY HARTUNG, a well-known sewer contractor, died recently at his home in Hamilton, Ont., at the age of 51.

GEORGE P. BRECKON, head of the firm of G. P. Breckon & Co., sheet metal workers, Toronto, Ont., died suddenly at his plant on March 30th.

WILLIAM E. MANN, M.Can.Soc.C.E., died as the result of having fallen down the elevator shaft in the Alberta Hotel, Edmonton, Alta., March 29. 1916. Mr. Mann was at one time division engineer for the Grand Trunk Pacific Railway, and was a member of the Edmonton branch of the Canadian Society of Civil Engineers.

H. N. DANCY, president and managing director of H. N. Dancy & Son, Limited, mason contractors, and for upwards of half a century a resident of Toronto, died in this city recently. Mr. Dancy was born in Ditchling, Sussex, England, in 1846. Among other large buildings erected under his supervision were the new Wycliffe College, General Hospital, Administration Building and Knox College.

LUNCHEON OF TORONTO BRANCH CANADIAN SOCIETY OF CIVIL ENGINEERS.

The Toronto branch of the Canadian Society of Civil Engineers proposes holding a luncheon at the St. Charles Hotel, Toronto, on Thursday, April 27th, at 1 p.m. It is hoped that sufficient attendance will be warranted to justify the securing of a good speaker for this occasion. We would, therefore, urge upon all members of the branch who can possibly do so to make it their business to attend this luncheon as undoubtedly it will be a pleasant and profitable occasion.

The secretary of the branch, L. M. Arkley, asks that members ascertain as fully as possible the names and standing of as many prospective members as possible in the vicinity of Toronto. Co-operation on the part of each member in this matter would be heartily appreciated by the executive.

ONTARIO HEALTH OFFICERS' ASSOCIATION.

T. Chalkley Hatton, chief engineer of the Sewerage Commission, Milwaukee, Wis., is to deliver a paper on "The Treatment of Sewage by Activated Sludge," at the meeting of the Ontario Health Officers' Association, to be held in Convocation Hall, University of Toronto, May 30th and 31st, 1916.

COMING MEETINGS.

AMERICAN WATERWORKS ASSOCIATION.—Thirty-sixth annual convention to be held in New York City, June 4th to 8th. Secretary, J. M. Diven, 47 State Street, Troy, N.Y.

REMOVAL NOTICE.

The British American Oil Co., Limited, has moved its head office at Toronto from the Lumsden Building to the Royal Bank Building, corner King and Yonge Streets.