PAGES

MISSING

Volume 30. Toronto, February 10, 1916. Contents of this issue on page 5.

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

MAIN STREET SUBWAY, MONCTON, N.B.

NOTABLE IMPROVEMENT RECENTLY COMPLETED BY CANADIAN GOVERNMENT RAILWAYS ON THE INTERCOLONIAL RAILWAY IN THE CITY OF MONCTON—NOTES ON ITS DESIGN AND CONSTRUCTION.

THE Canadian Government Railways have recently completed the construction of a subway to carry the tracks of the Intercolonial Railway over Main Street in Moncton, N.B. This crossing was previously of a dangerous character owing to the busy traffic on both railway and street. The intersection had become a particularly annoying one in recent years, so, in the summer of 1914 the Government Railways decided to eliminate the level crossing by constructing, with the consent of the ratepayers, a steel and concrete subway. The improvement is an important one for the city of Moncton, affecting not only Main Street, but Archibald and Foundry Streets, as the accompanying layout diagram illustrates.

Preliminary operations were commenced in December, 1914. They comprised a considerable amount of excavation and a diversion of the water, sewerage and gas mains. This work was carried on during winter months and dynamite was sometimes resorted to by the contractors in excavating through some three feet of frost. Excavation was completed early in March, 1915. Directly in the centre the ground was excavated to a depth of 13 feet, while the tracks were raised some 5 feet and graded accordingly on both ends. The excavated material, amounting to about 15,000 cubic yards, was removed with a 28-ton Marion revolving shovel and transported from the site in 6-yard dump cars drawn by a Dinkey engine.

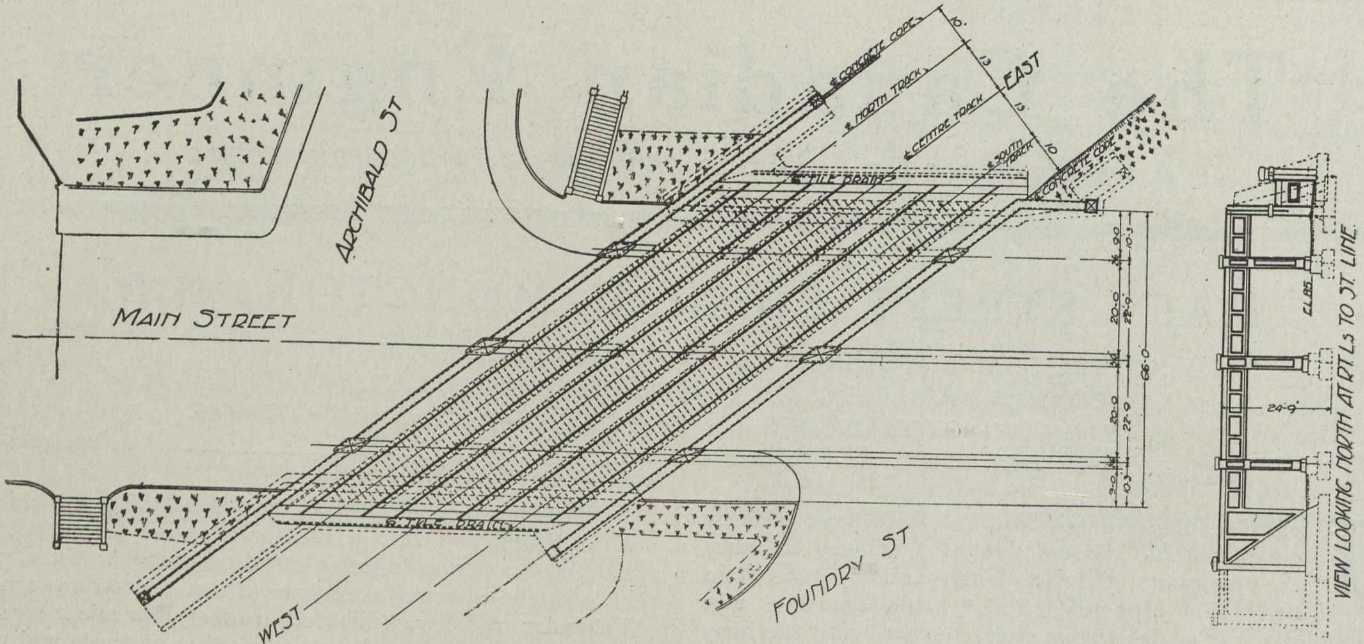
A temporary trestle was erected on the north side of Main Street and was in use for a period of about six months or during regular construction operations, and little inconvenience was caused to pedestrian traffic. Vehicular traffic was diverted to other convenient streets.

The structure is of steel encased in concrete and with reinforced concrete abutments. As illustrated by the views from points on Main and Archibald Streets, it presents a well-balanced appearance, the design being artistic, yet practical, and the finished work giving a pleasing effect. The subway is 80 feet in width and is spanned by a bridge 115 feet in length. The latter has a reinforced concrete waterproof floor and carries three tracks and two walkways for railway employees. Both upper and lower floors are provided with adequate drainage facilities. The general features of the structure are indicated in the drawings shown herewith.

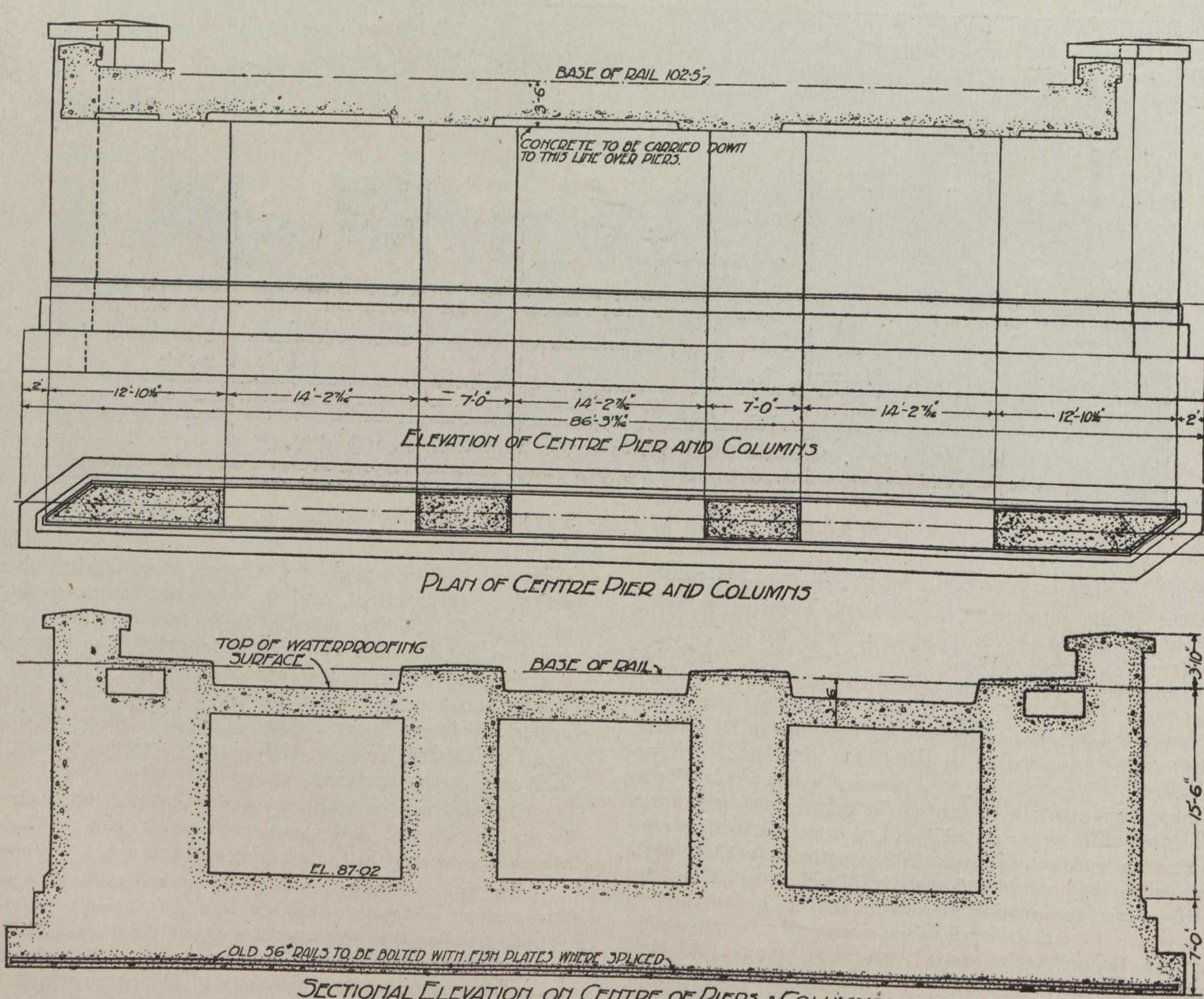
View from Archibald Street of Main Street Subway, Moncton, N.B.

The subway is lighted on the exterior with cluster lights, as shown, and underneath with ceiling lights, which are located in the openings of the piers.

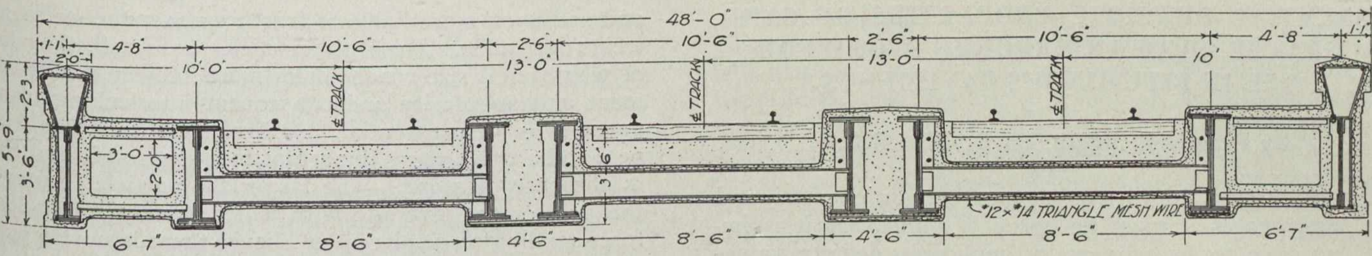
The improvement included laying wood block paving for a short distance on either side of the subway. The foundation for this work was prepared first by a six-inch layer of cinders rolled with a 16-ton roller. Over this was spread concrete to the thickness of 6 inches, which was covered by a finished paving composed of 3-inch creosoted



General Layout of Main Street Subway, Moncton, N.B.



Column Details of Subway.



Cross-section Through Span, Showing Arrangement of Concrete on Girders.

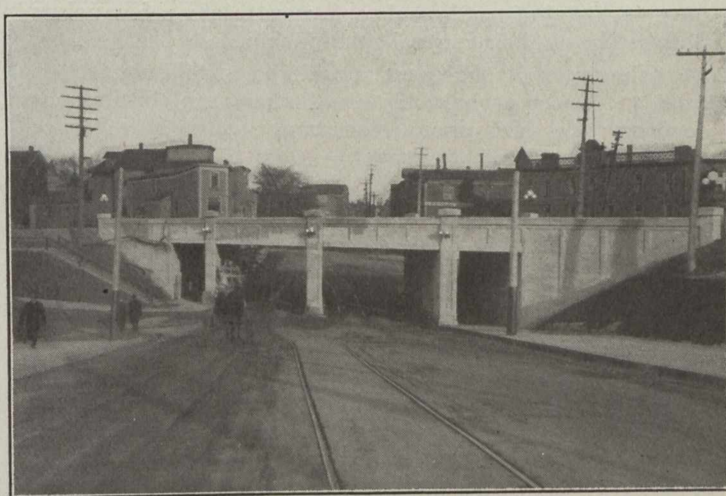
wood blocks, set on sand and the space between the blocks filled with hot pitch.

Apart from paving, the portions of the streets affected by the crossing elimination have been suitably banked and sodded, the grass-finished terraces sloping towards the subway adding considerably to its artistic appearance.

Concrete work began on May 27th, 1915, and was completed November 20th. Some 27 cars of cement, 175 cars of gravel, 25 cars and 10 scow loads of sand were used. Three mixers were employed. The exposed surfaces of the concrete are to be tool finished, this operation having been partly completed when the accompanying photographs were taken.

As shown in the illustrations, street railway tracks are laid on both roadways, through the subway. The track west of it has a 7 per cent. grade, and a 5 per cent. grade eastwards. The Archibald Street approach has also a 7 per cent. grade.

Mr. F. P. Gutelius is general manager of the Canadian Government Railways, and Mr. C. B. Brown chief engineer. Mr. W. A. Duff, engineer of bridges, designed the subway. Messrs. Soper and McDougall, of Ottawa, were the general contractors, Mr. A. L. McDougall being superintendent of the work. Messrs. Rhodes, Curry Co., Limited, Amherst, N.S., were contractors for the steel work. Mr. G. C. Torrens was engineer-in-charge and Mr. F. Stratton chief inspector for the railway.



Subway at Moncton, N.B., Looking Easterly Along Main Street.

THE PRESENT STAGE OF THE PACIFIC GREAT EASTERN RAILWAY CONSTRUCTION.

The Pacific Great Eastern Railway is now operating as far as Clinton, a distance of 180 miles from Squamish, the tidewater port of Howe Sound. All the remainder of the line to Prince George has been graded with the exception of 30 miles at Horse Lake, in Northern Cariboo. What still remains to be done to make a completed railway is to build bridges and lay steel from Clinton to the junction with the Grand Trunk Pacific at Prince George. Approximately $22,500,000 has already been expended on the line, according to Hon. Lorne Campbell, Minister of Mines, B.C., who is chairman of a government committee reporting on uncompleted railway projects, and the company, owing to its inability to market its bonds, is now out of construction funds. It has been estimated that it will take $6,500,000 to finish the work and secure the completion of a real link of communication with the rich interior of the province.

Mr. Campbell states that the Pacific Great Eastern, in the first instance, was assisted by the government, by way of a guarantee of bonds to the extent of $35,000 per mile. Early sales of bonds were very successfully made, and the company had every expectation of being able to finance the undertaking without difficulty. But the war intervened and calculations were upset. Issues of all kinds were barred from London, and the only place where money can be obtained is New York, and there is now a very poor market.

The authorized extension of the Pacific Great Eastern into the Peace River country is on a slightly different basis from the portion on the line from Prince George to Squamish. The line was surveyed to the eastern boundary of British Columbia, but no market could be found for the securities, even though guaranteed by the government. That part of the line is, therefore, untouched, and the situation precisely the same as if the contract had never been entered into. Construction work by the company is altogether contingent on the marketing of the bonds at reasonable figures.

"If the government," said Mr. Campbell, "should at present desire to proceed with the Peace River connection it would have to supplement its original guarantee by an interim loan, or otherwise assist the company with funds that would, for the time being, take the place of the proceeds expected from the sale of the bonds. Thus, so long as conditions continue as they are, the rapidly growing traffic of the Peace River country will be diverted to Edmonton and the east, instead of following the route to tidewater on the British Columbia coast."

The Minister of Mines, speaking of the immigration flood which he believed would follow the war, stated that he could conceive of nothing better calculated to meet the situation than the opening of the rich interior of the country through the speedy completion of the Pacific Great Eastern Railway.

ESSENTIAL PHYSICAL PROPERTIES OF SAND, GRAVEL, SLAG AND BROKEN STONE FOR USE IN BITUMINOUS PAVEMENTS.*

By Francis P. Smith, Ph.B., M.A.S.C.E.

In discussing the various physical properties of mineral aggregates it must be borne in mind that it is impossible to fix universally applicable definite values for them, as these will vary with the type of pavement and the kind and density of the traffic to which it is subjected. In order to understand fully the extent to which these considerations affect the selection of the mineral aggregate to be employed and modify any standards set for their essential physical properties, it is necessary to have clearly in mind the different types of bituminous pavement and of traffic and to discuss briefly a few points illustrative of their mutual relationship.

The types of pavement considered in this connection are: (1) Sheet asphalt, binder, surface; (2) bituminous concrete; (3) bituminous macadam; (4) asphalt block; (5) oiled macadam; (6) gravel.

Broken stone or gravel is used in all of these types, but in the case of sheet asphalt their use is restricted to the binder course in which they are not directly subjected to wear. In all the other types the broken stone or gravel forms part of the wearing surface. Obviously in the binder course neither of them would be required to possess the same degree of wear-resisting quality as when used in the surface.

The kind of traffic may be classified as: Iron-tired, chiefly horse-drawn; rubber-tired, chiefly self-propelled; mixed, both horse-drawn and self-propelled; and without entering into a detailed segregation, the traffic itself may be classified as: Light, medium, heavy.

Stone and gravel which would crush under heavily loaded iron-tired traffic would carry the same weight without fracture if rubber tires were used. The same distinction would apply in the case of heavy traffic as compared with light traffic.

A certain amount of crushing, thus increasing the proportion of fine material in the mineral aggregate, is desirable in certain types of pavement, such as tarred slag, when sufficient quantities of a soft bituminous binder are used with it which will readily cost the freshly fractured surfaces at ordinary atmospheric temperatures.

Where the bitumen is present in insufficient quantity or where it requires temperatures higher than atmospheric ones to make it adhere satisfactorily to the particles, the reverse is true.

Having before us this very wide range of conditions which must be met, we next come to a consideration of the physical properties themselves which are ordinarily regarded as essential. These are: Shape, character of surface, wear-resisting quality, size, cleanliness.

Shape.—Owing to the fact that all bituminous cements soften materially under heat and therefore lack stability in hot weather, it is desirable and necessary to obtain as great a degree of stability as possible in the particles whether they be coarse or fine. Gravel, with its rounded particles, has much less stability than broken stone. For this reason it is often passed through the crusher before using it. Stone which is crushed so that the particles are chiefly cubical in shape is to be preferred to stone that is crushed so that slivers predominate. These slivers do not compress as easily as do cubical particles to form a compact mass with a minimum of voids and are much more liable to fracture under the stress and weight of traffic. When the particles are small, their lack of weight and size render them more subject to displacement and angularity and consequent interlocking of the particles is very essential. At first sight this would appear to be much more important in the case of sand than in the case of stone. The larger the particle, however, the greater the leverage with which it may act under a force tending to displacement, hence there is not so great a difference between the relative importance of angularity in sand and stone. In fact, in certain cases it is more important with stone than with sand. In the binder course in sheet asphalt pavements, which is intended to increase the stability of the sand wearing surface and key it to the concrete and retard its movement upon the surface of the concrete, sharpness of stone is essential. For this reason gravel makes a very inferior binder and should not be used where it is possible to obtain stone. When used, it should be cracked by passing it through a crusher. Not only do rounded particles move on each other with greater ease than angular particles, but in masses they have fewer points of contact.

Character of Stone.—As our consideration of the materials under discussion is limited to their employment in bituminous pavements, it is necessary for us to consider the surfaces of them chiefly in connection with their ability to receive and retain a coating of sufficient thickness of the bituminous cementing material. Certain types of surfaces are much more desirable from this standpoint than are others. Broadly speaking, a rough, pitted and somewhat absorbent surface is the best. Smooth, glossy surfaces do not readily retain a thick coating of bitumen and require a relatively high heat to insure properly coating them. At a high heat the bitumen becomes very liquid and readily runs off of them, which results in a coating of undesirable thinness. Even when the temperature at which they are coated is no higher than that employed with rough surfaces, their smoothness permits the bitumen to drain off more readily. This is particularly the case with flint particles and sands containing them, when coated with bitumen and examined under a glass, invariably show the minimum thickness of coating on the flint particles sharply contrasting with the surrounding rougher surfaced quartz particles which have retained a coating of normal thickness. As compared with a non-absorbent surface, an absorbent one *per se* is to be desired. Unfortunately, most particles which have absorbent surfaces are lacking in resistance to wear and therefore, notwithstanding their superiority from the standpoint of coating them with bitumen, are not suitable for heavy traffic, more especially of the iron-tired variety. Where the bituminous cement used is lacking in cementing value an absorbent surface is especially necessary.

The speaker knows of a number of roads in which distinctly inferior bituminous cement was used which gave excellent satisfaction under medium and light traffic due to the fact that the mineral aggregate was a porous limestone. The same bituminous cement with hard non-absorbent rock failed utterly when used in similar types of construction on roads carrying an equivalent traffic.

The outer surface of the particles must be firmly adherent to and form a permanent part of the particles themselves and must show no tendency to scale off when heated. Certain sands, upon heating, appear to form loosely adherent scales upon the surface of their particles which are not removed by attrition in the mixer but which, under the stress of traffic and atmospheric changes in temperature, become loose and detach themselves, carrying the coating of bitumen with them. Pavements laid with this type of sand have been known to disintegrate

*A paper read recently before the Graduate Section of the Highway Engineering Course at Columbia University.

from this cause alone within a few weeks from the time they were laid. Gravel, freshly broken slag and stone are ordinarily free from this defect. Slag which is glassy does not coat as well with bitumen as do the more basic slags.

Wear-resisting Quality.—This, while a very important property, is perhaps more of a variable one than any of the other qualities mentioned. The degree required depends upon the kind and density of the traffic, the size of the particles, the type of pavement and the hardness of the wearing surface considered as a whole. We have already noted that an iron-tired traffic exerts a greater crushing action than a traffic that is carried on rubber tires and it goes without saying that a dense traffic is more severe in this respect than a light traffic. Up to a certain point, the larger the particle, the greater the liability to fracture and where the traffic is very heavy, aggregates consisting of relatively large particles will not give satisfactory service even though composed of the hardest known rocks, unless the particles are sufficiently massive to resist fracture, as, for instance, ordinary paving setts, which are, of course, outside the limit of bituminous pavements. In other words, broken stone or gravel of from ½ to 1½ inches in size requires more careful scrutiny as to its resistance to fracture than do sand or paving blocks. Resistance to fracture is, of course, only one of the elements going to make up wear-resisting quality. Hardness is also a requisite, although a very hard and at the same time brittle material would not be suitable for use in bituminous pavements. A pavement which is soft and yielding as a mass does not require as hard and tough a mineral aggregate as does a more unyielding pavement. The shock or impact, as well as the grinding action of traffic, is minimized by the plasticity of the pavement in the same way that it is difficult to break a rock of relatively small size when supported on a yielding bed. When the particles are heavily coated with a relatively fluid bitumen, fractures of the particles are to a certain extent self-healing. In this type of pavement, therefore, somewhat softer rock may be safely used than in those types in which the bitumen is harder and the coating on the particles thinner.

Size.—This property has to do not only with the actual size of any one particle or set of particles, but also embraces the question of the relative size of the different particles composing the aggregate as a whole, which constitutes what is frequently referred to as the grading of the mass. As previously mentioned, large sized aggregates will not carry excessively heavy traffic and this not only refers to the difference between broken stone and sand, but to different varieties of sand as well. For ordinarily dense and heavy traffic, sheet asphalt pavements carry from 2 to 10% of sand particles which will just pass a 10-mesh sieve and are approximately 0.027 of an inch in diameter. Where the traffic is exceptionally heavy, particles of this size are liable to fracture and the maximum size must be still further reduced. In certain heavily travelled streets in Glasgow, Scotland, the speaker was forced to limit the maximum size of the sand particles to those which would pass a 30-mesh sieve. Such particles would have a diameter of approximately 0.01375 of an inch. The ability of a very fine and comparatively soft aggregate to sustain the heaviest known traffic is perhaps best exemplified by the French rock asphalt pavements. These pavements are largely composed of particles which will pass a 200-mesh sieve and have an approximate diameter of 0.00235 of an inch. The particles themselves are composed of a soft limestone thus showing the possibility of using relatively soft materials when they are in a fine state of division. The bitumen with which they are coated is relatively quite soft, which again accentuates a point previously referred to; *viz.*, the possibility of using soft materials with a fluid bitumen. The relative size of the different particles or the grading of the mineral aggregate is perhaps one of the most important considerations in the construction of a bituminous pavement. On it much of the success of the pavement depends. The maximum size of the particles and the allowable proportion of maximum sized particles is, as we have seen, dependent upon the traffic. If all the particles were of practically the same size, they would touch at only a few points of contact and the pavement would have a large percentage of relatively large voids. The weakness of the bond due to the few points of contact would make it pick up or ravel under traffic and the relatively large sized voids would permit the bitumen to drain off the hot aggregate during transit to the street or road, leaving a very thin coating on the particles and thus still further weakening the bond. Any considerable excess of bitumen in the mixture would result in the formation of "fat spots" in the pavement where the excess of bitumen had collected. If the temperature at which the mixing took place was lowered, there would be danger of not properly coating the particles and in cold weather a mixture of this type would be very difficult to rake and would break up under the roller, and it would be impossible to compress it into a compact mass. It is, therefore, essential to fill up these large sized voids with smaller particles. If all of these smaller particles were exceedingly minute, they would present a very large surface area to be covered by bitumen, and would, therefore, increase the cost of the pavement. The mass formed by them would be very plastic owing to the relatively high percentage of bitumen necessitated by the conditions of mixing, and would not key the larger particles together as firmly as if the filling mass were partly composed of the largest sized particles which would go into the voids between the large aggregate. The French rock asphalt, while composed almost entirely of very small particles, has a very high degree of stability and contains a relatively low percentage of bitumen by which it has been impregnated by natural processes in which time was not a factor. The average time of mixing a batch of bituminous pavement does not exceed one minute and the consistency of the bitumen is usually much harder than that found in the French rock. It is therefore impossible, under working conditions, to satisfactorily coat a fine aggregate with as small a percentage of bitumen as is found in the French rock and the stability of the mixture is lessened by this relative excess of bitumen. It is, therefore, essential to first fill the voids between the maximum sized particles with the largest sized pieces that will go in them. The remaining voids should then be similarly filled and so on down to those voids which can only be filled by particles passing a 200-mesh sieve. The proportion of these particles will not ordinarily exceed 15% in a sheet asphalt pavement, the governing factor being the production of a dense surface which will not be water-absorbent and having as large a proportion of mineral aggregate as possible. Closeness of grain could, of course, be obtained by an excess of bitumen, but this would increase expense and reduce stability. Where the maximum size of the particles approaches one inch the percentage of 200-mesh material in the pavement is, of course, much lower than in sheet asphalt pavements and varies from 3 to 5% on the average. Particles of 200-mesh sand are not desirable in a pavement owing to the fact that they detract from its stability and if present to any considerable extent, tend to make the mixture mushy. All, or the greater portion of, the 200-mesh material should be finely ground limestone or Portland cement, as this materially adds to the the stability of the pavement.

In order to comprehend how the increase in fine material adds to the surface area to be covered with bitumen, let us consider a one-inch cube of stone. It has six sides, each 1 sq. in. in area, or a total of 6 sq. ins. Let us now saw it through the middle. It has now the original six sides and two more, each of 1 sq. in. in area, or 8 sq. ins. in all. Keeping the pieces together and cutting it again in a plane at right angles to the first cut we add two more square inches in surface area, making 10 sq. ins. in all, although the volume of the mass has not been increased.

In certain of the tarred slag pavements in which a very soft tar is used, the pavement as laid is very deficient in fine particles. The top layers of slag are expected and do crush to a very considerable extent under traffic and the fine particles thus produced are coated by the soft tar at atmospheric temperatures and are incorporated into the pavement; thus, in a short time forming a dense compact mass which, under light and medium traffic, gives excellent satisfaction. A large quantity of this pavement is laid on country or suburban roads in England and costs about half a crown (62½ cts.) per square yard. With any other type of bitumen which was not very fluid and which would not coat particles satisfactorily at atmospheric temperatures, such a pavement would be a very dangerous type to lay. The sharp particles of slag key very firmly together and once the sufficient amount of fine material is produced by traffic crushing, the pavement is a remarkably stable one and sufficiently close grained to keep the water out. As illustrating the grading in various kinds of pavement, the following typical examples are given:—

	Sheet Asphalt. Heavy Traffic. %	Sheet Asphalt. Light Traffic. %	Topeka. %	Bituminous Concrete. Hot Mixture. %	Bituminous Concrete. Cold Mixture. %
Bitumen	11.0	10.5	8.5	7.0	6.5
Passing 200 mesh..	14.0	10.5	8.5	5.0	4.5
" 100 " ..	14.0	10.0	6.0	4.0	1.5
" 80 " ..	13.0	10.0	6.0	2.0	1.5
" 50 " ..	19.0	14.0	6.0	5.0	1.5
" 40 " ..	11.0	14.0	10.0	4.0	1.5
" 30 " ..	10.0	13.0	10.0	4.0	1.5
" 20 " ..	5.0	10.0	9.0	3.0	3.0
" 10 " ..	3.0	8.0	6.0	5.0	5.5
" 8 " ..	...	...	6.0	3.0	5.0
" 4 " ..	...	...	14.0	7.0	8.0
" 2 " ..	...	...	10.0	20.0	40.0
" ¾" " ..	...	...	....	14.0	11.0
" 1" " ..	...	...	....	12.0	9.0
" 1½" " ..	...	...	....	5.0	...
	100.0	100.0	100.0	100.0	100.0

In addition to the increase in stability due to the proper grading or sizing of the different articles and the consequent increase in density, a reduction in the size of voids is obtained. The latter feature is essential in that it keeps the water out of the pavement. Any bituminous pavement which is sufficiently porous to permit the water to enter it and be retained therein will soon disintegrate due to the loosening of the bond between the bitumen and the particles by the action of the water. Another consideration involved in the selection of the size of the mineral aggregate is the kind of surface desired on the finished pavement. The larger the aggregate the rougher and less slippery the surface. We have already seen, however, that with a very heavy traffic, large sized aggregates are not permissible. A smooth, fine-grained pavement composed of small particles, if properly designed, is suitable for all kinds of traffic but is undoubtedly more slippery than the coarser type.

Cleanliness.—Many sands and gravels have finely divided clayey material adhering to their larger particles. Such sands and gravels are unsuitable for use in bituminous pavements unless first washed. When passed through the heating drum or dryer, this clayey deposit becomes burned on to the surface of the grains by the heat to which it is subjected to such an extent that it is not removed by attrition in the mixer. It thus prevents the bitumen from coming into contact with the actual and permanent surface of the larger grains and subsequently breaks loose from them, carrying the bitumen with it. This results in the disintegration of the pavement as the uncoated particles soon wear or wash away, leaving depressions in which water will accumulate. Clayey material, unless finely pulverized after drying, is always objectionable. Even if it does not adhere to the grains, it bakes into balls in the dryer, only the outside of which can be coated with bitumen and these balls readily break up under traffic, leaving similar depressions to those above described. A pat of surface mixture made of clayey sand will, when broken open, invariably show these clay balls with uncoated powdery centres. In a recent type of bituminous pavement the manufacturing process involves the pulverization of the mineral aggregate after it has been dried and heated. Under such conditions clay makes a most excellent paving material, as it readily absorbs the asphalt and clings tenaciously to it, the bond between them being much stronger than in the case of sand, gravel or crushed rock. Under certain special conditions, therefore, that which is ordinarily to be avoided becomes highly desirable. Crushed stone or gravel from which the dust has not been removed and which has been allowed to stand exposed to the weather will almost invariably have the larger particles partly covered with strongly adherent stone dust which has formed a sort of cement by the action of water, and material of this kind should be rejected. For this reason, most specifications call for freshly crushed stone. This is especially important in the case of stone for use in asphalt blocks. The bituminous cement largely used in the manufacture of these blocks has a high melting point and is therefore not very fluid at the temperatures employed during mixing. Under such conditions, the use of a clean stone is absolutely essential. A very fluid bitumen might perhaps be sufficiently absorbed by these fine particles to permit of its reaching the actual surface of the stone through capillary action during the mixing process and might even be relied on to subsequently coat the larger particles at atmospheric temperatures after their imperfectly adhering mineral coating had become detached in the pavement by the stress of traffic. With a bitumen of high melting point and low ductility this would, however, never take place.

At first sight it might appear that the addition of 5 to 20% of finely ground Portland cement or lime dust to the mixture would produce the very conditions of finely divided particles adhering to the larger ones that have just been classified as extremely undesirable. It must be remembered, however, that this filler is added to the mixture *after* it has passed through the heating drums and is in itself dry and there is, therefore, no chance of its becoming baked on or firmly attached to the larger particles.

In the practice of his profession, the engineer is frequently confronted with the problem of selecting not that which is economically the best in the long run, but what is the best that can be done with the appropriation that has been put at his disposal, and the speaker hopes that the foregoing discussion will in some degree aid him in this most difficult task. If the sand is unsuitable or very expensive to obtain and the traffic is not very heavy, and a satisfactory supply of rock at a reasonable price is at hand, rock is obviously the material to use. If the rock is unsuitable or dear and the sand good and cheap, a sand asphalt mixture will carry practically every kind of traffic. With a cheap local supply of bitumen of fair but somewhat inferior quality, an absorbent limestone will often make a very satisfactory pavement for carrying light traffic. Sands which are lacking in fine or coarse particles can frequently be brought up to the proper standard of grading by the addition of fine or coarse unweathered crusher screenings.

Summary.—Sand should be clean grained, hard and moderately sharp. The grains should be chiefly quartz and should have rough pitted surfaces. If necessary, as will usually be the case, the proper mesh composition or grading must be obtained by the mixing of several sands or possibly by the addition of unweathered crusher screenings. In the ordinary type of sheet asphalt pavement the presence of clay is undesirable, either as a coating to the grains or disseminated throughout the mass. For medium and heavy traffic pavements all particles retained on a 10-mesh screen should be discarded. For light traffic three to five per cent. of 8-mesh particles can be incorporated in the pavement with advantage. Sands containing a large percentage of flinty grains should be avoided.

Gravel should be clean grained, hard and free from adhering clayey particles. It is lacking in stability owing to the roundness of its particles and is usually considerably improved by passing it through a crusher. Gravel with a rough pitted surface is to be preferred and gravel containing a large percentage of flinty particles is to be avoided. Unsuitable for the construction of pavements carrying heavy traffic and inferior in all respects to crushed stone.

Slag. Hard, dense basic slag is to be preferred. Should be stable when exposed to weather and not show any tendency to slack or disintegrate. Only suitable for light traffic and should preferably be coated with a very fluid bitumen.

Broken Stone. Should be freshly crushed, preferably in cubical shaped particles. Size and hardness required depends upon the traffic which the pavement is to carry. Dense, hard limestone will carry medium and light traffic satisfactorily. When the traffic, though light in volume, is composed of heavy iron-tired units, a dense, hard trap is required. Trap is now comonly used for asphalt block manufacture, although in the past a large number of asphalt blocks made from limestone gave excellent service under light traffic. Granite is not usually satisfactory, as it is too coarse and uneven in texture and much of it is friable and it is liable to shatter in crushing. Mesh composition just as important as with sand. Not suitable for use in pavements carrying very heavy traffic.

RAILROAD EARNINGS.

The following is a record of the transcontinental railroads' gross earnings for the first three weeks of January:—

Canadian Pacific Railway.

	1916.	1915.	
January 7	$1,874,000	$1,316,000	+ $558,000
January 14	1,863,000	1,321,000	+ 542,000
January 21	1,910,000	1,391,000	+ 519,000

Grand Trunk Railway.

January 7	$ 880,702	$ 753,522	+ $137,180
January 14	966,301	779,745	+ 186,556
January 21	980,914	795,830	+ 185,084

Canadian Northern Railway.

January 7	$ 541,100	$ 315,700	+ $225,400
January 14	469,300	349,300	+ 120,000
January 21	504,000	322,600	+ 181,400

THE ACTIVATED SLUDGE PROCESS OF SEWAGE TREATMENT.

In *The Canadian Engineer* for December 2nd, 1915, there appears an abstract of an International Engineering Congress paper on "Disposal of Suspended Matter in Sewage," contributed by Mr. Rudolf Hering, D.Sc., of New York. We are now able to present a very able discussion of this paper, submitted by Dr. Gilbert J. Fowler, of Manchester, who replies to some of Mr. Hering's comments in an interesting way that will be appreciated by many of our readers who have been closely following our articles and references to the activated sludge process of sewage treatment.

Dr. Fowler states that experience at the Withington sewage works of the Manchester corporation bears out much of what Dr. Hering has stated in regard to the operation of the Imhoff tank. The necessity for periodically stirring the scum is a somewhat serious matter; if mechanical agitation is to be used it will introduce complication and cost. The statement that exposure to the air tends to increase putrefaction, appears *a priori* open to question, and he would like rigid scientific evidence on the point. His experience with the Imhoff tank has confirmed him in his belief that the final solution of the sewage problem is not to be found in processes involving anaerobic action but on the lines of aeration, putrefaction being avoided at every point.

The history of the development of what has come to be known as the "activated sludge process" is carefully given in the first paper by Messrs. Ardern and Lockett (Jour. Soc. Chem. Ind., No. 10, Vol. xxxiii., May 30th, 1914.)

The articles which have recently appeared in American technical journals, describing experimental work at various centres, are clear evidence that the work of the English investigators marks an advance on anything previously accomplished.

It is a matter for satisfaction that the interchange of scientific work on both sides of the Atlantic should eventuate in progress for the general good.

The question of priority where so many workers are involved is of small importance in itself. When, however, statements are made by Dr. Hering and others which obscure the scientific understanding of the process, it is important that they should be corrected.

It is quite true that he (Dr. Fowler) was much impressed by Mr. Clark's work at Lawrence, and to the Massachusetts workers is due the idea of building up by prolonged aeration of successive quantities of sewage a growth which would rapidly purify sewage in the presence of air. But the question of expensive surfaces, difficult to construct and handle, still remained and because of this the possibilities of the process were not favorably considered by the Metropolitan Sewerage Commission with whose president the matter was carefully discussed. The writer, therefore, returned from New York considering the problem of how to bring about purification in open tanks with, at any rate, the least possible addition of costly chemical precipitants. The idea of adherent growths was therefore abandoned in favor of some process of bacterial or enzymic activity, a line of thought which had previously been present in the mind through a suggestion by Dr. Maclean Wilson (Jour. Soc. Chem. Ind., No. 23, Vol. xxx., p. 1348, 1911.) From this line of thought was developed what has come to be known as the "M7" process, which was described in a paper by the writer and E. M. Mumford at the Congress of the Royal Sanitary Institute at Exeter in July, 1913.

By this method a bacterium was made use of, discovered in colliery waters, termed "M7," which had the property of precipitating hydrated oxide of iron from solutions containing salts of iron, together with organic matter.

Sewage from which the grosser solids had been removed by sedimentation was treated with a small quantity of iron salt and inoculated with the organism referred to, and aerated for several hours. Perfect clarification took place, and a deposit containing a very high percentage of nitrogen (as much as 10 per cent.) was formed.

The effluent from this process could be nitrified at very high rates on percolating filters.

Inasmuch as preliminary settlement of the sewage was called for by this process, with production of ordinary sludge, and as the effluent still required final treatment on filters for complete oxidation, the method, although having many advantages, did not completely realize the object of the researches.

In the development of the field experiments in connection with this process, valuable practical experience on the economical application of air was, however, gained. Contemporaneously with this work, experiments were being carried on at Davyhulme, at the writer's suggestion, on the continuous aeration of successive quantities of sewage, as in the Massachusetts work, and these experiments ultimated in the activated sludge process described in the various papers of Messrs. Ardern and Lockett.

It is now possible to correlate the various results which have been obtained and to get some steps nearer to a proper understanding of the nature of the process. The writer's present idea is that it can be referred entirely to bacterial activity. It was distinctly stated, in the first paper by Messrs. Ardern and Lockett that their sludge did not contain any algal growths; the process thus differs essentially from that which was in operation at Lawrence at the time of the author's visit and which was subsequently described in the annual report of the Massachusetts State Board of Health for 1913, p. 289 and seq.

It would appear, therefore, that the activated sludge process consists broadly of three operations: a clotting or clarifying action, a rapid carbon oxidation process, and finally, nitrification. It is probable that the first process is, to some extent, the result of the activity similar in character to "M7" organisms which was definitely shown to depend on enzymic action whereby traces of iron appeared to start the flocculation of the whole sewage. The "M7" bacillus is probably fairly ubiquitous, as it has been found that sewage containing iron and a certain amount of partially activated sludge but in which clarification has not been effected, can be made to clarify almost at once by the addition of a small quantity of properly activated sludge. Simultaneously with clarification, the organic matters in solution follow the usual course of oxidation, which takes place rapidly owing to the enormously extended area of bacterial activity. In the writer's opinion, the outstanding advantage of the process lies in the fact that the sewage is really clarified and the process of clarification results in the precipitation of the emulsified nitrogenous matter in the sewage. This has hitherto not been arrested in any process of tank treatment, with the possible exception of certain precipitation processes which involve the addition of large quantities of costly and inert chemicals. Experiment has shown that bacterially precipitated sludge is quite extraordinarily active as a manure and there seems every reason to believe that an important step has been taken in the ultimate aim of economic sewage disposal, *viz.*, the return of nitrogen to the land.

A great deal of research remains to be done on the conditions of activity of the sludge, both as an agent in sewage purification and as a manure, but advance is only possible by patient and exact biochemical investigation, and it is of the utmost importance that unfounded assumptions and short-cuts of all kinds, which have been responsible for so much waste of public money on sewage treatment plants in the past, should be avoided.

It cannot be too strongly emphasized that the proper treatment of sewage is a matter, in the first place, for the scientific specialist; when he has worked out the governing facts of the situation, it remains for the engineer economically to construct the plant which fulfils these conditions.

In the present case, the engineering problem is a comparatively simple one; it is merely to keep the activated sludge uniformly mixed with the sewage in presence of the necessary air. A large amount of work has been done in this country and also by Mr. Chalkley Hatton at Milwaukee and Dr. Bartow at the University of Illinois in collaboration with the writer, and the experimental plants of various dimensions capable of dealing with quantities varying from 60,000 gallons to as much as 2,000,000 gallons per day are in course of operation or construction.

In all comparisons of cost between one process and another it is essential that result should be compared with result. Unfortunately, this rule is not always adhered to and a given process, *e.g.*, is said to be cheaper when on examination it gives much less satisfactory results. Where strict comparison is made the advantages of the activated sludge process are, in the majority of cases, beyond question, and the writer considers that any further large expenditure on works of the conventional type is—in view of the results already obtained—seriously to be deprecated.

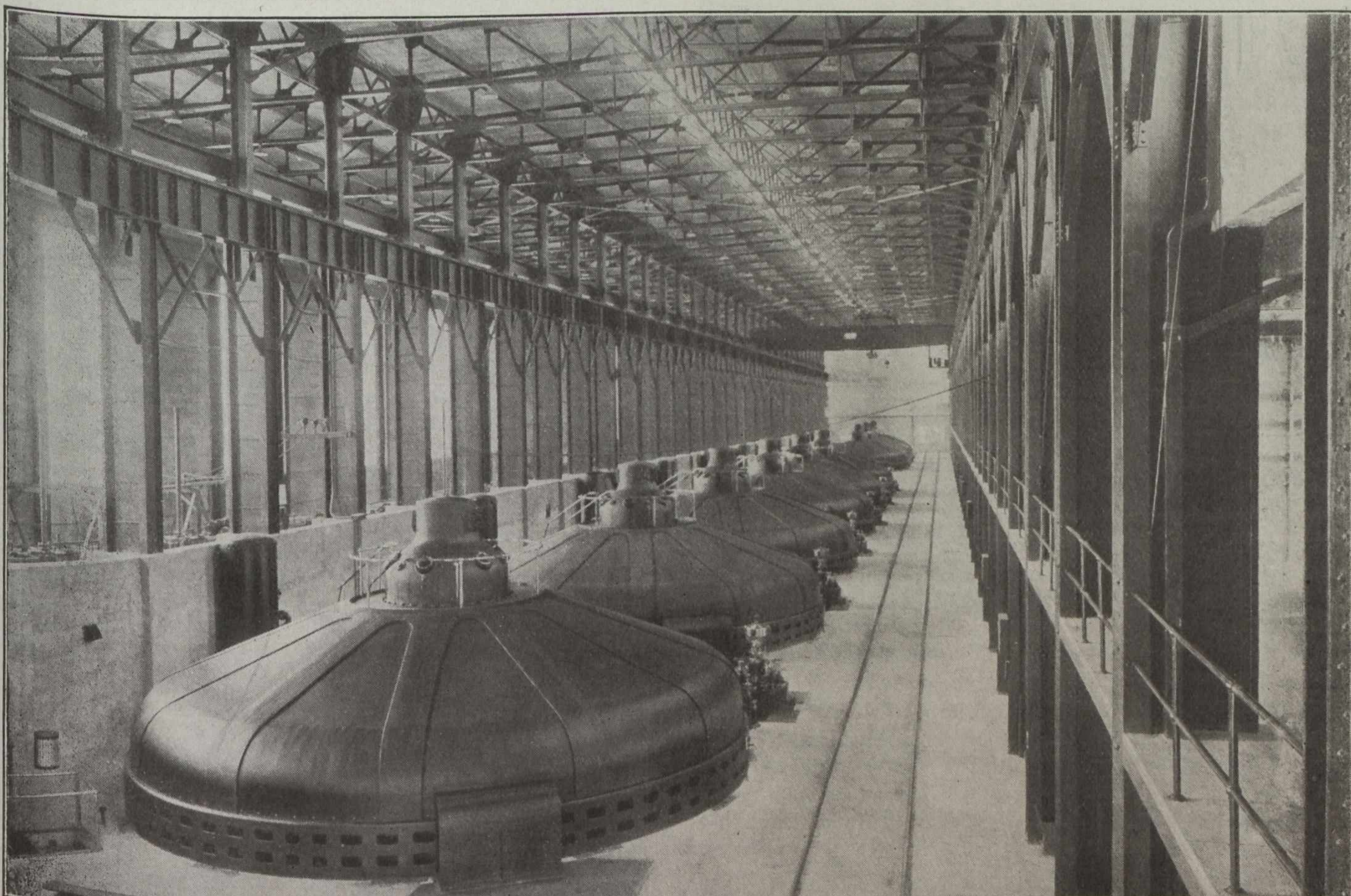
HYDRO-ELECTRIC POWER IN EASTERN ONTARIO.

Representatives of Eastern Ontario municipalities have recently taken up with Sir Adam Beck, chairman of the Hydro-Electric Power Commission, the question of supplying them with power and radial lines. There has been but little activity as regards the development and transmission of hydro-electric power by other than private companies in Eastern Ontario in recent years, during which time the western peninsula has been experiencing phenomenal rural and urban improvements as a result of the supply of power and equipment furnished by the Commission. This delay in Eastern Ontario has been largely due to difficulties of a technical nature existing between the Federal and Provincial Governments as regards the water power development in the Trent Valley. In this connection Sir Adam made an important announcement to a delegation which waited upon him on February 1st. He stated that the existing difficulties had been practically removed, subject to the approval of the two parliaments, and, if these bodies corroborated the proposed agreement, the province would have control of the future development of water powers within its boundaries. When the necessary legislation giving effect to this understanding has been enacted, the municipalities in Eastern Ontario may expect a betterment of the situation.

The Winnipeg office of The Canadian Engineer has been moved from Room 1008 to Room 1208, McArthur Building. The new telephone number is Main 2663. Mr. G. W. Goodall remains in charge of the office.

CEDARS RAPIDS POWER DEVELOPMENT.

MESSRS. Henry Holgate and Julian C. Smith read papers last fall, before the Canadian Society of Civil Engineers, on the design and construction of the Cedars Rapids Power and Manufacturing Company's hydro-electric plant at Cedars, near Montreal. On December 2nd, 1915, R. M. Wilson, chief electrical engineer of the Montreal Light, Heat and Power Co., followed with a paper on the electrical design, construction and tests. These three papers jointly give a very complete record of the entire work. Brief abstracts of Messrs. Holgate's and Smith's papers appeared in *The Canadian Engineer* in the issues for November 18 and December 16, 1915, respectively. Following are a few of the most interesting points covered by Mr. Wilson's paper:



Interior View (Looking North) of the Power House at Cedars Rapids, Showing Some Important Structural Features and Illustrating the Arrangement of the Nine Units.

The generating plant consists of nine 10,000 kv.a., 6,600-volt, 3-phase, 60-cycle, vertical units, and three 1,250 kv.a., 2,300-volt, 3-phase, vertical exciter units. Voltage regulators are installed on each unit, maintaining a steady voltage and preventing cross-currents between the units. The main generator busbars are not in the power house, but are installed in the transformer house. The power and transformer houses are 800 ft. apart, connected by feeder cables.

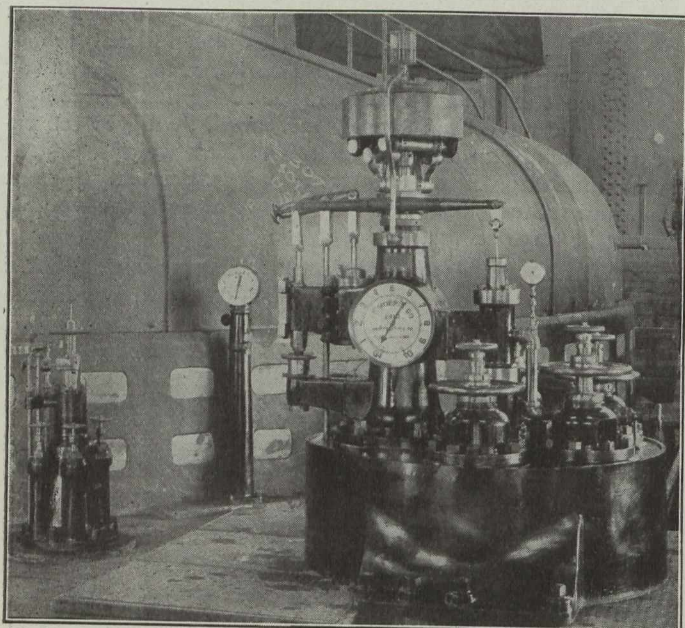
Size of Units.—The design of the generating system was the main point in the consideration of the electrical layout, and had to be worked out in conjunction with the water-wheel design. Mr. Smith explained in his paper why the vertical type of unit was adopted. The next step was to determine the size of unit, having regard for contract obligations that are most onerous as regards continuity of service.

Two sizes were considered, *viz.*, 15,000 kv.a. and 10,000 kv.a. The smaller unit was adopted because: (1) with the larger unit, too great a percentage of the plant capacity would be put out of commission by the failure of any unit; (2) 15,000 kv.a. vertical units had never been constructed and the company did not wish to experiment; (3) the cost of other apparatus, such as cranes, bearings, etc., would have been greatly increased, owing to the excessive weight of the larger units. The weights of the rotor and stator of the smaller unit are respectively 213,000 lbs., and 146,000 lbs. For a 15,000 kv.a. unit, the weights would be 425,000 lbs. and 300,000 lbs.

A unit smaller than 10,000 kv.a. was not adopted owing to the larger power house that would have been required, and on account of the larger operating staff, etc., that a greater number of small units would have necessitated.

When the size of unit had been decided upon, the design was discussed with manufacturers prior to sending out specifications, in order to impress upon them the importance of securing the most economical ratio between the diameter of the unit and its height. The result was that the design adopted saved 7 ft. in height of power house, as well as reducing the cost of the hydraulic installation.

The generator specifications required that the stator be in four sections; that the design be for 75 per cent. power factor, and 25 per cent. overload for two hours; that full rated capacity must be delivered at a normal potential of 6,600 volts; that full load rating in amperes at a voltage of 7,200 volts must be carried for several hours without damage; that the temperature rise must not exceed 45 deg. C. at end of a 48-hour run; that the iron losses must not increase more than 5 per cent. after two years' operation.



One of the Main Governors (Unit No. 9.)

The efficiency guaranteed at full load was to be 94.5 per cent. at 75 per cent. power factor; 95.5 per cent. at 90 per cent. power factor; 96.1 per cent. at 100 per cent. power factor. The highest efficiencies guaranteed—at ¼ load—were to be 95 per cent. at 75 per cent. power factor; 95.8 per cent. at 90 per cent. power factor; 96.4 per cent. at 100 per cent. power factor.

The units installed have met the most sanguine expectations. The outside diameter of the stator is 37 ft. 4 ins., and the unit is the largest in diameter which has been installed to date. The height of the stator frame from the floor line is only 33 inches.

Excitation.—In providing for the excitation the usual practice of installing large D.C. units, water-wheel driven, was departed from. In their place were installed three A.C., 1,250 kv.a., 2,300-volt, 3-phase units, excited by an 18-kw. D.C. generator on same shaft and turbine-driven, also a bank of three 1,000 kv.a. transformers, which permits of one of the large units being used for excitation purposes in emergencies.

These A.C. generators furnish the energy for driving the individual motor generator sets for exciting the large units. This method was adopted because in case of trouble on an individual exciter set only one main unit would be affected; all auxiliary machinery would be A.C. motor-driven with low operating costs; it is easier to obtain automatic voltage control with individual generator exciter sets; the investment in cables, switches, etc., is lower; the cost of spare apparatus is reduced; and in emergencies one of the large units can be used.

Switchboards and Switchgear.—The dominant point kept in mind in design of switchboards and accessories was to obtain the most flexible system consistent with minimum initial cost and continuity of service. The double busbar arrangement was adopted and designed in such manner that a failure on any one section would not cripple the next unit. One main control and instrument board is installed in the power house. In the transformer house a control desk and instrument board are installed for controlling the step-up transformers and out-going lines. All switching apparatus has been installed in such manner that extension to the plant can be made without interfering with operation of present units.

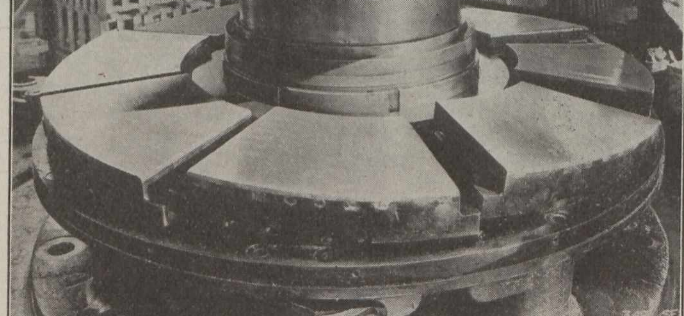
All busbar and switch structures are of reinforced concrete, which was adopted in place of brick because barrier work could be made thinner, loading on floors was much less, and it was easier to obtain greater clearances for live parts to ground in same space. For switch cells and busbar structures, 277 cu. yds. of reinforced concrete were required, at an average cost of $58.70 per cu. yd.

The generators, exciters, switchboard apparatus, etc., were supplied by the Canadian General Electric Co., Ltd.

Cables.—All cables used on the main generators operating at 6,600 volts were installed for 13,200 volts pressure. Cables used for 2,300 volts operation are installed for 4,400 volts. The increased cost is more than offset by insurance against failures. Lead-covered, paper-insulated cables were used in all places subjected to moisture. All cables were designed with cross-sectional area of sufficient size to carry 50 per cent. over normal current continuously. All large single conductor cables on A.C. circuits have rope cores to minimize skin effect. In designing cables, 1,200 c.m. per ampere was generally allowed.

The most important part of the cable design was the size and kind to use on the main units connecting power and transformer houses. The final adoption was four 3-conductor, 300,000-c.m., lead-covered, paper-insulated cables per unit.

Some of the reasons governing this decision were: (1) Increase in apparent resistance of single-conductor lead-covered cables, carrying heavy currents at 60 cycles was found to be abnormally high; (2) the three-conductor cable was slightly cheaper in initial cost; (3) in the event of failure of one of the four cables, partial service could be obtained during repairs.



The Kingsbury Bearing of Unit No. 5, During Installation Operations.

Where the cable runs were comparatively short, single-conductor cable was used to facilitate handling, and on account of the fact that the outside diameter was less, thus taking up less room.

The cables were supplied by the Northern Electric Co., Limited.

Transformer House.—This building is of reinforced concrete, built on the unit principle, and contains about 1,825 units. It is 228 ft. long, 130 ft. wide and 90 ft. high from basement floor to roof. The load per square foot on all footings is 2,500 lbs. This may appear small, but was due to the nature of the soil, which made heavier loading inadvisable.

In this building are the busbars, with necessary switches, etc., and the step-up transformers for the Massena and Montreal systems. The principal reason for having the step-up transformers removed from the power house was the desire not to have large quantities of oil in too close proximity to the generating apparatus. There was also considerable saving effected in the rock excavation for the power house, and the arrangement permitted easier construction in regard to the exits for the transmission lines.

The auxiliary transformers were supplied by the Canadian Westinghouse Company, Limited.

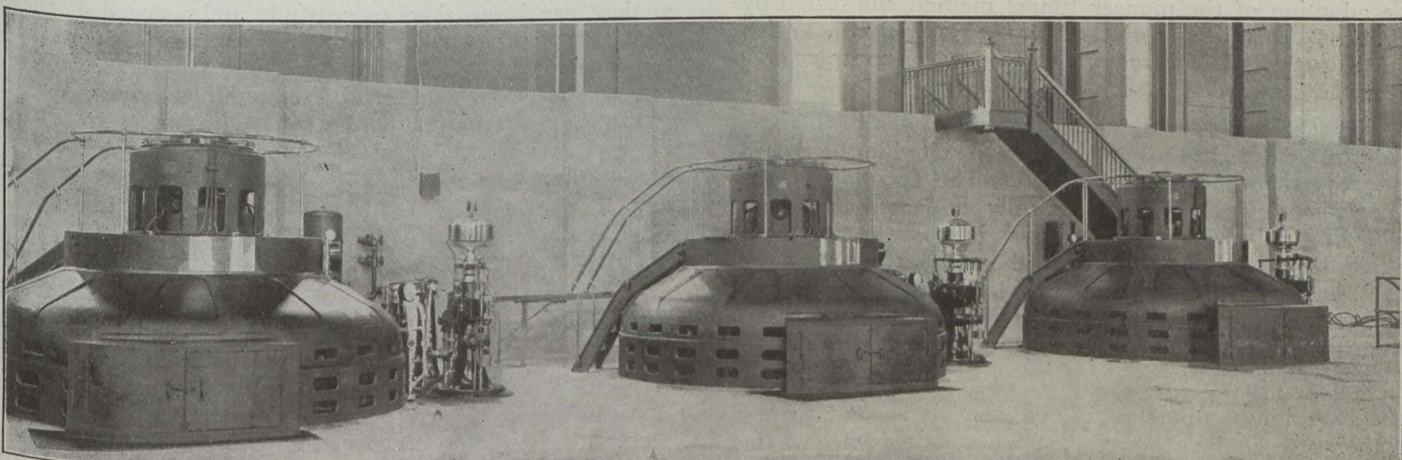
Tests.—The tests carried out on the generating equipment were for efficiency, field characteristics, regulation, heat runs, overspeed, high potential and oscillograph. The efficiency test was made by the method known as the Decelleration Core Loss Test. The field characteristics at different power factors were determined by means of the no-load saturation and the short circuit impedance curve. The regulation was taken as the drop in voltage expressed as a percentage of no-load volts. Heat runs were made with various power factors and loads, with different degrees of ventilation. The overspeed test was made by throwing the water-wheel gates wide open and unit allowed to rotate without load or brakes. A high potential test of 15,000 volts was made on armature windings and 2,200 volts on field coils for one minute. Oscillograph tests were made under all conditions of short circuits, including single-phase and three-phase, as well as tests for wave form under different power factor conditions.

One interesting test was made by short circuit under normal load. It was performed as follows: The unit was loaded by means of a water rheostat, located in the gate house, and the unit short circuited by means of a special oil switch.

At the moment of short circuit the field current jumped from 305 to 560 amperes, and the armature current to about 8 times normal current, the speed of the unit raising from 56 r.p.m. to 66, then back to 53, and finally settling down to 56. The wheel gate opening as a result went through a large variation, causing a considerable water surge in the gate house.

Cost.—The following summary contains the costs of the electrical installation for the first development of 100,000 h.p.:—

	Per kw.
Generators, exciters and blowers	$10.04
Switchboards and high-tension switchgear	2.18
Switch cells and bus structures	.26
Control cables and conduits	.54
Main cables and ducts in power house and transformer house	.23
Feeder cables, ducts and trestle	1.40
Auxiliary power cables and conduits	.28
Auxiliary transformers	.22
Auxiliary switchboards	.37
Storage battery installation	.11
Lighting system	.19
Heating system	.19
Miscellaneous	.24
Total	$16.25



The Exciter Units, with Their Governors.

These costs include engineering supervision and interest during construction.

The total cost of the transformer house, including crane, turn table, transfer truck, etc., was $3.02 per kw. The cost per cubic foot was $0.098; per square foot of floor, $0.251. The floor area is 1.2 sq. ft. per kw.

Operation.—The plant was first placed in commercial operation on December 27th, 1914. The load has been built up gradually until now the plant is operating at its maximum output with a daily load factor of over 90 per cent. Three shifts of 8 men each, and one operating superintendent, comprise the staff. The superintendent is W. G. Hullett. Very little trouble in operation has been experienced to date, everything working out smoothly.

COPPER LINING FOR TUNNEL.

Bids are being solicited by the Board of Water Supply of New York City, calling for furnishing and placing copper lining in a portion of the city tunnel of the Catskill water supply aqueduct. The actual length to be lined is about 1,200 ft. of 12-ft. tunnel. The copper generally will be 5/64-in. in thickness, and the sheets will be joined by brazing and attached to the surface of the existing concrete lining by bolts fastened into the masonry. After completion, the tightness of the brazed joints is to be tested by light water pressure on the back of the copper lining.

TUNNELING AT ROGER'S PASS.

At a sectional meeting of the Canadian Society of Civil Engineers, held in Montreal on January 12th, Mr. J. G. Sullivan, chief engineer of western lines for the Canadian Pacific Railway, read a short paper descriptive of the construction of the Roger's Pass tunnel up to the meeting of the east and west headings on December 20th last. This important work is referred to on another page in several paragraphs of the address of Mr. F. C. Gamble, retiring president of the Society. Several articles have previously appeared in *The Canadian Engineer*, descriptive of the scheme, of which the tunnel is a part, for the reduction of grades, elimination of curvature, removal of snowsheds, and shortening of track, in the mountain division of the line.

In his address, Mr. Sullivan first reviews the development in traffic which ended in the decision of the company with respect to double tracking and grade reduction, and which directly resulted in the conclusion to proceed at once with the driving of the tunnel. The paper contains a number of interesting quotations from correspondence covering methods and speeds of driving and discussing the adoption of the pioneer tunnel method suggested by Mr. A. C. Dennis, superintendent for Foley Bros., Welch and Stewart, the contractors to whom the contract was afterwards awarded.

The principles worked out together by Mr. Sullivan and Mr. Dennis are those which have resulted in the record progress that has been achieved. The function of the pioneer bore has already been fully explained in these columns, and we present the following paragraphs from Mr. Sullivan's paper relating to the manner in which the work is carried out, it being remembered by the reader that the primary object of the bore is to facilitate blasting at any point in the tunnel without interfering with operations at other points.

The pioneer tunnel at the east end is located 50 feet to the north of the centre line of the main tunnel, and the pioneer at the west end is 50 feet south of the centre line of the main tunnel. The mode of operation is as follows: The drilling in the small headings is done in the usual manner, using in general Leyner drills, making an advance of 6 or 7 feet for each round of holes. The muck is shovelled by hand from steel plates into half-yard cars and hauled back, either by a mule or small compressed air locomotives, the latter being used after the haul got to be a considerable distance. The muck from the headings is carried out through cross-cuts into the pioneer tunnel, where it is carried back to a cross-cut, and there carried out on a trestle over the standard gauge tracks in the main tunnel and dumped into standard gauge cars, from which point it is removed to the fills in a similar manner to the muck loaded by steam shovels in the enlargement. The muck from the heading on the west end in a similar manner goes into the pioneer tunnel at a cross-cut, crosses back to the main tunnel in a cross-cut, where it is dumped into standard gauge cars. In the enlargement of the main tunnel the drilling is done well ahead of the shooting. At first the radial holes were drilled at right angles to the axis of the tunnel. This did not give the best results, and it was changed to a drilling showing an inclination of about one in four away from the direction in which the tunnel is being driven. The muck is all loaded by steam shovels into standard gauge 12-yard capacity dump cars. The shovels have dippers of 1½ cu. yds. capacity and are worked by compressed air. The cars are hauled to the mouth of the tunnel by standard gauge compressed air locomotives and from there by standard steam locomotives.

Doors are put in the cross-cuts between the pioneer and the centre heading. All of these doors are kept closed back of the shovel, and when shooting takes place in the enlargement of the tunnel the door at the first cross-cut beyond point of shooting is opened. This creates a very strong draught back over a pile of freshly shot muck and makes conditions such that the men can return to work in ten or fifteen minutes after a shot. The shooting of the muck in the enlargement of the main tunnel is done in the following manner: One round of holes is shot at a time, the holes in the bottom of the tunnel being shot in advance of the holes on the sides or on top. In some cases the top holes are not shot until all of the bottom holes have been shot out. Usually six or seven rounds of holes are shot before the steam shovel starts cleaning up the muck, that is, a distance of 30 ft. to 35 ft. The shooting is generally continued until the tunnel becomes so full of muck that no more shooting can be done. The largest amount that was ever shot at one time was on November 20, 1915, when 84 feet was shot in eleven hours.

In conclusion, Mr. Sullivan states that all expectations as to speed have been more than realized, and that for any rock tunnel where the rock is of sufficient hardness to stand until after the mucking has been done, this method can be worked successfully and a speed of three miles per year can easily be made at a much less cost than tunnels driven at the same speed by the European method; and furthermore, the radial shooting has proven that a great deal less over break can be expected from this method than where holes are put in parallel with the axis of the tunnel.

AN UNUSUAL RAILWAY IN THE WEST.

The Hudson Bay Company owns a very unique and serviceable little railway which it constructed about 60 years ago on Grand Island, in the Athabasca River. It is a portage railway whereby some dangerous rapids are avoided by the passenger and freight traffic on the river. According to the Engineering News, the railway has shown a profit of $1,000,000 in 60 years' service although its cost, including equipment, was less than $1,000.

The track consists of strap or bar-iron rails on wood stringers laid upon wood ties. The equipment consists of two flat cars. The freight rate is $2.50 per ton, the men handling their own goods and shoving the cars along the line.

A scow going inland (downstream) lands its cargo at the upper end of the island and then goes down the rapids in about 70 seconds. The vertical descent is about 65 feet. In the quiet (but swift) water below, the crew hold the boat with the oars till they can pick up a timber thrown out from shore and attached to a light line. With this a heavier cable is pulled out, and the boat then hauled to shore for reloading. A boat coming out upstream is either taken through the rapids by tracking or is hauled across on the railway.

Mr. Alcide Chausse, city architect of Montreal, presents the following figures relating to building in a number of Canadian cities in 1915, as compared with figures for the previous year:—

	1914.	1915.
Montreal	$17,394,244	$7,486,221
Toronto	20,684,288	6,651,889
Winnipeg	12,160,950	1,826,300
Ottawa	4,397,920	1,605,160
Hamilton	3,703,865	1,523,248
Vancouver	4,484,476	1,504,300
London	1,837,735	1,207,630
Halifax	879,320	1,063,985

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

Index to Volume 29, July to December, 1915

ISSUE	BEGINS PAGE	ISSUE	BEGINS PAGE	ISSUE	BEGINS PAGE	ISSUE	BEGINS PAGE
July 1	101	Aug. 19	269	Oct. 7	437	Nov. 25	605
" 8	125	" 26	293	" 14	461	Dec. 2	629
" 15	149	Sept. 2	317	" 21	485	" 9	653
" 22	173	" 9	341	" 28	509	" 16	677
" 29	197	" 16	365	Nov. 4	533	" 23	701
Aug. 5	221	" 23	389	" 11	557	" 30	725
" 12	245	" 30	413	" 18	581		

ARTICLES

*Illustrated Article.

EDITORIAL

*Illustrated Article.

AUTHORS

PERSONALS

OBITUARY

BOOK REVIEWS

GENERAL PRINCIPLES OF ROAD IMPROVEMENT

By W. Muir Edwards,
Prof. of Civil and Municipal Engineering, Univ. of Alberta.

AMONG the few subjects which are of vital interest to all members of the community, the construction and maintenance of public roads should surely find a place. To the casual observer it might appear that as the network of railways becomes closer, the outlay required for public roads should decrease. The exact opposite is the true state of affairs. The construction of branch railways means a more dense settlement of the country, increases, therefore, the burden on the tributary roads, and thus justifies an increased expenditure on public highways. Improved financial conditions coincident with, or following closely upon, railway expansion results in an increased use of motor-driven vehicles both for business and pleasure. The increased speed of this class of traffic requires improvement of roadways already in existence, introduces new factors in the construction of projected highways and makes more difficult the maintenance of all public roadways.

In considering the economic principles governing highway improvement and maintenance, it is well to distinguish between the several classes of both roadways and traffic. Considering first the former, we might make the following division, confining ourselves, for the sake of simplicity, to four sub-heads, *e.g.*, (1) Roads with a hard surface passable at all seasons for any type of traffic; (2) roads passable at all seasons only for slow traffic, and for the remainder of the year for fast traffic; (3) roads impassable at certain seasons of the year for all but light traffic, and for the remainder of the year passable for both slow-moving loads and fast traffic; (4) roads as above, except that for the remainder of the year slow-moving loads only can be accommodated.

Any passageway to which we apply the term "road" should come at least under the fourth of these classifications. Such a roadway can be successively raised into the higher classes at a cost for each improvement capable of definite estimation. The cost of such improvements, together with the cost in the first place, is affected greatly by local conditions, but in general it might be said that the cost of obtaining the first type of roadway is much greater than is involved in any of the other three. The raising of the fourth to the third is a matter of upkeep. To obtain the second from the third may require some additional constructional work, the main question, however, being upkeep, but the construction of a road with a hard surface serviceable for all traffic at all seasons of the year is a comparatively costly piece of engineering work. This cost, together with suitable methods of construction, will be considered in a later article. The economic problem with which we are faced is to determine to what extent we are justified in making the expenditures necessary to obtain one of these types of roads. All will agree that a road connecting each quarter section with the point where delivery of produce may be made and at which supplies may be obtained is essential and should be provided. What we must consider is just how much expenditure is justified in order that roads of the third, second or first class may be obtained and equally important how shall the acquired expenditure for any of these types be allotted.

The benefit accruing from improved roadways is not alone directly financial, but also that due to improved social and domestic conditions in the community. It is well to emphasize this latter benefit since it is not possible to demonstrate to a farming community that, on a purely financial basis, they are justified in spending any considerable sum in road improvement except in so far as such expenditure is devoted to the elimination of features which would otherwise unduly limit the maximum load which may be hauled at any season of the year. For example, an expenditure might be made to reduce a grade which at all seasons affects the maximum load, but would not be justified if applied to making passable at all seasons of the year a road which for the greater portion of the time is passable with reasonably heavy loads.

The above may not be in accordance with many of the statements of the ardent advocates of "good roads." However, in dealing with the purely financial side of the question as it affects the greatest user of the roadway, *i.e.*, the farmer, it must be remembered that he is primarily a raiser of produce, and secondly, at times which he can more or less select, a freighter of this produce to a shipping point and of supplies to his farm. The dairyman and market gardner do not come under this general statement, but form as yet a small proportion of the farming community and the tonnage they move is small compared to the total produce of the farm. Indeed, even in ordinary farming a very considerable proportion of the produce transports itself to market on the hoof and is not concerned as to the class of road over which it is driven. Moreover, in figuring the cost of the remainder of the farm produce which is hauled to town and which is affected by the classification of the roadway current freight rates cannot be fairly applied.

In other words, in dealing with the saving to the farmer we must not figure the cost per ton-mile of marketing produce as though this were done by a man and a team whose sole business was the hauling of loads. If you asked a farmer for a price to freight ten tons to a farm five miles away he might quote you $7.50, or a rate of 15 cents per ton-mile, but if you asked the same farmer what it cost him to haul ten tons of his grain to an elevator five miles away he might conceivably answer "nothing." This is, of course, not strictly accurate, but unless there is work for the man and team on the farm which must be done by some one else, the cost is certainly not $7.50. So that the sum of money involved in the transportation question is not as large as in many cases it is made out to be. Again, the saving in being able at any time to send his produce to a shipping point, is often overestimated except in special types of agricultural activities.

As has already been stated, there is no question as to the financial necessity of a road upon which the farmer may get to and from his point of distribution and supply. The raising of this road from the fourth to the third class involves little expense, but the improvement into the second, and assuredly into the first class must be justified in addition to financial gain by the comfort of driving over a good road rather than a poor road, the increased ease and possibility of frequent intercommunication and the improvement into community life generally. It is difficult to put these benefits into dollars and cents, but they are very real nevertheless. That much of these benefits, not now enjoyed, may be obtained at a reasonable outlay will be pointed out in a later article of this series dealing with country roads.

The traffic in the roadways might be divided into classes, according as it affects construction and maintenance. We will again only attempt four such divisions, *i.e.*, (1) horse-drawn vehicles, loads 2 to 3 tons, speed 2½ to 3½ miles per hour; (2) horse-drawn vehicles, light loads, speed 6 to 8 miles per hour; (3) motor vehicles, loads 10 to 20 tons, speed 10 to 15 miles per hour; (4) motor vehicles, load about 1½ tons, speed 20 to 60 miles per hour. Again, as a basis of apportioning cost, we might make a division into local and through traffic. The former might be defined as that originating in the neighborhood of, and centering upon, a local shipping and distributing point and the latter as originating in, and travelling between, the large centres of population. Local traffic might consist of any of the four classes, but except in the neighborhood of large centres where conditions are peculiar and deserving of special treatment, would in the main be comprised in the first two divisions with an addition of a small but growing percentage of the more moderate speed of the fourth class. Through traffic would be almost entirely of the fourth class.

On the basis, therefore, of the requirements imposed by the traffic and of the nature of this traffic we might broadly classify the roadways of the western provinces into main highways, branch highways and country roads. The main highways would be those required by conditions in the neighborhood of large centres and by through traffic. The cost of these might therefore be very well borne by the province at large, such revenue being obtained from the users thereof as may be deemed advisable. The branch highways would be the main arteries covering ing on the local centres. The type of construction might not be as heavy as in the case of the main highways, and the cost might be borne by the surrounding district, with possibly provincial assistance. The country road connects up each farm with the main or branch highway and the cost should be borne entirely by the local improvement district or by the adjacent land.

MUNICIPAL IMPROVEMENTS AT NIAGARA FALLS, ONT.

According to Mr. W. C. Jepson, who has been acting city engineer of Niagara Falls, Ont., in the absence of the city engineer, Mr. F. J. Anderson, who is now an officer in the 98th Overseas Battalion, the city laid 12,900 lineal feet of concrete sidewalks, for the most part 5 feet in width, during 1915. A small quantity of brick pavement was laid, the base being concrete and with grout filler and sand cushion. A short length of 1-course concrete roadway was also put down.

As nearly all paving work is petitioned for by the citizens, and as these petitions are often not presented before spring, Mr. Jepson could not give an estimate of the probable amount of paving which the city will lay in 1916. Last year some 2,500 feet of 18-inch main sewer and 9,500 feet of 10-inch and 12-inch laterals were laid.

The Muddy Run trunk sewer is now the chief sewer proposition for consideration. At the present time the Park Street sewer is overloaded. To relieve it and to dispense with Muddy Run Creek, which is practically an open storm sewer running through the city, it is proposed to build a trunk sewer estimated to cost from $250,000 to $300,000. Of this sewer, about 3,000 feet will be in tunnel under Huron Street, and 4,400 feet of it will be in the open, practically paralleling the course of Muddy Run Creek. There will be a 3 or 3½-ft. diameter pipe for sanitary flow and a 5½ or 6-ft. pipe to act as storm sewer. This project will be proceeded with as soon as the financial conditions improve.

Toronto's park area is now 1,861 acres. High Park, with 335 acres, is the largest, and the Island comes next with 330. The boulevard mileage as planned is 43.33 miles, and 1.80 has been constructed. Ravine driveways planned have a mileage of 6.38, and there have been partially constructed 7.27 miles.

DISTRIBUTION SYSTEMS, METHODS AND APPLIANCES IN IRRIGATION.*

By J. S. Dennis, H. B. Muckleston and R. S. Stockton,
Calgary, Alberta, Canada.

THE most important part of the distribution system is the farmer who is to use it. If the man is not successful, the project is a failure. When an irrigation project is proposed or built, its primary object is to make homes on the land. There may have been other reasons for its construction, but unless the first is accomplished, no matter how well the project is conceived, or how much engineering skill is shown in its construction, it cannot be considered a success.

The secrets of success are as follows:—

(1) A sufficient water supply. Many projects have been constructed in the past with little or no attempt to ensure a sufficient supply of water for the irrigation of the lands. The necessary assurance that the available sources of supply are sufficient, can be attained only after observation covering a long period of years. Such work is beyond the resources of any private individual or corporation and should be undertaken by the governments.

(2) Good construction. This must be considered as a term of which the meaning is relative. A quality or character of construction which would be considered necessary in an old and established country might be sinful extravagance under pioneer conditions. Many of the failures in new countries may be charged to setting too high a standard for the construction of the works. New countries find it difficult to raise capital but have little trouble in paying maintenance charges, and even if the ultimate cost is higher by reason of temporary expedients in first construction, the project may be better off in the long run. This is also true in a divided sense. It may pay to adopt a high standard in the large main arteries of the project on which the settler has to pay for the maintenance, and a much lower one in the distributaries where he does the actual work himself.

(3) A well organized system for transporting and delivering to the settler, the water on which he depends. Mere capacity to deliver water matters little to the success of the project. It must actually do so in the proper quantity and at the time when it is most required. It is true, too, that while a well organized operating force can go very far towards success, it cannot go all the way. Quite as much, or even more, depends on proper use of the water after it is delivered. To this end the settlers and the canal management must co-operate.

Where irrigation by flooding is the general rule, it is to the settler's individual interest that he obtain water in as large a "head" as possible at certain critical times, but it is manifestly impossible to build the whole canal system large enough to provide such a head for all the settlers at the same time, hence, it is to the interest of the community that the available supply be made to go as far as possible without restricting any person in the use of a practicable irrigating head. Evidently, these two requirements conflict and can only be reconciled by co-operation. Let the settlers so prepare their land and diversify their crops as to be able to take turns at the available supply, or else let them learn to get along with a small uniform head delivered continuously. Neither is impossible and both have been worked, but it is generally conceded that the former is the preferable arrangement.

Good Design.—It is also evident that proper design of the distribution system is of very great importance in successful management.

* From a paper presented at the International Engineering Congress, in San Francisco, Cal., September 20-25, 1915.

The distribution system for a large irrigation project divides itself into several parts, which although closely inter-related, present certain individual aspects in connection with the location, construction, operation and maintenance of these unit parts. These different parts of an irrigation system will be considered under the heads of Main and Secondary Canals, distributary ditches and the farm ditches used in irrigating individual holdings.

The managers of practically all large systems constructed in the last ten years have agreed as to the advisability of the policy of building the system complete to a delivery at the boundary of the individual holding or farm unit. The reasons for this are, first, the economy in cost and the engineering skill available for the location and construction work; second, the fact that a farmer starting in on a new place had enough to do during the first few years to prepare his land and build the farm ditches for irrigation. It may be pointed out just here, that one of the greatest sources of failure of new settlers on irrigation projects, is their inability or failure to suitably prepare the land and extend the distribution system without which their efforts at irrigation lead to disappointment and fault finding, and very frequently, to an absolute failure.

The engineering problems connected with the location and construction of the main canals are many and varied, but are well understood by the men who have followed this line of work. The important matters of general policy affecting this part of the system concern alternative use of timber and concrete or masonry for the structures, the duty of water and the method of delivery, the source of water supply and land to be covered. In Canada, the lands to be irrigated, the water supply and the construction of works must all be investigated and approved by the Dominion Commissioner of Irrigation, which insures that fake irrigation companies do not discredit legitimate irrigation enterprise.

The distributary ditches carrying water to the individual farm units do not present any very large engineering problems, but they do require, for satisfactory results, a knowledge on the part of the locating and constructing engineers of the detailed and practical requirements of irrigation as carried out in the field by the farmer and an experience in operating and maintaining such ditches and the various structures that are a part of them.

The size of the distributary ditches should be determined not by the duty of water, but by the size of the head of water that it is desired to deliver to each water user, and the method by which such water is to be delivered. No matter how the water right is stated, the practical requirements of irrigation necessitate a delivery by rotation in sufficiently large heads to insure the rapid and economical irrigation of the land with a minimum waste of water. Such a system enables the crops to be irrigated at the proper time and increases the duty of water. It enables the farmer to cultivate as well as irrigate his land, which is of fundamental importance. On large holdings, the rotation may be carried out as between different parts of the farm, but with smaller holdings a compulsory rotation is most desirable. The distributary ditches should be designed and built to carry a flow of at least two cubic feet per second to each delivery. This allows a satisfactory irrigating head for flood irrigation, which system is considered to be the best adapted for the majority of cases where the holdings are large, the slopes good and the crops consist largely of grain, hay and roots.

Distribution of Water to the Farm.—The proper place for main laterals is on the divide or watershed if they can get there, or as near as possible if they cannot. The distributing laterals should follow the line of quickest descent, to avoid interfering with drainage. This latter is not always feasible owing to the rectangular system of land subdivisions in use in some countries and a compromise must be arrived at whereby the laterals follow the survey lines as far as topography will permit. This compromise always results in some interference with drainage and almost always costs more in consequence. Another very important feature in the design of the distribution is the provision of a sufficient number of tail ditches. These are to carry surplus canal water into the natural drainage lines of the country and should not be confused with drainage ditches which are those built to assist the natural drainage lines in disposing of surplus irrigation water or precipitation. Tail ditches are an operating convenience, drainage ditches, an agricultural necessity. Under favorable, though unusual topographical conditions, it is possible to so arrange things as to combine the drainage ditches and the lateral system into one over a portion of their length. The system is not a good one, as it aggravates any tendency toward salting or alkali and sometimes results in silting up the natural drainage lines unless they have a very pronounced fall.

Distribution on the Farm.—If the distribution outside the farm is the vital point in successful operation, the proper distribution on the farm is the most important factor in successful agriculture. No matter how regular nor how certain the water supply to the farm may be, it is worse than useless if not properly applied to the land.

There are many methods of irrigation in use, the choice in individual cases resting on many factors, such as character of crop, soil, subsoil, slope, preparation of land, custom of irrigator, available labor and many others. No matter what method be used, the farmer must build on his own land a miniature system to distribute the water. Part of this system will be permanent and part only temporary to be ploughed each year. Economical and proper use of the water is impossible unless the land is properly prepared to receive it, and it is just here that many irrigation projects have come to grief through lack of consideration of the problems of the water user, and not extending to the man on the land such advice and assistance as will enable him to advance on right lines.

Construction.—It is not sufficient for economical operation that a system be well designed. It must be well constructed. It is not meant by this that the highest standard shall be used, but merely that what is done shall be well done. It is a question which is the most difficult to operate cheaply, a well designed, badly constructed system, or the reverse. If anything it is the latter, for faults in construction can usually be remedied but faults in location are persistent and in many cases impossible to correct.

This should not excuse bad construction, however. Bad construction is seldom cheap in the first cost and never economical. It is usually the result of too little attention to small details and to lack of proper supervision. Costly design may be easily almost nullified by cheap supervision. One very common cause of trouble is breaching banks. Sometimes this is attributed to omission in the specifications but it is generally due to non-observance of the provisions which are in them.

The methods and tools used in earthwork naturally vary much with local conditions. In North America, horse power and tools, except in the very largest canals, are well nigh universal. When manual labor is cheap, other methods would be used. The same applies to structures. A design or a material, or a method of construction suited to India would be out of place in Canada, and a design suited to a tropical climate would be altogether wrong in a northern climate, when frost is one of the principal agencies of destruction. Again, too, construction by contract may be advisable under one set of circumstances, and the exact contrary in another. There is no doubt that there is great economy in building structures of a permanent type in the main carrying canals when the money available will permit of this policy. Such structures besides being more economical as to actual construction and maintenance through a series of years, also add to the reliability of the canals and this feature is a most important one in giving satisfactory service. The failure of a dam, headgate or drop, in a main canal at a critical time, may not only entail a considerable loss to the farmers individually and a large total loss, but does more than anything else to bring about dissatisfaction among the water users.

Maintenance.—One very important factor and a frequent cause of trouble, especially in co-operation schemes, is insufficient attention to maintenance and renewals. A structure shows signs of requiring attention, but for various reasons, such as lack of funds, or because it is no person's particular business, nothing is done. It fails in some part and is hastily patched up, finally it fails as a whole at a critical time and something approaching disaster may result. Proper attention at the right time would probably lengthen its life very considerably and would certainly avoid the disastrous results of a failure when such can least be afforded.

Engineering.—Another very important prevalent cause of trouble, especially in co-operation schemes, is cheap engineering. This does not necessarily mean cheap men in charge. On the contrary, it is not unusual to find expensive consulting engineers without sufficient funds to make the proper surveys when they are most needed. Almost invariably it will pay to spend a considerable sum on an accurate topographical survey of the whole area to be included in the project. There are very few projects where an accurate large scale topographical map would not save its cost many times over, but comparatively speaking, how few there are, where such a map is available on which to project and co-ordinate the whole system down to the last detail or even beyond. For instance, a settler needs aid or advice in preparing a difficult piece of land; with an accurate map available, a scheme can be worked out in the office and carried out on the field with little change; without it, a special survey must be made. Again, it is not unusual to find the work as a whole in very competent hands, but for lack of funds the details are placed in charge of inexperienced men who have to acquire their knowledge at the expense of the constructing organization, with a resulting cost far in excess of what it need have been had the proper skilled assistance been available from the start.

Management.—Many projects suffer from petty economies in the management. A competent manager is worth an adequate salary and should get it, for he can save its cost many times over. It is hard to convince canal companies of this fact and as a result we find costly projects in the hands of cheap managers with the inevitable result of unnecessarily high operating charges. Large corporate or government managed projects do not suffer to the same extent from this cause as the small cooperation schemes, but even then it is not unknown. The necessary qualifications for a competent manager, of course, vary with the condition under which the project is operated. The successful manager, who has been accustomed to Indian or Egyptian conditions, might fail utterly under conditions as they exist in North America.

So, also, the organization must differ. Some of the governing factors may be outlined as follows:

(1) The extent to which the settlers are organized, or, in other words, to what extent do they relieve the management of the whole or a part of the details of operation and maintenance?

(2) The size of the project. Evidently the organization of a project covering two or three hundred thousand acres must be more complex than one of two or three thousand.

(3) The type of the project. Distribution by open ditches must need a different organization from distribution by pipes, and pumping projects from purely gravity projects. Again, a project which is divided into units by well marked natural features differs from a project confined to one valley with one long straight-away canal. Character of construction also enters, as on it depends that which requires most supervision, operation or maintenance.

Another and very important factor is the character of the settler. By this is meant his race or nationality, the system of government to which he is accustomed, his habits and customs. The laws of the country are important, so also is the respect in which laws are held, considered as a national or racial characteristic.

COST OF DRILLING ANCHOR BOLT HOLES FOR QUEBEC BRIDGE.

The following is a detailed statement, for which we are indebted to Engineering and Contracting, of the cost, for labor and material, of drilling the anchor bolt holes for the Quebec Bridge. The holes were drilled with a "Calyx" core drill, the diameter of the drill being 4½ ins. and that of the core 3⅜ ins. The number of holes drilled was 176, and the number of linear feet drilled 800, or an average of about 4.6 ft. per hole. The holes were drilled through solid granite. The costs given include every item except power for operating the drills, the drills being driven by a 5-h.p., alternating-current, electric motor. It will be noted, from the following data, that the cost of drilling, including equipment but excluding power, was $2.50 per linear foot.

Labor.	
Dougherty, at north shore	$ 263.60
White, at north shore	238.25
Brown, at north shore	16.50
Mooney, at north shore	51.80
Raymond, at north shore	72.10
Dougherty, at south shore	291.80
White, at south shore	285.40
Total labor	$1,219.45
Travelling expenses, Dougherty	40.22
Total	$1,259.67
Material.	
Calyx shot drill	$ 450.00
Belting, 12 ft. 3 ins.	1.76
Shot, 2,000 lbs.	100.00
Express on shot	3.00
Drill spindle, 4 ft. x 6 ins. long, one	22.85
Shot feed complete, one	4.50
4-in. shot bits, eighteen	117.00
1-in. stop cocks, two	1.86
4-in. core barrel plug, one	15.50
4-in. x 2-ft. core barrels, two	16.00
16-ft. 3-in. belting and rivets	9.53
Total material	$ 742.00
Total labor and material	$2,001.67

NOTES ON TUNNEL SURVEY WORK

METHODS OF DETERMINATION OF DIRECTION BETWEEN SHAFTS AND OF TRANSFER AND EXTENSION OF LINES UNDER GROUND.

By M. H. Marshall, A.M.Can.Soc.C.E.,
Assistant Engineer, Irrigation Office, Dept. of the Interior, Calgary, Alta.

WHILE descriptions of tunnel constructions are fairly numerous, very little has been written about the methods of carrying out the surveys for such works and the following article is an attempt to make these methods plain to such engineers as are not familiar with the procedure usually adopted.

Usually when a contract is let for a tunnel or other work the contractor rushes his plant to the site and expects to start at once, so that it is important that all the surveys should be completed before the plant is placed on the ground. While this is not always possible, it is certainly advisable, since, if the location of the centre line of the tunnel is known, the engineer can generally arrange for the hoisting plant to be so placed as not to obstruct his vision; whereas if the plant is once erected on the site, it is difficult to get it moved and will probably result in the engineer having to offset his line, practically doubling his work.

In cases where a tunnel is driven on a straight line from shafts which are in view of one another or which can be seen from an intermediate point, no special survey is required, as a hub can be set on the highest point between the shafts and a line ranged to it from each of them. An accurate chainage should, however, be taken between the points so that the grade elevations of the tunnel may be determined or the survey connected with other parts of a system.

When, however, the shafts are in such a position that they cannot be seen from one another or when a curve is introduced in a tunnel, the P.I. of which cannot be seen from both shafts, a triangulation becomes necessary.

Before starting on the survey it is a good plan for the engineer to walk over the ground, following the proposed location as nearly as possible, as by this means he can get a good idea of the best way to arrange his survey work. Triangulation stations should be kept clear of the sites for shafts which are generally in some predetermined position; if this is not done the points will disappear as soon as the excavation is started, neither should they be placed too close to the shaft, as movements of the earth, due to settlement and also to vibration of the machinery, are liable to disturb them.

Points from which lines are to be given for driving tunnels should be carefully referenced to other points, as far away as practicable.

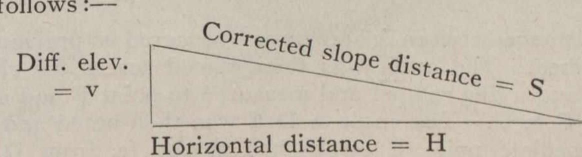
In making a triangulation survey contained angles should be read and not deflection angles, as this will tend to eliminate errors due to transiting the telescope. Each angle should be read accumulatively, starting from a point near zero and the mean of the total reading taken. This will eliminate, as far as possible, errors in the graduation which exist in all transits. Four to six readings should be taken and the angle read on both verniers. The object in not setting the verniers at zero at the start is to avoid bias. Station points may be made of wood or steel and should be strong enough to stand hard driving. If wood is used they should be made of seasoned timber about 3-in. x 3-in. section and about 12-in. to 15-in. long, driven to within 2 in. of the ground surface. When the stake is fixed, a flat-headed nail with a head about ½ in. diameter is driven in the centre of it and the centre of the nail is marked with a steel punch. Steel pikes are used for driving in concrete or macadam highways and should be from 4 in. to 6 in. long and ¾ in. to 1¼ in. diameter, sharpened at one end. These are driven flush and a punch mark placed in the centre as before. When giving a sight to the observer a steel arrow point is held vertically in the punch mark and a whitened board or paper held behind it; or a tripod may be set up and a plumb-bob hung directly over the point.

For plumbing over the punch mark at the instrument station, a wind shield made of a piece of stove pipe about 4 in. in diameter, with a hole cut in one side at the bottom, will be found very useful on windy days. The plumb-bob, which should be heavier than ordinarily used, is dropped through this and can then be brought to perfect steadiness in any weather.

While agreeing that the importance of the operations may justify in some cases the use of special appliances for making tunnel surveys, it has been the experience of the writer that most of these can be made by the engineer himself at a much less cost than they can be obtained from instrument makers and while not presenting so fine a finish, give just as good results in practice.

Bases are usually chained with 100-ft. steel tapes ½ in. wide, and the temperature at which the tapes used are standard, should be known.* The makers will supply this information or the tape can be compared with a government standard. Corrections are made on the basis of 0.01 ft. in 100 ft. for each 15° Fahr. rise or fall in temperature. Measurements should be made both ways and no attempt should be made to read even 100 ft. For chaining points between stations, small spikes or stakes may be used, lined in with the transit and marked with a punch mark or pencil.

The intermediate points should be determined by the slope of the ground and elevations taken at these points with a level. It is then a simple matter to reduce the slope measurements to horizontal measurements, which is done as follows:—



$$H = \sqrt{S^2 - v^2}$$

A reliable spring balance should be attached to the tape and a uniform pull of 12 lbs. applied when taking measurements. It is a good idea to set out, on a level floor or walk at headquarters, a standard 100 ft., so that a daily check can be made before starting work and corrections made accordingly.

The transit should have a 6-in. or 7-in. limb with verniers or micrometers reading to 5-in. or 10-in. sections by approximation if the triangulation is elaborate and to 20-in. for more simple triangulations. It should be fitted with cross-hairs set at about 70 in. to one another as this

* About 62° Fahr.

arrangement allows the sighting lines to be more readily centered and bisected than a vertical wire. An adjustable head for centering is also essential.

Fig. 1 shows a triangulation made for the purpose of determining the line of a tunnel about 3,200 ft. between shafts. This tunnel was driven through blue clay and presented no particular construction difficulties. When the junction was made the centre lines were found to be practically parallel and about ¼ in. apart. The district under which the tunnel was located was thickly populated and covered with houses and trees and no direct sight could be obtained between the shafts. A triangulation was, therefore, necessary.

The line paralleled a steep side hill which sloped to a river, upon the opposite bank of which were extensive flats. These offered an exceptional chance for securing a good level base and points D, E, F and G were established across the river.

The only line upon which a traverse could be run along the top of the hill was along a winding lane and a check triangulation was made on this route.

Starting at a point west of the first shaft which we will call A, another point, C, was established down hill on the left bank of the river and a point D was established on the right bank on the same line. The river was too wide for a direct measurement. A point H on the tunnel line was fixed by the position of a manhole and could be seen from A.

The angle A H D was then noted and also an angle P A D taken to connect the survey with other work, and the distance between A and C was measured as previously described. The outfit was then moved across the river to D and a line ranged and measured to point F and also from F to G. The angle A D F was then noted and an intermediate point E established at 200 ft. from D to enable the distance C D to be calculated. The angle D E C was then read. A point B east of the second shaft could be seen from both F and G, and angles were taken at these points to this station from the bases D F and F G.

The measured bases are shown full in the diagram and the calculated sides are shown dotted. Sufficient information having been secured to complete the preliminary triangulation, the work was plotted in the office and the calculations started.

The base measurements were first corrected for temperature and then reduced to horizontal distances and the survey was plotted from the information obtained. It was first necessary to calculate the distance C D across the river so as to secure a continuous measurement from A to D. This was done by solving the triangle C D E from which the distance was found to be 179.69 ft., which, added to the distance A C, gave a total distance of 870.50 ft. from A to D.

The triangulation system was then divided into three triangles, A D F, F G B, and A F B, which were solved in the order named, care being taken to make any adjustments necessary, any differences being divided out proportionately. The distance between the points A and B was thus computed and found to be 3,245.60 feet and the angles which it was necessary to turn at the points A and B from the bases to establish the centre line were determined.

The traverse was then checked by latitudes and departures and the distance A B computed to be 3,245.61, which was practically a dead check. A summary of this check is given.

Bearing.	Length of course. Feet.	Lat.	Dep.	Diff. Lat.	Diff. Dep.
S.	870.50	870.50	......	......	......
N. 73° .25′ E.	2,447.12	698.43	2,345.33	172.07	2,345.33
S. 89° .56′ .46″ E.	496.25	0.50	496.24	172.57	2,841.57
N. 13° .54′ .54″ E.	1,125.88	1,092.83	270.85	920.26	3,112.42
S. 73° .31′ .44″ W.	3,245.61	920.23	3,112.41	0.03	0.01

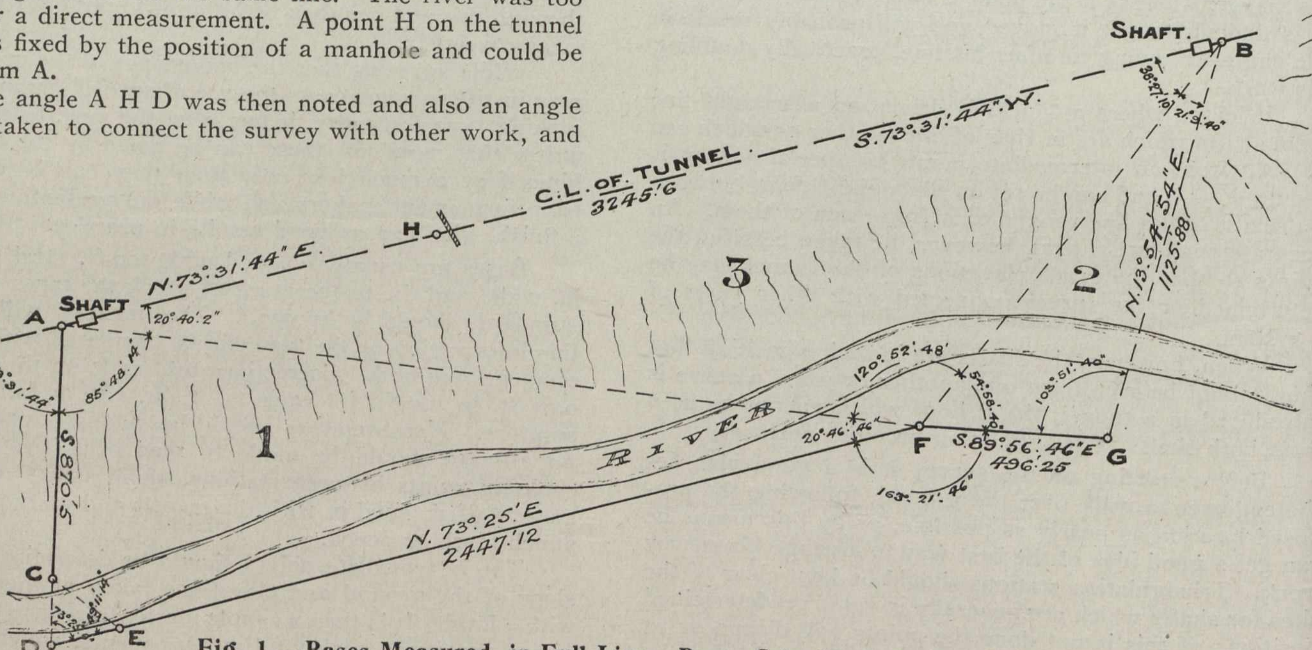


Fig. 1.—Bases Measured, in Full Line; Bases Calculated, Broken Line.

Upon working up the check traverse made between the points A and B along the hillside the results were found to agree very closely with those previously obtained.

The triangulation described is a fairly simple one, but the methods adopted can be applied to a more elaborate system if required.

Before construction starts, bench marks should be established well clear of each shaft for the purpose of fixing the grade elevations. They should, as far as possible, be placed so that the levelman can see both the bench mark and the shaft, from his initial set-up, midway between the points.

When a tunnel is projected under a city, following or crossing street lines, it is sometimes advisable on account of traffic interference, to make the surveys at night. The temperature is then more equable and the sight when illuminated, can be clearly seen by the observer. A box about 12 in. square with a front of tracing linen or frosted glass is used behind the sighting points and is illuminated in any convenient manner.

Having discussed the method of determining the direction between shafts, it is now proposed to give a short description of the method of transferring the lines underground and prolonging them until a junction is effected between the workings from adjoining shafts.

The first business is to lay out the working shafts, which should be upon the centre line if possible, although this is not always feasible. They should be long enough to give about 10 feet in the clear between the plumb-lines. As soon as the shaft has been timbered up and excavation started, a nail is driven into the timbers and a distance marked, showing depth from top of nail to subgrade. As soon as bottom is reached, line will be required by the miners for opening up the sidelengths.

The direction being known from a given point, the instrument is set up and an angle turned that will give the proper direction, or if a point has already been

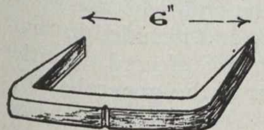


Fig. 2.

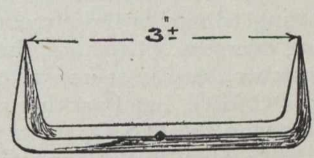


Fig. 3.

established on the centre line this is sighted on very carefully, so as to bisect the arrow or plumb-line. The telescope is then depressed and a point given on a brace on either end of the shaft; six-inch iron dogs, as Fig. 2, are then driven central to these points, care being taken to see that a line dropped from the dog will clear all obstructions below. The dogs being driven fairly tight, a small plumb-bob is dropped over them and the telescope focused on the cord, which is then moved so as to bisect the line of sight and a pencil mark is drawn on the face of the dog on either side of the cord. A file nick is now made between the lines about 1/16 inch deep and plumb-lines dropped to the bottom of the shaft. The transit cannot be used in the bottom until one or two tunnel lengths have been excavated and completed, but centres can be given with sufficient accuracy, by stretching a cord from the shaft into the tunnel and adjusting it so that it just touches either plumb-line.

Some engineers use a slow-motion screw device for bringing the lines into adjustment but the iron dog will be found to give as good results, and perfect adjustment can be secured by striking the shoulder of the dog with a hammer, so as to draw the line over as required. The usual practice is to use 25 B.W.G. piano wire for the plumb-lines, but the writer prefers to use a strong plaited line, such as is used by sea fishermen. If this is treated in a bath of boiled oil and dried it will remain waterproof and be free from kinks, and will give considerable service. It has the further advantages of being easier to handle and requiring a lesser weight to bring it taut. The piano wire requires at least 20 lbs. to effect this, while about 7 lbs. is sufficient for the cord. This difference in weight will be appreciated by the assistant who is responsible for carrying the weights around.

For use with the cord, the writer designed a plumbing weight as shown in Fig. 4. The body of the weight is in the shape of a shell with three vanes cast on the sides at angles of 120°. A screw top similar to those used on an ordinary plumb-bob is fitted and the line knotted through this. When the lines are dropped down the shaft the plumb-bobs are suspended in a pail of water and the tension on the cord will cause them to rotate. The vanes, however, soon stop this movement and the lines come to perfect steadiness in a very short time. Care must be taken to see that the plumb-bob does not touch the pail anywhere, or that the lines are fouled by any of the braces.

When it is desired to project the line into the tunnel, the transit is set up behind the back line, just near enough to clearly focus it, and the instrument is set on the centre of the line. The focus is now altered to catch the forward line which will probably be found to be off. The transit must now be moved either to the right or left and the operation repeated until both lines are exactly bisected when in focus. When this result has been attained a point may be given in the tunnel as far ahead as can be seen and two intermediate points should also be established on the permanent work. If, on checking the line at some later date, these three points are found to agree they may be adopted as a permanent base and the line extended from them.

For fixing centres in a brick-lined tunnel, a small steel dog, made as Fig. 3, is very useful. This is driven astride the keying course so that a space is left between the inside of the dog and the brick. When giving line a plumb-bob is suspended by a cord, with a lighted screen behind it and the line moved until the transit bisects it. A pencil mark is then made on either side of the line and a nick filed between them. The plumb-bob is now hung in the nick and the line adjusted by tapping the dog with a hammer until the line is truly bisected.

The ordinary tripod will not be found of much service underground as it is difficult to obtain a rigid foundation, on account of tracks, etc.

To overcome this, a platform is sometimes suspended from the roof and rigidly braced and the transit is placed upon this on a small tripod. The observer's seat should be independent of the platform. A sketch of such a tripod made of malleable cast iron suitable for a three-screw instrument is shown in Fig. 5. For an instrument of ordinary design, a screwed ring must be attached to the body of the tripod. The tripod shown in the sketch has V grooves cut in the top at angles of 120°. The ball at the foot of the levelling screws rests in these and the weight of the instrument will retain it in place. A hole about 3 inches in diameter is cast in the top of the tripod so that a small plumb-bob may be dropped from the instrument for centering purposes. This is very useful

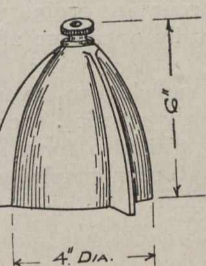


Fig. 4.

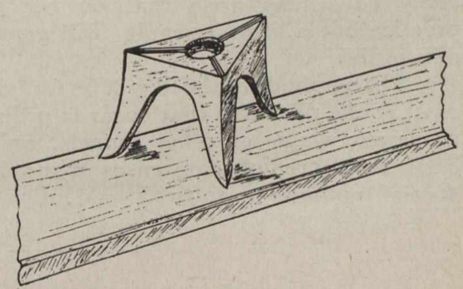


Fig. 5.

when ranging curves, for setting over the B.C. or other points.

For small tunnels up to 12 feet diameter it is best to use a plank wedged across the tunnel at springing for a platform. The top of the plank should be cleaned, so that the tripod can be moved easily upon it when making lateral adjustments.

When a curve occurs in a tunnel, the P.I. must be carefully located by a surface survey and then established in the tunnel from the information obtained, although this cannot always be accomplished owing to the point coming outside the limits of the tunnel section.

In such a case, when the B.C. has been established, the point is plumbed on to the platform and the transit set up over the point, a sight being taken on the back tangent. The telescope is then transited and an angle turned off, which must be calculated from the distance of the face from the B.C. This point should be checked by again sighting on the back tangent with the telescope turned through an angle of 180° from its original position and then reversing and setting out the same angle as before, the mean of the two observations being the correct point on the curve. This process is continued as far as can be seen, when the transit is moved forward to an intermediate station and the usual procedure followed. When the curve is completed and the E.C. established, the transit is set over it, a sight is then taken on one of the intermediate points and an angle turned which will give the direction of the forward tangent. This should be very carefully checked as soon as the tunnel has proceeded far enough to give a good working base line for the new direction.

It frequently happens that the B.C. is so near the working face that a point on the curve cannot be focused. In such a case a line fastened to one of the back points on the tangent and passing vertically over the B.C. is stretched into the heading and a cord measurement taken from the B.C. to the approximate centre. The deflection angle is then calculated for this cord and the natural sine of this angle multiplied by cord length will give the length of an offset from the produced tangent, at right angles to it, that will pass through the centre, at the end of the cord.

Grade elevations are established as follows: The grade at the shaft being determined, a stout nail is driven in one of the top braces of the shaft and the elevation of the head noted. A steel tape is then lowered vertically down the shaft and another nail fixed about invert level. The difference between the heads of the two nails is then measured and the measurement subtracted from the elevation of the upper nail, will give the elevation of the head of the lower one. This can now be used as a turning point from which bench marks can be established through the tunnel. These are sometimes placed in the roof so as to be clear of interference from traffic, the rod being inverted when a reading is taken and the reading added to the H.I.

Engineers who have to deal with tunnel work will find many conditions arise that do not occur in ordinary practice but a little ingenuity will generally overcome all difficulties.

The methods outlined will be found sufficient to cover most of the problems that occur in ordinary practice, such as sewer, water or other tunnels, and will also form a basis for more intricate cases that may occur requiring special methods to determine the alignment.

SUBMARINE OIL PIPE-LINES.

Owing to the unfavorable nature of the comparatively shallow water close in to the coast, the Mexican Eagle Oil Company originated the idea of laying submarine pipe-lines to points where the largest tankers could be conveniently moored for loading purposes at any state of the tide and weather. They have three deep-sea loading berths at Tuxpam Bar with duplicate pipe-lines to each berth; the Penn Mexican Fuel Company also has two loading berths equipped with pipe-lines in duplicate. The lines terminate in 43 feet of water, which is below wave-action, and at the point where the pipe ends 120 feet of armored flexible hose is attached. The free end of the hose is closed by a blank flange and allowed to lie on the sea-bottom when not in use, its position being marked by a buoy with a chain sufficiently strong to lift it.

The rise and fall of the tide is approximately two feet, so that the depth of water, 43 feet, is sufficient for the largest tank steamers to load at any time. Tankers of 15,000 tons dead weight, drawing 28 feet, are regularly loaded.—Journal of the Royal Society of Arts.

ENGINEERS' CLUB, TORONTO.

The annual meeting of the Engineers' Club of Toronto was held last Thursday night, February 3rd, at the Club headquarters, about forty members being present.

The chair was occupied by Mr. C. H. Heys, president of the club, who, in presenting the annual report, made reference to the disturbed conditions of the country and their effect upon the membership.

A very healthy feature of the report is the present membership of the club as compared with that of a year ago. At the close of 1914 the total membership of the club was 455, whereas at the end of December, 1915, the total membership was 493. Furthermore, since then 49 new members have been accepted, making the present membership 542.

In the course of his address, the president paid a fitting tribute to those members of the club who are serving overseas. Of these, there are 28, and included in that number there is one on whom has been conferred the title of "C.M.G." and another, a member of the general staff, has won the D.S.O.

In view of the important engineering works that are being carried out and proposed in and around the city, the hope was expressed that with the large number of men who must necessarily be engaged on these works, together with the present membership, the year 1916 should prove a very successful one for the club in every respect.

Votes of thanks to the retiring president for his painstaking and able administration in 1915 and also to the secretary and the staff were proposed and most heartily supported.

The five new directors elected at the meeting to take the place of those retiring were: Messrs. H. G. Acres, Alfred Burton, J. B. Carswell, T. H. Stevens and M. P. White.

The full Board of Directors for the year will be as follows: Messrs. H. G. Acres, J. R. W. Ambrose, W. A. Bucke, Alfred Burton, J. B. Carswell, E. L. Cousins, A. G. Cumming, D. A. Dunlap, Arthur Hewitt, Chas. H. Heys, Chas. W. Power, L. V. Rorke, T. H. Stevens, M. P. White, T. S. Young.

Altogether the meeting was a very encouraging one and augurs well for a very successful year's work. After the meeting refreshments were served.

STEEL BILLETS FOR GREAT BRITAIN.

Mr. J. E. Ray, Trade Commissioner, Birmingham, has cabled the Department of Trade and Commerce, Ottawa, asking for quotations from Canadian manufacturers in connection with five hundred tons steel billets, three inches square, eighteen feet long, carbon point ten point fifteen; and same quality four square, two feet eight inches, carbon point three point thirty-five, earliest delivery c.i.f. Liverpool. Quotations are also asked c.i.f. Liverpool, earliest delivery for square steel billets, 200 tons each, size 2 inches, 2½ inches, 3 inches, 3½ inches, 4 inches, lengths 16 to 18 feet, carbon point 1 to point 15. It should be stated whether process is acid or basic. Firms interested are invited to cable Mr. Ray quotations forthwith.

The Department of Highways, Ontario, will be pleased to receive current catalogues and literature from manufacturers of and dealers in roadmaking material and equipment. Geo. Hogarth, Chief Engineer of Highways, Parliament Buildings, Toronto, Ont.

The 1916-17 estimates tabled in the House of Commons by the Minister of Finance recently provide for the organization and equipment of an Explosives Division of the Mines Branch, Department of Mines, Ottawa, for investigative work in connection with the manufacture and storage of explosives.

Editorial

CANADA'S CAPITOL FIRE.

Whether the great conflagration in Ottawa last week was the result of incendiarism is still a questionable matter. It is doubtful if the Commission which is to investigate the origin of the Parliament Building fire will be able to satisfy itself as to whether it was the crime of an enemy, the caprice of a maniac, or the outcome of an accident. But, at all events, the Commission will take cognizance of the rapidity with which the fire spread and of the inflammable nature of the interior of the building.

As an edifice of architectural beauty the central structure of the Ottawa group of federal buildings has been the pride of Canada for half a century. Older than the Dominion itself, its corner stone was laid in 1860 by the Prince of Wales, the late King Edward VII. While the original building cost $5,000,000, it is doubtful if an equal sum could replace the added embellishments and interior grandeur.

Its destruction has been serious; above all, in deplorable loss of life and in physical injury to many of our statesmen upon whose shoulders rests at this crisis grave responsibilities. Next in importance, probably, has been the obliteration of volumes of records, documents, parliamentary proceedings, papers, etc., not in the library or vaults. This loss will be felt for many years to come. There is also the serious disruption and distraction of an important parliamentary session. There is, lastly, the building loss.

That the fire leapt with incredible speed over the recently shellacked floors is common to the reports of many of the rescued. Induced by heavy drafts, a little headway, and the great edifice became a formidable fire trap.

It is to be hoped that Parliament will see its way clear to proceed immediately with the construction of a new federal home; that the design will demand the strictest devotion to the science of fireproofing, classical and grand though the architectural features may be made; that the idea of modern fireproof construction be extended without delay to other buildings of the Capitol group; and that the Government library, which by good fortune escaped with damage by water alone, will be among the first to receive attention in this respect. Had the fire destroyed the Ottawa library, Canada's loss would have been considerably greater than it is.

THE COAL SITUATION IN SASKATCHEWAN.

There is a serious shortage of coal in the province of Saskatchewan at the present time, according to press dispatches. It was announced in the Provincial Legislature on January 31st that in a certain village people are closing their homes and going to live at the hotel, the latter being the only place securing a supply of coal. The report states further that farmers were driving 50 and 60 miles in search of purchasable fuel. The severity of winter conditions during the month of January practically paralyzed transportation facilities in many sections, and the fuel situation has accordingly become acute.

This seems strange in a province possessing large coal deposits. According to a recent report prepared by Mr. D. B. Dowling, of the Geological Survey, the Souris area, comprising eight townships, is estimated to contain 2,304,000,000 tons of coal, while the western portion of the province contains, in an area of about 5,900 square miles, deposits probably aggregating 24,000,000,000 tons. The latter figure is an approximate estimate, but the Souris deposits have been calculated from investigation of actual thickness and extent of seams.

Coal is of many varieties, however, and the Saskatchewan deposits furnish fuel of the lignite class only. Some of the physical characteristics of this lignite in its raw state prevent its successful and economical use. As a result, the production during recent years has been in no way comparable with the increase in population. There has, accordingly, been an increasing dependence upon outside sources of supply, with the resulting dearth of fuel at the time of greatest need, *viz.*, when the railways are tied up owing to stormy weather.

There are 12 operating coal mines in Saskatchewan. In 1914 these produced 232,299 tons of coal, averaging $1.61 per ton. Although this is the largest output on record for the province, the average for the past four years has been 219,080 tons—extremely small in proportion to the needs of the province.

The importance of devising suitable methods of utilizing the large resources of lignite have been brought to the attention of the government and the results of investigations are now available. As large quantities of the same variety of lignite exist also in the province of Alberta, it is important that these investigations be followed up, although Alberta has a good supply of coals of harder and greater heat-giving varieties.

The Saskatchewan Government report, prepared about fifteen months ago by Mr. S. M. Darling, on the briquetting of Saskatchewan lignite, emphasized its adaptability for use for domestic and power purposes. In view of the high price of anthracite in the province, and more especially of the liability to coal famine, such as that now being experienced, the problem of developing local coal deposits should be thoroughly investigated.

THE WINNIPEG-SHOAL LAKE AQUEDUCT.

As a result of a number of cracks that have appeared in some of the constructed portions of the Shoal Lake aqueduct, considerable interest has been aroused in Winnipeg by statements reflecting upon the engineers of the aqueduct scheme and upon the adopted design of the works. The statements of Mr. M. T. Cantell, formerly employed in the engineering office of the District, have created a certain amount of misapprehension in the minds

The Winnipeg office of The Canadian Engineer has been moved from Room 1008 to Room 1208, McArthur Building. The new telephone number is Main 2663. Mr. G. W. Goodall remains in charge of the office.

of the citizens as to the real situation, and the Commissioners are at present proceeding to advise the public in detail regarding the condition of the work.

The Greater Winnipeg Water District is a corporation comprising, in addition to the city of Winnipeg, the city of St. Boniface, the town of Transcona, the rural municipality of St. Vital and portions of the rural municipalities of Fort Garry, Assiniboia and Kildonan, all of which adjoin the larger city. The system of water supply which the District is constructing is designed for a gravity flow of about 85,000,000 Imperial gallons of water per day from Shoal Lake, over a distance of about 95 miles, with a difference of elevation of approximately 300 feet. Since the first official announcement of the scheme, in September, 1913, many articles have appeared in *The Canadian Engineer* relating to the unique features of its design and the progress of construction of the portions already under contract. The part of the works to which the above-mentioned charges refer is a concrete aqueduct extending from Shoal Lake to within ten miles of the city of Winnipeg, a distance of 84.73 miles. The lengths, slopes, elevations and dimensions of its various sections will be found in an illustrated article which appeared in the issue of this journal for October 23rd, 1913.

The line of the aqueduct is through a practically unsettled country with large areas of swamps, marshes and muskegs. Throughout the greater part of the work so far completed an excellent foundation for the aqueduct has been secured at convenient depth, the subsoil for practically the entire distance being a sandy clay impervious to water. The deepest muskeg encountered by the aqueduct trench has been 15 feet. The foundation for the aqueduct along this section has been prepared by placing a gravel bottom protected by piling along the sides. The aqueduct over this portion is reinforced on account of the soft yielding sub-surface stratum. This is practically the only instance, we understand, where aqueduct foundations have as yet been required.

The sections which have occasioned the controversy are in a portion of the aqueduct extending through prairie where the cuts have been shallow and where the soil is of clay with no admixture of sand or grit and with varying moisture content. Difficulties in maintaining rigid and unyielding foundations in this region had been expected, but in order to build an aqueduct through this country that would have been proof against settlement and against cracks, concrete pile foundation would have been necessary, greatly increasing the cost of the work. It has been officially stated that before the specifications were written it was known that there were places in this section where settlement might occur after the work was constructed; but it was also known that the percentage of the total length which would be apt to settle would be very small and that it would be more economical to repair or even reconstruct these portions than to design an aqueduct that would not admit of any settlement at any point.

The portion in which settlement has actually occurred is where, in shallow cut, 4 feet of backfill had been placed over the arch. When the cracks appeared experiments were commenced to determine where the full amount of backfill, *viz.*, 4 feet, could be placed without injury to the concrete, in order to avoid a repetition of the condition under consideration. The engineers feel that no anxiety should exist, for the reason that settlement was expected, that the cracking is not of serious consequence and can be repaired at small cost, and that the behavior of these portions will be a guide in the construction of the remaining work. Of the 12 miles of the aqueduct completed, it is stated that considerably less than one-half mile has shown defects on account of settlement. On January 25th the Commissioners submitted a tabulated statement, from which the following percentages have been derived:

Percentage of whole aqueduct having cracks in invert ¼ in. in width	.27
Percentage of whole aqueduct having cracks in invert 1/16 in. to ¼ in. in width	.37
Percentage of whole aqueduct having hair line cracks	8.17
Total percentage of aqueduct having any crack	10.81
Percentage of whole aqueduct having no cracks that eye can perceive	89.19
Total	100.00

The statement is also made that only 2.64 per cent. of the completed work is sufficiently affected to require attention.

This is an official reply to the statements that were circulated on January 22nd to the effect that 8 or 10 miles of the aqueduct were absolutely useless and would have to be reconstructed at a cost of upwards of $2,000,000. These and other statements and allegations received such publicity in the Winnipeg press that the stability of the work completed to date was a matter of doubt in the public mind. The statement submitted to the District did not lay specific charges regarding construction, but had to do simply with the question of design. Mr. Cantell's own summary of his contentions are as follows:

"(1) That a sum of money in excess of $25,000 was paid by the commission for absolutely useless plans.

"(2) That the plans which were submitted by me would have fulfilled their requirements completely, and had one of them been accepted it would have cost approximately $1,125,000 less than the plans originally submitted.

"(3) That the designs at the present time being followed were prepared to be used only in rock, and they are being used in all kinds of soil, including clay and muskeg, and if used throughout the line, failure and very heavy additional cost are inevitable."

With respect to the expenditure of $25,000 "for absolutely useless plans," remembering Winnipeg's long and laborious search for a suitable water supply, little need be said. The scheme at present under way, estimated to cost over $13,000,000, is the result of many years' investigation of suitable sources and of thorough preliminary engineering study and design. Regarding the second contention, it is only necessary to observe that the plans submitted by Mr. Cantell no doubt received the consideration of the authorities. Mr. Cantell was in the employ of the District at the time when the adopted plans were under consideration. The validity of the third contention is inconceivable. The personnel of the engineering staff of the District, and the thorough preliminary investigation of the line of the aqueduct are known to our readers.

GARRISON CREEK STORM OVERFLOW SEWER, TORONTO.

The article in *The Canadian Engineer* for January 27th, 1916, relating to the construction of the main Garrison Creek storm overflow sewer and extensions, Toronto, presented some figures of labor and material costs. For a better understanding of the information given in this important section of the article, we have received from the author the following figures, upon which the labor costs were based: Engineers, 50c. per hour; foremen, $4 per day; bricklayers, 70c. per hour; signalmen, 30c. per hour; laborers, 25c. per hour (average; teams, $6 per day.

COAST TO COAST

Hamilton, Ont.—The question of a municipal gas plant came up at a meeting of the board of control last week when a shortage of gas was under discussion.

Kingston, Ont.—R. H. Fair, road superintendent, reported that during 1915 the sum of $21,416.25 had been expended upon the good roads system in the county.

London, Ont.—The agreement between the London Railway Commission and the Michigan Central Railway Co. for operating over the lines of the London and Port Stanley Railway has been signed.

South Vancouver, B.C.—Two piers of the bridge across the north arm of the Fraser River, between Twigg Island and Richmond, were swept away by ice recently, causing considerable damage to over 100 feet of the structure.

Toronto, Ont.—Plans and specifications are almost completed for the construction of an eastern entrance to Exhibition Park. The proposition involves a bridge over the railway tracks and the laying of a considerable length of street railway line.

Welland, Ont.—Last year $231,367.04 was expended by the county on the good roads system, upon which the government grant amounted to $77,222.35. About 83 miles have been completed to date out of a total of 133 miles, and the cost averages about $5,000 per mile.

West Vancouver, B.C.—Considerable damage has been done along the water front by recent heavy storms. A portion of the roadway of the Pacific Great Eastern Railway has been washed out, the service being temporarily interrupted. Several docks and light houses were also slightly damaged.

South Vancouver, B.C.—In connection with the present sewerage scheme which the municipality has under construction, Mr. S. B. Bennett, municipal engineer, reports that up to January 21, $154,000 had been spent on sewer construction, leaving a balance of approximately $146,600 to complete the work.

Quebec, Que.—The C.P.R. will lay out extended terminals in Quebec after the new station is completed, and business recommences under more favorable auspices. The company has extensive terminals; but the new layout will prepare for and anticipate the future. The Transcontinental will use the new station as well as the C.P.R.

Prince George, B.C.—The experiment which the Grand Trunk Pacific is carrying out of burning oil as fuel is regarded with interest by other railway corporations. The Grand Trunk Pacific uses oil on 700 miles of track, in the West. To make this possible it had to complete and set up oil plants at Jasper, McBride, Prince George, Endako, Smithes and Prince Rupert. The original cost was very heavy, but the advantages are many and important.

South Vancouver, B.C.—Construction work is under way on the Commercial Street trunk sewer, some 850 ft. of 48-inch and 580 ft. of 42-inch pipe being laid. The engineer has recommended a further length of 1,875 ft. of 42-inch pipe to extend southward, and estimates in connection with this a total expenditure of $17,800. The Albert Street trunk sewer requires about 550 ft. of pipe to complete it. The pipe used in these sewers is being manufactured by the Pacific Lock Joint Pipe Company.

North Vancouver, B.C.—The Amalgamated Drydock and Engineering Co., Limited, will establish, under the supervision of the Dominion Government, a drydock and shipbuilding plant on the north shore to cost about $4,500,000. The government has subsidized the undertaking and the city of North Vancouver has guaranteed bonds to the extent of $750,000. The graving dock will be 1,150 ft. long with an entrance width of 110 ft. and a depth at ordinary spring tides of 41 ft. over the sills. The dock will be in two sections, 650 ft. and 500 ft. long respectively. With the exception of the Lauzon dry dock at Quebec, it will be the largest on the continent.

Hamilton, Ont.—A meeting of the board of control was held last week at which Mr. J. N. Stanley, one of the engineers of the Hydro-Electric Power Commission of Ontario, exhibited the hydro-radial plans showing the proposed routes of the various entrances into the city. It is proposed to carry the passenger traffic through the centre of the city and to divert the freight traffic to the north end. The aim is to have the hydro-radials and the C.N.R. use a common right-of-way for freight. It is planned to have the city assume control of an electrically operated interswitching system for the use of all steam and electric railways subject to the rulings of the Board of Railway Commissioners.

PERSONAL.

F. T. LEVERSUCH, general manager of the London and Port Stanley Railway, has resigned.

E. B. STAVELEY, of Quebec, is the president for 1916 of the Quebec Association of Architects.

R. L. BRACKIN has been elected chairman of the Public Utilities Commission of Chatham, Ont.

R. WRIGHT has been appointed superintendent of terminals of the Grand Trunk Railway System.

JOHN DIGBY, formerly assistant engineer, has been appointed city electrical engineer of New Westminster, British Columbia.

WM. TANSLEY has been appointed district superintendent of the Canadian Pacific Railway, with headquarters at London, Ont.

WM. McNAB, M.Can.Soc.C.E., principal assistant engineer of the Grand Trunk Railway since 1907, has been appointed valuation engineer for the company.

A. W. WHEATLEY, vice-president of the Canadian Locomotive Company, Kingston, Ont., has been appointed president of the Lima Locomotive Corporation.

H. H. VAUGHAN, Mem.Can.Soc.C.E., vice-president of the Montreal Ammunition Co., Limited, has been made a vice-president of the Dominion Bridge Co.

H. M. SCOTT, Assoc.M.Can.Soc.C.E., who has been for a number of years in the employ of Mr. Henry Holgate, consulting engineer, Montreal, has enlisted for overseas service.

FRANK P. VAUGHAN, manager of the Vaughan Electric Company, Limited, St. John, N.B., was recently elected a member of the American Institute of Electrical Engineers.

H. N. KEIFER, of the Northern Electric Company, Vancouver office, has been elected secretary of the Vancouver section of the American Institute of Electrical Engineers.

F. M. RUTTER, for a number of years on the engineering staff of the Canadian Pacific Railway, has been appointed superintendent of transportation of the Eastern Ontario Section of the C.P.R.

A. G. GRAVES, city commissioner of Calgary, addressed the Calgary Branch of the Canadian Society of Civil Engineers a short time ago, the subject being "The Administration of Public Utilities."

J. L. MORRIS, C.E., O.L.S., of the firm of Morris and Moore, land surveyors and architects, Pembroke, Ont., and ex-mayor of the town, has been appointed engineer for the township of Pembroke.

C. H. RUST, city engineer of Victoria, B.C., read a paper last week before the Seattle Branch of the American Society of Civil Engineers, describing the design and construction of the Sooke Lake waterworks system.

ARTHUR CRUMPTON, M.Can.Soc.C.E., has been appointed assistant valuation engineer for the Grand Trunk Railway System. Mr. Crumpton has occupied the position of assistant engineer for the G.T.R. since 1892.

E. T. COCKRELL, secretary of the Burrard Inlet Tunnel and Bridge Company, Vancouver, B.C., has resigned. Mr. Cockrell is attached to the Sixth Field Company, Canadian Engineers, and is leaving shortly for the front.

F. BURCHELL, C.E., of the Nova Scotia Construction Co., and a graduate in civil engineering of Queen's University, Kingston, has enlisted for active service and is now a bombardier in the 63rd Battery at Fredericton, New Brunswick.

C. D. HOWE, engineer in charge of the construction of the Dominion Government grain elevator at Burrard Inlet, addressed the Vancouver Branch of the Canadian Society of Civil Engineers recently on the subject of elevator construction and grain transportation.

Lieut.-Col. C. H. MITCHELL, C.E., general staff officer of the Canadian corps in France, has received the D.S.O. in recognition of distinguished service at the front. Col. Mitchell is well known to our readers as a member of the consulting engineering firm of C. H. and P. H. Mitchell, Toronto.

Lieut.-Col. GEO. H. DAVIS, B.Sc., of Barnet, B.C., and formerly town engineer of Woodstock, Ont., who is in command of the Second Pioneer Battalion, which has been in England for the past few months, is seriously ill and in a hospital as a result of a fall from his horse. Col. Davis, who is an associate member of the Canadian Society of Civil Engineers, is a graduate of McGill University, Montreal.

ENGINEERING SOCIETY DINNER.

The 26th annual dinner of the University of Toronto Engineering Society was held on February 4th, Mr. W. L. Dobbin presiding. Upwards of three hundred graduates and undergraduates of the Faculty of Applied Science and Engineering were in attendance. Among the speakers were President Falconer, Dean Ellis, Lieut.-Col. W. R. Lang, Mayor T. L. Church, Geo. G. Powell, deputy city engineer, and L. M. Arkley, secretary of the Toronto Branch of the Canadian Society of Civil Engineers.

At the recent annual meeting of the Corporation of Land Surveyors of the Province of British Columbia the following surveyors were elected officers for the ensuing year: President, W. S. Drewry; vice-president, E. B. Hermon; secretary-treasurer, W. S. Gore; board of management, N. F. Townsend, F. C. Green, O. B. N. Wilkie, S. S. McDiarmid, J. Elliott.

OBITUARY.

The death occurred recently of Mr. Alexander Graham at the age of 51. The deceased was superintendent of construction in the engineering corps of the Department of Public Works, Ottawa, and at the time of his death was in charge of some government work under construction at Sturgeon Falls, Ont.

The death occurred recently of Mr. Guy Colin Carman, M.Can.Soc.C.E., in former days a prominent civil engineer and railway builder. The deceased was in his 80th year. When the Canadian Pacific Railway was under construction Mr. Carman was engaged on the British Columbia section of it. For many years he was engineer of the Cornwall Canal, from which position he retired some fifteen years ago.

CORRECTION.

In "Niagara River Pollution," on page 217 of last week's issue, the wording of the first paragraph conveys, by no means, a clear meaning owing to the inadvertant omission of one line and the repetition of another in its stead. The first sentence on page 218 should read: "It is likely that an intercepting sewer will be proposed to collect the discharges from the Seneca, Park and Orchard outlets and to convey the sewage to a projected disposal plant, presumably near the Orchard Street outlet." The sentence in question refers to a probable requirement of the coming report of the International Joint Commission regarding the pollution of boundary waters.

COMING MEETINGS.

NINTH CHICAGO CEMENT SHOW.—At Chicago, Ill., February 12th to 19th. R. F. Hall secretary, 208 South La Salle Street, Chicago, Ill.

NATIONAL CONFERENCE ON CONCRETE ROAD BUILDING.—Second National conference to be held at Chicago, Ill., February 15th to 18th, 1916. Secretary of the Advisory Committee, J. P. Beck, 208 South La Salle Street, Chicago, Ill.

AMERICAN CONCRETE PIPE ASSOCIATION.—Annual Convention to be held in Chicago, February 17 and 18, 1916. Secretary, E. S. Hanson, 538 S. Clark Street, Chicago, Ill.

CANADIAN LUMBERMEN'S ASSOCIATION.—At Ottawa, February 18th, 19th and 20th, 1916, annual convention. Frank Hawkins, secretary, Ottawa.

NATIONAL PAVING BRICK MANUFACTURERS' ASSOCIATION.—Meeting to be held in Cleveland, Ohio, February 21st and 22nd. Will P. Blair secretary, Brotherhood of Locomotive Engineers' Building, Cleveland, Ohio.

AMERICAN ROAD BUILDERS' ASSOCIATION.—Thirteenth Annual Convention to be held at Pittsburgh, Pa., February 28th to March 3rd. E. L. Powers secretary, 150 Nassau Street, New York, N.Y.

CANADIAN MINING INSTITUTE.—Eighteenth annual meeting to be held at the Chateau Laurier, Ottawa, March 1, 2 and 3. Secretary, H. Mortimer-Lamb, Ritz-Carlton Hotel, Montreal.

THIRD CANADIAN AND INTERNATIONAL GOOD ROADS CONGRESS AND EXHIBITION to be held at Sohmer Park, Montreal, March 6, 7, 8, 9 and 10, 1916. General Secretary, Geo. A. McNamee, New Birks Building, Montreal.