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Contents of this issue on page 5

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ROAD MATERIAL RESOURCES OF ONTARIO

NOTES FROM A GEOLOGICAL REPORT ON THE OCCURRENCES OF SUITABLE SAND, GRAVEL AND STONE, THROUGHOUT THE PROVINCE.

WITHIN the last few years there has been a great awakening to the need of better roads in the various provinces of Canada. Two of the provinces, Quebec and Ontario, now have official departments or bureaus whose business it is to supervise the building of their country highways, and it is probable that other provinces will soon follow the good example set them by these two.

The materials with which the great majority of highways are surfaced are broken stone and gravel. Certain gravels and some kinds of stone are tough and hard, and may be used upon roads subjected to heavy travel; others are softer and soon wear out under the abrasive action of the traffic. The taxpayer and road-builder are interested, first, in the relative cost of placing any one of a number of available types of broken stone upon a particular road to be constructed; and, second, in the relative service or wear that can be obtained from them after they are on the road. A local stone, even if rather soft, can sometimes be used to advantage to cover a country road. If the traffic over the road is light, the surface may last long enough to repay the neighboring taxpayers, in the time and money saved in hauling their produce, for the cost of building. If the traffic is heavy, the surfacing with a soft stone may mean a great waste of money, for under such conditions a road surfaced with soft stone may wear out and need resurfacing in a year or less.

It is, therefore, important that the deposits of stone and gravel occurring in the more thickly populated districts of Canada be studied to determine their road-making qualities, and mapped to enable road engineers to estimate the amounts available and the distances of the deposits from prospective roads.

In the spring of 1914 the geological survey branch of the Department of Mines, Ottawa, began a general survey for road materials in the Province of Ontario.

The officers of the Geological Survey have been studying occurrences of stone and gravel in all parts of Canada for more than half a century, and have much information of this kind at hand; they are, therefore, able as an organization to carry on the work of further explorations in this department to advantage. The results of the first season's work are reported in the recently issued summary report (for 1914) of the Department.

The plan which is being followed is to co-operate with the provincial highway departments, and to carry on the surveys in such a manner that the information obtained can be put to immediate use in road-building operations. For example, a report upon the materials available for a concrete road, which is now being constructed between Toronto and Hamilton, was furnished to the provincial highway commissioner when the project was under contemplation, and another upon a road from Toronto to Oshawa was transmitted to his department later. Both reports are based upon surveys made last summer. Besides work of this kind, detailed surveys have also been made of particular counties and a general survey in order to locate deposits of high-grade material.

During the last field season the work has been entirely confined to Ontario, but the department expects to make explorations in both Ontario and Quebec in 1915, and in other parts of Canada.

The information obtained will be on file at the office of the Geological Survey, and will, under suitable restrictions, be available to the public. Reports upon materials for special highways will be furnished those engaged in building them wherever it has been possible to do the necessary field work, and the Survey will print reports upon the road metal deposits available in certain districts. These districts will probably comprise one or more counties, or may embrace a whole province, the report in such cases being a more generalized account of the better classes of road materials in the province.

The following is a brief résumé of the season's work. Information in greater detail upon road materials within the areas visited is on file in the office of the Survey and is available to those engaged in road-building upon application to the Director of the Geological Survey.

North Shore of Lake Huron.—Deposits of trap rock were examined along the north shore and on the outlying islands from a point north of Little Current to Blind River, and at Thessalon, Nestorville, and Bruce Mines.

At Bruce Mines a large quarry is now in operation with a crushing plant capable of handling 500 tons per hour. The quarry is on the water's edge and the crushed stone is loaded directly from the plant into large barges. The material is of very good quality for road and concrete work. The prices quoted in July, 1914, were $1 and 80 cents, respectively, per ton f.o.b. quarry for two grades, the higher price being charged for four sizes of material from less than ¼ inch to 1½ inches. Freight charges by boat without unloading were 35 cents to Detroit and 40 cents to Cleveland.

Other deposits of trap rock were found which contained several million tons of diabase, lying on the shores of islands and on the mainland. In most of them it would be possible in quarrying to obtain from 30 to 50 foot faces above the water level. Some of them lie near deep, natural harbors where docks could be constructed at low cost for boats drawing up to 20 feet of water. In other words, the deposits offer very excellent chances for economical quarrying and for cheap transportation by water of the crushed rock. There is no doubt that practically all the diabase will make excellent road material.

A Geological Survey party under the direction of Mr. W. H. Collins mapped strips of country from 5 to 10 miles wide along parts of the railway line between Bruce Mines and Sudbury. Areas of trap rock, of which there are many, were mapped within these strips and notes made on a few gravel deposits. A trunk highway following the railway is now under construction between Sault Ste. Marie and Sudbury.

The local road materials which are available for the lake port towns of south-western Ontario are, as a rule, of very poor quality, and as the population of this portion of Ontario increases the need for first-class road materials will be felt more keenly.

First-class trap rock can be transported by boat from the north shore of Lake Huron to points on Lakes Huron and Erie in old Ontario at a cost which will be very little higher, and in some cases lower than the freight charges by rail for inferior local material. When used in macadam roads subjected to heavy traffic, trap rock is very much superior to the local materials. Its greater durability in cases of that kind far outweighs its greater cost. It is of importance that builders of roads should realize the importance of the north shore as a source of supply for road material of high grade.

Essex and Kent Counties.—The bedrock in Essex and Kent counties is covered by from 50 to 200 feet of clay and sand, with occasional patches and ridges of gravel. The only bedrock available is at Amherstburg and on Pelee Island. The Amherstburg material is of poor quality. The limestone on Pelee Island has not yet been tested, but it is rather soft under the hammer and will probably not do for heavy traffic.

There is a ridge of sandy gravel between Essex village and Leamington, most of which is of poor quality. Scattered deposits of field stone were seen in the neighborhood of Kingsville and very sandy gravels at the town of Sandwich and to the south and east of it. Essex county contains no really first-class road material.

An area of gravels occurs in the south-eastern part of Kent county, south of the Pere Marquette Railway. These gravels lie in ridges which are all sand and gravel, or occur as patches of gravel in clay ridges. Most of these gravels, if not too sandy, make good light traffic roads, but are not durable enough for heavy country traffic, such as that between the villages of Blenheim and Ridgetown. The best gravel in the county seems to be that found on the Talbot road, a few miles east of Morpeth, which not only wears, but cements well. Good gravel is found on the Lake Erie beach, but it occurs in small amounts. Sandy gravels occur in the beds of the Thames and Sydenham Rivers, and areas of sand and gravel to the north-east of Ridgetown.

By far the greatest part of these two countes is underlain by boulder clay, and the roads in these sections are almost entirely unsurfaced, that is, they are clay roads. These clay roads are very sticky and slippery in wet weather, and, although most of the gravels found in Essex and Kent are too sandy and not durable enough for good macadam work, they will greatly improve a clay road if properly placed upon it. All the areas of sand and gravel in the two counties were, therefore, carefully examined and mapped.

The North Shore of Lake Ontario.—A narrow belt of gravel extends along the shore-line of Lake Ontario from Trenton to Niagara Falls and beyond. The gravels lie with sand in long, narrow bars along the winding shore-line of an ancient extinct lake (Lake Iroquois). The old shore is from 2 to 7 miles from the present shore of Lake Ontario, and 116 to 400 feet in elevation over it. This belt lies along one of the principal avenues of traffic in Ontario, and the character of the gravels is, therefore, of particular interest. They have been examined and mapped from Trenton to Hamilton.

The deposits are practically entirely of sand and gravel, the sizes of the material varying greatly from place to place. Clay is present in a few deposits only, but lime is very frequently found in greater or less amounts as a coating on the gravel pebbles. A small percentage of clay is an advantage in gravel used for the building of gravel roads. In concrete work of any kind, however, clay is a distinctly undesirable ingredient, and it is probable that a coating of calcium carbonate pebbles is also a source of weakness.

The relative durability of the gravels in this belt has been estimated from the relative proportions of the hard and soft pebbles in them, and from the way in which they wear on road surfaces. The more durable gravels appear to be those at the east and west ends of the city of Toronto, and from there west to Erindale village.

From Trenton to Toronto they are rather uniform in composition and in probable wearing qualities. The poorest gravels lie in three bars between Burlington and Oakville.

The party under Mr. M. Y. Williams examined the broad belt in south-western Ontario, south-west of the Niagara escarpment. Their work was not primarily concerned with road materials, but they incidentally located and examined a large number of gravel deposits. The belt so mapped is from 25 to nearly 100 miles wide and stretches from the Niagara River to Bruce peninsula.

The work in general was under the supervision of Mr. Leopold Reinecke, of the Geological Survey staff.

At the close of 1914 there were 2,562 water meters in London, Ont., an increase of 486 during the year. Only 17 per cent. of services are metered, although 24 per cent. of the water consumed passes through meters and furnishes 40 per cent. of the revenue. The consumption is about 81 imp. gal. per capita, and costs $34.15 per million gallons.

Should developments in the near future prove as highly successful as those during the past year, the United States is in a fair way to cast off the grip of the German Kali syndicate, which has had a practical monopoly of the world's potash salts industry. Experiments made in the Searles Lake basin of California have resulted in the production of potash salts at a cost under $10 a ton, in competition with the German kainit, 50 per cent. pure potash, produced at a cost of approximately $8 per ton. Other good potash prospects are those at Marysvale, Utah, and immense deposits in Wyoming, owned by a New York banking house, the latter claimed to run 10 per cent. potash as mined from the ground.

Costs of street repairs in Chicago have been reduced by the municipal asphalt plant. During 1913, according to the Municipal Record, asphalt pavements were repaired at a cost of 81.1c. per sq. yd., or 87.1c. per sq. yd., allowing for plant depreciation and interest on investment. At a total cost of $62,637.03 or $1.175 per sq. yd., 53,342 sq. yd. of brick pavements were repaired. Granite block pavements to the extent of 59,345 sq. yd. were repaired at 53.2c. per sq. yd., or a total of $31,593.04. Macadam pavements cost 12.16c. per sq. yd., 1,880,365 sq. yd. having been repaired at a cost of $227,443.03. Of cedar block pavements, 2,595 sq. yd. were repaired at a cost of $524.49, or 20.25c. per square yard.

FAILURE OF SEA-WATER CONCRETES.

THE failure of sea-water concrete has probably caused the concrete industry more arduous study, labor and anxiety than any other single trouble.

There is yet considerable disagreement among authorities as to the causes of sea-water disintegration, but there seems to be quite general concurrence in the opinion that the formation of calcium sulphoaluminate by interaction between the sulphates of sea water and the aluminates of the cement, are in very large measure responsible. This salt, calcium sulphoaluminate, increases largely in bulk with crystallization, and if such deposition of crystals were to take place in the pores of concrete, disruption by physical action might reasonably be expected. If this disrupting action were repeated numberless times in each of the countless pores existent in the average concrete, serious if not total disintegration might be expected.

In Mr. N. C. Johnson's paper, read at the June convention of the American Society for Testing Materials, on the "Microstructure of Concretes," he states that if the formation of such an expansive crystallin material were pictured as taking place in the cement matrix of a concrete, there would have to be imagined a gradual straining of the confining material, until rupture took place. It is significant as to the correctness of such an hypothesis that in the cement matrix of all concretes so far examined which show outward signs of disintegration, interior evidences of such strain are found by microscopic study.

In babbitts and bronzes, incipient fracture from stress is evidenced by "shear planes," or "slip bands," where one portion of the material has flowed over the other. In Fig. 1, reproduced at 110 diameters, taken from pile caps, Staten Island Ferry Pier, New York Harbor, are shown similar "shear planes" in a sea-water concrete which is noticeably disintegrating. It will be observed that these shear planes are at right angles to the polish scratches on the specimen, so that the lack of identity cannot be questioned. Under visual examination, these show as iridescent bands, changing in color as the focus is changed, as if they went to a considerable depth and at an angle to the plane of the surface examined.

Mr. Johnson indicates that this is not an isolated case, but that it is one of the most characteristic of all the formations found in under-water concretes.

Fig. 2, at 110 diameters, shows a second sample taken from pile caps, Staten Island Ferry.

Fig. 3, at 110 diameters, shows a third sample taken from pile caps, Staten Island Ferry.

Fig. 4, at 110 diameters, is taken from Pennsylvania Railroad Co. ferry piers, Cedar Street and Hudson River, New York Harbor.

It is very evident that all are of the same general type and nature, and that they indicate a condition of incipient rupture which is not only indicative of tremendous internal strains on the concrete, but also of a possibly dangerous condition of incipient rupture along the planes of these strain bands.

With regard to the latter, it is at least reasonable to infer that any force of a potency capable of causing incipient fracture in the cement matrix would exhibit further manifestations. Assuming that these shear planes are also relief planes for tremendous confined crystallin pressures, an extension of the crystallizing substance into such relief planes might be looked for.

If these shear planes are actually relief planes for crystallin, expansive formations in the pores of concrete, it is reasonable to expect that these planes would find their origin in a pore or fissure. This is found to be true. It is not always possible to connect the shear plane definitely with any pore or fissure in the plane examined, but in others this can be readily done. In samples magnified to 130 diameters, the formation of these relief planes have been noted in radiants from a pore; and the hard crystallin filling, different in texture and color from the cement matrix, could be seen by visual examination almost filling the pore and putting out feelers, or wedges, into the radiating fissures.

Nor is it reasonable to expect these wedging tenacles to stop with the formation of a slight relief fissure. Such a fissure must necessarily be narrow and as well adapted as was the originating pore to draw up the salt-bearing solutions by capillarity. This would mean, by a repetition of the same actions of capillary attraction and of solution, concentration and crystallization, that the formation of a crystallin intrusive feeler would follow in the relief fissure; and further, that this would grow so long as fresh supplies of solutions could be brought into it.

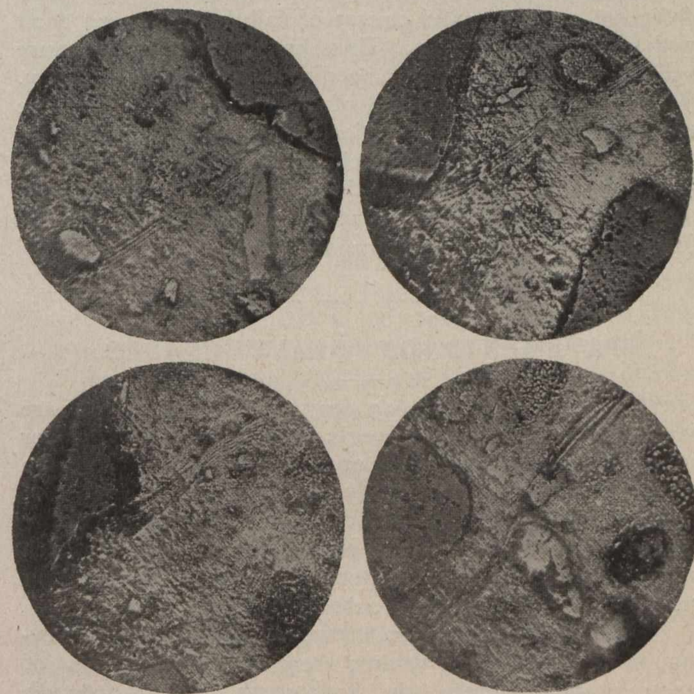

Fig. 1.—Examples of Shear Planes in Under-water Concrete (x110).

It has been found that these formations are not confined to salt-water disintegrations, and it must be inferred that compounds other than calcium sulphoaluminate are responsible for some disintegrations. Indeed, it would seem as if this line of reasoning might lead to an exclusion of sea water *per se* as the cause of disintegrations. The type of disintegration is cancerous in its nature, deriving its malignant substance through solution from the substance destroyed, just as cancer of the human issues has its sustenance directly from them. If this is true, the problem of making durable concrete for all services is essentially one of making concrete impervious.

Disintegrating actions of a like nature are exhibited in a number of concretes exposed to a wide variety of conditions of service. One of the most common are sidewalks, where ground water is absorbed by capillarity. Another common exhibition of them is in retaining or buttress walls exposed to seepage. In fact, so common are such conditions that they are accepted as the inevitable, and in the long run, a multiplication of such instances, caused directly by careless workmanship and lack of understanding and knowledge, are going to be factors in creating distrust of concrete in the popular mind, that will do a vast amount of damage to the concrete industry.

The subject of increasing hydration is a very important one. Results have indicated that much can be accomplished through lowering the surface tension of the mixing water by one means or another. These results, however, are not conclusive by any means. They are but tentative, and, although it was expected to have further results available at this time, this expectation was not realized through discontinuance of experimentation. This phase of the question, therefore, will be left for discussion until another time.

In conclusion, the author explains that in his paper defective concretes and causes of failure have been dealt with almost exclusively. This has been done because such concretes are those needing attention and study. Perfect concretes take care of themselves, and they are chiefly of interest in a critical study as forming bases of comparison. With this clearly understood, it is believed that there will be little cause for misinterpreting the attitude of the writer towards concrete as a material for general construction purposes.

PAVEMENTS ON HEAVY GRADES.

Grades greater than 15 per cent. on city streets are few and far between. Reports come in of 20 or 30 per cent. or even greater, but upon investigation these are generally found to be greatly exaggerated. Streets of even 10 to 15 per cent. are difficult of ascent for either horses or automobile traffic unless the pavement is both smooth and of such a character as to give a good gripping surface to horses' feet and automobile tires.

Mr. Stanley E. Bates, writing in Western Engineering, states that in Milwaukee there are two stretches of steep grade, namely, on Eighteenth and Nineteenth streets, where the grades are 13.5 per cent. and 15.3 per cent., respectively. Before improvement, these streets were little better than storm water courses and it was an extremely rare occurrence for any kind of traffic to try the ascent. In order to remedy this condition it was decided last year to pave them with concrete.

The concrete pavements of Sioux City, Iowa, some of which lie on 16 per cent. grades, were taken as a model for the construction, though some changes were made from the Sioux City specifications.

Both streets were paved 30 feet wide, the thickness of concrete ranging from 6 to 8 inches. Unprotected, transverse joints of tar and felt were spaced 25 feet apart and the concrete was crowned 4 inches.

The aggregates used in this work were sand, which was clean and well graded, and crushed granite ranging in size from 2 inches down. The surface was not corrugated but was finished rougher than is common for pavements on more level grades.

The Tagona Water and Light Company, with Ontario charter, has been dissolved.

DUCTILITY OF BITUMEN.

THE normal ductility of a bitumen is the distance expressed in centimetres that a briquette will stretch before breaking when tested under standard conditions. The standards and the method usually employed in ascertaining the ductility of a sample are outlined in the report of one of the subcommittees of the American Society for Testing Materials as follows:—

The mould used for making bitumen briquettes has the following dimensions:—

Total length (internal)	7.5 cm.
Distance between clips	3.0 cm.
Width of clips at mouth	2.0 cm.
Width of briquette at minimum cross-section (half-way between clips)	1.0 cm.
Thickness of briquette throughout	1.0 cm.

The clips containing the briquettes are pulled apart under water kept at 70° F. at a uniform rate of speed of 5 cm. per minute. They may be operated by any means that will give a uniform pull without appreciable vibration, the line of pull to be horizontal.

Some little work was done by the committee during the past year in the way of testing standard samples sent to different laboratories. Four sets of samples were sent to six different laboratories. The samples were selected by Mr. A. W. Dow, the chairman, from materials which were known by him as those on which it was difficult to obtain concordant results in this test. They were prepared with care in his laboratory so as to have the samples of each set as nearly identical as possible.

The directions accompanying the samples were as follow:—

Six briquettes from each sample should be pulled for ductility, pulling three of these at a time if the machine is so constructed. The sides of the mould may be either amalgamated or chalked, but please report which method is used. Make note of the way in which the moulds were filled. Give accurate measurements of the different moulds used, stating distance between clips, thickness of mould, width of smallest cross-section, width at clip and length-over-all internal measurement.

The asphalt sample must be melted by placing it in a hot-air oven heated to a temperature not exceeding 310° F. The sample must be thoroughly melted and well stirred, and at the time of pouring into the mould must be at a temperature between 290 and 300° F. (actual temperature of sample). The sample must not remain in the hot-air oven in a melted condition more than one hour. In filling the mould with the melted asphalt, pour in a steady stream into the centre of the mould, allowing it to flow both ways into the wider parts of the mould. When as much asphalt has been poured as will more than fill the centre portion of the briquette, the two ends of the mould may be filled, if necessary, by pouring asphalt into them. Allow the briquettes to cool in the laboratory at a temperature above 60° F. When they are sufficiently cool they must be levelled off in the mould by cutting off excessive asphalt with a hot putty knife. While this levelling is being done the centre portions of the mould must be squeezed together as tight as possible by hand so as to prevent them being forced out by the cutting. After this, the sides of the mould may be removed and the sample placed in water and kept within 1° of a temperature of 77° F. for at least one hour, and not longer than two hours. At the end of this time the three samples should be placed in the machine and tested for ductility by pulling apart at the rate of 5 cm. per minute.

Please make note of time when sample was placed in the hot-air oven and when it was removed and poured into mould; also the time when cut and placed in water at the standard temperature, and the length of time it remained in this water before testing. Note also temperature variation of water in standard bath and also in tank of machine while test was being made.

The results obtained are given in Table I.

In one or two cases where the ductility of the sample determined by any laboratory varied materially from that obtained in the laboratory of the chairman, the sample was investigated. In two cases, these variations were shown to be due to differences in the samples and not to conditions in the method of manipulation. The results, as will be seen, are not as concordant as are desirable, but these variations are now under investigation and we are in hopes of finding out where the difficulty lies.

It must also be borne in mind, as above stated, that only such samples were sent out on which it appeared difficult to obtain concordant results. There are many classes of materials which will give the same ductility time after time. From investigations carried on so far by the chairman, it would appear that this lack of concordance in ductility on different samples is due to some physical change which takes place in the sample.

Table I.—Results of Tests for Ductility.

Sample No.	Ductility Determined by Different Observers, ce· timeters pulled before rupture.					
	Kershaw.	Gage.	Broadhurst.	Pullar.	Kleeburg.	Dow.
10923 (Test A)	55	49	36[a]	..	53	52
	58	46	36	49	52	53
	82	48	42	52	48	57
10923 (Test B)	51	54	35	..	46	48
	59	48	35	..	53	60
	75	44	36	..	48	69
11020	26	24	22	..	22	20
	30	26	28	..	22	21
	30	24	21	..	23	24
	23	25	..	..	23	24
	28	23	..	..	24	24
	39	..	..	..	17	21
11018	68	45	76	..	39	78
	70	52	66	..	37	77
	68	46	56	..	32	73
	45	44	..	..	34	78
	50	..	..	..	33	77
	54	..	..	..	34	..
10923	52	40	61	..	31	62
	54	41	60	..	32	46
	66	46	44	..	40	60
	39	43	..	..	34	47
	54	..	..	..	36	47
	67	..	..	..	38	52

[a] This sample was checked by Dow, who obtained the same results as Broadhurst, showing that the sample was lower in ductility than those sent to the other observers.

The Broken Hill Proprietary Company, Limited, of Australia, has a 350-ton blast furnace, three open-hearth furnaces and a combination structural steel and rail mill constructed, and 60 by-product coke ovens under construction at Newcastle, New South Wales. The company controls large iron-ore deposits in South Australia.

OILING ROADS TO PREVENT DUST.

THE use of asphaltic oils to prevent or reduce dust on ordinary roads, in distinction to their use in constructing oiled-macadam and similar pavements is discussed by T. R. Agg, of the University of Iowa, in a recent number of Oildom. Oils containing from 40 to 50% of so-called "asphalt" are the best to use. Preparations for oiling a street should be started several weeks before the actual oiling is to take place and preferably in the early spring. The street should be carefully shaped with an even slope of about one inch to the foot from crown to gutter. As the surface settles, the roadway should be dragged until it becomes hard, smooth, and free from depressions. The street is then ready for oiling. As the principal object of oiling is to prevent dust, there should be no dust on the roadway when it is oiled. If there is any dust it should be removed before oiling. This will involve some expense, but it will be found to be worth while. In case the decision to oil a street is not made until well along in the summer, when the surface has become dry and hard, the surface should be disturbed as little as possible, as it will be found difficult to get the newly placed earth to pack properly. Oiling at this time of year should be avoided whenever possible as the results are sure to be inferior to those obtained when the road is oiled early in the summer.

The oil may be distributed with an ordinary street sprinkler, the adjustment of the spray to give the proper amount of oil being found by trial. Sidewalks and crossings should be kept clean and care taken to avoid forming pools at any point. The crossings may be covered with dust or sand before the oil is applied. After the street has been under traffic, the crossings may be cleaned.

After the oil has been spread, it should stand for a day without being covered, and then just enough sand should be spread upon it to keep the oil from being picked up by traffic. About two or three loads to the block will usually be needed. More sand may be applied after the street is opened to traffic, wherever there are spots that may seem to need it. Where a street is oiled for the first time, about one-half gallon to the square yard should be used. After the first application, if the street is oiled every year, one-third of a gallon to the square yard is all that is necessary. With oil costing $1.68 per barrel, the cost of oiling by the method described should be six or seven cents per square yard.

COBALT ORE SHIPMENTS.

The following are the shipments of ore, in pounds, from Cobalt Station for the week ended July 9th, 1915:—

Right-of-Way Mines, 88,800; Mining Corporation of Canada, (Townsite City Mines), 86,530; Dominion Reduction Company, 88,000; Beaver Consolidated Mines, 64,505. Total, 327,835 pounds, or 163,917 tons.

The total shipments since January 1st, 1915, are now 16,424,940 pounds, or 8,212.4 tons.

Mr. D. A. Thomas, who is to represent Mr. Lloyd George, minister of munitions, in Canada and the United States in the purchasing of war munitions, is a Welsh coal mining magnate. He is head of the firm of Thomas and Davey, coal sale agents. He is a member of parliament for Cardiff, and is one of the prominent men in Great Britain. He was born at Aberdare in 1856, and was educated at Cambridge University. He was on the Lusitania when it was torpedoed but was rescued.

SPECIFICATIONS FOR WOODEN PILES.

THE typical specification for a wooden pile, as used by most railroads, municipalities, etc., and as advocated by most producers, reads about as follows: The pile shall be so straight that a line stretched from centre of butt to centre of point will not leave the pile more than 1/100th (for example) of the length of the pile.

Mr. E. P. Goodrich, consulting engineer, on the staff of the Commissioner of Public Works, Borough of Manhattan, writing in Professional Memoirs, Corps of Engineers, U.S. Army, raises the following points in criticism of this specification:

(1) It is obviously impossible to stretch a line from centre of butt to centre of point; and, therefore, a substitute method has to be employed, which latter should logically also be substituted in the specification. Obviously, the pile will naturally lie on a flat surface so that its greatest curvature is horizontal. A line is then stretched from the butt to the point over the centre of each; and, by sighting down vertically along the string, the distance between the projection of the string and the side of pile is noted.

(2) What relation should exist, if any, between the crookedness of a pile and its length? Obviously, again, the pile must be straight enough to be placed in the pile-driver. It also must not be so crooked that a blow of the hammer will bend it so as to damage it; and it must not be so crooked that its final load will produce a bending moment in the pile so large in amount as to produce stresses exceeding a safe maximum. This load condition and the phenomena during driving are practically identical in nature, except that one is static and the other dynamic. Now, the theory of bent columns, or what is the same thing—of eccentrically loaded columns, or of arches, must of necessity apply to piles.

Again, it is obvious that with relation to members of the general size and shape of piles, the length has no effect upon the stresses due to eccentricity of loading at any section—the latter being due only to the amount of the eccentricity and the area of the corresponding section.

(3) What should be the maximum permissible crookedness? It would seem that it should depend upon the permissible maximum bending stress for the material composing the pile and of the area of the latter. Most engineers would doubtless concede a relatively high unit stress as permissible for the condition of combined direct stress and bending of a pile. From this, it is seen that when all piles are designed to be uniformly loaded when finally in place, a greater bend is permissible in a pile of large diameter than in a smaller one, because a less unit direct stress will exist in the large pile and a greater one due to the eccentricity of load may be allowed. Such a specification may not make inspection easy and may possibly be considered impracticable for other reasons, but its logical possibility is evident.

Of course, different kinds of wood must have different permissible bends. Also, the designer's load per mile will influence the allowable bend, if the limit placed on the total maximum unit stress is constant.

Assume, for example, a 12-inch round pile, area where bearing on soil commences 100 square inches, designed loading per pile 15 tons or 30,000 pounds. Then the direct stress per square inch is 300 pounds. If a safe total unit stress of combined compression and bending of 2,400 pounds is assumed [the recommendations of the Committee on Wooden Bridges and Trestles of the Am. Ry. Eng. & M. W. Assn., Vol. X., Part 1, page 564, are for long-leaf pine 3,800 ultimate, 1,300 safe stress, $1,300 \left(1 - \frac{l}{60D}\right)$ for long columns, 6,500 ultimate extreme bending, 1,300 safe], then 2,100 pounds may roughly be assumed as the maximum permissible bending stress due to eccentricity of load at the section. Since the moment of inertia is about 1,016.164 and the section modulus is 169.364, the maximum permissible eccentricity of stress at the ground level mould be 11.9 inches. Again, at a point approximately 8 inches in diameter, where the total direct stress may have been reduced by half, with an area of about 50 square inches, the permissible bending stress may be assumed at 2,250 pounds. The moment of inertia is 196.704, the section modulus 49.176 and the permissible eccentricity 7.4.

Examples might be multiplied; but it would seem evident from the two given that a modification in the type of specification now in use might be advantageous. It seems obvious that the permissible bend should not be measured in terms of the length of the pile, but rather in terms of its diameter at each point along its length. With this idea in view, the following wording with reference to yellow-pine piles is submitted for criticism:

The pile shall be so straight that a line held in contact with any two points selected so as to give the maximum deviation shall not be distant from the surface of the pile at any point more than the diameter of the pile opposite that point.

WATER-POWERS IN NORTHEASTERN CANADA.

The interior of Ungava or New Quebec is a huge plateau which rises somewhat abruptly within a few miles of the coast line to heights of 500 to 2,500 feet. The various streams, therefore, afford numerous water-powers, more especially where they leave the interior plateau to flow through the strip of low lands, a few miles wide immediately adjoining the coast. For instance, on Great Whale River, within 20 miles of the mouth, there are three falls 150 feet, 230 feet and 65 feet respectively. On the south branch of this same river, a few miles from its mouth, a fall of the river gives 136 feet. Nastapoka Falls near the coast has falls 170 feet. Near Richmond Gulf, the Wyachuan River falls give a head of 315 feet. A remarkable case of very high water-falls in the interior is that of the Hamilton River. The Grand Falls of this river are situated some 300 miles from Rigolet. They have a sheer drop of 302 feet, and Dr. A. P. Low, of the Geological Survey of Canada, has estimated their discharge at 50,000 cubic feet per second. For twelve miles above the falls, the river rises rapidly, so that in that distance the difference of level, including the falls proper, is 760 feet. Adopting the discharge estimated by Low, these figures would give approximately 1,500,000 h.p. for the falls proper and 3,660,000 h.p. for the twelve miles of falls of the river. However, Dr. Low only saw the river during a period of high water and the above figures are probably much too high. In the data compiled by the Commission of Conservation and published in the "Report on Water-Powers in Canada," the possibilities of Grand Falls are based on a low-water drainage of 0.4 cubic foot per second per square mile of drainage area, which is the quantity generally adopted under the climatic conditions of the country. Under these conditions, the estimated power of the falls would be 120,000 h.p. and of the total fall for a distance of twelve miles 300,000 h.p.

PRACTICE IN HIGH-HEAD HYDRAULIC PLANTS.

In a paper read at the June convention in San Francisco of the National Electric Light Association, Mr. J. P. Jollyman, of the Pacific Gas and Electric Company, gives the following interesting notes on high-head practice, chiefly as exemplified by Pacific Coast plants.

Pipe-lines.—By reason of the high pressures carried and their length, pipe-lines for high-head plants, and particularly for plants having 1,000-ft. head or over, are a problem of importance. Cast-iron pipe with bell and spigot joints has been used in a few installations in the past on heads as high as 700 ft. Pipe-lines of this kind are not very satisfactory since the cast iron is not well adapted to withstand shock from a sudden change in water pressure nor the stresses set up by changes in temperature. The joints cannot of themselves withstand the tendency to pull apart, hence the pipe must be held in alignment by being covered with earth or be supported on a continuous line of concrete piers. While it may be the best material for high-pressure fire systems the conditions on a steep hillside are so different from those in a city street that cast iron is no longer considered a suitable material for high-head pipe-lines, and it has been abandoned in favor of other materials.

Present practice favors the use of steel with either riveted or welded joints. The use of riveted pipe in California is, in a way, a development of the practice which was followed by the hydraulic miners. One of the most noteworthy examples of early practice in the use of riveted pipe is the syphon crossing the west branch of the Feather River near Cherokee, which has a maximum head of 887 ft. and a diameter of 30 in. This pipe was installed in 1870 and is still in fair condition. Riveted pipe is reliable since hidden flaws in the plates are rare and the strength of the joints can be determined with accuracy. It is so flexible that bends up to about 9° can be made at any round-about joint and small changes or corrections made at every field joint. Pipe of this type has been cold-rolled and cold-punched up to 1¼ in. thickness and down to 52 in. diameter. Thicker riveted pipe has been made but the holes in this have been drilled and the process of manufacture is more like that of boilers than of typical riveted pipe.

The disadvantages of riveted pipe are the excess weight in the cross-section due to the efficiency of the riveted joints being 87% or less, and the higher coefficient of friction due largely to the protruding rivet heads. Pipe with welded longitudinal seams and with either riveted or flanged round-about joints has the advantages of minimum weight and low friction losses and is being used for high-head work. In general, welded pipe has not proved quite as reliable as riveted pipe, but the process of welding has been rapidly improved and the new welded lines are satisfactory.

It will generally be found that a material saving in weight can be made by tapering the diameter of a high-head pipe-line in such a way that the total head lost in friction will be the amount considered permissible, rather than by selecting a uniform diameter which will give the same total friction-head. This is particularly true where the profile is such that the slope increases as the head increases. In a recent riveted line whose profile had this characteristic, the diameter was tapered from 72 in. at the upper end to 52 in. at the lower end where the head was 1,375 ft. One of the latest welded lines has been tapered from 42-in. diameter to 36.8-in. equivalent diameter, the 42-in. pipe being divided into two 26-in. pipes.

The problem of anchoring a pipe on steep slopes is important. The weight of the pipe and the stresses set up by changes in temperature have to be considered. The lines must be rigidly anchored at the power house and should be anchored to concrete piers at sharp bends. Expansion stresses in a straight line held rigidly at each end are about 195 lb. per sq. in. for each degree Fahrenheit change in temperature. Experience indicates that horizontal and vertical bends in a long pipe are of great advantage in absorbing the changes in length due to these stresses. Slip-joints have been used at various points along the pipes, but they are a cause of serious trouble in that the pipe tends to blow apart at the joint. The present tendency is to avoid long runs of straight pipe and to use slip-joints only at points near the upper end of the pipe.

Gate-Valves.—Special fittings such as Y-pieces or gate-valves are generally required at the power house on

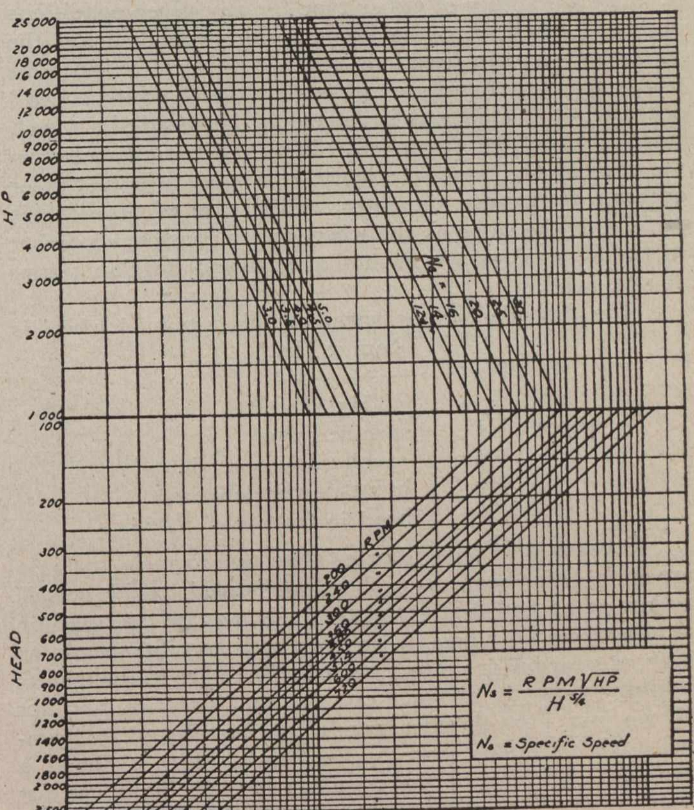

Fig. 1.—Chart for Computing Specific Speed.

nearly all high-head lines. The practice of connecting all pipe-lines to a common header-pipe and taking all the connections from the header to the water-wheels has been abandoned for the simpler plan of feeding a certain number of wheels from one pipe and reaching these wheels through Y-pieces. These Y-pieces are usually of cast steel heavily ribbed to strengthen the sections that are not circular.

Gate-valves are an item of great importance. The disc of a 36-in. valve under 1,000-ft. head must withstand a pressure of 440,000 lb. when closed. Present practice favors a gate with a single disc and with an operating-gear of sufficient power to move the disc under full-head. With so powerful an operating-mechanism any form of wedge-disc is objectionable, since the stresses in the body of the gate may be greatly increased by the wedging of the disc; besides, the great pressures against the disc due to the water alone will be sufficient to prevent leakage.

The Johnson or needle-valve form of gate seems to be well adapted to high-head requirements particularly where closure under normal or abnormal velocity may be required. This valve is a recent development and has not yet come into general use.

In assembling the special fittings which connect the pipe-line with the wheels it is usually necessary to connect between two parts whose positions are fixed. In doing this it is of great importance that it shall be so done that no stresses will be thrown on the fittings by attempting to bring together surfaces which do not fit exactly. A much better way is to provide one piece in every assembly which can be fitted into place in the field.

Water-Wheels.—The water having been delivered to the power house under a head ranging from 250 to 2,000 ft., the next problem is to secure a water-wheel which will efficiently utilize the available energy. Two types of water-wheels are used: the Francis turbine for heads up to 700 ft., and the impulse water-wheel for any head up to 5,000 ft., a plant in Switzerland having a head of 5,412 ft. The suitability of either type for any given conditions of head, speed, and the horse-power depends upon the relation of certain functions of their physical proportions which are conveniently expressed as the "specific speed" of the wheel. This term is defined as the speed of a wheel, whose ratio of jet diameter to impulse-circle diameter, in the case of the impulse wheel, or whose ratio of runner opening to runner diameter, in the case of the Francis turbine, is the same as the wheel under consideration, but whose dimensions are such that it would develop 1 h.p. at 1-ft. head.

The formula for the speed of this assumed wheel is

$$Ns = \frac{Rpm \times Hp}{H5/4}$$

where Ns = specific speed
Rpm = revolutions per minute
Hp = horse-power delivered
H = head in feet.

Present practice indicates that the Francis turbines are suitable for heads as high as 700 ft. and specific speeds as low as 12 and that impulse-wheels may be operated on any head up to 3,000 ft. or over with specific speeds as high as 4 for heads up to 2,000 ft. There are so few plants employing heads above 2,000 ft. that practice has not shown just what specific speeds can be reached with impulse-wheels under these higher heads. Fig. 1 shows a graphical solution of the equation for specific speed for heads from 100 to 2,500 ft., speeds from 200 to 720 r.p.m., and from 1,000 to 25,000 h.p. An inspection of this diagram shows that there are many combinations of head, speed, and output which give specific speeds between 4 and 12 and which therefore cannot be met by either a Francis turbine or by a single-jet impulse-wheel. To secure a proper solution it becomes necessary to change the speed, or the output required from a single-jet wheel. In general, it may be said that the most desirable speeds for water-wheel generators from 3,000 to 15,000 kw. are in the neighborhood of 400 r.p.m., and that these speeds tend to call for impulse-wheels having high specific speeds and Francis turbines having low specific speeds.

From the standpoint of efficiency the water-wheel is by far the most important part of the plant since under favorable conditions a greater gain can be had in the efficiency of the wheel than in any other part. It is therefore essential that the speed and output of the units be selected with reference to securing the best possible conditions for the water-wheels. Minimizing leakage and taking care of end-thrust are problems of great importance in the design of Francis turbines. Present practice gives a satisfactory solution for both these problems. Balancing is accomplished automatically by the proper arrangement of the leakage ports.

The attachment of the bucket to the wheel-centre and the shaping of the bucket so as to avoid interference with the jet are most important in impulse-wheel design. At 1,000-ft. head the impact of the jet on the bucket is 21,650 lb. for 10,000-h.p. output. The stresses on the bolts holding the bucket to the wheel are therefore high and change very rapidly as the bucket passes under the action of the jet. The best forms of attachment thus far developed are (1) "chain bolting" using a double wheel-centre and a bolt which passes through the lugs of two adjacent buckets, or (2) the "two-bolt" or "three-bolt" arrangement which employs a single disc with buckets having two lugs straddling the disc and extending for some distance toward the wheel centre. Two or three bolts, preferably tapered, are passed through the lugs and the wheel-centre.

Control.—The only method of governing the Francis turbine consists in varying the positions of the wicket-gates which changes the amount of water supplied. For heads above 250 ft., and particularly where the pipe-lines are long, some form of pressure regulator must be provided to lessen the rate at which the flow of water in the pipe-lines is reduced, when the load is suddenly decreased. Practice indicates that the Escher-Wyss type of pressure regulator, which is essentially an inverted needle-valve, is most satisfactory. This pressure regulator automatically opens when the turbine closes and closes at a rate sufficiently slow to prevent shock. If the load fluctuations are severe the regulator can be set so as to operate synchronously with the turbine and maintain a constant flow in the pipe. The relief valve is not a limiting feature in designing Francis turbines for higher heads since they are used on heads as high as 2,000 ft. in connection with other types of wheels.

Two general methods have been developed for governing impulse-wheels. A deflecting nozzle is used in which the jet is deflected from the wheel when the load decreases, and restored when the load returns. In combination with a needle-valve, by which the output of the jet may be varied at a rate sufficiently low to prevent shock, the deflecting nozzle is a very simple, safe, and satisfactory means of governing. A modification of this method consists in using a "cut-off hood" to deflect the jet from the wheel. This plan is suitable for small wheels and low heads, especially where a simple arrangement is desired. To minimize the loss of water, direct governing of the position of the needle-valve is used with some form of relief valve to reduce the shock on the pipe-line. The best form of control will depend upon local conditions. No one form will meet all requirements.

Generators.—The generators in the high-head plant are of interest in that they have to meet conditions somewhat different from those of any other plant. Experience confirms the theoretical necessity for a rotor which will be safe at the maximum runaway speed which may be attained by the water-wheel. In the case of the impulse-wheel the runaway speed approaches 100% overspeed, and the Francis turbine of low specific speed may reach nearly 75% overspeed. It is therefore considered necessary to have the rotor so designed that no part will be stressed beyond the elastic limit at 100% overspeed. The speeds most favorable for the high-head water-wheels are of an order which gives a well-proportioned generator when the rotor is designed to be safe at 100% overspeed. In other words, the rotor will be from 9 to 10 ft. in diameter at 400 revolutions per minute.

As a precaution against damage from the excessive voltage which may be generated on a runaway with full excitation, it is sometimes required that the generator windings shall withstand the voltage generated under this condition. This requirement tends to limit the normal terminal voltage to 6,600 or less. Some plants have been installed with 11,000-volt generators but the most recent plants have been 6,600 volts.

Longer life for the generators and more comfort for the operators are secured by enclosing the generators and taking the air for ventilation from outside the building. High-head plants are frequently operated under conditions which give a high load-factor, hence the heating of the generators reaches a maximum and may be sustained for days at a time. The necessity for giving special attention to ventilation in such cases is easily seen.

Practice tends strongly toward a combined water-wheel and generator-unit with a horizontal shaft and with the water-wheels overhung on one or both ends. The simplicity, accessibility, and compactness of this type of unit make it desirable. This arrangement is naturally the most logical for impulse-wheels. Now that balancing against end thrust in the single-discharge Francis type of wheel has been accomplished, the horizontal arrangement for the turbine has no drawbacks and many advantages. A single-discharge Francis turbine for 20,000 h.p. and 360 r.p.m. at 520-ft. head has been built for a unit of this type and while not yet in operation there is no doubt that its performance will be satisfactory. While the tail-water fluctuations exceed 20 ft. and it is considered essential to so arrange the units that high water could never reach the generators even if the power house should be flooded, the vertical arrangement of the unit is necessary when the Francis turbine is used. The overhanging of a wheel on each end of the shaft is often desirable and is necessary in many cases to obtain the desired size of unit while at the same time using the most economical speed. For operation at partial loads this arrangement is more efficient than the single-wheel unit.

General Arrangement.—The general arrangement of high-head plants is usually simple insofar as the hydraulic end is concerned. There is no difficulty in obtaining a sufficiently large output from one unit to render many units unnecessary. In fact only one of the modern plants has more than four units planned or installed. Whereas in a steam-electric plant it is necessary to have a steam engineer as well as the electricians, in the operation of a hydro-electric plant, electricians only are needed. This simplicity and economy is made possible by the simple horizontal unit which has everything on one floor where it may be conveniently watched by the switchboard attendant assisted by one or two floor-men.

The University of Washington, Seattle, has adopted an interesting plan to encourage the active development of local water power, affording free expert advice for proper and effective installations at available properties. In this, the primary purpose is to assist individual owners of water sites who might be unable at the moment to employ experienced engineering talent, as well as small rural communities similarly situated, inspiring active interest in the possibilities presented. The inauguration of this department has led to considerable activity along co-operative lines. Owners have been supplied with information applicable to service. In some cases recommendations to employ consulting engineers have been made, it being the particular province of the University to suggest the most feasible plan, with all essential data, rather than carry the proposed project to completion.

COAL FIELDS IN THE MIDDLE WEST.

A CONCISE statement of the area and probable contents of the various coal fields in the Canadian Middle West is given by Mr. D. B. Dowling in a recent Geological Survey report of the Department of Mines. The report refers in particular to Manitoba, Saskatchewan, Alberta and Eastern British Columbia. From it the following information has been obtained:

Location and Area.—In Manitoba, the coal-bearing rocks occupy a small area in the southern part, underlying an elevated portion called Turtle mountain. Thin seams outcrop around the base of this hill, and it is probable that others may be found higher up its slopes. With our present knowledge we can define an area of about 48 square miles near the western end of this hill as being available for mining.

The Saskatchewan areas lie principally in the southern part, and are being mined on the Souris River. The elevation known as the Coteau is also composed of coal-bearing rocks which continue westward in the Wood mountains and Cypress hills. This area, although not well prospected, contains possibly 4,000 square miles within which coal may be found. Between the two branches of the Saskatchewan River there is an area of possible coal-bearing rocks; but the horizons having good workable seams farther west, appear in this area to be rather poorly supplied, so that the value of this part as a coal field is problematical.

The province of Alberta is liberally supplied with coal areas. The western border of the southern part of the province consists of several ranges of mountains, formed generally of rocks which were, originally, the floor on which the coal formations were laid down. The elevation of the coal formations subjected them to greater denudation than the harder rocks beneath, consequently little of this material is left; but in the wider valleys remnants are still found. These, from the superior quality and amount of coal, form very valuable coal fields. The foothill belt, although not well prospected, will be found to contain many valuable areas in which a softer grade of coal may be found.

East of the foothill area, lies a great extent of coal-bearing rocks which are comparatively undisturbed. The coal in this region is well suited for domestic use, and as it is within the settlement belt, where wood is scarce, a demand for it is assured. These areas are delineated on the map as being occupied by the Edmonton formation and the coals may be referred to as the Edmonton coals. They extend north from near the international boundary to near the Peace River, underlying an area of at least 52,000 square miles of which 24,000 are considered as available for mining.

Another coal formation, the Belly River formation, occupies the southeastern border of the province, with an area of 11,568 square miles; the seams in this are of more value in the southern portion than farther north or east. The principal mines of this area are to be found near Lethbridge.

The eastern British Columbia areas are discussed principally because their structure is intimately related to that of the Alberta areas within the mountains. The valley of Elk River, which heads near the source of the Kananaskis, and occupies the same valley as the upper part of the latter stream, has exposures of coal-bearing rocks of the same horizon as those being mined in Alberta, at Canmore, Bankhead, Blairmore, and Coleman.

Kootenay Formation.—In eastern British Columbia exposures of the Kootenay measures are to be found in the Elk River valley, which heads near the Kananaskis. The field, which has been generally known as the Crowsnest area, contains 230 square miles of coal lands; estimated to contain 22,586,342,000 tons of bituminous coal as well as a possible large reserve deeply buried and probably difficult to recover. North of this, on the upper waters of Elk River, an additional area of 134 square miles has an estimated reserve of 12,941,000,000 tons. South, on the Flathead River, a small area is thought to contain 600,000,000 tons.

The Kootenay coals in Alberta are generally exposed in narrow bands in the mountains. These are here enumerated in order from south to north.

The Coleman area is estimated at 35 square miles with 38 feet of coal, giving an estimated reserve of 1,050,000,000 tons.

The Blairmore-Frank area is irregular in shape and broken by faults and folds; but assuming for it an area of 90 square miles, with an estimated thickness of 50 feet of coal, its total content would be 4,500,000,000 tons.

The Livingstone area lies north of Blairmore and west of the Livingstone range of mountains. The area containing coal approximates 343 square miles. A maximum estimate of its coal reserve would be 26,000,000,000 tons.

The Moose Mountain area, lying outside the first range of the Rocky mountains, consists of a narrow band encircling the upthrust Palæozoic rocks forming the mountain. It extends from near the main line of the Canadian Pacific Railway, south to Sheep River. Its area is estimated at 12 square miles, with a thickness of 15 feet of coal. This would give a probable coal content for the area of 200,000,000 tons.

The Cascade area is a long strip between the ranges, containing workable seams for a length of about 40 miles. It is estimated to contain about 769,000,000 tons of anthracite coal, and of the softer grades, 2,099,000,000 tons.

The Palliser area, on Panther River, is comparatively small, but with an area of perhaps 6 square miles, has, possibly, a coal content of 30,000,000 tons.

The Costigan area lies east of Palliser and in its area of 12 square miles is estimated to contain possibly 90,000,000 tons, mostly bituminous coal.

The Bighorn area, between the Saskatchewan and Brazeau rivers, is estimated at 87 square miles, with a reserve of at least 6,000,000 tons.

The Nikanassin area, the continuation northward of the Bighorn area, is estimated to contain in 48 square miles, 1,404,000,000 tons of which 259,000,000 is easily accessible.

This area lies east of the Bighorn area and with its continuation south and north, in an area of 25 square miles over 2,000,000,000 tons are predicted, of which 160,000,000 tons lie in an already prospected block.

The Folding Mountain and Brule Lake areas lie outside the mountains, on each side of the Athabaska River, and for these, an area of 10 square miles is estimated to contain 361,000,000 tons.

Roche Miette and Moose Creek areas lie inside the first range at the Athabaska, and for an area of 38 square miles are estimated to contain 624,600,000 tons.

Other areas north of the Athabaska are known to contain coal; but the delineation of these areas has not yet been undertaken.

Belly River Formation.—In Alberta and Saskatchewan the coals that belong to the Belly River horizon, grade gradually between lignite and bituminous, and are found over an enormous area. Roughly measured on the map, this area is about 33,192 square miles. An estimate on this basis would, however, be very misleading, since portions are known to be either unproductive, or to contain only small seams of inferior coal. Possibly the best areas are outside the boundaries of the exposures of the formation, since the upper coal seam may be considered as the base of the Pierre or Bearpaw shales. A total coal reserve, including these extensions, has been estimated at 223,358,000,000 tons, but a large part of this may not be immediately available. Most of the productive value is in Alberta. The proportions for the two provinces may be assumed as 189,450,000,000 tons for Alberta, and 33,908,000,000 tons for Saskatchewan.

Edmonton Formation.—The coals of the Edmonton formation in Alberta are generally lignites, but in the foothills grade up to bituminous. The foothill areas, though only narrow bands, have a length of about 400 miles. In the less disturbed areas at a distance from the mountains, this formation occupies an enormous trough, in the centre of which sandstone of Tertiary age probably forms a heavy cover and beneath which it may be impracticable to mine for coal. Surrounding this deeply concealed part, it is estimated that there may be an area of 52,405 square miles underlain by coal with an estimated maximum reserve of 800,958,000,000 tons. Half of this area is considered to have a more certain reserve which is placed at 383,697,000,000 tons of sub-bituminous coal.

Summary Statement of Estimates.

	Square miles.	Million tons.	
Eastern British Columbia.	370	56,878	Bituminous
Alberta—			
Coleman area	35	1,050	"
Blairmore-Frank	90	4,500	"
Livingstone	343	26,000	"
Moose Mountain	12	200	"
Cascade	56	2,099	"
Cascade		769	Anthracite and semi-anthracites
Palliser	6	30	Bituminous
Costigan	12	90	"
Bighorn	87	6,000	"
Nikanassin	48	1,404	"
Shunda	25	2,160	"
Folding Mountain and Brule Lake	10	361	"
Roche Miette and Moose Creek	38	624	"
Northern areas	13	159	"
Belly River area	25,974	189,450	Sub-bituminous and lignite
Edmonton formation	52,405	800,958	"
Tertiary beds	2,520	23,721	"
	81,674	1,059,975	
Saskatchewan—			
Tertiary beds	6,188	25,904	Lignite
Belly River beds	7,218	33,908	"
	13,406	59,812	
Manitoba—			
Turtle Mountain	48	160	Lignite

Tertiary Formation.—The coals of the Tertiary are all lignites in Saskatchewan. The Souris area, of eight townships, is estimated to contain 2,304,000,000 tons; while the remaining portion lying to the west—consisting of 5,900 square miles—has possibilities up to about 23,600,000,000 tons; a total for the area of 25,904,000,000 tons.

The Turtle Mountain area in the southern portion of Manitoba has an available area of 48 square miles, probably coal-bearing, which with 4 feet of coal, represents a possible total of 160,000,000 tons.

The total estimate for the three provinces of Manitoba, Saskatchewan and Alberta, and for the eastern part of British Columbia, approximates 95,598 square miles of coal lands with 1,176,825,000,000 tons of coal in reserve. In this total the various classes of coal occur in the following proportions:—

Anthracite and semi-anthracite ...	769,000,000 tons
Bituminous	242,313,000,000 "
Sub-bituminous	847,321,000,000 "
Lignite	86,422,000,000 "
	1,176,825,000,000 tons

TRANSMISSION LINES AND RAILWAY CROSSINGS.

A copy has just been received of a communication from the Board of Railway Commissioners for Canada to electric power transmission line owners relative to the insulators on high-tension electric power transmission lines at railway crossings. The Board directs that reasons, if any, should be filed with it before August 7th, 1915, why the following order should not go into effect on that date:—

All the insulators at wire crossings which are operated at a potential of 10,000 volts, or over, are to be renewed, or tested, and reported upon on or before November 1st, 1915, and until further notice at least once annually thereafter.

The following information will be required in the form of a report upon each crossing:—

1. State the location of the crossing.
2. State the operating voltages between:—
 (a) (1) Conductors.......volts. (2) Conductors and ground volts.
 (b) (1) Conductors.......volts. (2) Conductors and ground volts.
 (c) (1) Conductors.......volts. (2) Conductors and ground volts.
3. State the number of insulators (complete units).
 (a) Type ....No.
 (b) " . ... "
 (c) " . ... "
4. When and where were the insulators last tested?
 (a) Date ....place...............
 (b) " . ... " ....
 (c) " . ... " ....
 (d) " . ... " ....
 (e) " . ... " ....
5. To what tests were they subjected?
 (a)
 (b)
 (c)
 (d)
 (e)

APPORTIONMENT OF COST OF HIGHWAY BRIDGES BETWEEN STREET RAILWAYS AND CITIES.*

By Charles M. Spofford.

THE careful scrutiny of public service corporations exercised by legislative bodies in recent years, with the resulting demand for valuation of the property of many of these corporations for purposes of taxation or rate making, has brought many engineers into active touch with problems of valuation, as is evidenced by the numerous papers dealing with work of this character which have recently appeared in publications of engineering societies.

The transformation of street cars within the last twenty-five years from light-weight horse cars weighing no more than heavy trucks and drays, to large power-driven vehicles, frequently weighing forty or fifty tons and sometimes as much as seventy-five tons, has compelled the strengthening of many existing highway bridges otherwise adequate for all traffic, and has made it necessary to build new bridges of sufficient strength to carry these loads. The necessity of strengthening at their own expense existing bridges to provide for heavy cars was long ago forced upon the street railway corporations of Massachusetts by their inability to operate on some of their important lines, cars of a type which tests upon other lines had proven to be economical. This necessity is well illustrated by the strengthening of various bridges by the Boston Elevated Railway Company, a corporation controlling practically all the street car traffic in the city of Boston.

Perhaps the most important example of this is the repairs to the Boylston Street bridge across the Boston and Albany Railroad made by the railroad company at a cost of $60,000, following the recommendation of the writer. As the conditions at this structure were somewhat unusual and the solution a novel one, the brief description which follows may prove of interest even if not strictly pertinent to the subject-matter of this paper.

Boylston Street crosses the four-track main line of the Boston and Albany Railroad at an angle of 19° between centre lines of highway and railroad location, thereby necessitating a span of 216 feet centre to centre of end pins with such a sharp skew that the easterly end of one truss is only 67 ft. 6 in. from the westerly end of the other truss.

A through bridge with this skew would be impracticable without a central truss owing to the great length of the end portal, and even with a central truss would be unsightly. This difficulty was overcome by building two pairs of trusses—one pair on each side of the roadway. The trusses of each pair were 6 ft. 0 in. centre to centre, and were well braced together, thus giving lateral stability which an ordinary pony truss bridge would not possess, and at the same time avoiding unsightly overhead bracing. The bridge thus constructed was eminently stable, so far as lateral vibration was concerned, but the trusses were a little too shallow to insure freedom from vertical vibration.

To strengthen the bridge for street railway purposes, an additional truss was built on each side between the original trusses, and new floor beams were inserted carrying the entire load of the street cars for the greater portion of the length of the bridge. The new trusses were so designed as to receive their load from the new floor

* From a paper read May 10th, 1915, before the Western Society of Engineers.

beams only, the result being in effect that of providing a separate street railway bridge and thereby preventing vertical vibration due to the street cars from being felt on the sidewalks, which continued to be supported by the original trusses.

While street railways have been compelled either to strengthen existing bridges at their own expense or to forego the economies to be gained by operating heavy cars across them, no such compulsion has existed in the case of new bridges and it might seem as if the railways should be relieved from contributing toward their expense. Certainly the claim of the railways that the bridge is but a part of the highway on which they have the same right as others, and for the maintenance of which they pay a reasonable share in the form of taxes, is a legitimate one, and should be given due consideration. The fact, however, that trolley cars are so much heavier than other road vehicles, puts the companies under different obligations than other users of the bridges and makes it seem fair to assess upon them the extra expense required to provide for traffic of this character. This has been recognized by the Massachusetts Legislature, which has adopted in recent years the practice of providing for such assessments either by direct assessment, in advance of construction, of the amount to be charged to the railway, or by providing for its determination by a commission sitting after the bridge has been completed and the actual cost is known.

The assessment by statute of street railways to pay for the cost of new bridges has varied in Massachusetts from a minimum of 10 per cent. to a maximum of 25 per cent., the variation being probably due to the intensity of the desire of the street railway to operate heavier cars or to obtain new locations and to the arguments put before the Legislature by the interested parties. Such a method of determining the proportionate share to the railway may be reasonable in many cases, particularly if the total cost involved is comparatively small, and furnishes an excellent solution if each party agrees in advance upon its share.

The acts and resolves of the Massachusetts Legislature relating to grade crossing abolition specify in the case of the elimination of a crossing involving a street railway that the latter may be assessed an amount not exceeding 15 per cent. of the total cost.

In contrast to the method of determining by legislative enactment the share which the street railway shall pay toward the cost of new highway bridges over which it may wish to operate its cars, may be placed the method which has been adopted in the case of several large bridges in Massachusetts and vicinity, of determining the cost by hearings before a commission appointed by the court to decide upon the just and equitable charge to the street railway company. In cases of this sort, the engineer's services as an expert witness are needed, and the primary purpose of this paper is to present the questions at issue, to consider these questions and to present the decisions reached in certain of such cases. In order to set forth clearly points which may arise in such an investigation, the following list is given in which the writer has attempted to include all the elements entering into the problem which may influence the decision.

1. Type of Structure—(*a*) Temporary bridge; (*b*) ordinary permanent structure; (*c*) monumental structure.

2. Additional Dimensions Due to Street Railway—(*a*) Width; (*b*) length.

3. Additional Strength Due to Street Railway—(*a*) Superstructure; (*b*) foundations; (*c*) impact and future increase in loads.

4. Additional Cost Due to Street Railway—(*a*) Variation with increased width; (*b*) variation with increased strength.

5. Additional Convenience to Street Railway—(*a*) Increased speed of operation of railway.

6. Decreased Cost to Street Railway of Maintenance and Operation.

Type of Structure.—(*a*) and (*b*) Temporary vs. Permanent Bridge. The dead weight of a temporary bridge would ordinarily be much less than that of a permanent structure built to carry the same loads. It may be designed with higher unit stresses; permanent paving can be omitted, and piers and abutments may consist of pile trestles. Its width need be only sufficient for the immediate needs of traffic, and in case other bridges exist within a reasonable distance, very heavy drays and trucks may be prohibited from using it. The influence of heavy street car loads on the cost of such a bridge is evidently much greater in proportion than would be the case on a more permanent bridge, with its heavier dead load.

(*c*) Monumental Structure. If the structure is to be of a monumental type with towers, carving and other ornamental features, it would seem at first thought as if no part of such ornamental work could be legitimately charged to the railway. Further consideration, however, shows that the scale of the towers, carving and other ornamental features may be a function of the width of the bridge, and if increased width is necessary to provide for street car traffic, additional expense for this purpose may legitimately be incurred.

Additional Dimensions.—Whether any material increase in width to provide for street car traffic is necessary, depends upon the density of the traffic. If the street car service is infrequent, there would seem to be no reason for increasing the width of the bridge to provide for street cars other than by the slight amount necessary to provide safe clearance for crowded street cars. Ordinary traffic can readily run on the portion of the bridge occupied by the track with little or no delay, and space for extra lines of traffic need not be provided. An example illustrating such a case is the Meridian Street bridge of Boston. The apportionment of the cost of this bridge to the street railway was referred to a commission. Before the case came to a hearing, however, it was agreed upon both by the city of Boston, which the writer represented, and by the Boston Elevated Railway Company, that the proper distance centre to centre of trusses might be two feet six inches less for a bridge without street cars than for the bridge actually constructed which provided for two lines of street cars.

Another example illustrating the same case is the Chelsea North Bridge of Boston. Provision for four lines of traffic was evidently necessary on this bridge, but it was agreed by both sides before presentation to the Apportionment Commission, that a roadway forty feet wide between curbs, with trusses forty-four feet centre to centre, was required whether street cars were or were not to be operated, this space providing for four traffic lines. In consequence, no charge was made to the railroad for additional width.

In the case of the Cambridge bridge, a monumental structure providing not only for ordinary street car traffic including surface cars, but also for a double-track rapid transit line, a reservation was made along the centre of the bridge to be used exclusively for rapid transit trains. It is quite evident that in this case a marked increase in the width of the bridge was due to the provision for the rapid transit railway. The actual width required for this purpose, however, was not agreed upon prior to the hearing before the Apportionment Commission, and the railroad argued successfully that while the space out to out of curbs protecting their tracks amounting to twenty-seven feet might be a legitimate increase in the width of the bridge, they should not be charged for the entire space occupied by the curbs, particularly as one curb might have been omitted by placing their reservation to one side instead of in the centre of the structure.

In order to determine the proper width of a bridge with or without street car traffic, the following statistics concerning widths of vehicles may prove useful.

Street Cars.—Ordinary street cars operated in Boston are eight feet wide. The extreme width of the widest car is 8.79 feet. The distance between centres of tracks as specified by the Massachusetts Public Service Commission is 9.71 feet. The clear width required by two lines of the widest cars is, therefore, 8.79 + 9.71 = 18.5 feet.

Horse-drawn Vehicles.—The width of such vehicles as measured in the streets of Boston is given in the following table in which (a) = distance out to out of hubs; (b) = distance out to out of wheels; (c) = distance out to out of whiffletrees.

	(a)	(b)	(c)
Hay wagon	7.75	7.00	8.00
Heavy express	7.65	6.70	7.90
Heavy express	7.80	6.70	7.60
Ice wagon	7.40	6.60	7.00
Hack	6.08	5.25	6.83
Coal wagon (3 horse)	8.50	...	10.83

Motor cars.—Maximum width now in use, 10 feet.

In order to accurately measure the capacity of a bridge or street in relation to traffic, it is evidently necessary to consider the character of the vehicles and their speed as well as their number. For the purposes of making such a comparison, the London Board of Trade sets up as a unit a motor cab or carriage, and assigns the following numbers to other classes of vehicles.

Trade vehicles.		Passenger vehicles.	
1 Horse (fast)	3	Electric trams	10
1 Horse (slow)	7	Omnibuses (horse) ...	5
2 Horse (fast)	4	Omnibuses (motor) ...	3
2 Horse (slow)	10	Cabs (horse)	2
Motor (fast)	2	Cabs (motor)	1
Motor (slow)	5	Carriages (horse)	2
		Carriages (motor)	1
		Barrows	6
		Cycles	½

The Board lays down the following definitions:—

"Traffic Volume" at a point is the average aggregate number of traffic units attributable to vehicles which pass it per minute during the twelve hours from 8 a.m. to 8 p.m.

"Average Traffic Density" is the aggregate number of traffic units attributable to vehicles which pass the point during the twelve hours, per minute, per ten feet of available carriageway.

"Greatest Traffic Density" is the average density per minute, per ten feet of available carriageway, during the busiest hour, expressed in traffic units.

With the above units and definitions in mind, the following comparison of traffic on London bridges is clear:—

	Westminster Bridge	Waterloo Bridge	Southwark Bridge	Blackfriar's Bridge	London Bridge	Tower Bridge
Traffic volume	91.4	60.5	105.9	16.6	89.2	84.7
Average traffic density	20.3	22.0	14.4	5.8	24.1	24.2
Hour of greatest density	6-7	5-6	6-7	...	11-12	11-12
Density of that hour ..	23.8	22.5	15.3	...	27.4	27.9
Average vehicles	4.2	3.9	5.0	4.1	4.0	6.0

In connection with the width of bridges it should be remembered that the capacity of a bridge in vehicles per hour is considerably greater than that of the ordinary city street due to the freedom from interruption by traffic on intersecting streets and by vehicles stopping at the curb to discharge and receive freight or passengers. It is evident that the width of bridges on curves may have to be increased greatly to provide proper clearance for street cars.

It is seldom that the length of a bridge is a function of the street railway. Such a condition may, however, occur in the case of a bridge on a curve where the curve must be made flatter than would otherwise be necessary in order to provide proper clearance. The writer is familiar with two bridges where this has occurred. One of these is the temporary Chelsea North bridge, Boston.

Additional Strength.—The additional strength required to provide for street car traffic depends primarily upon the differences in weight and allowances for impact between ordinary vehicles and street cars. The specifications of the Massachusetts Public Service Commission require that all bridges in the state carrying street railways are to be designed for electric cars weighing fifty tons, and recommend that the following concentrated loads shall be assumed on the highway in addition to the uniform live load:—

(*a*) City bridges, carrying heavy loads, 20 tons on two axles, 12 feet apart.

(*b*) Suburban or town bridges, 12 tons on two axles, 8 feet apart.

(*c*) Light country highway bridges, 15-ton road rollers, with three wheels, or rollers—the weight on the 4-ft. wide front roller to be 6 tons, and on each 20-inch wide rear roller to be 4½ tons.

These specifications are under revision and the writer is informed by Mr. Lewis E. Moore, member of the Western Society of Engineers, and engineer of bridges and signals for the Public Service Commission of Massachusetts, that the following loadings will hereafter be specified. Two 50-ton trolley cars, with trucks 20 feet centre to centre, wheels 5 feet centre to centre, with impact varying from 25% to 10%, depending upon the loaded length required to give maximum stress; if the road wishes to operate standard freight cars, above weights to be increased 50%. One 20-ton motor truck, occupying a space 10 feet wide, 32 feet in length; axle loads 14 tons and 6 tons, respectively; axles 12 feet centre to centre; impact 50% on steel stringers, floor beams and hangers. Uniform live load is to be used with these loadings.

The increase in strength necessary to provide for street cars is most marked in the floor systems. It is less noticeable in trusses and girders, and least of all in foundations. In the case of foundations, the additional strength (size) depends largely upon the character of the bridge. In the case of heavy city bridges with paved floors, where no increased width is necessary to provide for street car traffic, the difference between the live loading of the street cars and that due to ordinary roadway traffic would not materially affect the foundations.

The allowance for impact and future increase of street car loads must be carefully considered in determining the additional strength of the structure. So far as the foundations are concerned, it is doubtful if any allowance for impact need be made.

The question of future increase in loading due to the street railway is a difficult one to satisfactorily adjust. An interesting example of a somewhat unexpected increase in this respect is noted in the Cambridge bridge case summarized later.

Increase in Cost.—The best plan to pursue in determining the difference in cost of bridges with and without street cars seems to the writer to be that of comparing two designs, one the detailed design of the structure, the other a stress sheet design with the cross-sections of all members carefully determined. The two designs should be similar in type. Allowance for the weight of the details of the second structure may be made by considering the details of each individual member to vary in weight in proportion to the variation in the cross-section of the main member, this relation being obtained from the detailed design of the first case, or if the structure has been completed, from the gross shipping weights reduced by the computed weight of the main sections. The same unit prices should be used in both computations.

In the case of a reinforced concrete barrel arch bridge, it would seem as if the additional cost would ordinarily be dependent entirely upon the increased width, since for such a bridge the effect of the concentrated wheel loads would be largely distributed by the dirt fill. For such a bridge it might be possible to estimate the increased cost by determining the cost of a strip of the bridge, using for this purpose the same unit prices as for the remainder of the bridge.

The question has arisen in some cases with which the writer has been connected, as to whether the cost of engineering, insurance, etc., should be assumed to vary directly with the cost of construction. This is perhaps open to legitimate discussion. It would seem to the writer as if these items should vary directly with an increase in width, since such increase would certainly involve additional engineering and inspection, and would prolong the time of construction. Whether the increase should vary directly with an increase in strength is not quite so obvious. Little additional engineering cost is required to provide for heavier sections in floor beams, stringers and trusses. On the other hand, it is probable that no better unit actually exists for determining the difference in these items than the total cost of the completed structure, and it would seem as if it would usually be proper to adopt this basis for determining additional charges for engineering, etc. In the cases of the Chelsea and Meridian Street bridges the percentage charged for these items was the same for bridges both with and without street cars, and this was agreed upon by the railways as a proper charge before the case came up for hearing.

Convenience.—In determining the proportion which a street railway should pay towards the cost of a given bridge, the question of greater convenience to the railway is one which deserves careful consideration. The advantage to the railway company of having a new bridge of ample size and strength to allow for unrestricted traffic running at a reasonable speed, and to provide for any probable increase in weight of rolling stock is a factor which may possibly result in economy of operation far in excess of the actual expenditure necessary to provide for increased width and strength. In the case of a new bridge providing an opportunity for a contemplated new line of railway traffic, it is quite conceivable that the railway might afford to pay a very considerable proportion of the cost. In fact, if the line is to be built, at all events it would seem as if the railway company could afford to pay towards the construction of the bridge an amount equal to the cost of a new structure plus the capitalized cost of maintenance less salvage, provided the bridge is to be owned and maintained by the municipality and equitable arrangements are made for reimbursing the railway if its franchise is taken away by no fault of its own.

That street railways have often agreed in advance of construction to pay a very considerable proportion of the cost of the bridge in some cases, is doubtless due to reasons such as this. Similar instances of great and immediate convenience to street railways, due to the reconstruction of an existing bridge, may readily occur. Such, for example, was the condition in the case of the Meridian Street bridge. In this bridge some of the timbers of the existing structure had actually begun to crush under the heavy cars operated by the railway, and for some time prior to the reconstruction, car traffic was not allowed across the draw-span, passengers being required to change cars and walk across the draw. This naturally imposed an undue inconvenience upon passengers and an extra expense upon the railway. In such a case it would seem quite clear that the railway might well pay toward the reconstruction of the bridge an amount in excess of the additional cost of the structure to provide for their loads. Another factor under this heading might well arise in the case of a draw-span over a stream with much traffic. The increased rapidity of operation which might conceivably occur with a new bridge would certainly be of value to the street railway in preventing traffic interruption.

Decreased Cost to Street Railway of Maintenance and Operation.—The fact that the cost of maintenance and operation of a highway bridge would ordinarily be borne by the municipality should be considered in apportioning the cost to the street railway. This would be particularly pertinent in the case of swing bridges, where it would seem as if a fair arrangement would be for the railway company to furnish the current necessary to open and close the bridge, and for the municipality to maintain the draw-tenders and other attendants. In general, it would appear that the street railway company might reasonably be charged as its portion of the capitalized cost of maintenance, a share proportionate to its contribution to the cost of construction.

Franchise Taxes and General Taxation.—All of the above discussion should be considered with due regard to the fact that the railway company is ordinarily subject to heavy taxes, and in consequence, should be entitled to operate across the bridge with vehicles of weight equal to that of the heaviest motor trucks. The only equity in charging the railway more than the ordinary transportation company is because of the heavy loads which it operates.

Conclusions.—The conclusions which the writer has drawn from his experience in apportionment cases of this character are as follows:—

(*a*) Additional width to provide for street cars is ordinarily necessary only in the case of bridges with narrow roadways, providing for no more than two lines of traffic.

(*b*) The extra expense involved in strengthening heavy city bridges of permanent type to provide for 50-ton trolley cars would not ordinarily be greater than 10% of the total cost, and may be as low as 6%. This percentage will be greater for light country highway bridges without paved floors, but if such bridges are designed for heavy motor truck traffic, as they should be, the additional expense will not be excessive.

(*c*) To apportion the cost equitably, and with credit to the engineering profession, the engineers on the two sides should try to agree upon the additional cost of provisions for street cars before the case is presented to an apportionment commission. This can ordinarily be done if both sides are reasonable.

(*d*) It is doubtful if the railroad company should ordinarily be charged for additional convenience due to the reconstructed bridge. This, however, is a matter the settlement of which hardly comes into the province of the engineer.

DIFFERENT SECTIONS OF SHEET PILING FOR VARIOUS CONDITIONS.

THE views shown herewith illustrate the use of sheet steel piling on several Canadian construction jobs. The first shows the cofferdams for the pier foundations of the Winnipeg-St. Boniface traffic bridge. The piling used in this work was in 35-foot lengths and penetrated about 25 feet of clay and 7 feet of hardpan.

The other illustration relates to the north wall of the Don River diversion in connection with the Toronto harbor

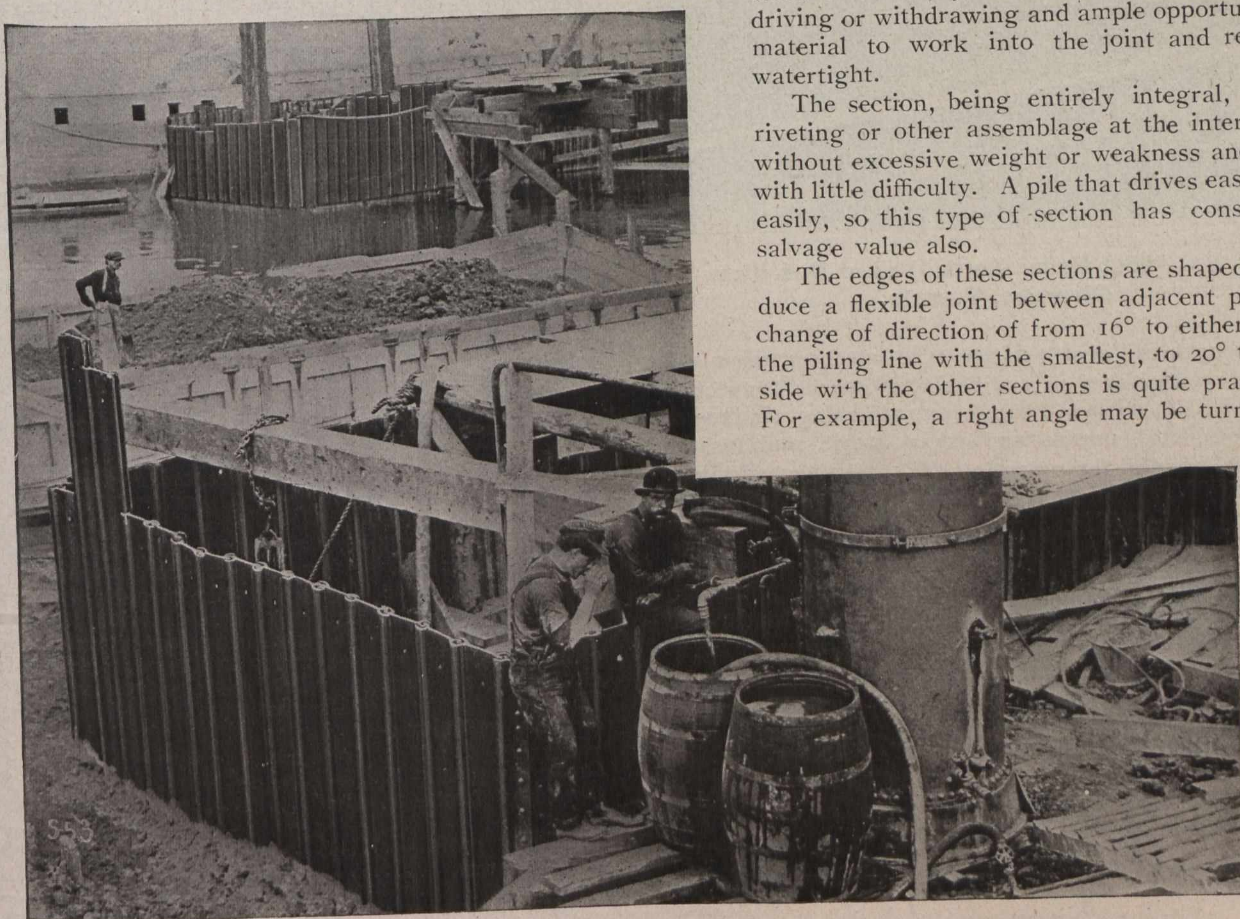

Fig. 1.—Cofferdam Work on the Winnipeg-St. Boniface Bridge.

and waterfront development, described in *The Canadian Engineer* for June 10th, 1915. The use to which the sheet steel piling has been put in this instance is adequately explained by the photograph.

In both of these instances the sheet piling used is of Lackawanna make. In the Winnipeg-St. Boniface job, although sunken logs were encountered, an Arnott No. 2 hammer drove the piling without having to deflect the piling line. Where the logs were encountered, driving was temporarily stopped until, after partial excavation, the logs were removed. The retarded piling sections were then driven to final position. These cofferdams were thoroughly watertight, and the contractors, Messrs. Macdonald and McCougan, state that the driving costs were very reasonable. After completion of the pier foundations the piling in these cofferdams was pulled by four and five-sheave wire rope blocks and found to be in good condition. It is the intention to use all of the steel sheet piling three or four times before completion of this work.

The Lackawanna Steel Company have furnished us with the following descriptive notes concerning the piling used on jobs such as those referred to above.

The section is of the double interlock type with similar hooks and guards on each edge. The hooks of adjacent sections engage to offer the greatest resistance to longitudinal displacement while the guards overlap and engage the outer surfaces of the hooks on the adjacent sections, thus preventing lateral displacement and co-operating to prevent longitudinal displacement. The contact surface in the joint is increased to three points (or lines) so that there is a positive, double, firm and close interlock, yet a minimum of friction in driving or withdrawing and ample opportunity for material to work into the joint and render it watertight.

The section, being entirely integral, without riveting or other assemblage at the interlock, is without excessive weight or weakness and drives with little difficulty. A pile that drives easily pulls easily, so this type of section has considerable salvage value also.

The edges of these sections are shaped to produce a flexible joint between adjacent piles. A change of direction of from 16° to either side of the piling line with the smallest, to 20° to either side wi'h the other sections is quite practicable. For example, a right angle may be turned with six 7-inch and with five of any other Lackawanna sections. The advantages of this flexible interlock in turning angles to pass obstructions, are clearly shown in Fig. 3. Small sumps, pits for pumps, circular caissons for foundations and the like can be made from this steel piling without bending the webs and without fabrication.

Clearance in the interlocked joint admits of great latitude in correcting the plumbness of each pile without distorting the interlock, should carelessness in driving or inequalities of the bottom throw the pile seriously ahead or behind.

In the development of the arched-web section, for turning sharp corners, special attention appears to have been given to securing a simple interlock that would produce maximum strength against pulling apart during driving, maximum tensional strength under pull in the direction of the piling web, as in the straight-web types and at the same time have the material so distributed as to give a section modulus producing the required lateral strength.

For constructions requiring high tensional and compressive strength, in connection with a fairly high trans-

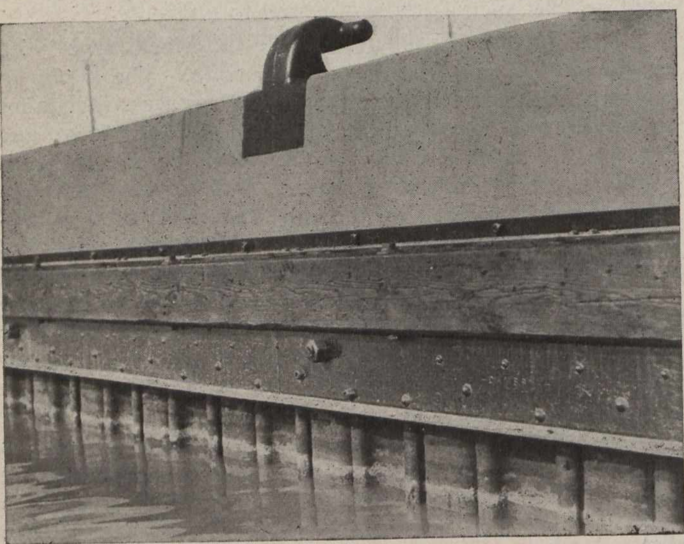

Fig. 2.—Piling Under North Wall of Don River Diversion, Toronto.

verse strength the centre flange type has been designed. The centre-flange acts as a stiffener, increases the section modulus and furnishes means for attaching transverse ties, braces, etc., needed in special work, and for the mechanical bond of the concrete facing in protected piling. One of the methods of protecting this piling with concrete is shown in Fig. 4.

Fig. 5 shows a type of piling that was just recently put on the market. It is cold rolled from steel plate into a type of section designed for use principally under the following conditions:—

(1) Where great economy demands a very low weight and cost per square foot of wall—lower than obtainable with the heavier sections of steel sheet piling.

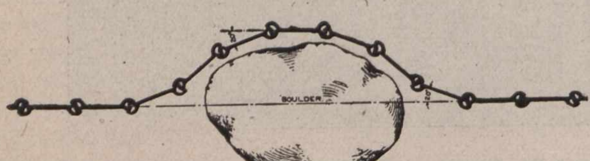

Fig. 3.—Showing How This Type of Piling May be Deflected to Pass Obstructions.

(2) Where the sheet piling need not be driven in long lengths nor in very dense material causing hard penetration.

(3) Where transverse strength of the sheet piling is secondary, due to remaining in position on both sides of the wall and neutralizing the lateral pressures.

(4) Where high resistance against the passage of water through the interlocked joints is essential. This, of course, implies a joint strength sufficient to assure installation of the piling wall without the opening or disarrangement of the joints.

(5) Where the sheet piling must resist rotting action of the teredo and other influences which would make timber sheet piling construction short lived. Steel plate sheet piling, if carefully painted, affords a permanent con-

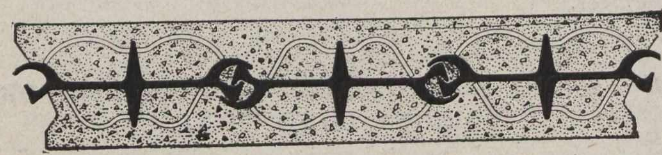

Fig. 4.—Method of Protecting the Centre Flange Type With Concrete.

struction well able to resist any ordinary corrosive action from earth, water or moisture.

The plate type of sheet piling is especially desirable for permanent work in cut-off walls under levees, for core-walls in earth dams and embankments and for cut-off walls underneath masonry foundations where the latter are constructed in saturated soils. In general, this type

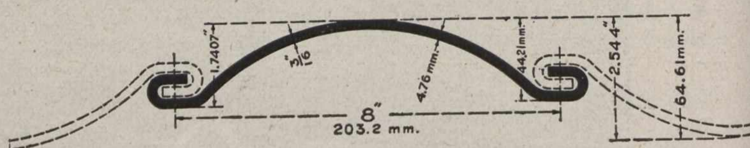

Fig. 5.—Plate Sheet Type. A Form Peculiarly Well Adapted to Light Trench, Cofferdam Work, etc.

of sheet piling seems to possess economic structural advantages for installations where a permanent impermeable wall of very light weight is required to prevent the passage of water.

MONTREAL WATER AND POWER COMPANY.

An excellent report was presented at the annual meeting recently, of the Montreal Water and Power Company. For the year ended April last, there was a decrease in gross revenue of only $8,227, or about 1 per cent., and in net profits, of $13,085, or 6 per cent. The company's business showed an increase of 5 per cent. over that of the previous year. The decrease in net profits was due largely to the fact that the previous year's returns were abnormal by reason of a considerable sum of money which was received from the city for water supplied when the city system broke down. The chief accounts of the company for the past three years compare as follow:—

	1912-13.	1913-14.	1914-15.
Gross revenue	$671,684	$783,689	$775,462
Operating expenses, etc.	299,446	324,340	330,494
Gross profit	$372,237	$459,349	$444,968
Bond interest	240,839	250,536	249,241
Net profit	$131,398	$208,812	$195,727
Less:			
Bond discount, etc.	28,828	29,551	29,936
Disputed accounts	8,000	15,000	......
Special reserve	2,000	12,100	2,168
Depreciation reserve	......	60,000	40,000
Total deductions	$ 38,828	$116,651	$ 72,104
Balance	92,570	92,161	123,623
Previous balance	4,311	96,881	189,042
Total balance	$ 96,881	$189,042	$312,665

The company's president stated in regard to the physical value of the company's properties, that an exhaustive investigation carried out by the American Appraisal Company, shows the reproductive value of the company's properties, after generous allowance for depreciation, to be much in excess of the amount it stands at on the company's books.

THE CHOICE OF ALLOYS FOR WATER WORK DESIGN.*

By Horace Carpenter.

In the design of waterworks equipment, the engineer makes use of the various non-corrosive metallic alloys only to such extent as the inaccessibility of the equipment or the danger of interruption of service render it imperative to use some material other than iron or steel. Consequently, the amount of such material has, in the past, been slight in comparison with the magnitude of other materials entering into such work, and the engineer has been content to accept, largely without question, such alloys as were commercially available, without any extensive study of the applicability of any particular alloy to the purpose for which it was to be used.

The increasing magnitude of such work, however, makes the proper selection of alloys of increasing importance to the engineer, and it is the purpose of this paper, not to attempt to set forth in detail any fixed rules to govern selection, but to open the way for discussion and to bring forth the results of the study of others who have been able to make a more detailed study of the matter than has the writer.

Alloys are used for waterworks construction in two forms:—

1. *Castings.* In this form they appear in parts the shape or purpose of which is such that it is possible for the material to pass directly from the foundry to the point of application, with only such intervening fabrication as tends in no way to alter the structure of the material, or to change its physical characteristics.

2. *Bars or tubes.* In this form these alloys must, in nearly all cases, be so fabricated after leaving the foundry that their structure and physical characteristics are materially changed. This fabrication consists of forging, rolling, extruding or drawing.

The ideal alloy must possess three characteristics which, in the order of their relative importance, may be classed as follows:—

1. The material must be able to withstand, for an indefinite period, the disintegrating action of the elements with which it is to come in contact, this action taking the form of corrosion, errosion or electrolysis, either or all of which may be present.

2. The material must be of such structure that it will successfully withstand disintegration due to the failure of its component parts to retain their original relation one to another, and must be free from internal stress which will produce progressive failure entirely independent of any exterior agency. This latter requirement implies a composition capable of successful fabrication under existing commercial conditions.

3. Since the materials are comparatively costly, it is desirable that the physical characteristics be as high as practicable in order that the desired result may be obtained at the least expense.

It is desirable to bring to your attention four of the classes of alloys, and to consider briefly their ability to fulfill the requirements of the above specifications, as follows:—

The bronzes, or copper-tin alloys.
The brasses, or copper-zinc alloys.
The copper-nickel alloys, and
The nickel-steel alloys.

The bronzes are of ancient origin and, in slightly varying composition, have been used for many centuries. The most commonly accepted composition to-day appears to be that of the so-called "naval bronze," consisting of 88 per cent. copper, 10 per cent. tin, and 2 per cent. zinc.

Castings of this alloy fulfill the requirements of the foregoing specifications in a very satisfactory manner. They are non-corrosive in the presence of nearly, if not all, the elements with which they are ordinarily brought in contact, they are easily obtainable, of a homogeneous character under ordinary commercial conditions, are stable and constant in physical characteristics, and the material is one that works well in the ordinary machinery operations.

Their physical characteristics are sufficiently high so that apparatus does not need to be unwieldy or unduly heavy in design to obtain the requisite strength under any ordinary conditions. A tensile strength of 30,000 pounds per square inch, a yield point of 15,000 pounds and an elongation of 15 per cent. in two inches can easily be obtained.

Rigid adherence to the composition as given above does not appear essential. The copper may be reduced to 85 per cent., with a corresponding increase in the zinc content, or with a corresponding addition of lead without materially changing the ability of the resulting casting to resist corrosion and without material change in its physical characteristics. In fact, in the presence of sulphur the addition of lead appears to aid the resistance to corrosion.

Where the material is to be used as a bearing metal, as in the seats of large gates, a considerable variation in the composition is desirable. The United States Reclamation Service has worked out for this purpose two alloys to be used in opposition to one another, as follows:—

82.8 per cent. copper, 4.8 per cent. tin, 4.4 per cent. zinc, and 8 per cent. lead.

82.7 per cent. copper, 7.1 per cent. tin, 5.3 per cent. zinc, and 4.9 per cent. lead.

Experiments by the writer, while indicating the impracticability of attempting to confine the composition as closely as indicated, demonstrate that alloys of this nature containing about 5 per cent. lead in one and 8 per cent. in the other, with corresponding differences in the tin content, were very satisfactory for the purpose.

Alloys of the above nature may be used for castings only, as their high tin content makes it impossible to hammer, forge, roll or draw them successfully, so that, where rods or tubes are required, the content of tin must not exceed 2 per cent., and most manufacturers hold to a maximum of 1½ per cent.

Where conditions of design require greater physical characteristics than shown by the bronzes, or where forged, rolled or drawn forms are required, the engineer commonly resorts to the brasses, of which there are an endless variety, many of them of little value, but of which a number have proven highly satisfactory.

For castings of this character, manganese bronze has been very generally accepted and has given very satisfactory service. A characteristic casting of this material shows a composition of about 56 per cent. copper, 40 per cent. zinc, 1 per cent. tin, 1.27 per cent. iron, and 1.8 per cent. manganese. It will be noted that the manganese content is small, and it does not appear essential that the analysis of the completed casting show any such content,

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the manganese being introduced in the form of the ferrous-oxide to act as a flux, and any residue being due to an overdose of the flux, and such residue should not exceed 2 per cent. Such castings, properly made, can be relied upon to show a tensile strength of 65,000 pounds, a yield point of 35,000, and an elongation of 20 per cent. in 2 inches. Certain manufacturers use vanadium in the place of manganese, and the resulting castings are of the same general character as manganese bronze. Castings of this material where purchased in small quantities are generally somewhat more expensive than those made of the bronzes referred to above, and it is the general experience that founders unused to the casting of manganese bronze experience considerable difficulty in obtaining satisfactory results. Where the quantity, however, to be used on a job is sufficient to appeal to founders experienced in handling the material, most excellent castings can be obtained at a price generally from 10 to 12 per cent. less than corresponding castings of tin bronze.

Forgings, rods and bars of these alloys show very satisfactory non-corrosive properties and physical characteristics considerably greater than the cast material, the exact amount depending on the size and manner of fabrication, and would appear at first glance to be ideal substitutes for similar steel products. Unfortunately, however, the demand for such rods and bars is of such recent origin that the art of fabrication does not seem to have advanced to a point where the product can be guaranteed against failure by disintegration, or by breaking or cracking without apparent cause. These failures in many instances have not manifested themselves until some months after the material has been fabricated and has passed a most rigid inspection, and have been entirely independent of any load thrown on the material. While no satisfactory solution of the causes of, and no remedy for such failures, have as yet been found, it does appear that the same are caused rather by the methods employed in rolling or drawing than by the composition of the material itself. It would, therefore, appear wise to exercise considerable conservatism in the selection of such rods, until the manufacturers have further perfected themselves, and have solved the various problems of temperature and rolling methods, and to use in their stead some of the brasses which have been manufactured for a sufficient length of time so that the engineer can feel comparative security in their use. Among these there appear Muntz metal, an alloy of 60 per cent. copper and 40 per cent. zinc, which in the larger sizes of rods can be depended upon to show a tensile strength of at least 40,000 pounds, and Tobin bronze with a tensile strength of 55,000 pounds, which together with other closely allied alloys are readily available.

Comparatively recently, one of our largest manufacturers of rods has produced an alloy containing about 57½ per cent. copper, 40 per cent. tin, ½ per cent. lead, ½ per cent. iron, and 1½ per cent. nickel, which possesses high non-corrosive properties, together with physical characteristics equal to or slightly superior to Muntz metal. This material is produced in bars and rods.

Tubes made of an alloy of 86 per cent. copper and 14 per cent. tin are extensively used in the navy in condensers, where they come in contact with salt water.

The most prominent copper-nickel alloy to-day appears to be Monel metal, a natural alloy containing about 60 per cent. nickel, 36½ per cent. copper, and 3½ per cent. iron. This material has been very successfully used both in the form of castings and rods for large and small work. Its physical characteristics are at least 65,000 pounds ultimate, 32,000 pounds yield, and 25 per cent. elongation for castings, with the ultimate and yield points at least 10 per cent. higher for rolled rods. Non-corrosive tests indicate that it is not acted upon by either the acids or alkalies as found in construction work. It has been somewhat extensively used for propellers for battleships, both by this country and by foreign countries. It is also used by many valve manufacturers as a seat metal for valves, for use with high pressure and superheated steam. It is also used in the form of forgings for valve stems for high-pressure steam and water valves.

This material has not been in use for a sufficient length of time to determine its non-corrosive qualities under all circumstances, but every indication points to its entire acceptability. It is a comparatively costly material, probably costing in its various forms about 50 per cent. more than the corresponding brass or bronze material, but its greater physical characteristics in many cases make this increase more apparent than real. It appears to require considerable skill on the part of the founder to obtain sound castings of Monel metal, and the unsuccessful attempts of some such have prejudiced many against its use.

The value of nickel-steel alloys for members under tension, as valve stems, has not received sufficient recognition by the waterworks engineer.

While unquestionably not possessing the non-corrosive properties of the brasses or bronzes, a proper steel alloyed with from 20 to 25 per cent. of nickel does possess such properties far in excess of ordinary carbon steels and combines with this property physical characteristics such that it should demand the careful consideration of the engineer.

In 1905 the Department of Water Supply, Gas and Electricity of New York City specified for valve stems a nickel steel to contain not more than 0.05 per cent. phosphorus or sulphur, between 0.21 per cent. and 0.41 per cent. carbon, and between 21 per cent. and 24 per cent. nickel and to have a tensile strength of at least 80,000 pounds, yield point of 40,000 and an elongation of 22 per cent.

One of these stems when examined after five years' service showed no indication of corrosion of that part immersed in water, and only slight pitting of that part exposed to air.

There appears to be very little data available showing the effect of various corrosive substances on alloys. Unquestionably many of the manufacturers of such materials have experimented to a considerable extent on such material, but there appears to have been, in the past at least, a dislike on their part to make public the results which they may have obtained. There are appended to this paper a few results of comparative tests that have come to the attention of the writer and which, while by no means complete or conclusive, may be of some assistance in the selection of non-corrosive alloys.

The Corrosive Effect of Moist Earth on Alloys and Steel.—Six test pieces were embedded in a box of rich earth, which was kept moist with water and occasional additions of ½ per cent. solutions of chlorides of sodium and magnesium. The weighed specimens, consisting of rods 15.2 cm. long by 1.2 cm. diameter, presented about the same area to the corrosive influences in the soil. After having been subjected to the conditions provided for a period of six months, the specimens were taken out, washed, dried and reweighed. The loss in weight represented the amount of corrosion in each case.

Sample	Original weight	Loss in weight	Per cent loss
	grams	*grams*	
Manganese bronze	171.87	0.16	0.09
Tobin bronze	162.11	0.19	0.11
Monel metal	160.76	0.19	0.12
Manganese bronze	161.65	0.19	0.12
Muntz metal	163.85	0.55	0.33
Steel	139.58	1.45	1.04

All the specimens showed the effect of more or less oxidation on the surface, the Monel metal presenting the least change in appearance as a result of corrosive action.

Corrosion Tests on Cast Manganese Bronze and Cast Monel Metal.—Relative corrosibility, as indicated by resistance to solvent action of acid solutions and acid solutions containing dissolved salts.

Small specimens of each metal about the same size and weight (35 grams, with length and diameter of 1.2 inch and 0.5 inch) were subjected to the action of 100 cc. of the solutions, in covered glass beakers, for ten days, at room temperature. The specimens were then removed from the solutions, washed, wiped, dried, and reweighed, the percentage loss in weight indicating the degree or extent of corrosion.

Corrosive or solvent action of 10 per cent. solution of sulphuric acid.

	Loss per cent.
Monel metal	0.096
Manganese bronze	0.018

Corrosive action of 10 per cent. sulphuric acid, containing iron sulphate.

Monel metal	0.32
Manganese bronze	0.37

Corrosive action of 20 per cent. solution of hydrochloric acid.

Monel metal	0.21
Manganese bronze	7.34

Corrosive action of 20 per cent. hydrochloric acid solution with common salt in solution.

Monel metal	0.31
Manganese bronze	1.64

Comparative Corrosion List of Various Alloys.
Duration of test 6 months.

	Copper	Zinc	Lead	Tin	Iron	Nickel
Alloy A	57.7	40.1	0.44		0.46	1.3
Alloy B	62.6	36.1	0.20	1.1		
Alloy C	62.7	35.1	2.20			
Alloy D	61.0	38.1	0.20	0.5		
Alloy E	89.0			11.0		
Alloy F	54.3	27.0	0.10		0.10	18.3

Solution No. 1—Sea water.
Solution No. 2—Ammonium chloride, 20 p.c. solution.
Solution No. 3—Ferrous sulphate, 10 per cent. solution.
Solution No. 4—Sulphuric acid, 10 per cent. commercial.
Solution No. 5—Swamp water.
Solution No. 6—Sodium hydroxide, 10 per cent. solution.

Alloy	Solution No. 1		Solution No. 2		Solution No. 3	
	Loss in weight, grams per sq. in. of surface	Appearance	Loss in weight, grams per sq. in. of surface	Appearance	Loss in weight, grams per sq. in. of surface	Appearance
A	0.0184	smooth sound	0.3790	rough sound	0.085	smooth sound
B	0.1364	smooth sound	4.2460	pitted, disintegrated	0.091	smooth sound
C	0.1590	etched sound	3.5980	very rough disintegrated	0.092	etched sound
D	0.1390	etched sound	5.4530	very rough disintegrated	0.093	smooth sound
E	0.1700	etched sound	6.8080	very rough	0.089	etched sound
F	0.0660	rough lengthwise cracks	0.5611	rough deeply pitted	0.041	etched lengthwise cracks

Alloy	Solution No. 4		Solution No. 5		Solution No. 6	
	Loss in weight	Appearance	Loss in weight	Appearance	Loss in weight	Appearance
A	0.102	etched sound	0.0030	smooth sound	0.0270	smooth lengthwise cracks
B	0.110	etched sound	0.0014	smooth sound	0.0300	smooth sound
C	0.132	etched sound	0.0043	smooth sound	0.0180	smooth sound
D	0.107	smooth sound	0.0117	smooth sound	0.0270	smooth sound
E	0.147	etched sound	0.0020	smooth sound	0.0320	corroded sound
F	0.063	etched sound			0.0045	clean sound

DOMINION STEEL CORPORATION'S OUTPUT.

The production of the Dominion Steel Corporation for June, 1915, compared with June, 1914, was as follows:—

	June, 1915. Tons.	June, 1914. Tons.
Pig iron	22,552	21,111
Steel ingots	28,680	26,629
Rails	13,044	16,998
Rods	6,435	1,981
Bars	797	2,347
Wire and wire products	3,167	1,541
Coal mined	481,820	485,449

The Standard mine at Silverton has resumed shipments to the smelter at Trail. The British Columbia Copper Company has started work again in its smelter at Greenwood and at the Mother Lode mine, after an idleness of 12 months. The United Copper mine at Chewelah has installed a new 20-stamp mill, which is in operation.

The new service to be given by the "National" train between Toronto and Winnipeg, through the co-operation of the Grand Trunk, Temiskaming and Northern Ontario, and the Transcontinental lines, will mean a distance between the two points of 1,257 miles. Through traffic will be undertaken by the Grand Trunk Pacific Railway at Winnipeg, and carried through to the coast at Prince Rupert when that is the routing. The service was inaugurated on July 13th.

RIVER SAND AS A FILTER MEDIUM.*

By L. A. Fritze.

IN the selection of sands for filtration purposes, it has been common practice to use the uniform kinds usually obtained from banks or the sea coast. Bank sands are to be found in different parts of the country, yielding a product which has proved very efficient as a filter medium.

The filter plant proposing to use these screened, sharp sands, generally finds the cost very high, so high sometimes as to almost make its use prohibitive.

To offset this cost, other sands have come into use, and prominent among them is river sand. If a river sand can be found free from mud and other objectionable matter and of a uniform size, there is no reason why it will not give satisfaction as a filter medium. If clay, mud, etc., be present, its removal may offset the financial advantage and make the bank sand cheaper in the end.

However, in this paper, advantage will be taken of the fact that clean, uniform sand can be obtained from river beds, and our cost data will be based on this product.

In some of the older plants in this country, river-sand has been in use for a number of years, with results that are very satisfactory.

In slow sand filtration and rapid sand filtration alike, these cheaper sands have been in service from seven to twelve years, and the results prove that a satisfactory effluent may be obtained.

Since the installation of bleaching powder and other sterilization agents, as an additional aid to purification, the necessity for a sand of such high merit as formerly is not now of such exacting importance. However, the size of the sand must be considered, for one too fine will clog quickly, and one too coarse will not yield a satisfactory effluent.

In rapid sand filtration, the use of river sand has become quite common. Inquiries sent to a number of these plants show that a very satisfactory water has been obtained with a sand one-fourth the former cost.

In Moline and Rock Island, the experience has been the same. River sand has been in service for two years with results which indicate its permanent use. This sand is obtained from the Mississippi River, above the city of Moline. A local sand company supplies the material, collecting it in the following manner. By means of a centrifugal sand pump on a boat, a barge is loaded. This barge is then unloaded at the docks of the company by a stream of water from the sand pump, into the river again. After emptying the barge, the sand is then taken from the river and pumped into the sand bins. By this means of unloading, the sand is thoroughly washed and freed from objectionable matter.

This raw, unscreened product has an effective size of 0.28 mm. and a uniformity coefficient of 2.11. When placed in a filter, the fine powder will find its way to the surface during washing. Unless this powder is removed, the filter will clog very quickly and necessitate an increase in wash water. By scraping the bed and freeing the sand of this material, a medium will be obtained with an effective size of 0.51 mm. and a uniformity coefficient of 1.34. For filtration purposes this sand is very efficient.

The loss due to the discarding of the fine powder will vary with the different sands, ranging from 5 to 40 per cent. The Mississippi sand contains about 5 per cent. fine powder, which is very easily removed by washing.

It has been found that the size of gravel used will effect the results obtained with river sand. Small gravel ¾-inch to ¼-inch was in use for a year, but the results show that larger gravel is needed.

To meet this, gravel 2 inches and over was placed next to the strainers to a depth of 9 inches. With the smaller gravel on this bed and the sand on top, conditions are very satisfactory. This filter has been in service six months and to date there has been no packing and strainer trouble.

Likewise in Rock Island, it was found necessary to supplant the fine gravel with the larger material, when the river sand was employed. Using the larger size gravel has eliminated considerable of their trouble.

The financial saving of the river sand over the more expensive bank sands is considerable. The cost of the Mississippi River sand per cubic yard delivered to the filter plant is 70 cents. The loss in this sand due to the fine powder is 5 per cent., making the actual cost per cubic yard 72.9 cents.

Large gravel to the depth of nine inches is needed to obtain satisfactory results. This quantity represents about nine cubic yards and costing $2.35 per yard, totals $21.15. This cost must be added to that of the sand.

The wash water required to free the sand of the fine powder is 125,000 gallons and costing one cent per 1,000 gallons, totals $1.25.

Considering these additional factors, the cost of the river sand ready for service in the filters is $1.47 per cubic yard.

For comparison, selecting a well known bank sand, commonly in use in this section of the country, that from Red Wing, Minnesota, the best grade of filter sand obtained at this place costs $3 per ton or $4.05 per cubic yard. The freight from Red Wing to Moline is $1.80 per ton or $2.43 per cubic yard, making a total cost per cubic yard, delivered to the filter plant, of $6.48. An additional charge of 25 cents per yard must be made for unloading, bringing the total cost per cubic yard to $6.73.

Using the two figures for sand cost as found at Moline, the river sand shows a net saving of $5.26 per cubic yard over the Red Wing bank sand. Thirty cubic yards of sand are needed per filter to make the medium the proper depth, and with the above figures the saving per unit is $158 or $789 for the five 1,000,000-gallon units in the plants.

It has been found that the yearly loss of sand due to various causes is about one cubic yard per filter. With river sand this means an annual loss of $3.65, with bank sand $33.65, or a net saving of $30 per year, using river sand.

Cost records on the cleaning of filters, that is, the removal of the sand and gravel, and the cleaning of the collecting system, show that 120 hours' time is necessary for the work, and the expenditure $30. In other words, one unit can be cleaned and the lost sand replaced in the other units for the same amount of money as needed for only replacing the lost bank sand.

It may be said in conclusion that river sand is being used with satisfactory results in a number of filter plants, that the cost is much less than the average bank sand, and that the waterworks proposing to buy new sand can well afford to investigate the quality and quantity available in their own locality, before purchasing.

* Read at first meeting Illinois Section, American Waterworks Association, March 10, 1915.

Editorial

NEED FOR ACTIVE SERVICE AT HOME.

Comparatively few Canadians realize the magnitude and extent of the war. The ultimate effect that it will have upon Canada is almost forgotten in the great desire to make Canada as effective as possible in bringing the struggle to a successful termination. This is the problem at hand, and it requires a full understanding of the fact that the nature of the solution rests with those at home as well as with those at the front.

This has been called an engineers' war, and at any rate it has proven its dependence upon engineering. The transportation of armies, the maintenance of health, the establishment of field fortifications and of communication lines, the vital topographical and geological investigations, the expedient and reliable serving of supplies and ammunition,—these are some of the problems detailed to the engineers to solve.

But the engineer's work does not begin on the battlefield. The manufacture of the contrivances used in warfare is under his direction also—or should be. The making of guns, transports, ammunition and the like, calls for the accuracy, reliability and despatch of the engineer. It should also be within his province to direct their transportation, to be ready when needed, to the line of action.

Canadian engineers are participating in the war both at home and in the field. They are not likely to receive elaborate mention in despatches, although deserved. Their work is not generally such as to win praise, as it is likely to be overshadowed entirely by impending events. But the engineer is used to this. It is his lot in peace as in war. The point to remember is that he is absolutely indispensable in either.

There should be a wider recognition of this fact at home. The services of the engineer are not being used to full advantage in the preparation and transportation of supplies. It will be a long time before the last has been said and written about the disgraceful affair, for instance, of army boots. Exorbitant prices and lavish commissions were bad enough, but the supplying of our soldiers, our volunteer Canadian soldiers, with boots that immediately proceeded to fall to pieces was inexcusable. It is regrettable that the foot discomforts and pain experienced by the soldiers on their route marches could not have been reflected upon the manufacturers who represented their own interests and also upon the inspectors, who should have represented no interest except that of the Dominion of Canada and her soldiers.

It now develops that although the second Canadian division has been in England for some time, over 150 motor-driven transport wagons belonging to it have yet to be shipped from Ottawa. The excuse has been made that since the contingent has not gone to the firing line the motor trucks have not been needed. Who knows but that one of the chief reasons why the second contingent is still in England is that the trucks for the land transportation of its equipment are still in Ottawa? No doubt Kitchener has his own troubles supplying his great field and reserve forces with transport wagons. At any rate, the motor trucks of the second Canadian division should not be gathering dust and rust in Ottawa.

A prominent gentleman, with not more than the interest of the average loyal Canadian citizen, but with a comprehensive knowledge of the state of chaos which exists in some quarters, even after twelve months of war, observed that things were in a higgledy-piggledy state here and there, with the office boy and the office manager interchanging jobs with an irregularity that was profound. It was all due to inability to cope with the situation.

Evidently there is room a-plenty for the precision, reliability and despatch which characterize the working system of the engineer. The government should call upon Canadian engineers to do the work which political patronage is giving to incompetents.

WATER RIGHTS IN QUEBEC.

In the province of Quebec, stream legislation is attended by a consideration of some very important questions. This for the reason that many of the important rivers and streams are capable of being utilized in a threefold capacity, *viz.*, for navigation, for flotation of timber and for the development of electrical power. The Quebec Streams Commission, in whose care rest the problems arising out of the triangle of conflicting interests, has made an important recommendation to the government in its recent report. It urges a classification by legislative act of the rivers and streams of the province based on the area of the basin drained, the idea being that any water course whose drainage basin is not less in superficies than three hundred square miles should be set down as an "important stream." The utility which it possesses or which may be developed in connection therewith, it is urged, justifies its being regarded as a dependency of the public domain.

Industrial troubles and legal disputes over water rights have been numerous in Quebec. The industries involved hitherto have been those of milling and of lumber and timber development. Now a public utility—power development—steps in. The Commission urges that there is greater need of action now in the matter of stream legislation than there was in the past because of the new use of the streams in this increasing development of electric power, and of the need in cases of creating works for storing and regulating the waters so as to maintain throughout the dry season the efficiency of the plants.

It is true, of course, that the electrical developments apply for the most part to the larger streams, about the ownership of which there is generally no question. On the Ottawa the Dominion Government has undertaken to regulate the spring flood on the upper reaches. The Quebec Legislature has authorized means for doing like work on the St. Francis, and an extensive project has been outlined for maintaining throughout the season as nearly as may be the power of the St. Maurice. The rivers in question are used for navigation and for flotation as well as for power. The power development on each is large, however, and is likely to increase. Besides, there are many other streams whose power resources have remained as yet untouched, but whose development will be almost sure to occasion controversy. It is, no doubt, with full knowledge of past controversies, with resulting divergence and sometimes contradiction in the decisions, that the Quebec Streams Commission urges the government to take action soon. It is the more important as the law of France, from which that of Quebec is derived, does not meet the needs of the province's case in every particular, though it has the advantage of making the decision as to the character of a stream a duty of administrative and not of judicial officers.

A NAVAL INVENTIONS BOARD.

AN official announcement of the British Admiralty relates to the establishment of a Naval Inventions Board, and to the appointment thereto of some very prominent English engineers and scientists. The purpose of the board is to be of assistance to the Admiralty in co-ordinating and encouraging scientific effort in relation to the requirements of the naval service. It is stated that the board will comprise a central committee and a panel of consultants composed of scientific experts, who will advise the named committee on questions referred to them. The central committee will consist of Lord Fisher as president, Sir J. J. Thomson, Sir C. A. Parsons and G. T. Beilby. The consulting panel will comprise: Prof. H. B. Baker, Prof. W. G. Bragg, Prof. H. C. H. Carpenter, Sir William Crookes, W. Duddell, Prof. Percy Frankland, Prof. Bertram Hopkinson, Sir Oliver Lodge, Prof. W. J. Pope, Sir Ernest Rutherford, G. Gerald Stoney and Prof. R. J. Strutt.

This endeavor to organize the inventive capacity of the nation with regard to naval and particularly submarine navigation is a very important step. It was only two weeks ago that an announcement was made to the effect that a member of a committee appointed by the Royal Society to deliberate on scientific problems arising from the war had invented an apparatus whereby a submarine could locate another submerged submarine within a radius of twenty miles and keep in touch with it while within the radius. If this device can be easily and practically applied to the present-day submarine it will mean a great revolution in the naval practices of the present war.

Such governmental appreciation and encouragement will do much to activate invention and scientific research. Hitherto comparatively little inventive thought has been attracted by governmental requirements. The path of the inventor is one on which progress is possible only over a long series of wasteful and discouraging failures. He is of the pioneer class and, like other pioneers the fruits of whose struggles have added so materially to the civilization of the world, his labors and aims should be better appreciated. With the Naval Inventions Board to supervise his work, to separate the promising from the futile, and to indicate the gold among the dross, the naval inventor has attained at last a recognition that has long been his due. It has taken a big war to transform his wildest hope into a reality. It is for him now to exercise to the full his inventive mind,—a ready market awaits his achievements.

It is to be hoped that this is but a beginning of governmental recognition of civilian research, and that the organization and official supervision of inventions will expand in time to extend far beyond the present confines of munitions of war.

It is of interest here to note that the United States Navy Department is likewise establishing a bureau of invention and development, with an advisory board of civilian inventors attached to it. Last week Thomas A. Edison consented to act as chairman of the latter and a number of notable engineers will co-operate.

CONCRETE BRIDGE FLOORS.*

IN the Cleveland grade crossing work, it was required that the railroad bridge floors be relatively noiseless and waterproof. In former years every effort has been put forth to build shallow floors so as to minimize the change of grade. Such floors have always permitted the muddy water to seep through upon people passing below and have operated as drums in accentuating every sound from the passing trains. To overcome these defects the floors were made of I-beams and concrete slabs upon which tracks were laid and ballasted as upon the ground. Such a design requires a greater depth of floor, which means a greater change of grade, and more steel to carry the added weight of concrete. The bridge is therefore more expensive; but in cities where the noise is troublesome, the ballasted floor is a great improvement. Trains passing over such floors are noticed but little more than when passing over solid ground.

A concrete floor slab can also be made reasonably watertight. The writer's first experience with concrete was on the Missouri in 1887-88. Later it was used a little on the New York state canals, and still later in bridge construction on the Nickel Plate. During this period many experiments had been made and papers written in which it was sought to demonstrate that concrete can be made practically impervious to water and also that it cannot. Much concrete had been built that was very porous and there sprung up numerous business enterprises for the manufacture and sale of waterproofing material. Both observation and experience indicated that watertightness could be secured by either concrete alone or in combination with waterproofing. The requisite seemed to be that the material and workmanship should be the very best. If poor waterproofing were placed over poor concrete, the structure would leak. If the concrete were good, it would hold water, either with or without the waterproofing.

Especial efforts were made to avoid the entrance of water between the steel and concrete and at points of contraflexure and where cracks might develop from temperature changes. Bevel flashings of steel were riveted to the girder webs and malleable cast flashings were fitted around the stiffeners to cover and seal the edge of the concrete. This design was very successful. At points of contraflexure over curb supports and at Cedar Avenue over the centre columns, it was realized that cracks would develop and an attempt was made to forestall their appearance by the construction of joints. The joints were carefully provided with gutters and drainage pipes, and it was hoped that no trouble would be had with the water. The cracks were successfully forestalled, but the drainage was unsuccessful. The channels soon became clogged with cinders and the details of the steel work in the gross-girders did not leave room for a sufficient body of concrete, and in some instances the concrete proved imperfect. So, while the slabs proved generally tight, there has been some leakage at the points of contraflexure.

Much reliance had been placed on the use of direct labor and carefully selected foreman, but there came a

*Abstract from The Elimination of Grade Crossings on the N.Y., C. and St. L.R.R. in Cleveland, O., by A. J. Himes. Bulletin No. 160, A.R.E.A.

great rush of work at a critical time and the floors suffered. In East Cleveland at a later date, it became necessary to build waterproof joints at the hinges of the arch bridges.

The concrete in the floor slabs cost about $12 per cu. yd. in place.

Now that the bridges are completed and have been two or more winters in service, the conclusions are as follow:—

1. Concrete can be made watertight, under low heads, for all practical purposes.

2. The mixing, placing and ingredients of concrete are subject to such a great number and variety of defects that only the keenest attention will secure an impervious structure.

3. Contraflexure temperature changes and settlements will produce cracks.

4. It is best to forestall cracks with predetermined joints.

5. Joints may be sealed against water if well designed.

On the underside of the bridge floors the concrete is protected from locomotive blasts by cast-iron plates, ½ in. thick and 36 in. wide. They weigh 71 lb. per lin. ft. and cost $5.23 per ft. in place.

AN IMPORTANT INDUSTRY.

An analysis of war orders shows that the orders placed through the Canadian shell committee and for other munitions account for $254,000,000 of the $394,000,000 worth of orders. The shell industry in Canada has grown to be a large one and is increasing rapidly in size and importance. According to a statement of General Bertram to the Canadian Manufacturers' Association convention at Toronto last month, 60,000 artisans are employed in Canada, drawing weekly wages of $1,000,000 in 247 factories, manufacturing shells for the war arena. Orders for 9,000,000 shells have been placed here by the shell committee and for 8,100,000 cartridge cases, fuses, primers, and friction tubes. For these contracts orders have been placed for 170,000 tons of steel, 30,000 tons of lead and several thousand tons of other material. Canada will be shortly turning out 50,000 shells per day. The changes which were necessary in the equipment of the various factories by adding new machinery, or in the readjustment of existing plants, were made by the manufacturers themselves and at their own expense. These changes gave employment to many other factories which were not directly engaged in making ammunition.

In addition to the manufacture of several thousand tons of cordite and powder in connection with the present shell contracts, an important new industry has been initiated in the Dominion, *viz.*, the utilization of the by-products from the coke ovens of the Dominion Iron and Steel Company at Sydney, N.S., for the manufacture of the high explosive, trinito-toluene. The revenue alone from the contract placed with this company will be nearly $5,000,000. Other companies also are making similar materials.

The new rectangular filter bed which is to increase the capacity of the sewage disposal works at Regina by about fifty per cent. is now nearing completion and should be in operation in a week or so. The travelling distributor is now being erected. This bed differs from the others previously installed, the latter being of a circular type.

COAST TO COAST

Owen Sound, Ont.—The hydro-electric power line from Eugenia Falls has been practically completed. The poles average 60 to 70 ft. in length and are of Douglas pine from British Columbia.

Ottawa, Ont.—The Government Improvement Commission is macadamizing the Canal Road between Hartwell's Rocks and Hog's Bank. Stone retaining walls are also being placed along the sides of the Rideau Canal at this place.

Edmonton, Alta.—The city purchased Calgary's municipal paving plant last year for about $19,000, but up to the present time the new owners have not been able to put it into service, owing to the lull in paving operations.

Glacier, B.C.—Although previously announced that the Roger's Pass Tunnel of the Canadian Pacific Railway would be electrified, it is now reported that a system of ventilation is being worked out which may permit the use of steam power.

Guelph, Ont.—The Page-Hersey Iron and Tube Co. are reported to have taken on a full staff of men after having been running shorthanded for some little time. It is possible that the company may establish a galvanizing plant at an early date.

Toronto, Ont.—At a cost of about $62,000 a water-bound macadam roadway has been constructed by the York County road commission from the city limits easterly for a distance of about eight and a half miles. The work was done in sections and extended over a period of about three years.

Ottawa, Ont.—The total population of Canada at the beginning of the present year, according to an official estimate made by the Census Department, was 8,075,000. The growth of population since the census was taken in 1911 is officially estimated at approximately 850,000, or an average of about 200,000 per year.

Toronto, Ont.—The city has under consideration once again the construction of a duplicate waterworks system at Victoria Park. The scheme recommended by Mr. R. C. Harris, Commissioner of Works, about 18 months ago provides for an expenditure of about $4,000,000. Our readers are referred to *The Canadian Engineer* for January 22nd, 1914, for a description of the proposed system.

Winnipeg, Man.—The Public Utilities Commission has ordered the operation of street cars over the Arlington Street bridge at the C.P.R. yard. A number of alterations will first be necessary. The intersection of the grade and level roadway on the bridge is to be lowered four inches to overcome the angle at the top of the grade, and the roadway paving is to be relaid in such a manner as to provide for proper transverse and longitudinal expansion.

Montreal, Que.—Mr. J. E. Aldred, president of the Shawinigan and Cedars Rapids Power Companies, reports a programme of progressive development both for the companies and the industries with which they are associated. It includes the construction of a transmission line which will link up Quebec with the Shawinigan power, the installation of additional machinery which will increase the capacity of the Cedars Rapids plant, the building of a tramway system for Three Rivers and its immediate district, and enlargements to be carried out at the plants of both the Aluminium Company and the Canada Carbide Company at Shawinigan.

Timmins, Ont.—The mill building for the treatment of the gold ore has now been completed at the property of the Schumacher Gold Mine, Limited. The machinery, some of which is on the ground, is now being installed, including a tube mill and a Hardinge conical mill. The shaft is now down 440 feet and sinking to the 600-foot level is being gone on with, following the completion of which extensive development work will be commenced. At the 300-foot level a quartz vein has been cut, which is said to be 800 feet wide. This vein lies about 300 feet from the main shaft in a northwesterly direction and it is believed that the grade of ore from it will be good.

Vancouver, B.C.—Scarcity of snow and rain among the mountains of the north shore last winter has caused the water in the creeks on which Greater Vancouver depends for its water supply, to drop to a fraction of its volume at the corresponding period last year. In Seymour Creek, observations taken recently show that only half the amount of water registered at the intake last year is now flowing. At the Capilano intake, the situation is worse for there is only one-quarter of the water in the creek that there was at the end of June, 1914. According to Mr. J. T. Breckon, the city waterworks engineer, there is no cause for alarm, however, although the consumers are being requested to use sparingly of the supply for the present.

Winnipeg, Man.—The contract for putting in the sub-structure for the cantilever bridge to be built over the Nelson River at Manitou Rapids, for the Hudson Bay Railway, has been awarded to Robert McDonald, of Winnipeg, according to an announcement made by Chief Engineer Porter. Mr. Porter states that he is well satisfied with the progress being made in the construction of the line. The construction of the terminals at The Pas will not be started until next spring. The plans are now under consideration at Ottawa, and the work will be commenced as early as possible in 1916. By starting next spring the work can be finished coincidently with the completion of the railway in 1917. It is also stated that the electrification of the road is being considered, with a view of economy in operation. Engineers of the Water Power Branch of the Department of the Interior are examining the water falls on the Nelson and Grass rivers to ascertain the possibility of harnessing their power for the purpose. This is the first attempt to determine the question of electrifying the road on the volume of water power available along the line.

OBITUARY.

The death occurred last week at his summer home in Muskoka of Aubrey White, C.M.G., Deputy Minister of Lands, Forests and Mines for the Province of Ontario.

CANADIAN MUNICIPALITIES.

The Union of Canadian Municipalities held a special meeting at Niagara Falls, Ontario, on July 20th and 21st, at which were discussed municipal problems, chiefly unemployment arising out of the present situation. The annual convention, which was to have been held at Victoria, B.C., was postponed on account of the war, but the unemployment problem was considered too important a subject to be delayed further.

PERSONAL

C. R. McCORT, B.A.Sc., a recent graduate in civil engineering of the University of Toronto, has joined the staff of the Forest Products Laboratory of Canada, at Montreal.

A. M. BRAY, assistant professor of electrical engineering at McGill University, Montreal, has resigned to become professor of electrical engineering at Cornell University.

H. E. TANNER, formerly assistant town engineer of Chicoutimi, Quebec, and for three years on the engineering staff of the Transcontinental Railway, succeeds Mr. H. Hadley as city engineer of Verdun, Quebec.

J. J. CALLAHAN, formerly connected with the Southern Counties Traction Co., Montreal, has been appointed operating manager of the newly electrified London and Port Stanley Railway, for the Hydro-Electric Power Commission of Ontario.

G. R. G. CONWAY, whose resignation as chief engineer of the British Columbia Electric Railway Co., Vancouver, B.C., was recorded in our issue of July 8th, will establish an office as consulting engineer at Toronto. He has had very extensive experience in engineering work in England, Scotland, Mexico and Canada. His accomplishments in connection with the Girdleness outfalls project under the River Dee, Aberdeen, Scotland, electric railway power development and municipal work at Monterey, Mexico, the Coquitlam dam for the Vancouver Power Co., and the Jordan River power project on Vancouver Island are well known. Mr. Conway is a member of the Council of the Canadian Society of Civil Engineers; member of the Institute of Civil Engineers of Great Britain, holding the Telford gold medal of that institution and also representing the council as a member of the advisory committee for Canada; member of the American Society of Civil Engineers, the Institution of Mechanical Engineers of London, and the American Society of Mechanical Engineers; Fellow of the Royal Meteorological Society; member of the British Institute of Water Engineers, and of the American Waterworks Association.

COMING MEETINGS.

AMERICAN SOCIETY OF CIVIL ENGINEERS.—Annual convention to be held in San Francisco, Cal., September 16th to 18th, 1915. Secretary, Charles Warren Hunt, 220 West 57th Street, New York.

INTERNATIONAL ENGINEERING CONGRESS.—To be held in San Francisco, Cal., September 20th to 25th, 1915. Secretary, W. A. Catell, Foxcroft Building, San Francisco, Cal.

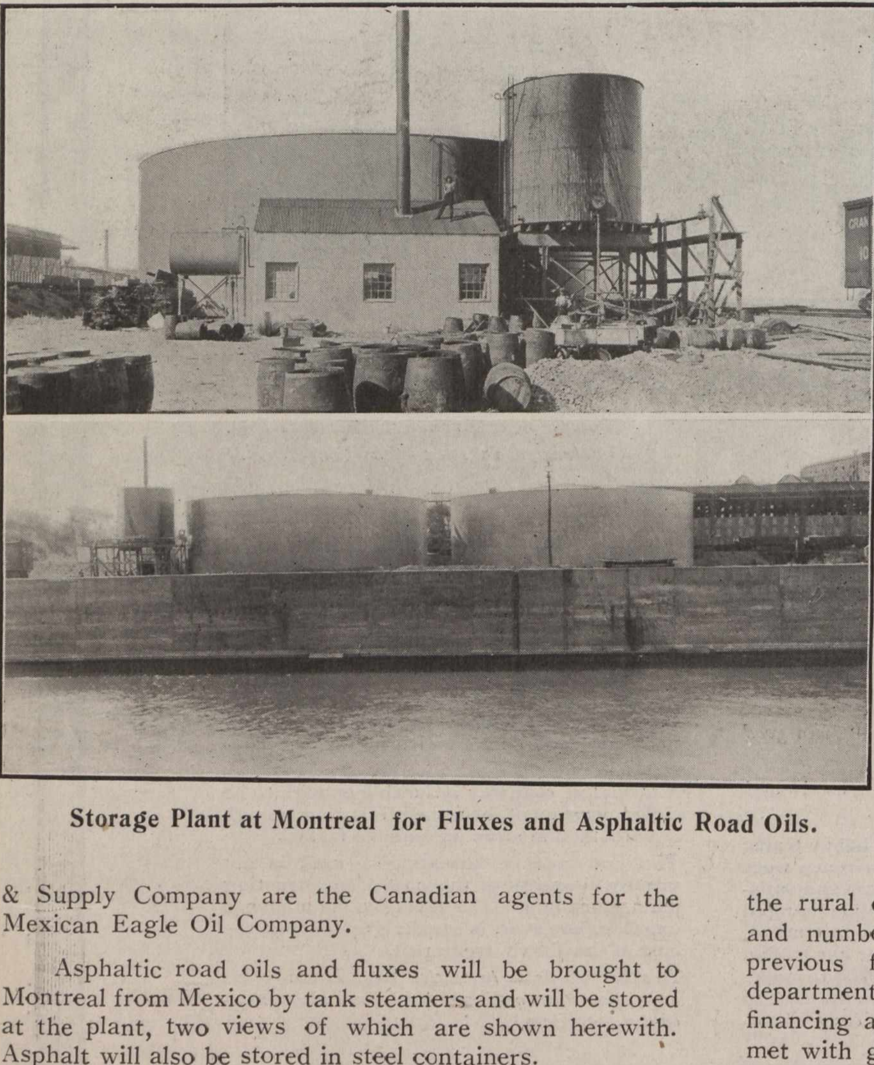
AMERICAN ELECTRIC RAILWAY ASSOCIATION.—Annual convention to be held in San Francisco, Cal., October 4th to 8th, 1915. Secretary, E. B. Burritt, 29 West 39th Street, New York.

The resignations of Mr. Breckon, waterworks engineer, Mr. D. B. McLay, assistant engineer on construction, and Mr. R. M. Grancey, bridge engineer, have been accepted by the city council of Vancouver, the resignations to take effect on July 31.

START OF CANADIAN ASPHALT PLANT.

In Montreal there has been completed the erection of an asphalt storage and barreling plant which is the start of what will likely be the first Canadian asphalt refinery. Two 37,500-gallon tanks and one smaller barreling tank have been erected by the Asphalt & Supply Company, Limited, of Montreal, on property that has been leased for a long term of years from the Montreal Harbor Commission.

Lord Cowdray, who is at the head of the Mexican Eagle Oil Company, has long favored the idea of establishing an asphalt refinery in Canada. The Asphalt & Supply Company are the Canadian agents for the Mexican Eagle Oil Company.



Storage Plant at Montreal for Fluxes and Asphaltic Road Oils.

Asphaltic road oils and fluxes will be brought to Montreal from Mexico by tank steamers and will be stored at the plant, two views of which are shown herewith. Asphalt will also be stored in steel containers.

The provision of storage and barreling facilities is generally considered to be the first step toward the establishment of a refinery, so that in all probability another industry will soon add to the list of Canadian-made products.

M. Beatty & Sons, Limited, announced on July 17th, that the control and management of the company had been changed. According to one of the officials of the company, Mr. H. L. Beatty has been elected President, and Mr. A. O. Beatty, Vice-President and General Manager. Mr. Harris T. Dunbar, of Buffalo, has been elected a member of the Board of Directors. Messrs. V. R. Browning and B. F. Miles, Directors, and R. A. Greene, General Manager, who have had charge of the business for the past three years, have severed their connection with the company.

INSECT BORERS IN PIPES.

Insects so rarely bore into metal and such boring is so altogether surprising that instances that come to the notice of entomologists are likely to be commented on in entomological literature. In a report of the South African Government entomologist, which appears in the Transactions for May, 1915, of the South African Institute of Electrical Engineers, such an occurrence is referred to, in which case longicorn beetles had escaped from roof timbers by piercing zinc plates at nail holes plugged with solder. The metal penetrated had a hardness of 3 as compared with lead 1.5.

The report refers also to a note in Scientific American of 13th June, 1891, translated from Gesundheits Ingenieur of 15th January, 1891. A lead pipe, which on a previous occasion had been found similarly injured, was found to be bored by a "wood wasp," the culprit being discovered with its head in the hole. The note then refers to an insect-bored lead bullet preserved in the U.S. National Museum. The bullet was found (in 1877) embedded in an oak tree, and when split out was discovered to have a hole bored through it by a longicorn larva, the bullet having laid in the track of the borer's tunnel in the wood. The larva was found in the tunnel. The other reference is to a borehole made through a lead pipe, also by a longicorn larva that found the lead in its path after boring through wood. The lead in this case was 2½ mm. thick.

SASKATCHEWAN TELEPHONE EXTENSIONS.

The report of the superintendent of rural lines in the province of Saskatchewan shows that during the year ended April 30, 1915, there has been a pronounced development of telephone service throughout the rural districts, and the increase, both in mileage and number of subscribers, was greater than in any previous fiscal year since the organization of the department. This is due to the fact that the methods of financing authorized under the new Rural Telephone Act met with general approbation, and were in consequence largely taken advantage of.

The following summary of the work of the branch during the past year will be found interesting:

Number of companies organized	151
Number of companies incorporated	126
Number of debenture applications approved amounting to $904,800	157
Number of debentures issued amounting to $970,100	176
Increase in number of rural and private telephone systems in operation	152
Increase in mileage of rural private systems	4,783
Increase in number of rural and private telephones in operation	4,743