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MOLYBDENUM.

During the recent turning to commercial use of steel alloys molybdenum has played an important part and workable deposits located in Canada will doubtless give impetus to the steel industries of this Dominion.

Until recently, molybdenum was required only for the manufacture of chemical preparations, principally ammonium molybdate, which is much used in the determination of phosphoric acid. Molybdic acid is used as a blue pigment in the manufacture of porcelain, and for dyeing silks and woolens. In various compounds molybdenum is used for coloring leather and rubber. Ammonium molybdate is said to be used for fireproofing, also as a disinfectant for cloth used in railway passenger carriages. The importance of this element and its compounds to steel is caused by the similarity of the production to tungsten steel.

Molybdenum is more potent than tungsten, and only about half as much of the molybdenum is necessary as would be required were tungsten used.

Molybdenum steel is used for rifle barrels, propeller shafts, large guns, wire, and particularly for the manufacture of high speed tools. Molybdenum high speed steel contains from 8 to 10 per cent. molybdenum. When the other elements exist in the right proportion, a steel is obtained of great hardness, with the peculiar property of retaining its temper when heated to a high degree, differing in this respect from all carbon steels. Owing to this property it is possible to take extremely heavy cuts at high speed, the tool often being heated through this hard use to a dull red heat without impairing its usefulness.

Molybdenum was discovered by Carl William Scheele, a Swedish chemist, toward the end of the eighteenth century; to this chemist also belongs the honor of discovering and isolating chlorine, ammonia, manganese, bartya and oxygen. Molybdenum, although discovered by the above mentioned chemist, was not isolated from its compounds until several years later. It has an atomic weight of 95.3 (4 = 1) the symbol of Mo, it is a member of the tungsten uranium group, and has a specific gravity of 8.62. It occurs principally as sulphide (molybdenite) and as lead molybdenate (wulfenite); as an element it presents a white, extremely hard and brittle metallic appearance.

Molybdenite, MoS_2, is the commonest of the ores, and is the one most widely distributed in Canada. In color it resembles lead, and presents physical properties in many ways similar to graphite; the specific gravity of MoS_2 is 4.7 in contrast to graphite, which is 2 to 2.2. It has a hardness of less than 2, may be scratched by the finger nail, and when rubbed on white surfaces leaves a mark resembling that left by a pencil. It generally occurs in six-sided tabular crystals which may be split into thin sheets deficient in elastic properties. Occasionally molybdenum as the sulphide is accompanied by molybdite (MoO_3 [?])*; this usually is found as an earthy powder, quite soft and of a lemon yellow color.

Wulfenite has the formula $PbMoO_4$, and contains 39.3 per cent. MoO_3. This material may be briefly described as follows: color, yellow to brown; streak, almost white; specific gravity, nearly 7; hardness, less than 3 (easily scratched by the knife, but not by the finger nail); crystals, thin tablets, usually either four of eight sided. Wulfenite does not, so far as is known at present, occur in Canada in economic quantities. Wulfenite and molybdite are both alternation products of molybdenite, and may, therefore, be expected in the upper levels where oxidation is relatively prominent.

MoS_2, as a general rule, occurs in very coarse veins of granite, called pegmatite, which often intersect such rocks as gneiss, slate, and quartzite. They contain various minerals of economic value, principally muscovite and feldspar. Genetically these veins owe their origin to material derived from large masses of granite, which are usually to be found in the vicinity, and which probably occur at no great distance beneath the pegmatite mass. Molybdenite is occasionally present in these veins in varying quantities, and some of the important ore bodies of Canada are of this type, as, for example, those at Romaine in Quebec and Glengarry in Cape Breton.

Many quartz veins have originated in a method similar to pegmatite veins—the fissures have been filled by material derived from underlying, deeply-seated granite masses. Some quartz veins are almost free from feldspar, others contain so much that it is doubtful which should be designated.

The preparation of the crude ore for the market is one of the most difficult problems in ore dressing. Up to the present it is doubtful if a satisfactory solution has been arrived at. The mineral is very soft, and usually occurs in a very hard gangue, largely quartz and feldspar. In attempting to crush by stamps or rolls, much of the molybdenite is finely divided, so that a large loss results by sliming. On the other hand some of the larger flakes resist the action of the rolls, and may be separated by means of sieves. In density, molybdenite is heavy enough to separate readily by washing, were it not for its perfect cleavage giving rise to very thin scales and plates, which readily float away and are lost.

In general, there are three methods of molybdenite concentration which may be applied after cobbing and hand picking:—

The ore may be crushed and concentrated by washing. Mr. J. Walter Wells some years ago carried on experiments with this method of treatment in view. A brief report of the results of this work is given in the following extract:—

"Experiments were carried on by Mr. Wells for the purpose of finding suitable methods for concentrating the Canadian ores. On a sample containing 50 per cent. pyrrhotite, 10 per cent. pyrite, and 6.5 per cent. molybdenite in a gangue of calcite, biotite, quartz, and pyroxene, good results were obtained by crushing in a jaw crusher, hand picking of the large flakes of molybdenite, recrushing in rolls set to 0.2

*It has been recently shown to be somewhat complex, and to be a hydrated iron molybdate, containing 59.42 per cent. MoO_3.

inch space, and successive sizings in screens from 0.3 inch to 0.5 inch mesh. The oversize from the screens, which consisted of molybdenite, mica, and rock, was treated on a Wilfley table, and yielded a commercial product. The Hartz jig was not adapted for concentrating this ore; but good results were obtained with the Wetherill magnetic separator, although, owing to the high current and slow speed necessary, it is doubtful if this separation can be done on a practical basis. Treatment by a modified form of the Elmore process

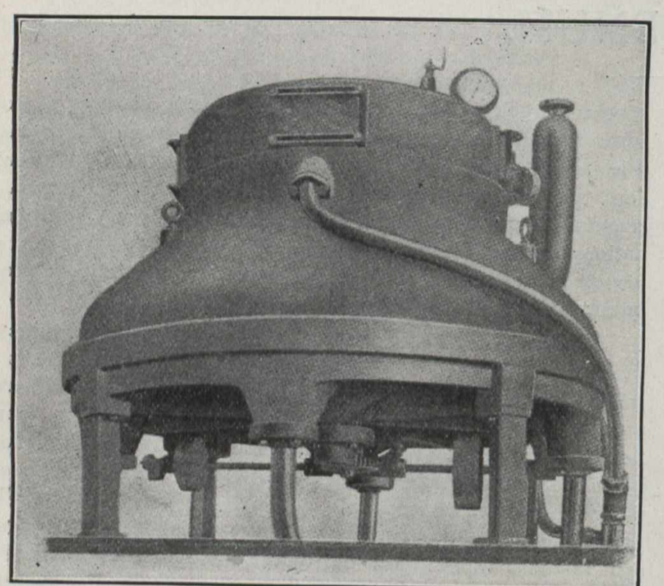


Fig. 1 Illustrates an Elmore Concentrator.

was only partially successful, as the large particles of molybdenite were not affected by the oil. Another sample consisting of quartz and feldspar with 2.5 per cent. molybdenite, was crushed and sized, but gave no clean ore on any of the screens. The whole sample was then ground to pass an 0.05 inch screen, and concentrated on a Wilfley table; the final concentration being effected by the oil process. The experiments carried out by Mr. Wells showed that no standard method can be adopted for concentrating molybdenum ores. Separate mill tests are required to determine the proper treatment in each case."

Crushing and dry concentration has been employed at Cooper, Maine, where the ore is granite, containing fairly coarse foliated molybdenite. According to T. L. Walker, M.A. Ph.D., the plant of the American Molybdenum Company consisted of a 35 horse-power boiler and engine, a Sturtevant jaw crusher and roll, and four sets of special rolls, each 3 feet in diameter and 10 inches wide. The crusher was located a couple of feet above the floor, from which the material, crushed to about one-fourth inch square, is elevated to the Sturtevant roll, 18 inches in diameter by 4 inches wide, which reduces the ore to about one-eighth inch. It is then elevated to a bin at the top of the building, from which it falls to a series of two special rolls, thence elevated to a third special roll, and run through a 34 mesh screen. The molybdenite caught on the screen is delivered to a box at the end. The material going through the screen is carried by an elevator and screw conveyer to a fourth roll, from which it falls onto a 40 inch screen and from that to a 60 mesh screen. What goes through the 60 mesh screen is elevated and sent to the tailings pile. It is readily seen that the repeated elevations of the material mean a considerable waste of power. In a report to the government Mr. Walker says: "Such a process, if mechanically perfected, might work profitably on deposits where, as in this one, the molybdenite flakes are comparatively broad, but would be wholly unsuited to deposits like many of those in Colorado and elsewhere, in which the individual flakes are of almost microscopic size."

A process apparently well suited to molybdenite ores has been recently brought forward by F. E. Elmore, and is as follows:—

"Based primarily upon the fact that, in a flowing pulp of crushed ore and water, oil has a selective action for the metallic mineral particles as distinct from the rocky particles or gangue. This selective action is materially increased in some cases by the presence of an acid; gases dissolved in water are liberated, partially or entirely, upon subjecting the same to a pressure less than that of the surrounding atmosphere. These liberated gases may be augmented by the generation of gases in the pulp or by introduction from an external source. The gases attach themselves to the greased mineral particles, and being largely increased in volume as a result of the partial vacuum applied, cause the greased particles with their attendant bubbles of air or gas to float to the surface of the liquid."

A London (England) company manufactures the apparatus, and in order to demonstrate the suitability of this process for various ores, they have established a testing plant and make trial on small shipments. Three such experiments made in concentrating molybdenite resulted as follows:—

Sample Number	Nature of Gangue	Per Cent Molybdenum. In Ore	In Tailings	In Concentrates	Per Cent Saved
1	Feldspar	3.40	0.25	40.80	93.2
2	Much garnet and magnetite	2.30	0.06	51.57	98.1
3	Not stated	5.21	0.17	54.7	97.0

A sample of the ore from the claims of the St Maurice Syndicate, Lake Kewagama, was treated by this process by

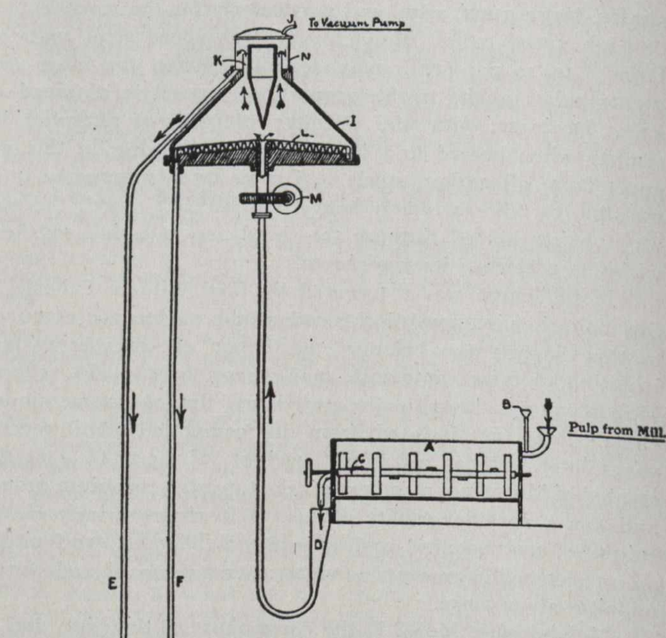


Fig. 2.—Elmore Vacuum Concentrator: Section.

the Denver Engineering Works Company, of Denver, Colo. The sample was small, but the concentration was very satisfactory, with a minimum loss in the tailings as illustrated by the following report:—

Following are the results obtained by the Elmore process on the sample of molybdenite submitted by Mr. J. C. Gwillim. The mineral seemed free at 16 mesh, but owing to the small diameter of the delivery tube of the laboratory machine it was found necessary to crush it finer before making the test.

500 grains of ore assaying 1.70 per cent. molybdenum were agitated four minutes with 5 c.c. acid, 2 c.c. Beaumont oil, then four minutes more with 5 c.c. acid and 1 c.c. oil—2.5 c.c. acid were used for gas, and test was under vacuum 2.25 minutes. The following products were obtained:—

20 grains concentrates ...... 42.90 per cent. molybdenum.
472 " tailings............ trace.

This gives the ratio of concentration of 25 tons into one and a recovery of 100 per cent. The recovery figures are slightly in excess of 100 per cent. owing probably to discrepancy of a few hundredths in crude assay. The tails showed acid reaction and were quite clean.

The amounts of acid and oil used could probably be lowered very materially, but owing to the lack of time and urgent requests to rush the work these investigations were not undertaken.

Fig. 2 will serve to indicate the principles involved and the type of apparatus used in this process of concentration.

At the Great Knaben mine in southwestern Norway, which has produced from 25 to 30 tons of molybdenite annually since 1902, water concentration with jigs and tables has been abandoned, and more satisfactory results are said to have been obtained by the use of the Elmore oil concentration. The ore is first cobbed, and the poorer ore sent to be concentrated.

In 1899, Professor J. B. Porter, of McGill University, made some experiments on the concentration of molybdenite for the Geological Survey. From the two samples examined he concluded that the most satisfactory method was cobbing and hand-picking.

The following extract from the Report of the Geological Survey of Canada gives the main results of Professor Porter's investigations:—

The first, or Egan Township, sample, weighing 289 pounds, and containing in all 15.92 per cent. of molybdenite, was cobbed and hand-picked in the Survey, yielding 39 pounds of clean mineral in crystalline flakes. The remaining 250 pounds of the cobbed ore was then sent to Professor Porter, who ascertained that it still contained 2.8 per cent. of molybdenite. By a dry process of rolling and screening, followed by jigging, nearly all the molybdenite was extracted from this ore, in a series of concentrates ranging from 70 per cent. to 15 per cent. in molybdenite. It is not necessary to refer to the details of treatment here, but the results appear to show that in the case of molybdenite ore of this class, in which the crystalline masses are of considerable size, it would not be economically possible to employ any crushing and concentrating process. The problem resolves itself into one of cobbing and hand-picking at remunerative rates. The associated minerals in this case were: pyroxene, iron pyrites, and mica.

The second, or Ross Township sample, weighed 250 pounds. The gangue was chiefly quartz, and, although the molybdenite made a considerable showing, it was found by Professor Porter to amount to only about one per cent. This specimen was not cobbed or hand-picked. By concentration it was determined that about 52 per cent. of the molybdenite could be saved in the form of a concentrate containing 33.50 per cent. of the mineral. The grade of this concentrate appears, however, to be too low for present commercial requirements.

The ores of molybdenum, so far as is known at present, occur in Canada in Yarmouth county, Shelbourne county, Lunenburg county, Halifax county, Cape Breton county, and Victoria county, Nova Scotia. In the vicinity of Burnt Hill Brook and the Main Southwest Miramichi, New Brunswick. At St. Jerome and Mamkuagan Bay, Quebec. In Haliburton, Victoria, Hastings, Addington, Carleton, Frontenac, Leeds and Renfrew counties, Ontario; also in the Nipissing and Rainy River district and in several localities in British Columbia.

The present annual world production of molybdenum ores is quite insignificant—only a few hundred tons. Norway, Queensland, New South Wales, Japan, and the United States, are the chief producing countries. In all of these the output is much subject to rapid variation.

In Canada there has been no regular production of molybdenum ores up to the present time.

The production of 150 pounds of molybdenum is listed in the mineral statistics for 1886. The place where the ore was mined is not indicated. This appears to be the first appearance of molybdenum in the mineral statistics of Canada.

In 1902 about 4 tons of molybdenite bearing ore valued at $400 were mined in the township of Laxton, Victoria county, Ontario.

In 1903, 85 tons of crude ore containing about 4 per cent. molybdenum were mined in the east half of lot 5, concession XIV., in the township of Sheffield, county of Addington, Ontario. About 500 tons of rock had been blasted out in order to obtain this ore; so that the ground as broken contained less than one per cent. molybdenum.

In 1894, in the township of Aldfield, in the county of Pontiac, the Foote Mineral Company of Philadelphia carried on operations, not with a view to producing molybdenite in a commercial way, but to securing specimens for museums and for teaching purposes. The amount of molybdenite obtained was very small.

During the summer of 1909, Lieut.-Col. John Carson and associates, of Montreal, carried on explorations near Romaine, on the north shore of the Gulf of St. Lawrence. They made at least one shipment of about 2 tons of ore. This was shipped as samples, and for experiments in concentration.

With regard to foreign production, it is equally difficult to obtain satisfactory statistics, as the amount involved is small and the production spasmodic. In recent years Queensland and New South Wales have become relatively large producers.

FIREPROOFING TIMBER TRESTLES.*

Timber railway bridges which need fireproofing most are those on high speed lines and those which are visible for only a short distance to the engineman. The larger the bridge the greater the need of fireproofing.

Most fires on timber bridges are started from the top by sparks and coals from locomotives. Not many bridges are ignited by fire from outside sources, and it is therefore hardly necessary to fireproof for these causes, beyond cleaning away vegetation from the vicinity of the bridge. Fire dropped from locomotives has burned many bridges and almost all such fires can be avoided by the use of a good type of fireproofing. The types of fireproofing used mostly at the present time are as follows:—

A. Ballasted floor pile bridges; about the same amount of ballast being placed under the tie, on the bridge, as on an embankment.
B. Metal covering on the ties.
C. Ballast covering from 2 to 4 ins. thick on the ties; a wood filler being placed between the ties to support the ballast.
D. Metal covering on the caps and stringers.
E. Metal covering on the ties with 2 ins. of ballast thereon.

*From the committee report read before the American Railway Bridge and Building Association ot St. Louis, October, 1911.

F. Ordinary pile bridges built with certain kinds of treated timber.
G. Fire resisting paints.
H. Pile bridges having I-beam stringers.

The fireproof feature of ballasted floor timber trestles is not the most important reason for adopting this type of construction, and the details of such bridges can not properly be considered here, except to say that the ballast serves as a first-class fire protection for the timber. These bridges with treated timber cost about 75 per cent. more than the ordinary pile bridges.

The method of entirely covering the ties with metal is favored by many roads. It affords very good protection when the sheets are firmly attached and in good condition. If the metal used is of poor quality and light weight, holes will soon develop and if it is not properly fastened it will soon work loose and the ends will curl up. If these things happen the covering is apt to assist ignition rather than prevent it, because the loose ends and holes will catch coals and sparks. There are many different ways of putting on this covering, the principal difference being the method of attaching the galvanized iron around the track rails. In most cases, No. 22 iron is used. To obtain the best results the metal should be securely fastened and of such a quality and weight that it will last a reasonable length of time. It should last as long as the timber in the bridge. When a good quality of No. 22 galvanized iron is used, this type costs about 75 cts. per lin. ft. of single track bridge.

Ballast covering over the entire deck is another type which affords good protection so long as everything is in good condition and no timber is exposed. Gravel ballast is used in most cases, although stone, slag and clay are also used to a considerable extent. The vibration will cause the ballast to bunch over the more rigid parts of the bridge, leaving some of the ties exposed. A very serious objection is that the ballast holds the moisture which causes decay in the timber. Clay affords a good protection and can be obtained in almost any locality; it is more stable under vibration than gravel, but it will hold moisture longer than the other materials. The draft of high speed trains tends to remove the ballast covering from the bridge.

The position of the filler blocks between the ties should be considered. The two extremes are—placing the filler on the stringers and, placing it flush with top of ties. Placing the filler directly on the stringers necessitates a large amount of ballast for covering without gaining anything over a smaller amount as regards fireproofing. The decay of the timber is faster, because the contact surface between ballast and timber is larger, and the larger volume of ballast will hold more moisture. If the filler is placed flush with the top of the ties, the gravel rests on an unbroken surface and will readily move about, due to the vibration of the bridge and the draft of trains, which will leave bare spots. Probably the best way is to place the filler so that it will come about 1 in. below the top of the tie and then place 3 ins. of ballast on the filler, which would provide 2 ins. of ballast above the ties. With gravel ballast such construction costs about 35 cts. per lin. ft. of single track bridge. Sometimes galvanized iron is placed over the guard rail in connection with the ballast covering. This adds about 15 cts. per lin. ft. to the cost.

Galvanized iron is placed on the tops of caps and stringers by a number of roads, the object being to protect the timber from weather as well as from fire. In this way the ties are left bare but the more important parts of the bridge are protected. It is not difficult to keep such covering in place. The metal should be of quality and weight sufficient to last as long as the timber. Using a good quality of No. 20 galvanized iron the cost is about 60 cts. per lin. ft. of single track bridge.

Sometimes a covering of ballast about 2 ins. thick is placed on the metal covering of type B. This partly overcomes some of the objections of this type, in that if some of the edges of the galvanized sheets work loose or holes develop in the metal the presence of the ballast will prevent fire. The draft caused by trains and the vibration of the bridge will cause the ballast to move about and leave bare spots as in type C. Also the ballast will retain moisture; but this is not so serious as in type C, because the ballast does not come in contact with the timber; however, the moisture will rust the metal. The use of gravel ballast will increase the cost of type B about 6 cts. per lin. ft.

On one road, zinc treated timber was found to be of value in resisting fire. The trestles are built in the usual way and treated timber used. This type probably adds $1.50 per lin. ft. to the cost of a pile bridge and it would not pay to use it for the one reason of fireproofing because the cheaper types would afford just as good protection.

Fire resisting paints are used to a considerable extent in the East and in Canada, with good results in most cases. The Board of Railway Commissioners of Canada requires that if Clapp's paint is used, one coat must be applied at least every five years. It costs about 27 cts. per lin. ft. for labor and material to paint a single track bridge with this paint.

The use of I-beams for stringers reduces the probability of fire, although this can hardly be called a method of fireproofing timber trestles. Such construction costs about 20 per cent. more than ordinary pile bridges.

Inquiries were made of 86 railroads regarding the methods of fireproofing timber trestles. From these 79 replies were received, 29 of which stated that no fireproofing of any kind was used. The remaining 44 replies are summarized as follows, showing the number of railroads using the different types:

Types used.	
A	6
B	2
C	3
D	5
G	4
A and D	6
A and H	1
A and C	6
A, B and D	2
A, B and C	1
A, G and F	1
A, C and D	1
B and C	1
B, C and E	1
B and D	1
C and D	2
D and G	1

Most railroads favor the ballasted floor pile bridge because of its many desirable qualities in addition to fireproofing. In type D, a metal covering on caps and stringers, the protection from weather is an advantage about equal to fireproofing. In types F and H, treated timber and use of I-beam stringers, permanency is a strong argument for their use, aside from the fireproofing qualities.

The types used solely for fire protection are: B, metal covering on ties; C, a 2 to 4-in. ballast covering; E, metal covering and a small amount of ballast; G, fire-resisting paints.

With a ballast or metal covering inspection of bridges is quite difficult and repairs are also more difficult and expensive to make. Type G is the simplest and most satisfactory form, is comparatively moderate in cost, and does not change the general construction of the bridge in any way.

CEMENT CONCRETE ROADS.*

Concrete is not a new material, having been employed centuries ago by ancient civilizations, and it is somewhat notable that their use of concrete was largely in association with highway construction. So durable have been some of the old Roman roads that they are still in use in Southern Europe, and are believed by the more ignorant peasantry to be of supernatural origin.

The modern use of concrete in highway work includes many details. It is largely used for pavement foundations, sidewalks, bridges and culverts, bridge abutments and retaining walls, bridge floors, curbs and gutters, man-holes, catch-basins, hand-rails, and other special features.

Concrete has become the recognized foundation for asphalt, brick and other high-class pavements for streets of towns and cities, and for the foundation of brick pavements for country roads. Its use as a paving material for the surface of the street or road has, however, been looked upon with considerable uncertainty, although in a number of cases, some degree of courage has been shown in carrying on this class of work.

Windsor has been the principal place in Ontario to adopt this type of paving, and reports as to its merits have, to the present, been favorable. Experimental blocks have been laid in Brantford, Chatham, Toronto, and other cities.

Recently the good roads movement in the United States has led, in some degree, to the adoption of concrete for country road construction for main highways radiating from large cities. The requirements of traffic have led to the adoption of a type of roadway consisting of a central concrete pavement from 10 to 18 feet wide. On each side of this are gravel or macadam shoulders, making a road of the desired width, usually from 24 to 30 feet from outside to outside of gutters. The cost has varied according to local conditions, but including shoulders, drainage and culverts, has been approximately $1.35 a square yard of concrete.

Concrete pavements are laid in much the same way as concrete sidewalks. The sub-grade is excavated and rolled. This should be carefully done, so that the monolithic pavement will have a base of uniform strength. If the sub-soil is of sand or gravel, the concrete may be laid directly on it, but if it is clay or other impervious soil, it should have a layer, three or four inches thick, of gravel, cinders, broken stone or other strong and porous material. The sub-grade should have the same camber or crown as the finished roadway is to have. If a town street, curbs are laid first; but if a country road, curbs are not used, the surface being merged into the gravel or macadam shoulders.

Over the sub-grade the concrete base is spread to a depth varying with the amount of traffic, usually four or six inches. The mixture should be proportioned for greatest density, but common practice employs a 1:3:7 mixture of cement, sand and broken stone; or a 1:8 mixture of cement and gravel. The base should be immediately covered with a wearing surface 1½ or 2 inches thick of strong mortar or concrete.

At intervals of about twenty or twenty-five feet there should be expansion joints across the roadway, about 1½-inch wide; and at the curb similar longitudinal joints, to be filled with pitch or asphalt.

To reach good results, the greatest care must be taken in particulars now well known in paving and general concrete construction. As with any form of road construction the drainage should be ample. The surface coat should be immediately spread on the base before the latter has commenced to harden, so that union will be complete. A well rolled and uniform foundation will prevent much cracking. The mixing of the concrete should be thorough, as imperfect mixing is the cause of a vast amount of poor concrete. The surface should be protected from the sun in the usual way with straw, sand, burlap, and should be kept moist until it is fully hardened. As a rule, a concrete road or pavement should not be opened for traffic in less than ten days or two weeks.

A perfect pavement, meeting all desirable conditions of cost, durability and service rendered has not yet been found; and as requirements in many cases are of an opposite character, it is not probable that an ideal pavement for universal use will ever be invented. The more important qualities usually sought in a pavement or road material are that it should be:

(1) Low in first cost.
(2) Easily and cheaply maintained.
(3) Smooth and hard, so as to offer least resistance to traction.
(4) Easily cleaned.
(5) Noiseless.
(6) Not dust-producing and not muddy.
(7) Non-absorbent and sanitary.

In Wentworth County, on the Dundas and Waterloo Road, Built in 1909.

(8) Such as to give a good foothold for horses.
(9) Comfortable for those driving on it.
(10) Neither glaring nor hot.

The principal objections to concrete as a material for roads and pavements have been that the surface is too hard and glassy to give a proper foothold for horses; that it is rigid and therefore hard on the feet of horses; that it reflects heat and has an unpleasant glare; that expansion joints chip at the angles and under constant traffic deepen to holes; that cracks due to defective construction and to uneven foundations are difficult to repair, and, like expansion joints, chip at the corners.

On the other hand, it has been recognized that were these difficulties overcome, concrete has certain merits. It is low in first cost, as compared with other high-class pavements, and is one of the cheapest materials yet available for a permanent pavement or roadway.

Attention has recently been drawn to concrete pavements which have been treated with a surface painting of tar over which a thin layer of fine gravel is spread, just sufficient to be saturated and held by the tar.

In appearance these pavements resemble sheet asphalt, the tar and sand coating overcoming the glare and reflection of heat. The tar and sand fills the expansion and depressions, serving as a wearing surface. The expansion joints disappear from view and do not chip at the corners. The tar-sand coating deadens the noise of traffic, makes the pave-

*Abstracted from Annual Report on Highway Improvement, Ontario, 1911.

ment impervious to moisture. If cracks appear these are painted with tar and sanded so that they, too, disappear, and they do not crumble under traffic. The treatment, in short, overcomes the more objectionable features of the concrete pavement.

Concrete pavtments as heretofore laid in Ontario have cost about $1.15 a square yard. The tar treatment has cost about 2 cents a square yard, and the treatment has been found to last for two years, making the cost of tarring and sanding 1 cent per square yard per annum. If further experience proves the success of this treatment, it should be useful for the smaller towns and villages in paving their main business streets, and would be exceedingly effective for main highways radiating from large cities.

CONTROLLING BRAKES FOR TROLLEYS ON TRANSFER BOOMS.*

By Frey Broberg.

The design of controlling drums and brakes for trolleys on transfer booms, carrying automatic buckets, is naturally dependent upon the effect on the controlling rope, which holds the carriage at any point on the boom for the purpose of taking on or dumping a load.

As most of us know the automatic bucket is operated by two ropes, the closing and holding rope. The former, when pulled, closes the bucket and carries two-thirds of the total load when bucket is hoisted in order to keep the same closed. The office of the second rope is to carry the remaining third

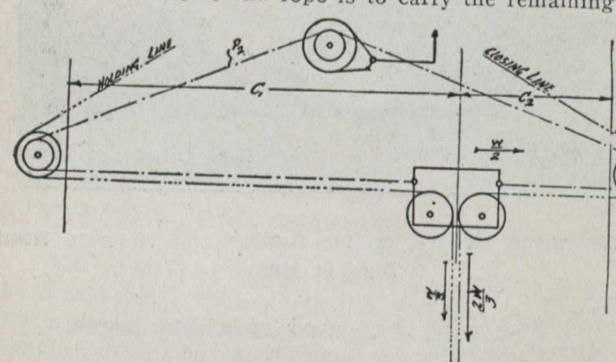


Fig. 1.

of the load and keep the bucket suspended when the pull on the closing line is released at dumping.

In order to move the trolley or bucket carriage back and forth on the tracks of the boom, without an extra engine, the difference of tension in the above mentioned ropes is brought into use.

The holding line is carried from the trolley round a sheave placed at the loading end of the transfer boom and is led from here to the engine via various sheaves, according to conditions. The closing line on the other hand is carried from the trolley round a sheave at the dumping end, as the sketch shows. An endless line, wrapped a few times around the controlling drum is the controlling rope. The drum can be placed at any convenient point.

To brake this drum and thus make the trolley stop or retard its motion, at the operator's will, a foot-lever is placed near and from here the pressure of his weight is carried through an arrangement, very much like the arrangement of block signals in a railway yard, to the controlling drum, and is ultimately transferred into friction between the brake-band and the controlling drum.

*From Industrial Engineering.

There are two ways to operate a transfer boom of this design. One way is to have the controlling drum braked constantly and only partly release the brake in order to move the carriage. The other way is to keep the brake released and only bring the brake in action when it is desired to stop. It has been found that this latter method is more practical and efficient than the first method because it is difficult for one man to operate four levers simultaneously. The levers are one steam throttle (or electric switch, if electric power is used), two friction levers and one lever for the controlling drum. By using the second method it is not necessary to operate these levers at the same time.

It is true that by working a carriage with this method more strain is exerted on the controlling rope, but only one man is needed.

Because a drum working under these conditions has to stand harder service and because this is the way mostly employed by operators of "Transfer Booms," "Boston Towers" and Gantry Cranes, we will analyze the effect when the second method is employed.

To ascertain this effect the movement of the trolley is divided in two cycles. The first cycle extends from the beginning to the point at which the operator begins to retard the motion. The second cycle starts at this point and prevails until the trolley is brought to rest. The length of the cycles are, of course, subjected to the operator's will. The longer the second cycle the less power is needed on the brake, but more time is used.

By marking:

D = Total distance of travel.
C_1 = First cycle of movement.
C_2 = Second cycle of movement.
W = Total load.

$W_1 = \frac{W}{3}$ = Strain on holding line.

$W_2 = \frac{2W}{3}$ = Strain on closing line.

$P_1 = \frac{2W}{3} - \frac{W}{3} = \frac{W}{2}$ = Force of acceleration in first cycle.

P_2 = Constant retardation force in second cycle.
V = Initial speed in first cycle = 0.
V_1 = Finishing speed in first cycle.
= Initial speed in second cycle.
V_2 = Finishing speed in second cycle.
F_1 = Acceleration in first cycle.
F_2 = Retardation in second cycle.
E = Effect on rope at end of first cycle.
= Effect on rope at beginning of second cycle.
G = Acceleration of gravity.
T_1 = Time of first cycle.
T_2 = Time of second cycle.

By applying the known quantities to the equation, the acceleration due to the weight and constant power is found. Having the initial speed, the found acceleration and space of travel, the time is found for the first cycle. In the second cycle the initial speed is, of course, identical with the finishing speed of the first cycle and the finishing speed of the second must be nil. Space is known and with the speed time is found.

It is obvious that the sum of the effects of power and speed and time of both cycles must be equal to 0 to insure perfect rest of trolley.

$$P_1 = M.\ F_1$$

$$P_1 = \frac{W}{2}$$

$$M = \frac{W}{G}$$

$$\text{Then } F_1 = \frac{G}{2} \quad (1)$$

$$E = \frac{P_1\ C_1}{T_1}$$

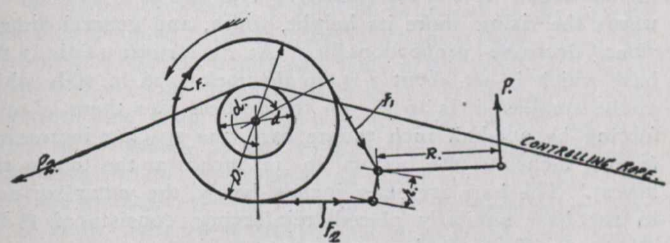


Fig. 2.

$$C_1 = \frac{1}{2} F_1\ T_1^2$$

$$\text{And } C_1 = \frac{G\ T_1^2}{4}$$

$$T_1^2 = \frac{4\ C_1}{G} \quad (2)$$

By inserting this result in the equation we get:

$$E_1^2 = \frac{P_1^2 - G - C_1}{4} \text{ For first cycle.}$$

$$E_2^2 = \frac{P_2^2 - G - C_2}{4} \text{ For second cycle.}$$

And ultimately we have:

$$P_1^2\ G = P_2^2\ C_2^1$$

$$\left\{ \begin{array}{l} P_1 = P_2 \sqrt{\dfrac{C_2}{C_1}} \quad (3) \\ P_2 = P_1 \sqrt{\dfrac{C_1}{C_2}} \quad (4) \end{array} \right.$$

= constant strain in controlling rope or retardation force in second cycle.

To determine the size of the brake band on the controlling drum is an easy matter when the strain on the rope is known. Corresponding to the letters in the figure.

F = Friction between band and surface.
P_2 = Tension in rope.
D = Diameter of brake rim.
d = Diameter of controlling drum.
u = Coefficient of friction.
e = Base of nat log.
F_1 = Tension in dead end of brake band.
F_2 = Tension in live end of brake band.
r = Radius of brake cam.
R = Radius of brake lever.
X = Angle embraced by brake band.

We have:

$$F = F_1 - F_2$$

$$F_2 = \frac{F}{e^{ud} - 1} \qquad \frac{F_1}{F_2} = e^{ud}$$

$$\text{and } F_1 = \frac{F.\ e^{ud}}{e^{ud} - 1}$$

$$\text{On ordinary brake bands } \frac{1}{e^{ud} - 1} = 0.83$$

$$\text{and } \frac{e^{ud}}{e^{ud} - 1} = 1.83$$

$$\text{Thus } F_2 = \frac{F}{1.83}$$

$$F = \frac{P_2\ d}{D}$$

$$\text{And } F_2 = \frac{P_2\ d\ 0.83}{D} \quad (5)$$

$$F_1 = \frac{P_2\ d\ 1.83}{D} \quad (6)$$

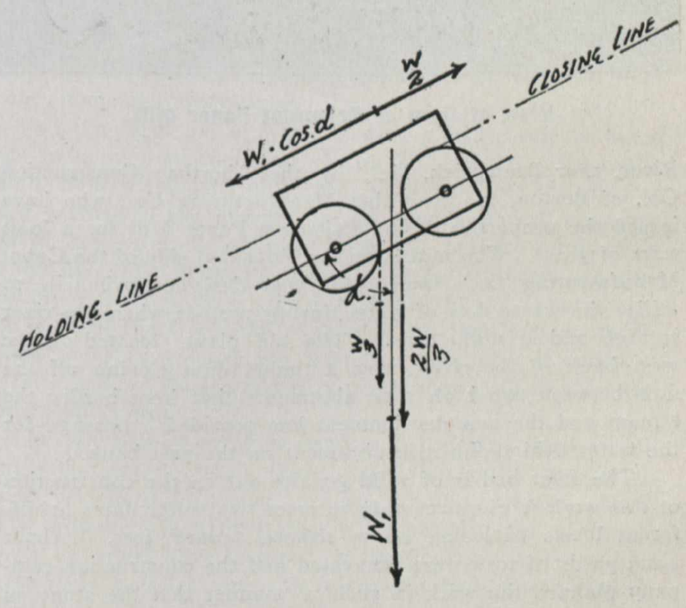


Fig. 3.

This latter tension determines the size of the band. For the length of lever:

$$R = \frac{F_2\ r}{P} \quad (7)$$

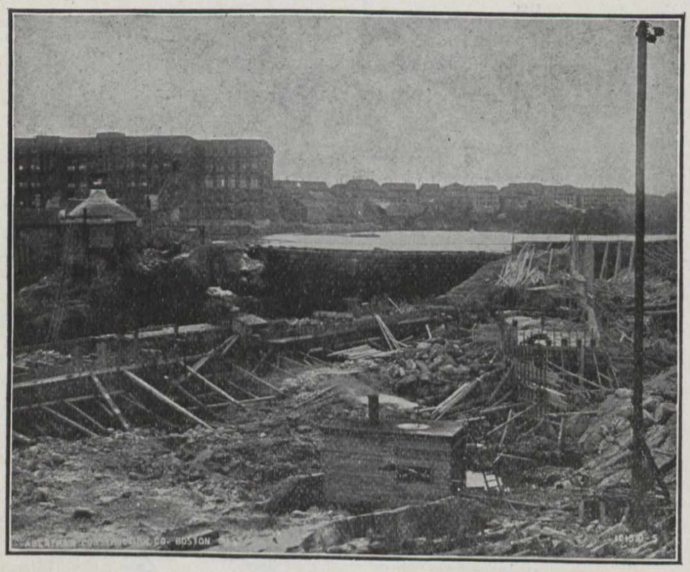
In this search no attention has been paid to the weight of the trolley and no allowance has been made for stiffness of cables.

However, when the boom is inclined P_1 in the first cycle is changed to $\frac{W}{2} - W_1$ cos. d when going up. For going down $P_1 = \frac{W}{2} + W_1 \cos. d$ — W_1 being the total load of bucket and carriage.

Sometimes it happens that P_1 when going up becomes negative on account of a steep incline. When this is the case, which has to be analyzed, the controlling line gets the tension only when the carriage is at rest or going down.

A NEW REINFORCED CONCRETE PAPER MILL.

A reinforced concrete paper mill, dam, forebays, and flumes have recently been completed on the Androscoggin River, near Brunswick, Me., by the Aberthaw Construction Co., of Boston, for the Cabot Manufacturing Co., who have leased the properties to the Pejepscot Paper Mill for a long term of years. The mill is on the Topsham side of the Cabot Manufacturing Co.'s dam, and was designed primarily to utilize the waste flow of water during periods when the river is high and at night time. The old plant, located on the west bank of the river, uses a timber dam closing off the flow between two high rock abutments that here border the stream and the new development has provided a passage for the water behind the rock abutment on the east bank.



View of Dam of Pejepscot Paper Mill.

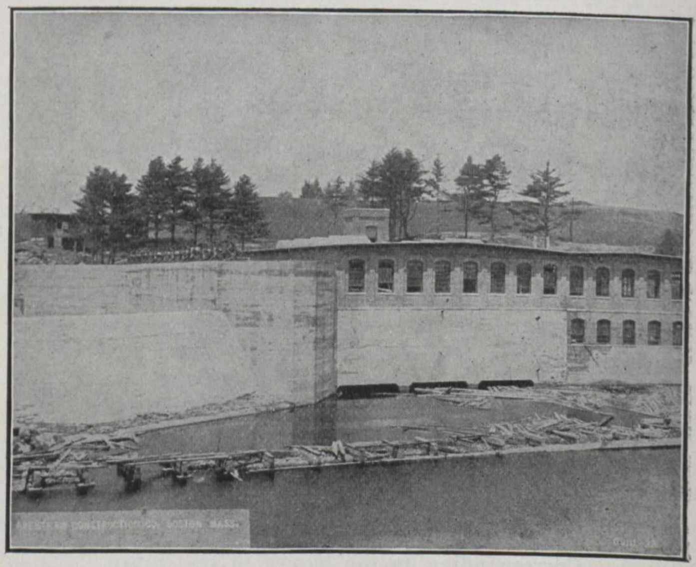
The river bed is of solid granite and in the construction of this work it was necessary to erect two coffer dams at different levels enclosing about 106,000 square feet. About 4,223 yards of rock were excavated and the construction company planned the work in such a manner that the stone as blasted was crushed and used in the concrete work, thereby eliminating the necessity of bringing stone from another source.

The general arrangement of the construction plant consisted of one derrick located at the point of excavation and one at the stone crusher, both connected by two industrial tracks running on trestles which were shifted in accordance with the location of the blasting. The former derrick lifted the skips filled with rock onto flat cars, while the latter took them off and dumped them in the pile from which the stone reached the crusher by a conveyer. Below the crusher was the concrete mixer discharging into cars that were carried to the various points of work on an industrial track.

The sectional ogee type dam, which extends from a ledge in the river to an abutment on the river side of the mill, is constructed of concrete of proportions 1:2½:5 with 30 per cent. of the excavated rock embedded, and is 135 ft. long, 27 ft. wide at the base and 7 ft. 5¼ in. wide at the top, which is 20 ft. above tail water elevation. The upstream face is vertical; the downstream face forms an angle of about 32 deg. with the perpendicular and with an 8 ft. arc is swung into the horizontal upper edge of the toe, which like the upstream face, is keyed into the solid rock. As the slope of the ledge is generally about 30 deg. the height of the dam increases as it approaches the abutment, the top of which is 12 ft. above the crest of the dam and about 51 feet from the bottom of the river on the tail race side of the mill.

The wing retaining wall, located on the shore side of the mill, is about 85 ft. long and its top is at same elevation as the abutment. It is of the cantilever type and as it extends towards the rising shore its height, width, and general dimensions decrease proportionally. At its largest section, the base which is set about 3 ft. in the rock, is 16 ft. wide while at the smallest it is 10 ft. In the vertical face there is reinforcing by one-half inch square bars, the spacing increasing from 4 inches at the bottom to 12 inches at the top in the lowest. The bars are set 2 inches below the outer surface. In the base similarly placed reinforcing consists of ⅞-in. bars generally 12 inches on centers.

The fill in back of this retaining wall consists of about 3,000 yards of silt, which, by an ingenious hydraulic sluicing arrangement, was brought from the river bed up the stream and then carefully puddled and tamped. A 50-ft. derrick with an orange peel bucket raised the earth from the river bed to a slanting hopper located on a wooden tower about 25 ft. high. Discharging horizontally against this slanting face were about twelve 2-inch water pipes all connected to a 6-inch supply which ran across and above the hopper, and connected with a motor driven centrifugal pump located on the ground directly beside the tower, and with a 6-inch suction to the river. The hopper opened into the sluice down which the silt was carried by gravity to the front of the retaining wall. The cost of this fill exclusive of the cost of the plant was nine cents per yard. The outlay on the plant was $630, and this would have been the same if the fill had been many times larger instead of only about 3,000 yards.



Pejepscot Paper Mill During Construction.

The mill itself is a building 116½ ft. by 112 ft. 8 in., and, with the exception of the one-story brick superstructure, is entirely of reinforced concrete of proportions generally 1:2:4. The head gate platform in front of the mill is 32 ft by 113 ft. with the gates ahead of the racks which are protected by a concrete fender wall 23 ft. deep. There are five flumes in all. Four of these have two gates each with openings 8½ ft. by 14½ ft., and are 59 ft. long by 20 ft. wide and 15 ft. deep. The fifth flume is 127 ft. long of the same section, but has three gates. Each forebay is about 19 ft. wide and 32 ft. deep.

Each of the four smaller flumes contain three pairs of 35-in. Victor turbines developing 1,370 horsepower per unit under a twenty-foot head. These do not drive anything but the grinders, three to a unit. A pair of 35-inch wheels is located in the long fifth flume, which is used for power purposes. The waste spaces at the ends of the flumes are utilized for white water tanks. Running at right angles to the flume walls are three tail races 88 ft. long with a section 18 ft. by 20 ft.

As to the equipment, it may be said that at the present time it is planned to install twelve grinders and seven wet machines. Over the flumes and back of the forebay is located the wet machine room, 68 ft. 4 in. by 110 ft., with a roof of yellow pine plank covered with tar and gravel, and supported at the middle by four 10-in. square pine posts running lengthwise with wooden trusses on either side. On the same level and situated over the long flume is the wood room, 44½ ft. by 21 ft. Directly in front of the flumes and 14 ft. below the floor of the wet room is the grinder room, 44 ft. 6 in. by 87 ft., with a stock chest 10 ft. deep underneath. In this room steel trusses support the roof 31 ft. above the floor. The windows in the mill are abundant, while skylights have also been provided.

A railroad siding has been constructed from the Lewiston branch of the Maine Central railroad to the mill, a distance of 3,000 ft. This siding extends somewhat beyond the mill and will be used not only for the pulp mill, but the teams from the paper mill in the future will haul to and from this siding instead of making the long haul to the Brunswick freight yard, thus effecting a large saving in time and teams.

This entire work was designed by I. W. Jones, engineer, of Milton, N.H. The inspector was Freeman R. Preble. With the exception of the superstructure of brick erected by Charles E. Hacher, of Brunswick, the entire contract was executed by the Aberthaw Construction Co., of Boston, Mass.

CANAL OF STEEL.

In connection with the Nile irrigation system at Wadi Kom-Ombo there has been constructed a canal of steel five thousand two hundred feet in length, whereby water from the service reservoir is distributed to the earth canals. In section this metallic canal is U-shaped, twenty feet broad and twelve feet deep. It is made up of seventeen sections, connected by expansion joints, and the riveted steel plates of which it consists are six millimeters in thickness. During the construction the engineers were troubled among other things by the unequal expansion of the metal. The expansion was greatest on the side where the sun happened to shine full upon the plates and the inequality was often sufficient to displace the end of a section about to be joined as much as four inches to one side or the other.

AN IMMENSE CLIFF.

The greatest unbroken precipice seems to be brought to notice by Capt. C. G. Rawling, of the recent British exploring expedition to Dutch New Guinea. It extends from Mount Carstenz, westward to the Charles Louis Mountains, a length of eighty miles, and the height was estimated to reach 10,500 feet at Mount Leonard Darwin. Where the theodolite could be used, measurements were made up to a height of 6,500 feet.

THE FLOW OF WATER IN CYLINDRICAL CONDUITS.*

By Sidney A. Reeve, Esq.

This paper was suggested by a perusal (in 1909) of the paper entitled "Experiments at Detroit, Mich., on the Effects of Curvature upon the Flow of Water in Pipes," by Messrs. Williams, Hubbell, and Fenkell. It relates to that portion of the subject which treats of the distribution of velocities at various points in the cross-section of a pipe. Although the paper referred to is utilized as a text, the writer's purpose is to raise considerations which apply broadly to the general concept of the flow of water in pipes.

Such flow always occurs with velocities which are greatest near the axis of the pipe and least near its walls. Messrs. Williams, Hubbell, and Fenkell conclude that the distribution of these velocities is such as to be expressed, as a function of the distance from the axis, by an ellipse having the diameter of the pipe as its conjugate diameter. The velocity at the wall is said to be one-half that at the axis, while intermediate velocities vary as $(0.5 + y)$ Vc, wherein Vc is the axial velocity and y is the abscissa of the eclipse, having its major axis equal to unity and its minor axis equal to the pipe diameter.

Whether or not this be the true form of the function, there is no doubt that the velocities vary in some way generally similar to that stated. At the same time, the assumption seems to be general, among investigators of the subject, that the lines of flow are usually and naturally straight and parallel with the axis. The fundamental natural fact that water flowing in a conduit cannot proceed along straight parallel lines, under the basic laws of fluid equilibrium, and that it never does so, seems to have escaped from its proper place in the premises of their arguments, as well as from their pitometer observations.

All the filaments of water flowing side by side within a pipe must possess the same hydraulic energy. Energetic equilibrium within the pipe will always direct the flow of each particle in the direction of an equalization of energies, should any external influence upset the balance temporarily or locally. The filaments near the walls, however, are continually subject to such an external distributing influence, in the form of the frictional resistance of the wall surfaces. Thereby they are constantly kept in a condition of deficit of velocity head. Thence results a continuous fault in the energetic equilibrium.

As the sum of pressure head and velocity head for all filaments must be equal, those near the walls, possessing lesser velocity head, must possess greater pressure head. This, however, is hydrostatically impossible; yet, hydrostatically, it would have to occur, if the filaments were moving in straight parallel lines, therefore the hydrostatic equilibrium becomes unstable, following the instability of the energetic equilibrium.

The water, in order to regain its stability of equilibrium, is forced, by this unbalance of hydrostatic pressure, to abandon its original—or, at least, its hypothetical—straight-line parallelism, and to turn to right or left into a helical path. Since the instability of equilibrium is indifferent as to right or left, in whichever direction it happens to be started it persists insistently, because it finds therein stability of equilibrium.

A similar phenomenon is familiar in the helical outflow of water from a stationary wash-bowl. While the source of of the instability in this case—the radially centripetal lines

*Paper in October Proceedings of American Society of Civil Engineers, Vol. xxxvii., page 1113.

of approach toward the outlet—is somewhat different from the case of frictional flow within a long cylindrical pipe, yet stability of equilibrium is regained in quite the same way; and fractional resistance is also present as a contributory factor, although of minor importance. It is virtually impossible to make the water flow from the wash-bowl in parallelism with the axis of the outlet. It insists on whirling helically to right or left, whichever way it happens to be started; and whichever way it whirls, it regains thereby its stability.

Within the helical whirl the pressure head, acting radially outward, is not everywhere equal. Owing to centrifugal

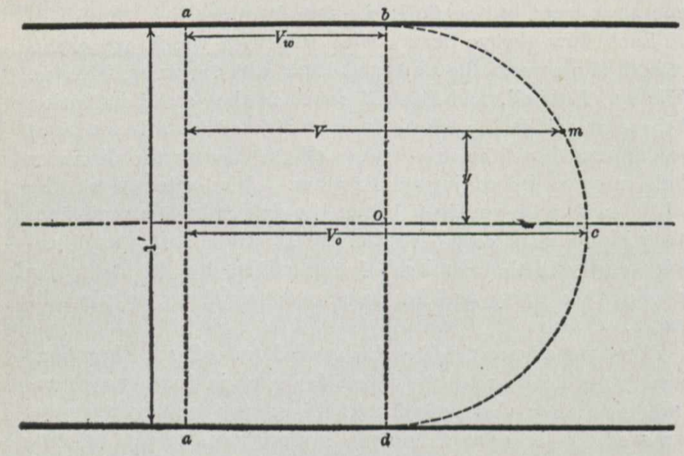


Fig. 1.

force, it is greater near the periphery. Equilibrium will be found when the rise in radial pressure, due to the greater radius and velocity of the whirl, as it passes from the axis to the wall of the pipe, just counterbalances the loss in velocity head due to the slower progress of the water along the pipe near the walls. The more the axial progress of the water is arrested by friction, the more it whirls, instead of progressing.

The energy of the whirl, however, cannot be all of that disappearing in the form of axial velocity. It must be something less than this, for the frictional resistance must be continually made good. The loss of axial velocity must go to two destinations, namely, the whirl, and the wall friction. The current parallel with the axis is both diverted and retarded by the wall friction. In other words, the oblique velocity along the helical path cannot be any greater, and must be somewhat less, than the maximum, axially-directed velocity in the center. Yet this oblique velocity is itself made up of two components, namely, (a) the velocity at any point in a direction parallel with the axis (that reported by the pitometer observations), and (b) the transverse velocity of whirl. That is, the helical velocity at any point in the pipe outside of the axis must be less than the velocity in the axis; and, because it is helical, instead of parallel with the axis, its axial component must be less, again, than its complete oblique self.

It is this second discount from the original maximum—the measurable axial velocity—which alone the pitometer measures in the traverse of the pipe away from the axis; but it is the first discount from the maximum velocity only, down to the oblique, helical velocity (only one component of which the pitometer measures), which supplies the energy visible in the whirl.

A mathematical solution of the situation will probably make it clearer. Let Fig. 1 represent the longitudinal section of a cylindrical conduit, having a diameter of 1 ft. Let Vc be the axial velocity therein, represented by the distance from the line, aa, to the point, c. Let Vw be the velocity, parallel to the axis, of the filaments touching the walls, represence by the distance from the line, aa, to the line, bd. For the present it is sufficient to assume, as determined by observation, that $Vw = \frac{1}{2} Vc$.

Let V be the velocity parallel with the axis at any point, m, in the cross-section of the pipe, at a distance, y, from the axis. Then at every such point the true velocity of the water will be a helical one, U, greater than V, because including some portion of the tangential component, yet less than Vc, because constantly contributing energy toward the wall. It is the deficit in velocity head of U below Vc which must be made up in centrifugal force, in order to counterbalance the excessive pressure head near the wall; yet this centrifugal force is the result of a tangential velocity which is itself a component of U.

Let v be the tangential velocity at any point. Then

$$U^2 = V^2 + v^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Therefore, the deficit in linear velocity head which creates the deficit in pressure head necessarily counterbalanced by centrifugal force, is

$$\frac{1}{2g}(Vc_2 - U^2) = \frac{1}{2g}(Vc_2 - V^2 - v^2) \quad \ldots\ldots (2)$$

The centrifugal force which must be developed to counterbalance this, if stated in the form of a differential increase as one passes from the axis outwardly, is

$$dPc = \frac{v^2}{y} dM = \frac{v^2}{y}\frac{dW}{g} = 2\frac{v^2}{2g} \, 0.433 \, \frac{dy}{y} \quad \ldots\ldots (3)$$

wherein 0.433 is the weight of a prism of water 1 sq. in. in cross-section and 1 ft. long.

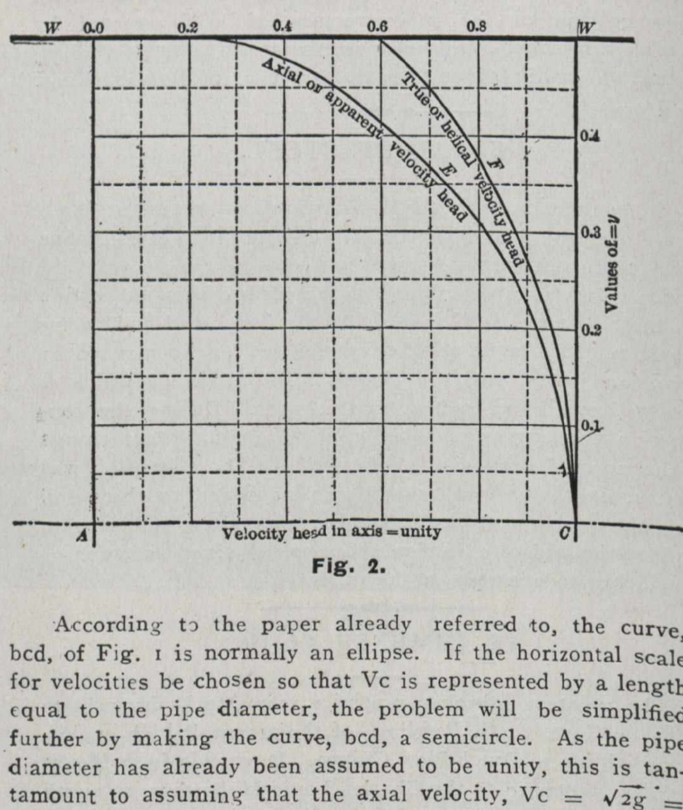


Fig. 2.

According to the paper already referred to, the curve, bcd, of Fig. 1 is normally an ellipse. If the horizontal scale for velocities be chosen so that Vc is represented by a length equal to the pipe diameter, the problem will be simplified further by making the curve, bcd, a semicircle. As the pipe diameter has already been assumed to be unity, this is tantamount to assuming that the axial velocity, $Vc = \sqrt{2g} = 8.02$ ft. per sec., and that all other axial velocities which might occur in practice would beget phenomena everywhere proportional thereto—an assumption which seems to be justified by the facts now available. In that case,

$$\frac{V}{\sqrt{2g}} = \frac{1}{2} + \sqrt{\frac{1}{4} - y^2} \quad \ldots\ldots\ldots\ldots(4)$$

$$\frac{V^2}{2g} = \frac{1}{2} + \sqrt{\frac{1}{4} - y^2} - y^2 \quad \ldots\ldots\ldots\ldots(5)$$

and, from Equation 2,

$$\frac{1}{2g}(Vc_2 - U^2) = \frac{1}{2} - \sqrt{\frac{1}{4} - y^2} + y^2 - \frac{v^2}{2g} \quad \ldots\ldots(6)$$

It is the differential of this equation, converted from head into pressure per square inch by multiplication by the coefficient, 0.433, which must be equal to Equation 3.

From this final equation between Equations 3 and 6, we should be able to derive an equation for v or U in terms of y. The writer found difficulty in evaluating this equation, however, and as it is not one of general value, but is illustrative only of the assumed case of an elliptic form of traverse curve of velocities, its mathematical complexities were dodged by a recourse to graphical methods.

The results are shown in Fig. 2, in which AC represents the axis of the pipe and WW one of its walls. The abscissas of the curve E, measured from AW, give the values for $\frac{V^2}{2g}$. Those of the curve F, also measured from AW, give the values of $\frac{U^2}{2g}$. Those of the curve F measured from CW give the increment of centrifugal head over the axis, and the abscissas measured between the curves E and F give the values of $\frac{v^2}{2g}$.

Table 1, of values taken from Fig. 2, will also be of aid in realizing the situation. In this table α signifies the angle which a tangent to the helix at any point makes with a line parallel with the axis through the same point. Were the flow in any actual pipe quite in accord with the rigid theory of an elliptical traverse curve on which this argument has preceded the angle α, is the one at which the pitometer should be placed in order to obtain a maximum reading, for that particular distance from the axis of the pipe. Messrs. Williams, Hubbell and Fenkell speak of noticing negative readings at times, and of observing, in their investigation, maxima and minima at pitometer positions forming an angle with the axis; but the only angle mentioned is one of 45 degrees.

The writer, however, does not wish to give the impression that the actual flow is ever along truly helical paths. All that he is trying to emphasize is that the condition of affairs within the pipe must be one of unstable equilibrium, as long as straight and parallel flow is imagined to occur. In reality, this is the one sort of flow which cannot imaginably occur. In avoiding it, however, the water is diverted, not into a smooth, true helix, but into the greatest intricacy of turbulent eddies.

The fifth row of values, giving the ratio of the transverse velocities of whirl, v, to the distance from the axis, y, shows a fair degree of constancy. This signifies that the water might whirl, as it progresses, in a fairly homogeneous manner, not generally disturbed by the presence of the many small internal eddies just mentioned, although everywhere locally perturbed.

It will be noticed, too, that this ratio increases steadily and increasingly, as one passes from the axis to the wall. This is shown by Fig 3. It is natural that this increase should occur, because there must be a continual flow of energy from the general body of water toward the wall; but it is not probable that the rate of increase rises as rapidly near the wall as is shown in Fig. 3, because the wall must have some retarding effect on rotational, as well as on axial, velocities. The form of curve shown is due to the fact that the geometric form of traverse curve specified by the writers quoted becomes tangential to the wall where it intersects the latter, the rate of its velocity head then becoming instantaneously infinite. From all these considerations it appears probable to the writer that the traverse curve is not normally any particular geometric curve. It probably approaches the ellipse more nearly than any other form; but it probably loses its curvature somewhat, as it nears the wall, and intersects the latter at an appreciable, though slight, angle.

The entire situation will be best understood by keeping well in mind the distribution of energies in the mass of water. The mean axial kinetic energy of the water, of course, must remain constant, as long as the pipe diameter remains constant. This means that the supply of energy required for overcoming friction must be derived from a deficit in pressure energy, or head; and this is just what is observed in hydraulic phenomena, as a general fact. Friction reduces the pressure.

Strictly speaking, however, pressure energy cannot directly and of itself overcome friction. It is only motion which can do that. Friction is strictly a function of motion, appearing only when motion appears and non-existent under the greatest pressures if motion be absent. It is merely a name for the retardation of motion by the contact of mass with mass. The familiar hydraulic rule that friction losses are to be deducted from head is a mere convention—of the utmost convenience, and unobjectionable for engineering purposes, but not strictly true—and hence misleading in such

Table 1.—Values Taken From Fig. 2.

y =	0	0.10	0.20	0.30	0.40	0.45	0.48	0.49	0.50
$\frac{V}{\sqrt{2g}}$ =	1.000	0.990	0.958	0.900	0.800	0.718	0.640	0.600	0.500
$\frac{U}{\sqrt{2g}}$ =	1.000	0.993	0.972	0.934	0.875	0.834	0.803	0.790	0.774
$\frac{v}{\sqrt{2g}}$ =	0.000	0.077	0.158	0.249	0.354	0.425	0.480	0.515	0.592
$\frac{v}{y}$ =	....	0.77	0.79	0.83	0.88	0.94	1.00	1.05	1.18
tan. α =	0.000	0.078	0.165	0.277	0.442	0.592	0.750	0.858	1.184
α =	0	4° 27′	9° 22′	15°29′	23° 51′	30° 38′	36° 52′	40° 38′	49° 49′

an enquiry as the present one, as to the true situation within the water in the pipe.

There is, therefore, a constant disappearance of motion energy along the walls in friction—for friction is overcome by motion energy only as Arnold von Winkelried overcame the Austrian spears, by the extinction of the victor. This continual disappearance of motion energy along the walls, however, begets immediately, not the deficit of pressure head which it must finally become in form, after the books are balanced, but a local surplus of pressure head, due to the retardation of the water.

This surplus pressure can neither compress the water in the centre of the pipe, nor (because it acts radially) hasten it along its way. All that it can do is to beget the instability of equilibrium which leads to the whirling action, or to the myriad of tiny eddies into which it breaks up, which has already been described. It is this general whirling motion about the axis which transforms, after the manner of a centrifugal pump, the needed deficit of pressure at its source or centre, the axis of the pipe, into a surplus to meet the surplus pressure at the periphery.

There is thus effected a continual flow of energy from the general mass of the water to its periphery. Where the energy departs through the walls as heat; or, if it be still carried along with the water as heat, it is no longer hydraulic energy. The helical whirl in the pipe acts as a centrifugal pump for energy, using water as its working substance, yet discharging none of that water. It is only the energy which is discharged.

The situation may be better grasped by remembering that what is called the pressure of water is nothing but the centrifugal force of the tangential motion of its myriads of rapidly whirling molecules. It is quite natural, therefore, that it should be this form of energy which is called on to set up and maintain that general whirl of the entire mass of water which is needed to overcome friction at the expense of head.

The entire subject is much in need of investigation, in its arithmetical aspect, by the pitometer men. While such data as has been adduced here suffice to illustrate the general principles of action which must always be kept in mind, in conducting investigations of flow in pipes, yet it must not be supposed that they are reliable quantitative guides for situations other than the assumed premises of the argument.

One purpose of this paper, of educational rather than of practical importance, is to emphasize the fundamental mechanical fact that the natural path of mass in motion is always curvilinear. The straight line is never a natural path of motion. It is always the natural path of force. Mass in motion not only never follows a straight line voluntarily, but it cannot be forced to follow it, except approximately and temporarily, under constraint, with constant and inevitable dissipation of energy. The only occurrence of the straight line in Nature is in the transmission of force through a solid; for neither liquids nor gases confine their transmission of force to straight lines. Indeed, the prime instance of the straight line in Nature—the foundation of all our astronomy and triangulation, and properly the sole basis for our definitions of geometric right lines—is the path of light through the luminiferous ether; and Lord Kelvin says that the luminiferous ether is a solid.

The secondary natural instance of the straight line, the transmission of natural force through solids, civil engineers learned long ago; their structural elements of roofs and bridges are never curved. It is only more recently and reluctantly that mechanical engineers, under pressure from such leaders as Professor Sweet, Mr. John Richards, and others, have learned to confine themselves more exclusively to straight lines.

The converse proposition, the curvilinear nature of all free motion, is thoroughly recognized in all the work of naval architects and hydraulic engineers; but our textbooks on elementary hydraulics, nevertheless, seem to have overlooked the importance of this fundamental fact. The principles of the flow of water in pipes is only a single instance of this.

NORTHERN CANADA'S WATERWAYS.

Mr. James Cornwall, M.P.P., for Peace River, recently made public some interesting facts regarding waterways and waterpowers in Canada's Northland. Mr. Cornwall has a number of fur trading posts stretching from Edmonton to the Arctic sea coast, and is in a position to speak on the subject first hand.

We have better waterways to-day north of Edmonton than are those of the Mississippi. A steamer drawing seven feet of water can navigate on the Mackenzie from the Arctic ocean right to Fort Smith, a port within the province of Alberta. There are only two comparatively slight falls which would prevent this, and they can be portaged or got round at slight cost, much in the same manner as falls at Ottawa and other points.

The power available in the north country is incalculable; it is immense. There are wonderful latent possibilities in the Grand Rapids, in two falls on the Peace river, in the 200-feet fall at Fort Smith. Twelve falls are estimated to be capable of yielding 300,000 horsepower. There are two falls on the Hay river, which, according to Mr. Cornwall, eclipse Niagara. They are about two miles apart, and have never been mentioned by the official geographers or geologists. It is very doubtful if they are known to any save the fur traders, who alone really know and appreciate the wonders of the vast northland. A traveller Mr. Cornwall recently took with him into the north was astonished at the magnificence of these falls. He has oftentimes seen Niagara, but says it barely compares with the Hay river falls.

Around all these falls are vast amounts of timber particularly adapted to the pulp wood business. That industry must some day become one of the great businesses of the north. It may be a little visionary to see so far ahead, but with railway arteries opening up the country there can be no adequate comprehension of what may not be accomplished in a land where now only the fur trader holds sway.

Further north still is another rich industry. The Canadians derive no advantage from the whaling. It has been lost to this country by the energy and enterprise of our neighbors to the south. Annually they take eighteen to twenty million dollars out of the country through working the Canadian whale industry. The people of the United States have followed the whale around the world, and now get him in great numbers in the last whale fishing grounds.

The late Mr. Young, Chief Geographer for the Dominion Government, compared what has been done in Asiatic Russia in a province less advantageously located than is Alberta and the Peace River country. He took one province which, geographically speaking, is parallel with and might adjoin the Peace river and Mackenzie basins. It is not even so well situated, for its most southern point is 150 miles north of Edmonton. The comparatively primitive people in that Asiatic-Russian province have a population exceeding 1,650,000 people. They grew in a year more than eleven million bushels of wheat, more than four million bushels of rye, and more than thirteen million bushels of oats in 1907. The figures Mr. Young secured from the Minister of the Interior for Russia. The people there have 3,800,000 head of live stock; and they exported nineteen million pounds of butter.

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CONTENTS OF THIS ISSUE.

ENGINEERING EDUCATION.

Engineering education is a subject concerning which much has been written. Each person who has written on it, has a different view-point, and therefore, we have many different opinions as to the best methods of teaching.

In a recent address to the Engineering Alumni of the University of Toronto, Professor A. G. Christie describes the manner in which the University of Wisconsin attacks the subject. The full text of the address will be found in another column of The Canadian Engineer. Wisconsin, as pointed out by Prof. Christie, has carried the utilitarian idea to its limit, and, without doubt, the methods they have used have developed good men, and good city engineers. It is a question to be debated, however, whether our Canadian system, founded as it is on the English method, does not better serve the purpose of educating men to become engineers. Wisconsin has striven during their university course to educate the students as engineers. In our engineering schools in Canada, the aim has rather been to educate the students broadly so that later they may become engineers. At the same time, the work of the University of Wisconsin, in raising the standard of citizenship in the State, has been of immense benefit. The "Extension Division," is doing magnificent work with its local classes and correspondence work for those who are unable to attend the university. The Canadian Universities therefore, will do well to make a careful study of the methods and the work accomplished by the University of Wisconsin.

THE NIAGARA RIVER BOULEVARD.

We have much pleasure in calling attention to an address by Mr. John H. Jackson, published in this issue of The Canadian Engineer, describing some of the engineering features of the boulevard being built for the Niagara Falls Queen Victoria Park. This boulevard will in time extend from Lake Erie to Lake Ontario paralleling the Niagara River along its entire course. Only the very best materials are used in the construction and the engineering and architectural structures along the route are of the very best possible design. The funds necessary for carrying on this work both in the construction stage and afterwards for maintenance, are obtained from the rental of the power privileges at Niagara Falls to the different power companies operating there.

In a short time this income will approximate $300,000 per annum, and with this amount, we feel sure that the Niagara River Boulevard will become one of the most magnificent roadways on the American continent, especially under the capable administration of the present superintendent. Here again is an instance of the true principle of appointing engineers to fill positions of this character.

THE CANADIAN PUBLIC HEALTH ASSOCIATION CONGRESS.

The first annual congress of this association will be held at Montreal next week on Wednesday, Thursday, and Friday.

The formation of a Dominion Public Health Association as separate from the American Public Health Association, which is continental, appears to have received its impetus this year in a meeting of Federal and Provincial public health officials invited to confer with the Commission of Conservation of Canada.

Ever since Dr. Hodgetts, late chief health officer for Ontario, undertook the work of secretary to the Health Committee of the Conservation Commission he has worked steadily to bring all the scattered forces and energies into focus. The success of the conference and the enthusiasm shown for greater unity of action at once pointed clearly to the value of such conferences, and hence the establishment of a permanent association.

The practical work appertaining to many questions of public health are as much the province of the engineering as the medical profession; and we are glad to see that a special section of the congress will be devoted to such subjects as water supply, sewerage, town planning and the removal of garbage, etc., and that several city and town engineers will be represented.

We have in these pages had cause to deplore the want of combined action between the medical and engineering classes in many matters appertaining to municipal sanitary engineering.

At the annual meeting of the Canadian Society of Civil Engineers this year the present president called attention to the fact that many Provincial Boards of Health were now requiring that engineering plans for all proposed works of sewerage and water supply be submitted for approval; and that in many cases no representative of the sanitary engineering profession held office on these boards.

It does appear to us that this is a subject which the association might well take up, as it would only appear a matter of common sense that engineering plans be approved by a board of men who have some engineering qualification represented in their constitution.

We note that one of the features of the general session is a symposium upon the important question of biological sewage disposal, and that chemists, doctors and engineers will add from their special knowledge papers which should fairly cover the subject. The value of dividing a subject such as this into units and bringing together experts who can deal with each unit requires no demonstration from us.

At the present time, both for the guidance of Parliaments, Dominion and Provincial, and for municipalities, it is acutely required that some general standards with reference to sewage disposal be laid down. We are being told over and over again what the American expert would recommend in the way of sewage disposal for our urban centres. It is time that Canada develop a policy and standard of her own to suit her own peculiar and climatic conditions, and not depend upon the advice based upon data which may have reference to conditions entirely different from our own.

The above also applies to such questions as water purification and methods of removal and destruction of garbage.

We wish all success to this congress and trust that it may be the beginning of a career of usefulness in unifying the scattered interests and forces of this great country to the welfare and better health conditions of its people.

CANADIAN PUBLIC HEALTH ASSOCIATION.

Programme of the First Annual Convention to be held in Montreal, at McGill University, 13th-15th December, 1911:

Wednesday, 13th December.

10 a.m.—

General business meeting, including the adoption of the Constitution.

Registration of members.

Meeting of committees.

2.30 p.m.—1st General Session—Papers.

1. "Military Aspects of Sanitation," Colonel G. Carleton Jones, Director General, Medical Services, Ottawa.

2. "Duties of Authorities and Private Citizens Towards Consumption," C. J. Fagan, Esq., M.D., Provincial Officer of Health, Victoria.

3. "Medical Inspection and Care of Immigrants on Shipboard," J. D. Page, Esq., M.D., Quebec.

4. "Conservation of Food by Cold," P. H. Bryce, Esq., M.A., M.D., Chief Medical Officer, Department of Interior, Ottawa.

5. "Cheese Factory and Farm Well Waters," W. T. Connell, Esq., M.D., Professor of Bacteriology, Queen's University, Kingston.

6. "Tuberculosis a Public Question," Geo. D. Porter, Esq., M.B., Canadian Anti-Tuberculosis Association, Toronto.

7. "Factors in the Spread of Acute Intestinal Epidemics," H. W. Hill, Esq., M.D., D.P.H., Director Epidemiological Division, State Board of Health of Minnesota, Minneapolis.

8. "The Municipalization of Milk Supplies," W. A. Evans, Esq., A.M., M.D., D.P.H., Chicago.

9. "Hygiene of Canadian Waterways," William Oldright, Esq., M.A., M.D., Toronto.

10. A paper by Dr. Rutherford, Department of Agriculture, Ottawa.

8.30 p.m.—

Office opening of the Convention at the Royal Victoria College, Sherbrooke Street, Montreal, by the Patron, Field Marshal, His Royal Highness, the Governor-General.

Address by the Hon. R. L. Borden, P.C., Premier of Canada.

Address of welcome, by His Worship the Mayor of Montreal.

Address of welcome by the Hon. Sir Lomer Gouin.

President's address.

Conversazione.

Thursday, 14th December.

10 a.m.—Meetings of Sections—

Section 1—Medical Officers of Health; Convener, Louis Laberge, Esq., M.D., City Medical Officer of Health, Montreal.

Papers will be read in this section by J. W. S. McCullough, Esq., M.D., Chief Health Officer of Ontario; M. M. Seymour, Esq., M.D., Health Commissioner of Saskatchewan, and several others, names and titles of papers to be announced later.

Section 2—Laboratory Workers; Convener, J. A. Amyot, Esq., M.D., Professor of Hygiene, Toronto University.

Papers will be read in this section by W. T. Connell, Esq., M.D., Professor of Bacteriology, Queen's University, Kingston; C. H. Higgins, Esq., D.V.S., Biological Laboratory, Ottawa; Major H. M. Jacques, Esq., M.D., D.P.H., McGill Hygiene Laboratories; and several others, names and titles of papers to be announced later.

Section 3—Sanitary Engineers and Architects; Convener, T. Aird Murray, Esq., C.E., Toronto.

Papers—

1. "Garbage Removal and Destruction," R. K. Knight, Esq., C.E., City Water Department, Toronto.

2. "Chlorination of North Toronto Water Supply," E. A. James, Esq., C.E., Town Engineer, North Toronto.

3. "Gravity Mechanical Filtration at Saskatoon," Geo. Clarke, Esq., C.E., Toronto.

4. "Water Supply by Air Tank Pressure for Small Towns," F. McArthur, Esq., C.E., Town Engineer, Yorkton, Sask.

5. "Mistakes to be Guarded Against in Water and Sewerage Systems for Towns," A. E. Blanchard, Esq., City Engineer, Lethbridge, Alberta.

6. "Lantern Views of Lethbridge Sewage Disposal System."

7. "Natural Ventilation as Applied to Private Houses, etc.," T. W. Ludlow, Esq., B.Sc., M.A., Professor Architecture, McGill University.

Other papers will also be read at this section, the titles of which will be announced later.

Section 4—Social Workers; Convener, Mrs. Grace Ritchie England, M.D.

1. "Infant Mortality and Pure Milk," C. Blackader, Esq., M.D., Professor of Pediatrics, McGill University.

2. "Child Welfare," G. J. Adami, Esq., M.D., Professor of Pathology, McGill University.

3. "Defective Children," Miss Helen MacMurchy, M. D., Toronto.

4. "Citizenship in Connection with Public Health," T. A. Sherrard, Esq., Westmount, Que.

5. "Medical Inspection of School Children," Mrs. Smillie, Westmount.

6. "Infant Mortality," Miss Ellen Babbitt, Russel Sage Foundation, Washington, D.C.

2.30 p.m.—2nd General Session.

Symposium on Town Planning and Housing. Papers.

1. "Town Planning and Housing," Chas. A. Hodgetts, Esq., M.D., Medical Adviser Commission on Conservation, Ottawa.

2. "Town Planning and Civic Authorities," J. E. Laberge, Esq., M.D., Superintendent, Infectious Diseases Department, City Hall, Montreal.

3. "Insanitary Housing Conditions," Chas. J. C. O. Hastings, Esq., M.D., City Medical Officer of Health, Toronto.

4. "Insanitary Areas," James Roberts, Esq., M.D., City Health Officer, Hamilton.

5. "Municipal Powers in Dealing with Town Planning Schemes," Rickson A. Outhet, Esq., architect, Montreal.

6. "Rehousing in Canada," W. D. Lighthall, Esq., K. C., Westmount.

7. "Statistics on Housing," Percy E. Nobbs, Esq., architect, Montreal.

8. "Town Planning," Colborne P. Meredith, Esq., architect, Ottawa.

8 p.m.—Annual dinner of the association for members, delegates, and the ladies accompanying them.

Friday, 15th December.

10 a.m.—3rd General Session.

Symposium on biological sewage disposal. Papers:

1. "Physical and Economic Aspects of Biological Sewage Disposal Plants," P. H. Bryce, Esq., M.A., M.D., Chief Medical Officer, Department of Interior, Ottawa.

2. "Progress in Canada in Biological Methods of Sewage Disposal During the Last Twenty Years," Willis Chipman, C.E., Toronto.

3. "Engineering Problems Involved in Biological Methods of Sewage Disposal," T. Aird Murray, Esq., C.E., Toronto.

4. "Chemical Problems Involved in Methods of Sewage Disposal," G. G. Naismith, Esq., Ph.D., Toronto; J. O. Meadows, Esq., C.E., Montreal.

5. "Bacterial Problems Involved in Biological Methods of Sewage Disposal," J. A. Amyot, Esq., M.D., Toronto; T. A. Starkey, Esq., M.D., D.P.H., Montreal; H. W. Hill, Esq., M.D., D.P.H., Minneapolis.

12 Noon.—

Business meeting and election of officers for the ensuing year.

2.30 p.m.—

Meeting of new Executive Council.

Members proposing to attend, and sanitary authorities and other organizations sending delegates, are requested to kindly intimate their intention at as early a date as possible to the secretary of the Committee on Local Arrangements, F. C. Douglas, Esq., M.D., D.P.H., 51 Park Ave., Montreal.

In order that members and delegates may get the advantage of reduced railway rates on their return trip, they are requested to obtain standard certificates from their local passenger agents on purchasing their tickets to the convention.

ENGINEERING EDUCATION AT THE UNIVERSITY OF WISCONSIN.*

By A. C. Christie.†

The University of Wisconsin is one of the largest of the American State Universities. It is maintained by taxes levied on the citizens of the State and hence each feels that he has a real and vital interest in the work of this institution. The university has thus come to be regarded in much the same light as the Elementary Schools, in that it is intended to make higher education accessible to every young person in the State. The aim of the university must, therefore, be not only to maintain a high grade of scholarship, but also to provide education to which each is entitled, according to his abilities. In other words, the university, by its dissemination of culture and learning, must tend to make better and more useful citizens of those who come under its influence. That these results are being achieved can be demonstrated by the leading position Wisconsin has occupied for a number of years with regard to progressive legislation and forms of government.

The same ideals prevail in connection with engineering education as in all other courses. There are two distinct departments engaged in this work. One department, the College of Engineering, provides a four years' training for students, covering the usual class room, drafting, laboratory and field courses, which work is all given at Madison. The other department, known as the "Extension Division," is doing splendid work in trying to reach, by local classes and by correspondence, those who, for various reasons, are prevented from attending the university itself.

The College of Engineering offers courses in civil, mechanical, electrical, chemical and mining engineering. These courses are all very broad, for it is necessary not only to make the student a good engineer, but at the same time to make him a useful member of the community. He is allowed a considerable number of elective studies throughout his course and is encouraged to elect those subjects which will help to

*Abstract of address to Engineering Alumni of University of Toronto, at Engineers' Club, Toronto, Nov. 30.

†Associate Professor of Steam Engineering.

widen his point of view of business, public and social problems.

The technical courses themselves are much more general than is usual in many colleges. The first two years are devoted to the study of languages—with much emphasis on good English—mathematics, mechanics, physics and chemistry. The third year is the first one in which definite engineering subjects are taken up. In the fourth year advanced engineering is taught, and at the same time a greater number of electives are allowed.

Formerly a student in civil engineering was taught nothing of steam engines or of electricity. At Wisconsin he has to take both class and laboratory courses in these. The mechanical engineering students take class and laboratory courses in direct and alternating currents, in hydraulics and hydraulic machinery, in surveying and in materials. Similarly, the electrical man takes full courses in steam and gas engineering and other courses similar to those specified for mechanicals. Mining and chemical engineers take courses they are similarly mixed.

It would seem at first glance that too general an education was provided instead of specializing in one particular line. Experience has shown, however, that an engineer nowadays must have this general knowledge, as his work is becoming more complex every day. Besides this, a student is seldom able to foresee the line of work that he will take up after graduation, and very often does start in some line quite different from his specialty when in university. His general knowledge of the other fields of engineering is then of inestimable value to him in his chosen work. A few such cases might be cited in this connection. One recent civil engineering graduate is now in the steam and electrical department of a public service corporation. Another is in the gas business. A mechanical is acting as a civil engineer on one of the new Canadian railroads. An electrical is engaged in the manufacture of gasoline farm engines.

In the final years much emphasis is laid on commercial engineering subjects, such as contracts and specifications, economics, commercial mechanical engineering, electrical applications, works management, chemical manufacture, plant design, etc., so that students get ideas of the economic factors which are of first importance in engineering practice.

The method of teaching is such that very few pure lecture courses are given. Usually a text is selected and the classes broken up into groups of about twenty men. Then work is assigned in the text to be prepared outside the class room and each meeting then becomes a recitation of this assigned work with additional information from the instructor. Frequent examinations, known as "quizzes," are given to determine the progress each student is making in his work, and in many courses these take the place of, or rank equal to, the final term examination. This system requires steady and even work on the student's part, instead of the killing cram for one final examination, as in the old system. It also enables the class advisers to get rid of students who will not work or are totally unfitted for the course early in the year, and thus saves expense to their parents or guardians and time to the student.

All laboratory courses and field courses are laid out so as to form merely the application of class-room principles. In fact, all courses are very closely co-related. It has been found advisable in most of the laboratories to provide printed notes and instructions for the students. While these may not be as helpful in all cases as personal instruction, on the other hand it does not leave the student at the mercy of the instructor, who may not at all times impart his information with equal efficiency. Uniform methods of conducting laboratories have been most gratifying to all concerned.

It will be noticed that in all the work so far discussed the student's work has been very closely supervised. It has been objected that this tends to destroy the initiative of the student. On the other hand, it may be pointed out that the work of each graduate after he leaves college must be very closely supervised by his employers if mistakes are to be avoided.

To develop the initiative of the student each is required to prepare an original thesis for graduation. Very few of these are library subjects and, except in civil engineering, cover principally experimental and research investigations. A subject is assigned to the student, or selected by him, and a member of the staff is designated as director of that work. This director holds conferences with the students, receives reports of progress, and generally guides the student from wandering from his subject, but, at the same time, the real work of thinking is done by the student himself.

The faculty have a busy time of it. Certain men are appointed class advisers for from thirty to forty students and assist these men in the planning of their courses, help them in case of trouble, and are often even asked for advice on personal affairs. This ensures an intimate contact of faculty and students. Course committees and department committees meet weekly to discuss means and methods of teaching. The whole engineering faculty is called together monthly for an informal meeting to discuss such questions as "The Relation of the University and the Manufacturing Industries of the State," "The Utility of Research," etc.

No definite method has yet been devised whereby moral training can be provided for the students. Yet it has frequently been noted that the presence of the large body of female students at the university exerts a very great beneficial influence over the men.

Both men and women have student self-government organizations, in which cases of discipline, etc., are handled without interference from the faculty.

Social life is very active in Madison. There are innumerable clubs, fraternities, sororities, etc., where the students of all courses mix indiscriminately. In fact, society affairs often become a burden on the student.

It is the policy of the university to encourage the members of the engineering staff to take up a certain amount of outside work so as to be in close touch with actual engineering. Most of the men do so, several being connected with the State Railroad and Public Service Commissions. This outside work prevents the men from rusting in college routine and keeps them in touch with the latest developments in their special lines.

The Extension Division of the University of Wisconsin is doing probably the best work of any department. It reaches the tradesmen and those who are not able to attend the University. This work is carried on largely by correspondence, but a large corps of instructors are employed who visit local centers and meet the men taking the courses and help them over difficulties which are often hard to explain by correspondence.

Shopmen and men engaged in industrial work often find the need of training in their vocation. This need was recognized by the organizers of the now famous correspondence schools. But these schools were run for commercial purposes, and men taking such courses often became discouraged at the slow progress made. The result was that courses were seldom completed, though fees were paid. The University conceived the idea that this matter of education was rightly part of the State's duty to its citizens, and organized the Extension Division to carry out this work. Vocational courses are offered, in which the necessary mathematics and fundamentals of the trade are taught, finishing up with applications of these principles to the trade itself. Classes of mechanics and apprentices have been organized at all large shops through the hearty co-operation of the employers, and one of the travelling instructors meets these classes at regular intervals. Headquarters have also been established in several of the larger cities, where regular night classes are held and instruction given in drafting, etc. Men with necessary high school training but who cannot attend the University are enabled to take the regular engineering work by correspondence, while most of the laboratory work can be taken at the summer sessions of the College of Engineering at Madison. Those who are in business and have the means to take University work, but do not have the necessary high school preparation, can take up this preparatory work also by correspondence. Many men have been enabled to attend University by this method who would otherwise have been debarred.

This work has now been in progress three years, with very encouraging results. Time does not permit all the details to be discussed.

Wisconsin has been called "The Utilitarian University." This economic spirit, together with the democratic progressive ideas prevalent throughout the whole State, has reflected in the work of engineering education carried on at the University. The engineering departments strive not only to produce good technical and commercial engineers, but also to make all men who come within its influence better citizens of the State in which they live.

DEFLOCCULATION.*

Edward G. Acheson, Sc. D.

It is with much diffidence I come before you to speak on a subject that has not yet emerged from the embryonic state. My latest experimental researches had to do with it; I believe it will rapidly grow in importance in the scientific and industrial world; and finally, much work of a strictly scientific character remains to be done to reduce the fragmentary knowledge we now have of it to an exact science.

In my labors devoted to working out and developing industrial and commercial projects, I have upon several occasions found reactions, conditions and results that did not harmonize with the accepted theories and formulae of scientific men. Being an earnest believer in publicity, in order that any possible benefits that might accrue to the common welfare may the more quickly be enjoyed, I shall lay before you a detailed account of my experiments on the deflocculation of inorganic bodies. It will become very evident as my story unfolds, that throughout the series of experiments described and the working hypothesis employed, I was wholly disregarding the prevailing theories, and that I unconsciously entered the field of colloids.

Having worked out the problems involved in the manufacture of graphite from coal and other carbonaceous materials, I undertook, in the summer of 1901, the introduction of this artificially made graphite into the crucible trade. My first efforts were devoted to the making of a satisfactory crucible of my graphite, using as a binding material American clays. Many failures were met with, and I found it difficult to locate the cause of the failure, whether with the graphite or with the clay. I soon learned the manufacturers of crucibles in the United States invariably used as a binding agent for the graphite in the crucible body, clays imported from Europe. I secured samples of these imported clays, and found them much superior to the American ones in plasticity and tensile strength.

Chemical analysis failed to disclose the cause of the physical differences existing in the clays. The question involved interested me greatly, and I decided to endeavor to determine what produced the variations. I found it generally stated in the books that residual clays were non-plastic, and sedimentary clays were more or less plastic. Here was the starting point. Plasticity was developed by or during the act of transportation from the point of formation to the final resting place of the clay. I did not believe there was anything in the simple act of the suspension in water that would produce the effect noted, and therefore looked for the cause of the foreign matter carried by the water. It seemed the most likely agents were the organic substances washed from the forests into the running waters. With this idea in view, I made a few experiments with those substances I thought likely to be found in the washings of vegetation. One of my early experiments was to treat kaolin with a solution of tannin, and I at once noticed less water was needed to produce a given degree of fluidity; also that the tensile strength and plasticity were increased.

Tests were made on the increased tensile strength of clay, as the result of treatment with organic matter, and it was found that briquettes made of Harris kaolin and dried at 120°C. would break with a load of 5.73 kilograms per square centimeter, while the same clay, after treatment with 2% of catechu for a period of ten days, then formed into briquettes and dried at 120°C., would not break until the load was increased to 19.75 kilograms per square centimeter—an increase of more than 244 per cent.

I now began to wonder whether or not the effect I had discovered was known, as it might have much value to an industry of such collosal dimensions and antiquity as clay working. Moreover, it would be amazing if it should not be known, in view of the tremendous amount of experimental work that had been done on that art. I searched for some record of the addition of organic matter to clay during its working, and only one instance could I find, that of the Egyptians in brick-making, as recorded in the fifth chapter of Exodus. The accepted theory of using straw fibre as a mechanical binding agent had never appealed to me. Straw, however, contains no tannin, and the effect I had found had always been produced with tannin, or a substance containing tannin. I procured some straw, boiled it with water, decanted the resultant reddish brown liquid, and mixed it with clay. The result was like that produced with tannin, and equal to the best I had obtained. It now seemed likely that the Egyptians were familiar with the effect I had discovered, and believing this was why they used straw in making brick and were successful in substituting stubble for straw, I called clay so treated "Egyptianized clay."

The effect of organic matter, as typified by tannin, in producing deflocculation and a resultant colloidal state of clay is very readily shown; for instance, I have here some powdered kaolin, a small quantity of which I will place in a test tube, add water, and after shaking, set aside. Another portion of the kaolin I will put into a beaker, and moisten with a water solution of tannin, to which a small amount of ammonia has been added. After a thorough mixture has been made, using a glass rod to stir with, to eliminate as much as possible any grinding action, I will add more water and divide the contents of the beaker between two test tubes. To one of the tubes containing tannin-treated clay I will add a little common table salt. The three tubes I will place here before you, that we may examine them later.

In the summer of 1906 I succeeded in making artificially a high grade graphite which I wished to make applicable to

*An address before London Society of Chemical Industry, Nov. 7, 1911.

all kinds of lubrication. To meet the various demands, it would be necessary to have it remain diffused in liquids lighter than itself; for instance, water and petroleum oils. Recalling the effect of tannin on clay, which caused it to remain diffused in water, I treated a sample of my graphite with tannin, and found the same effect occurred. The graphite being black, it makes a better lecture demonstration than the clay I have shown you, and I will repeat my experiments, using graphite. I have here a sample of artificially made graphite, which has been disintegrated to a fineness that will permit it to pass through a sieve having 40,000 meshes to the square inch. I will introduce a small quantity of it into a test tube, add water, and after shaking, set aside. Another sample I will place in a beaker and moisten with a solution of organic matter, and after thoroughly stirring with a glass rod, I will add water and divide it between two test tubes, to one of which I will add table salt. These three tubes I will place beside those holding the clay, to be examined later.

The actual amount of deflocculating effect produced on the graphite in the beaker is very small indeed. In commercial work considerable mastication and time are required. I have here a bottle containing water having two to three-tenths of 1% of its weight in deflocculated graphite, the deflocculation having been produced by a treatment similar to that I have applied to the graphite in the beaker, and a little of it being poured on a filter, you see the black liquid running into the test tube below the filter. The paper retained none of the graphite on its upper surface, all of it having passed into and through the paper. I will now add two or three drops of acid to the black liquid in the tube, and after warming over a spirit lamp, will throw it on another filter paper, and you now see a clear, colorless liquid descending into the tube below the filter. This is the water in which the graphite in a deflocculated condition was diffused; the graphite, having been flocculated by the acid, is now retained on the upper surface of the filter paper. The effect I have produced with the acid could have been produced with a solution of salt, lime water, or any one of that large list of substances known as electrolytes, even so weak an acid as carbonic acid, if caused to bubble up through water carrying deflocculated graphite, will cause flocculation and sedimentation.

Upon being deflocculated, the graphite is diffused through the water in a colloidal state, and I have samples of deflocculated graphite in water which have stood for more than two years without showing any settling, notwithstanding the graphite is two and two-tenths times heavier than water.

I have been able to obtain this same effect on natural graphite, amorphous alumina and silica, lamp black, and my manufactured product, Siloxicon, which is an amorphous body having the formula Si_2C_2O. The effect can be produced with a long list of organic bodies; for instance, tannin or organic substances containing tannin, also with solutions containing the gum of the peach and cherry tree, or extracts from straw and grass. The off-fall from the barnyard proved to be very efficient. I speak of these organic substances as agents when used to produce deflocculation, and they act as protective colloids to the deflocculated body.

Some minutes have now passed by, and we will examine the tubes containing the clay and the graphite. We find the clay that had been mixed with plain water has settled. The mixture of clay, water, organic matter and salt has also cleared, while the tube containing the clay, water and organic matter remains muddy. In like manner the tube containing the disintegrated graphite in water has cleared; the second one containing water, graphite and organic matter remains black; while the third tube, which was set up the same as the second, but had a little salt added to it, has cleared. Apparently a great affinity existed between the organic and the inorganic substances introduced into the water. The inorganic body abstracted the organic from the water, and in doing so, was deflocculated. Each particle as it was thrown off was enveloped in an aqueous jelly of the organic agent, or at least such was the working hypothesis I followed to arrive at my results, and I find it difficult to think of this breaking up stopping short of the final subdivision with the resultant separation into individual molecules, or the smallest particles into which a body can be subdivided without loss of identity.

As I have already stated, I deflocculated clay in the year 1901 and graphite in 1906, and immediately afterwards a number of other bodies. I early understood I was producing colloidal conditions of these bodies, but not until the summer of the present year, 1911, did I read any treatise on colloids, being familiar with this state of matter only in a very general way. During the summer I procured a copy of the book "Colloids and the Ultramicroscope," as written by Dr. Richard Zsigmondy and translated into English by Jerome Alexander, of New York. I found the book extremely interesting, and at once wished to have a sample of my deflocculated graphite subjected to ultramicroscopic examination. Mr. Alexander kindly undertook the examination. He found the graphite in the deflocculated condition to be in a true colloidal state, the particles being in rapid motion, and he estimated their average size in linear dimensions to be 75 millimicrons. Seventy-five millimicrons are seventy-five millionths of a millimetre, and it would require slightly more than 13,000 of the particles to extend one millimetre. Now, the particles of disintegrated graphite, used as the crude material from which to produce deflocculated graphite, pass, as I have stated, through a sieve having 40,000 meshes to the square inch and their maximum linear dimensions is such that it would require 13 of them to extend one millimetre. Hence, the particle of disintegrated graphite is one thousand times greater in linear dimension than the deflocculated one. These are figures that certainly test our powers of appreciation.

I have been asked, "Why don't you speak of the graphite as colloidal?" Knowing now that it is in a colloidal state, I speak of it as being colloidal, but when I am speaking of my process I am talking of a method of producing deflocculation. When does that process of deflocculation stop? Is it short of the final subdivision and the throwing off of the molecule? I think not. I believe we are here dealing with molecules. Their size may not agree with what they should be as computed in accordance with accepted theories, but, nevertheless, I cannot conceive the subdivision once started, in the presence of sufficient deflocculating agent, will stop short of the final, with the freeing of the molecule and the creation of the colloidal state.

How did all this I have been telling you come to happen? The following quotation aptly tells how:

"It's generally the fellow who doesn't know any better who does the thing that can't be done. You see the blamed fool doesn't know it can't be done, so he goes ahead and does it."

Canadian insurance companies are recognizing in a practical way the value of lightning rods. There are now ten companies which make a reduction in favor of buildings that are properly rodded. The reduction ranges from 5 to 10 per cent. of the regular premium, the most of them allowing 10 per cent.

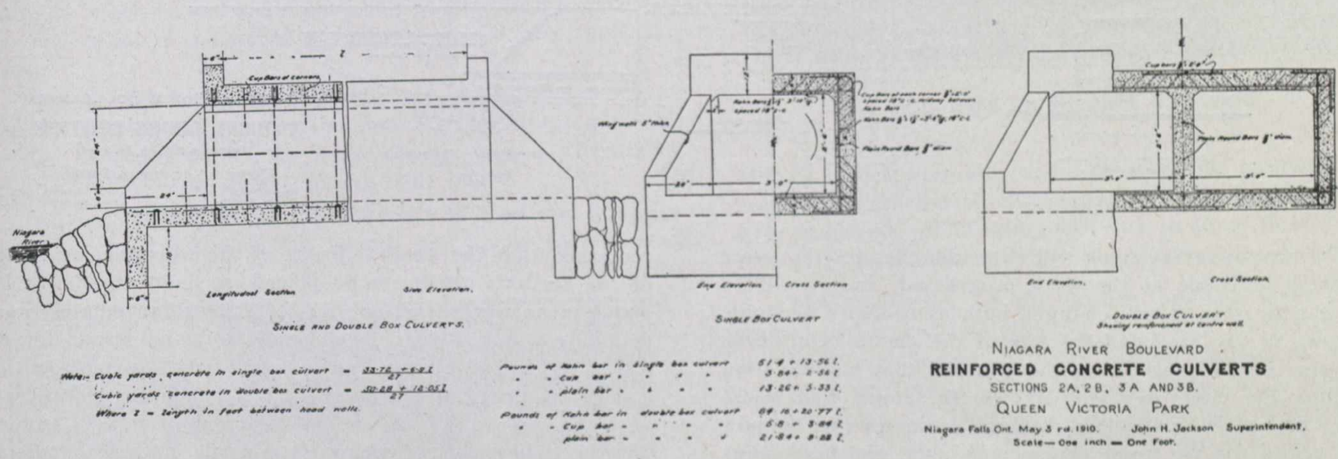
THE NIAGARA BOULEVARD DIVISION OF QUEEN VICTORIA PARK SYSTEM.*

By John H. Jackson.†

Notwithstanding that I speak to you to-night as an engineer among engineers, and, therefore, should feel entirely at ease, I must confess to considerable trepidation in following so closely after a week's course of lectures to Toronto citizens upon civic landscape work, by one of the large men in the profession from the other side of the water. I refer to Thomas H. Mawson, who told us many things of value, particularly when read in the light of the conditions that are to be faced in a country which is different from every other country. And while it is more the engineering features that I will be discussing, nevertheless, the landscape will come in for some remarks. I find that the ordinary idea, respecting the man charged with the guidance of park work is that he should be eminently fitted to place a bit of filigree work here, and a few shrubs there, so that some structure may appear as though Nature placed it there, and this, to my mind, is one of the strongest thoughts in Mr. Mawson's discourses, namely, that a building has a right to a location provided it is needed and ought not to be so surrounded as to give it the appearance of being ashamed of itself. Park work is far from the realm of filmy clouds and must, to be successful, deal day by day with problems as practical as those of any branch of the engineer's profession. At the present time in our system we are considering and designing lighting plants, water supply, sewerage systems, drainage and under drainage, roads, pavements and architectural features, and in addition we have to map out our financial programme, while as a side line, we have to watch the hay market to see when it is the proper time to sell the cut off some of our outlying portions.

The Queen Victoria Park system seems to be confined, in in the mind of the public, to that portion some two hundred acres in area at the Horseshoe Falls and extending about three-quarters of a mile northerly and southerly from the great cataract. This, however, is only about a quarter of our acreage and the extremities of the system, some thirty-five miles apart, begin at Lake Erie and end at Lake Ontario. The Commission is entrusted with parks at Fort Erie, Chippawa, Niagara Falls, the Whirlpool, Niagara Glen, Queenston and Niagara-on-the-Lake, as well as the Chain Reserve along the whole of the frontier, and it is the aim looked forward to with the greatest confidence that not many years hence broad boulevards may extend along the entire Niagara River interconnecting the several areas now being parked.

The topic of this talk is division No. 1 of the boulevard system in length some sixteen miles running southerly from Queen Victoria Park to Fort Erie. The general features of this length are as follows: The minimum width acquired is 100 feet from the top of the bank, making a general width of about 125 feet from the water's edge. At a great many points, however, and at all prominent projections additional width is taken to preserve the alignment of the roadway with not too sharp curves, and this land serves the purpose of providing small areas for park development, thereby breaking the monotony that might result from following a typical section too closely. Thus at nearly all the streams entering into the Niagara River where bridges have been built, considerable extra land has been purchased to allow of a proper setting for the structure and the development of its architectural features. At Black Creek midway between the extremities of this division there is enough land to provide a small plot for the use of the summer dwellers, and at Chippawa a park, one half a mile in length, is included. The development of this 100 feet in width has as its general arrangement 15 feet from the top of the bank left over for a path and low shrubbery followed by 30 feet for roadway purposes, of which the centre 18 feet is macadamized and 6 feet on either side is used for the shoulder to the roadway and drainage purposes. The remaining 55 feet is to be planted in accordance with plans that are now being worked out, and it is the intention to preserve as far as possible the natural growth that has taken years to develop. So far has this principle been



Sect.	Date.	Width.	Crown.	Depth of stone.	Layers.
1	1908	18′	10″	12″–6″	6-2 (no size): 5-3 (3″): 1-1 (1″): (4″ field tile).
1A	1909	22′	9″	12″–6″	6-2 (no size): 6-4 (3″).
1B	1910	18′-22′	9″	10″–7″	5-4 (6″): 3-2 (2″-4″): 2-1 (1″-1½″).
2–3	1910	18′	9″	10″–7″	5-4 (6″): 3-2 (2″-4″): 2-1 (1″-1½″).
4	1908	18′	10″	12″–6″	6-2 (no size): 5-3 (3″): 1-1 (1″)
4A	1910	18′	9″	10″–7″	5-4 (6″): 3-2 (2″-4″): 2-1 (1″-1½″).
4B	1911	18′	9″	10″–7″	5-4 (6″): 5-3 (1½″-2″).

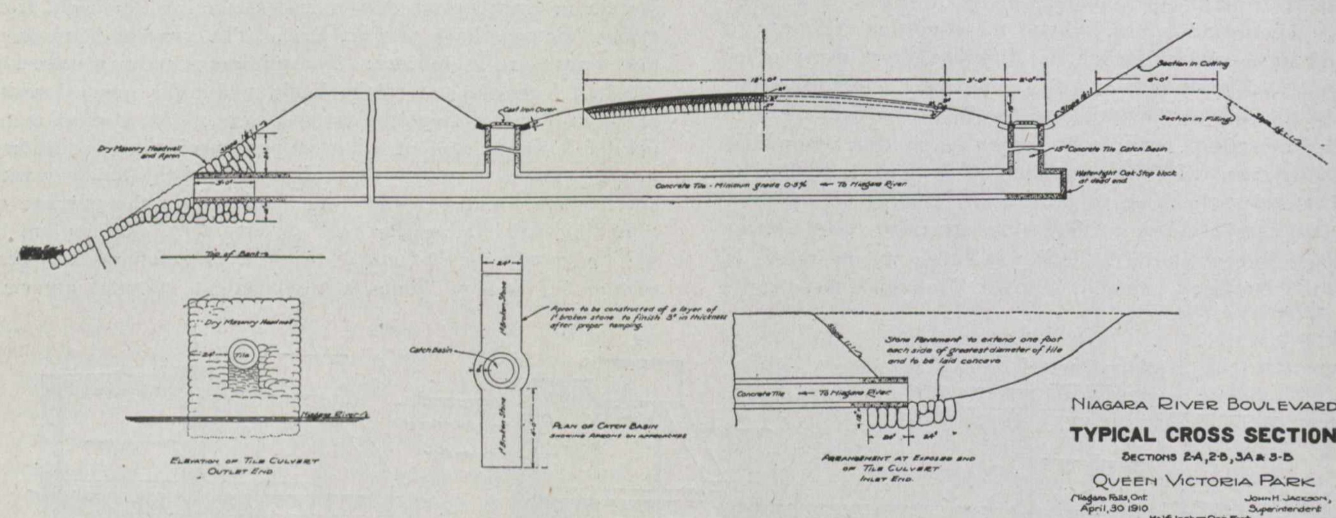
*Abstract of address to Toronto Branch Can. Soc. Civil Engineers, Nov. 30.
†Superintendent Queen Victoria Niagara Falls Park.

carried into effect that many large scale studies of different lengths have been made to preserve the healthy trees along the right of way, and new planting is made to correspond with the kind of growth that flourishes best at each section.

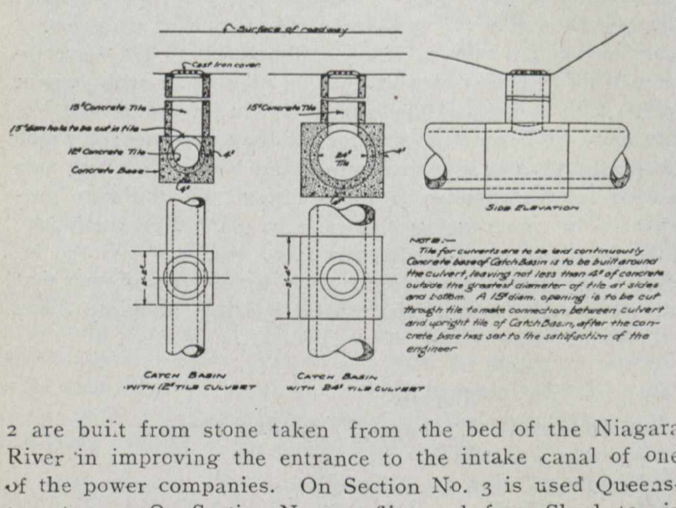
I wish now to take up the evolution of the engineering features of the construction. In 1908, when this roadway building was commenced, we found ourselves in possession of a general specification from the Highways Department of the Province, and considered it wise to depart as little as possible from this to commence with, but every operation was keenly observed in an endeavor to understand each problem and its solution.

use on the building of good roads throughout the various municipalities. I may also say that we have watched with considerable interest a 300-foot stretch of roadway in the city of Niagara Falls, built entirely of limestone screenings. The section of this is much heavier than the ordinary macadam roadway, but it has bonded perfectly and presents a surface equal to some of the best macadam construction. It is, of course, our intention to use an asphalt oil for dust laying and cushion purposes along the entire length of the boulevard, with pea stone and screenings for a blotter.

In noting the difficulties, some of them peculiar to this particular work, and others to this class of work, it may be

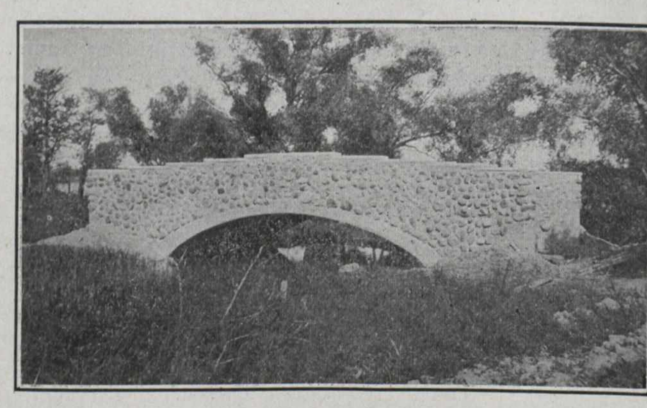


The accompanying table will show the changes that were considered desirable as the work progressed, and it will be seen that the section was changed both as to depth of stone, the crown of the road and the size of the metal. Our ideas have also changed respecting the material that may be used for filling the interstices and binding the stone, and where we had first used limestone screenings exclusively we are now using gravel for the lower course with sand and screenings for the top. Again, we have the feature of many different kinds of stone being used on the different sections, and all are being carefully observed to determine their wearing qualities. On Section No. 1 we have Queenston blue and grey stone, as also on Section No. 1A, Sections Nos. 1B and



2 are built from stone taken from the bed of the Niagara River in improving the entrance to the intake canal of one of the power companies. On Section No. 3 is used Queenston stone. On Section No. 4 a flint rock from Sherkston is employed, while Sections Nos. 4A and 4B are built of St. Davis limestone. On the entrance to the park itself we have Hagersville stone, and are now to use Thorold stone on one of the park roads. In as far as the experimental feature of this construction is concerned all of the records are at the disposal of the Department of Highways of the Province for

remarked that the general grade of the macadam over some of the sections could not be placed at more than five feet above mean water level and on the stretch immediately north of Black Creek a dead level grade could be struck for five miles. This, of course, means that we had to create the grades required for drainage, and it has been necessary to accept a fall as low as an inch and a half in one hundred feet, but where this is the case the grade of the gutter is increased to not less than two inches in one hundred feet. Catch basins have been plentifully supplied and are never more than five hundred feet apart, except on either side of a summit where they may be as much as eight hundred feet from each other. The drainage problem has been one of our



One Type of Bridge.

greatest and constant sources of difficulty, for it is believed that perfect draining of the subgrade and efficient apparatus for taking care of the surface water goes farther to make a road suitable for modern requirements than is ordinarily thought. The crown of the roadway, it will have been noted, has been altered from the first design, and where we had a rise from the edge of the macadam to the centre of 10 inches in nine feet, we now have one inch per foot, and where the macadam has been widened to twenty-two feet we have kept the rise at nine inches or thirteen-sixteenths of an inch per foot. Were the longitudinal grades capable of a greater fall per foot than we have, a much less crown would be preferred, and our experience has been that the twenty-two-foot road, with its flattened section, is used toward the outside to a degree far in excess of the eighteen-foot road. We have, therefore, had to sacrifice this very desirable feature and considered it expedient to do so for the drainage.

Another of the difficulties to be encountered was the effect of the Niagara River cutting in upon the shore line, and some twenty-five thousand ($25,000.00) dollars has had to be expended in a rip-rap protection to make the area acquired for the boulevard safe from erosion. At some stretches it was necessary to approach very near to the top of the bank and place the rip-rap far enough from the water's edge to build a new bank. Attention might also be called to the provision that has been made for accommodating a very much increased traffic which is expected within the next few years, and it is pointed out that the roadway can be readily increased to thirty feet in width by simply removing the earth shoulder, partially filling the gutter and extending the metal to the present edges of the gutter. Under this rearrangement the catch basins would be in the proper place to receive the surface water and would probably be kept at their present grade.

The bridges along the route, six in number, have perhaps given a greater degree of satisfaction from a designing point of view than any other part of the construction. The main features of these are shown in the table below.

All are of the arch type reinforced with steel and designed for a uniform load of 200 pounds per square foot in addition to a 20-ton roller or a 40-ton suburban car. I may say that our Commission has no policy respecting an electric railway on this public property, but it was considered wise to provide for such a feature if the proper developments of the district should point to electric traction as a necessity, and that is the reason for the heavy type of bridge adopted. Of course the architectural feature was most important, and it is believed that the structures, as built, will not lag behind the general high standard that has been set for this work. Usher's Creek bridge is built of Queenston blue stone with cobweb masonry, Boyer's Creek is built of field stone and boulders, Black Creek, the longest span (70 feet) was given the most attention and is veneered with Beamsville white or grey limestone with ashlar masonry and ornamental iron panels between pilasters on the parapet wall. Baker's bridge is built of red sandstone blotched with grey.

Arch Used on Niagara Boulevard.

Miller's Creek bridge is the only one built entirely of concrete and Frenchmen's Creek bridge is built of Queenston grey limestone. The intention being in all of these different structures to mark a mile stone on the route.

Arch Bridge During Construction, Showing Centering.

The foundation for the bridges probably gave us more anxiety than anything else, for the material was of an exceedingly treacherous character and each abutment, with the exception of Usher's Creek bridge, required to be piled. For the foundation, in place of a grillage we used rubble between the piles and allowed the caps to extend into the concrete. The abutment was then built usually in one operation to the point where the arch steel could be placed and then the concrete was brought to the springing line of the arch, and on a line nearly perpendicular to the tangent of the arch ring at this point. The arch ring itself was laid in one operation with the exception of the Black Creek bridge, where the width was divided into three sections, each of which was run continuously. As a further precaution on the Black Creek bridge the arch ring was keyed into the abutment by leaving in the bottom a transverse slot two feet six inches in width at the top, two feet deep, and one foot nine inches wide at the bottom. Dowels were set in both sides of this slot three feet centre to centre, and the lower main bars of the arch ring extended to the bottom of the slot and were wired to the dowels.

Bridge.	Stone.	Span.	Rise.	Centers.	Mileage.	Concrete. 1—2—3	Concrete. 1—3—6	Tons Steel.
Usher's..........	Queenston blue cobweb	50′	6′	5	163 3.1	126	92	6.7
Boyer's...........	Boulders	30′	5′	5	359 6.8	48	54	3.7
Black............	Beamsville white ashlar	70′	7′	5	438 8.3	376	241	20.3
Baker's..........	Red sandstone pibald	30′	5′	9 (Ellipse)	489 9.3	82	55	4.0
Miller's..........	Concrete	30′	8′	5	610 11.5	112	50	5.2
Frenchmen's......	Queenston grey	40′	4′	(hdrs. 6.5)	785 14.9			

REGARDING FIREPROOF BUILDINGS.

At a recent meeting of the American Society of Mechanical Engineers at New York, the statement was made that the United States is paying a preventable loss of more than $366,000,000, annually, this being the difference between European losses and those in our own country. In discussing this, Mr. Charles T. Main, of Boston, stated that the estimated cost of private fire protection, including capital invested in construction and equipment, is $50,000,000 with an interest account and watchmen's cost amounting to $18,000,000 more. It does not seem possible to omit very much of the public fire-fighting apparatus and systems on the private investment for this purpose, even if every building were proof against destruction by fire inside and outside, because the combustible contents of the city buildings and factories make it necessary to put in hydrants, sprinkler and pumping systems and to maintain fire departments in the same manner as they are now installed and maintained. The spreading of fire would be reduced and the losses decreasel accordingly.

In trestle mills the value of the buildings is not more than one-quarter of the total value of the property, and the value of the property and of the stock in process is also a very considerable amount. In some of the rooms in a cotton mill the stock in process is very inflammable, and a fire will start from a spark or a heated bearing on a machine and go from one end to the other almost like a flash of gun powder. The insurance companies therefore require, even in fireproof buildings, a system of fire protection of the same capacity and efficiency as is required in buildings of slow-burning construction. As the losses on the contents of the buildings form a large part of our fire losses, it would be well to look for better regulations in regard to the storage of combustibles in our city buildings, including the retail stores.

In regard to the statement that fireproof buildings can be built as cheaply as those of the slow-burning type, Mr. Main stated that in competition for a mill building recently, he obtained prices showing the cost of the concrete building to be about 25 per cent. more than for regular mill construction. This is probably due to the fact that the floor loads in textile mill work are comparatively light.

In regard to the statement that if a whole floor can be poured at one time engineers can figure the textile strength of concrete when designing, he understood it to be meant that that portion of the concrete below the neutral axis down to the rods can be figured for tension. Investigations in this country have generally shown that when a beam is loaded much in excess of its ordinary working load, the concrete below the neutral axis cracks. As the assumed working load limits may often be exceeded, especially in factories, such cracking might occur, and then the beam would not have the tension factor which it was designed to have. Test loads would almost always destroy the tensile strength of concrete below the neutral axis, and many other conditions which will occur in the best actual construction will also help to destroy it. It has been Mr. Main's experience that concrete cannot be made with sufficient scientific accuracy in the field, and voids, cracks, etc., will sometimes occur.

It is claimed that with the use of metal forms, mechanical handling and placing concrete, satisfactory work and good appearance can be obtained by omitting all wooden trim, casings, etc. This claim is far in advance of the work which most of the contractors have been able to produce. Most of them are wholly unable to come anywhere near to what would be termed certified concrete. Any educational work which the government could do for the people along the line of fireproofing buildings and houses would be eminently proper and useful, but it does not seem as if the government could place any taxes or restrictions on the use of wood or other materials which enter into the construction, since the supply of materials and knowledge of workmen is so varied in different parts of the country. If any legal steps were to be taken along this line, they should be taken by the separate States instead of by the Federal Government, and even then the conditions are so varied in a single State that it would be impossible to cover all cases.

Every engineer and business man should be in sympathy with most of the statements regarding the reduced cost of construction of fireproof buildings and improved quality of workmanship made in the press, and should hope that some day they may become common practice.

NEWFOUNDLAND AND NOVA SCOTIA STONE TRADE.

Newfoundland granite, although not quarried to any great extent, appears to be of superior quality. There are several varieties, all of an enduring nature, the most important being gray, green and red. The quantity quarried during 1910 is estimated at 500 tons, of which 430 tons were shipped to Canada.

About 4,000 tons of flint pebbles were gathered during the year, of which the United States took 3,883 tons, valued at $23,302. There is an increasing demand in the United States for these pebbles, consequently increased facilities were provided at various points on the beach for collecting and handling them, preparatory to shipment. One noticeable feature was the construction last fall of four large barges to carry these pebbles.

Only 1,400 tons of talc, valued at $2,800, and $40 worth of slate were exported; the talc going to the United States and the slate to Canada. There is only a local demand for slate, although it is claimed to be of superior quality, suitable for all purposes, and obtainable in three distinct colors—dark purple, red and pea green. Before 1908 considerable quantities were shipped to the English market. It is said that a mill for grinding talc and manganese is about to be erected on the shores of Conception Bay, and it should develop the talc properties in that neighborhood.

The Atlantic Pebble Company, operating at Manuels, has 180 men employed collecting pebbles. A track has been laid along the beach, and 14 machines are placed there to sort the stones in six different sizes. They are put up in sacks of 141 pounds each, and a steamer is expected about the middle of September to take a cargo to New York. It is the supposition that all the pebbles collected will be marketed in the United States.

It is reported that one of the limestone claims at Port au Port has recently been sold to the Dominion Iron and Steel Company, of Sydney, Nova Scotia. The company has had a large number of men working on these and other limestone properties since last November, and has drilled and sunk over 40 holes in testing the properties, but found only a small area of the required stone, a sufficient supply, however, for the next 25 years. This industry will give employment to at least 350 men all the year. Piers will be built and a shipping port made ready at once. The company will run an 8,000-ton steamboat between this port and its blast furnaces at Sydney, making three trips per week.

Metallurgical Comment

T. R. LOUDON, B.A. Sc.

Correspondence and Discussion Invited

FURTHER NOTES ON THE NATURE OF SOLID SOLUTIONS.*

By C. A. Edwards, M.Sc.

In a paper read at the annual general meeting in January, 1911, the author briefly discussed the nature of a constituent which so frequently occurs in metallic alloys, and which is usually described as a solid solution. This gave rise to a most interesting discussion; and though some few points were alluded to which supported the conclusions embodied in the paper, for the most part these conclusions were received with little favor. The objections to the author's views were numerous, and, if valid, indeed very serious. Owing to the magnitude of the criticism, the author considered it advisable to make his reply in the form of a short paper, because it would be easier to handle, and also because it would afford another opportunity for further criticism. Before again opening this interesting question, the author would like to make it perfectly clear that it is not one of nomenclature, for it is of little consequence whether we use the term "solid solution" or "mixed crystal"; but whichever term is used, it is most important for metallurgists to acquire a true and clear conception of the nature of that constituent, and thus remove the ambiguity which is now undoubtedly associated with the use of those terms. Solid solutions are probably of more frequent occurrence in industrial alloys than in any other constituent, and if their internal architecture could be conceived, it would be a step of some scientific value which may lead to an explanation of phenomena that have been hitherto inexplicable. In his previous paper the author's main conclusion was that "a solid solution of two metals or intermetallic compounds is an intimate crystalline mixture, and whilst the crystals are so small that the mass appears quite homogeneous, they are nevertheless sufficiently large to retain their identity." The most serious objection to this view was that it was opposed to the phase rule, and it is to this objection that the present paper is chiefly directed. Therefore, in order to decide if this definition is correct, or even theoretically possible, depends upon the answer supplied to the following questions:—

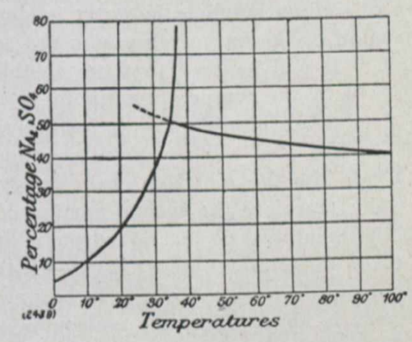
1. Are there any physico-chemical laws opposed to such a conception?

2. Is this definition in accordance with what is known of other types of solution?

Since solid solutions are regarded as being analogous to ordinary aqueous solutions, it is necessary to define the condition in which a salt exists when in solution before the state of a metal in solid solution in definable. It will be advisable, therefore, carefully to consider each kind of solution, after which it may be possible to fix the precise physical meaning of the term "solution." That there is, indeed, some uncertainty as to the meaning of this term will be evident on reading a quotation from Findlay's book on the phase rule. He says:—"With the conception of gaseous and liquid solutions everyone is familiar. Gases can dissolve in, or be absorbed by, liquids; and solids also, when brought into contact with liquids, 'pass into solution,' and yield a homogeneous liquid phase. On the other hand, the conception of a solid solution is one which, in many cases, is found more difficult to appreciate; and the existence and behavior of solid solutions, in spite of their not uncommon occurrence and importance, are in general comparatively little known. The reason of this is to be found, to some extent, no doubt, in the fact that the term 'solid solution' was introduced at a comparatively recent date, but it is probably due in some measure to a somewhat hazy comprehension of the definition of the term 'solution' itself."

A solution is usually defined as a homogeneous phase the composition and properties of which may be varied within certain limits. This is, however, only a general definition, which does not signify the condition of a substance when in solution.

Gaseous Solutions.—The first, and perhaps most perfect, class of solution is that of gases in gases. In gaseous solutions the molecules of each gas move freely round each other without producing any change in their respective properties. If we take, for example, a solution of nitrogen and oxygen, we know that the individual properties of these two gases are absolutely the same when in solution as when separated. Moreover, gaseous solutions are capable of being separated into their constituents by diffusion. Hence we are quite justified in concluding that gaseous solutions are finely-divided mixtures.



Solutions of Gases in Liquids.—With regard to solutions coming under this class, it is well known that all gases are more or less soluble in liquids. The amount of gas actually taken up by any liquid upon which that gas has no chemical action depends upon:—First, the nature of the gas; second, the temperature of the liquid; and, third, the pressure of the gas.

1. At 0 deg. Cent. water dissolves 2.1 volumes of hydrogen and 1.9 volumes of oxygen, proving that the amount of gas dissolved is different for different gases.

2. On raising the temperature it is found that the volume of gas dissolved by the liquid decreases.

3. From Henry's law, we know that the volume of gas which can be absorbed by a liquid varies directly with the pressure, but since the volume of a gas is inversely proportional to the pressure, it follows that at equal temperatures the volume of a gas dissolved by a liquid is the same at all pressures.

Dalton considered that the particles of a gas dissolved in a liquid were held between the molecules of the liquid. While this explanation does not account for the fact that a liquid dissolves dissimilar gases to different degrees, nor the fact that the solubility decreases as the temperature increases, yet it requires less assumption than any other explanation so far advanced, and for this reason, and also because it falls into line with the other types of solution, the author is inclined to believe in Dalton's opinion.

Solutions of Solids in Liquids.—In his previous paper, in discussing the action of the separation of water from an

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*Paper read before the Institute of Metals at Newcastle.

aqueous solution by means of a "semi-permeable" wall, the author said that solutions of salts in water are intimate mixtures which can be separated, to some extent, by mechanical means. This implies, and, indeed, the author said he was of the opinion, that salts preserve their identity when in solution. If this is not the case, on what other assumption can the osmotic phenomena be explained? If we now examine a few well-known examples, we will see that this statement is by no means without experimental proof. As a rule, the solubility of a solid in a liquid increases with rise of temperature; certain substances, however, such as slaked lime, decrease in solubility with rise of temperature; and this has been shown to be due to the fact that as the temperature rises the dissolved substance—in this case the calcium hydrate, $Ca(OH)_2$—loses water, and is converted into a less soluble substance—namely, lime, CaO. This is an instance of the dissolved salt actually being dehydrated when in water in the same way as when in solid pieces. This kind of decomposition, if it does not actually prove that the salt retains its identity when in solution, can only be explained with that assumption. If such changes are possible in aqueous solutions, with which metallic solid solutions are analogous, then it is quite reasonable to expect that similar changes may also occur in metallic alloys. Another interesting example is that of sodium sulphate; this salt exists as a solid in three forms—namely, the anhydrous salt Na_2SO_4, the heptahydrate $Na_2SO_4 \cdot 7H_2O$, and the decahydrate $Na_2SO_4 \cdot 10H_2O$. The solubility curve of sodium sulphate in water is shown in Fig. 1. The first portion of the curve represents the solubility of $Na_2SO_4 \cdot 10H_2O$. It will be seen that the solubility of this salt rapidly rises with the temperature up to 34 deg. Cent., after which it gradually diminishes with further rise of temperature. The decahydrated salt decomposes at temperatures above 34 deg. Cent. into the anhydrous salt, and water saturated with that salt; therefore the second portion of the curve corresponds to the solubility of the anhydrous salt in water. Now in such cases of solution the changes which occur in the solution seem quite inexplicable if it is assumed that the dissolved substance is absorbed by the molecules of the solvent, or, as is frequently stated, that the solute actually liquefies.

From these facts we learn that a dissolved hydrate can lose its water of hydration even when the particles of the hydrate are apparently in contact with water; whether the particles of solute and solvent are actually in contact is a matter that will be considered later. In any case it is evident that a dissolved body may undergo the same changes when in solution as when in the pure solid condition.

Van't Hoff's Law.—When the temperature of a system in equilibrium is raised, that reaction takes place which is accompanied by an absorption of heat, and conversely, when the temperature is lowered, that reaction occurs which is accompanied by an evolution of heat.

Le Chatelier's Law.—When the pressure on a system in equilibrium is increased, that reaction takes place which is accompanied by a diminution of volume; and when the pressure is diminished, a reaction ensues which is accompanied by an increase in volume.

These two theories are embraced in Le Chatelier's law, which may be stated as follows:—If a system in equilibrium is subjected to a constraint by which the equilibrium is shifted, a reaction takes place which opposes the constraint—i.e., one by which its effect is partially destroyed.

In accordance with this law, increase of solubility with the temperature must occur in those cases where the process of solution is accompanied by an absorption of heat; and a decrease in the solubility with rise of temperature will be found in cases where solution occurs with evolution of heat.

In applying the theorem of Le Chatelier to the course of the solubility curve, it should be noted that by heat of solution there is meant, not the heat effect produced on dissolving the salt in a large amount of solvent, but the heat which is absorbed or evolved when the salt is dissolved in the almost saturated solution. Not only does the heat effect have a different value, but it may even have a different sign. Despite its many forms, it should be noted that the solubility curve of any substance is continuous so long as the solid phase, or solid substance in contact with the solution, remains unchanged. If any "break" or discontinuous change in the direction of the curve occurs, it is a sign that the solid phase has undergone a change. Conversely, if it is known that an alteration of the constitution of the solid phase takes place, a break in the solubility curve can be predicted. From these facts it follows that a salt, even when in solution, may undergo the same changes on heating that solution as when the pure salt is heated alone, and as a logical consequence it follows that it is possible only if the salt retains its identity when in solution. Therefore the author considers he is amply justified in concluding that in all cases solutions are not absolutely homogeneous—that is, though they may have the same composition in all their parts so far as is shown by ordinary analysis or physical tests, yet there is a region beyond which a solution cannot be regarded as homogeneous, or, in other words, the particles of solute are not actually in union with the particles of solvent.

In the discussion on the previous paper it was suggested that this conception as applied to solid solutions was incompatible with the phase rule. Needless to say, the author fully appreciates the value of this important rule, and applies it whenever possible; but he would point out that there are limits to its application, and one of these limits is reached when it is attempted to apply the rule to the molecular constitution of a phase.

In deducing his law, now known as the phase rule, Gibbs regarded a system as possessing only three independent variables—viz., temperature, concentration, and external pressure; among other less important items no account is taken of the internal pressure of a phase, not even in the case of solutions. The rule defines the state of a system in equilibrium by the relation existing between the number of components and the number of phases present, quite independently of the amount of each phase and the internal constitution of the participating substances. Therefore in attempting to determine the internal nature of a solution the phase rule, as expressed by the equation $F = C + 2 - P$, should not be applied, for with this equation it is presupposed that a solution is homogeneous. But because in the application of the phase rule it is supposed that a solution is homogeneous, it does not therefore follow that that is indeed the case; and if it is decided that a solution is a physical mixture coming outside the region of the above equation, it will not detract from the value of the phase rule. For, as a matter of fact, while the author is convinced that the phase rule should be disregarded in trying to decide whether a solution is or is not homogeneous, in the strictest sense of the word, once this question is decided, and if in favor of the author's conception, it becomes even more important to apply the phase rule in order to know exactly what substance is in solution. An example of the limitation of this rule is evident in the case of gaseous solutions, when, from the point of view of the phase rule, there is only one phase present—namely, vapor; and yet there is not the slightest doubt that in gaseous solutions each gas present retains its own properties, and is unaffected by the presence of others.

Another interesting question was raised by Dr. Guertler. He said:—"If it was assumed, with the author, that there existed a very fine mixture of separate crystals in the one solid solution, there would have to be assumed a third thing between crystal and molecule. No evidence of such a thing was given, except by the osmotic phenomena." The author readily acknowledges the validity of Dr. Guertler's argument, and would say that the necessary evidence for the existence of such a third force is furnished by the osmotic phenomena of liquid and solid solutions, phenomena which are closely related to the laws of gaseous pressure. It is, of course, less easy to experimentally show the existence of osmotic pressure, by means of diffusion through a semi-permeable wall, as in the case of aqueous solutions; but magnitudes which are proportional to the osmotic pressure are furnished by the depression of transformation points brought about by the presence of foreign substances in solid solution. The author regards osmotic pressure as a pressure which exists between the particles of solute and solvent. It would appear that, in the case of aqueous solutions, osmotic phenomena are produced by the pressure exerted upon the water by the particles of solute, which results in an actual expulsion of part of the water. The author uses the word "particle" advisedly, because it conveys no definite idea as to size or molecular aggregation. From the foregoing reasoning, the conclusions at which the author arrives are:—

1. That gaseous, liquid, and solid solutions are members of the same family, the different states of these members being due to the differences in their molecular aggregation.

2. In all cases of true solution the molecules of each component remain unchanged—i.e., there is no association of dissimilar molecules—e.g., there can be no association of the molecules of a salt with those of water, when in the form of an aqueous solution, unless it results in the formation of a new compound. Thus in the case of gaseous solutions a uniform composition is maintained by the physical forces existing between what may be regarded as simple molecules; in liquid solutions a constant composition throughout the mass is maintained by the forces existing between dissimilar groups of molecules, but each individual group consists of only one kind of molecule. In the case of solid solutions, equilibria are maintained between the very small crystals of each component metal or intermetallic compounds.

3. With the expression $F = C + 2 - P$ representing the phase rule, solutions come under the head of homogeneous equilibria, but that equation should not be applied to disprove the author's conception of the internal nature of solutions, because, with it, the assumption is tacitly made that a solution is homogeneous, and thereby judgment is passed before the evidence is considered.

4. From a general point of view the term "solid solution" is to be preferred to "mixed crystals," but, whichever term is used, the author considers that such bodies consist of extremely small crystals of two or more metals or intermetallic compounds; and whilst these crystals are ultramicroscopic, they retain their individual properties.

With regard to the practical aspect of this interesting question, the author will only say that with this conception, and, so far as he is aware, with this only, can the discontinuity in the mechanical properties of the *a* brasses (discovered by Bengough and Hudson) which occur at 470 deg. Cent. be explained. Further, many other facts which are still not understood become qnite reasonable after accepting this theory.

It will be seen that this note deals more with the bearing of the phase rule upon the question; other less vital objections have for the moment been left out of consideration, because the author believes they were made as a result of some slight misunderstanding, and also because it is first necessary for members interested in the subject to decide whether they will accept the author's theory as being in agreement with well-known physical laws.

THE TIN PEST.

The adoption of a designation like "tin pest" seems to suggest that metals, like living beings, may be subject to infective diseases. That will appear absurdly fanciful to those who believe in a definite boundary-line between the living and the non-living, and may not be approved of by others, who feel less sure of the existence of such a boundary, but who would not compare a living organism built up of many compounds, constantly undergoing changes, with a metal or other elementary substance, which is uniform in its mass and endowed with certain permanent qualities. Yet Professor Ernest Cohen, of Utrecht, did not act without reason when he designated the peculiar decay of tin—which probably does not stand alone in this respect—by the name of a plague or pest. He has carefully investigated the phenomenon, and he has succeeded in demonstrating that the decay of tin can be prevented and cured. Tin should not be exposed to cold, to put the matter briefly. The subject is of considerable interest to engineers, and for this reason Professor Cohen's discourse on "The Allotropy of Metals," delivered at the Faraday Society, deserves attention.

The main facts of the decay of tin were recognized forty or fifty years ago. O. L. Erdmann noticed in 1851 that some organ pipes in the castle church of Zietz (Prussian Saxony) were decaying; he thought that the concussions to which the pipes were subject might, under certain conditions, cause a mechanical disintegration. When Fritzsche was consulted upon some peculiar Banca tin in February, 1868, by a St. Petersburg firm, Erdmann's observation had been forgotten. Some blocks of the bright white Banca tin—a very pure material—which had been kept in the customs-house sheds during the winter, had turned into a dull grey powder, and had begun to crumble. It was ascertained that the case was not isolated; tin buttons for military uniforms had changed into shapeless lumps, for instance. Fritzsche suspected the cold of the severe winter, and experiments convinced him of the correctness of his assumption; the storekeepers in a drug firm, he found out subsequently, had long known that tin should not be exposed to the cold. When Fritzsche heated the grains of his grey tin in hot water, it became bright again, and contracted at the same time; whether the heat was dry or wet did not matter. On the other hand, white tin, cooled artificially, became brittle and grey, expanding at the same time. When the grey tin was fused it changed into ordinary white tin again, and the transformation could be repeated. Fritzsche thus proved that decayed tin is not bad tin; yet, after the organ-pipes of a church in Ohlau, Silesia, which had been restored in 1837, were found badly corroded and full of holes in 1884, organ-builders did not consider such tin a suitable raw material for making new pipes, and the manufacturers of art objects shared this prejudice.

Professor Cohen's attention was first drawn to the matter when a badly-corroded 25-kg. block of tin was returned by a Moscow firm to Rotterdam because an adulteration was suspected. The tin was found to be very pure, containing not more than 0.05 per cent. of impurities. Experimenting with it, Professor Cohen confirmed and extended the observations of Fritzsche, and he demonstrated that the case of white and grey tin is entirely analogous to that of ice and undercooled water.

With the aid of his transition cell, Professor Cohen has proved that the transition temperature of tin is 18 deg. Cent. The transition cell is a glass vessel of **H** form. A few grammes of grey tin are brought into each limb, a solution of pink salt is poured over the tin, and platinum wires in glass capillaries are inserted into the limbs. When the one limb is heated by being dipped into warm water, while the other limb is kept cold, the grey tin in the warm limb turns into white tin. The whole cell is then slowly heated up in a water bath to 5 deg., 10 deg., and 15 . . . deg. Cent.; there is a potential difference between the grey tin and the white tin, which is measured by the Poggendorff potentiometer method. When the temperature has come up to 18 deg. Cent., the potential difference vanishes, showing that the grey tin (left in the formerly cold limb) has also been converted into white tin at that temperature. The reversible change may hence be expressed: grey tin $\overset{18^\circ}{\rightleftarrows}$ white tin. The addition of the pink salt accelerates the change in both directions; this can be explained, but Professor Cohen did not enter into this explanation during his discourse.

In order to measure the volume change accompanying the transition, Professor Cohen connected a cylindrical glass vessel, charged with about 70 grammes of grey tin and water, with a **U**-tube filled with mercury; on the mercury floated a piece of iron which was suspended by a thread from a pulley, and a long pointer was attached to this pulley. When the cylinder was lowered into warm water the grey tin changed into white tin, and the resulting diminution of the volume was indicated by a sinking of the mercury level and a rise of the pointer. In this way Professor Cohen demonstrated that the volume change at the transformation amounted to as much as 30 per cent., and this was confirmed by determining the densities of the two modifications, white tin having the density 7.28, and grey tin the density 5.70. This enormous increase in the volume leads to the disintegration of the white tin when passing into the grey modification; warts begin to appear on the surface, the tin swells, and the warts afterwards crumble into a grey powder.

Since the transition temperature of 18 deg. Cent. (64.4 deg. Fahr.) is so low, it might be objected that white tin should practically be unknown. But the change is very slow, and we know from the analogy of water that undercooling is possible. Yet if the theory be correct, all tin should turn grey as soon as the temperature falls below 64 deg. Fahr., and Professor Cohen found that this was so. He examined the tin coins and art objects of museums, and made inquiries of dealers in tin ware, and he was able to show photographs of some very badly corroded objects, coins, a coffee-pot, organ-pipes, &c., which were covered with warts and holes. At ordinary temperatures, as just stated, the change proceeds very slowly. At lower temperatures the change takes place more rapidly; at —48 deg. Cent. it is very rapid, and Professor Cohen has hastened the change by bringing the white tin in contact with some grey tin. When a block of good Banca tin was brought in contact with grey tin at —5 deg. Cent., the change was very marked in a few weeks, while a block kept at + 15 deg. Cent. was not badly corroded after eight years. The decay or transformation starts from the particle of grey tin, as a small crystal of ice, a germ of ice, dropped into the undercooled water becomes the centre of a crystallization. In a similar way every particle of grey tin becomes a centre for the formation of more grey tin; the transformation advances very slowly in the dense metal, but the particle of grey tin acts like the germ of a disease, and in this sense it may be said that the tin is infected, and that all tin is liable to infection with the tin disease or tin pest. In the cold galleries of museums the danger of the tin infection is particularly great, and this museum disease is very prevalent. It can be prevented by keeping the temperature above 18 deg. Cent.

Technically the tin pest is not so serious, fortunately, because it does not appear to affect the alloyed tin. In what way the presence of other metals exercises a retarding effect does not seem to be well understood. Professor Cohen did not refer to this side of the problem; but it was pointed out during the discussion, by Mr. J. W. Hinchley, that terne plates (whose coating consisted of a tin-lead alloy) made good moulds for refrigerating plant, while tin plates always failed. Whether or not lead is subject to a similar disease as tin is doubtful. Professor T. Turner mentioned that **Canadian architects distrust roofs built up of iron and glass and lead,** because the cold is believed to affect the lead. Professor Cohen had so far been unable to decide whether or not lead was liable to suffer from the cold. Cases of failure in the lead walls of sulphuric-acid chambers, which he had examined, and in which chemical corrosion seemed to be out of the question, rather suggested to him a different phenomenon, a strain disease, to which most metals were subject. To avoid confusion, he had not referred to this disease, of which Professor Ewing and Dr. Rosenhain spoke after his lecture. When crystals of metals are broken up by severe straining, they begin to recrystallize; that, in Professor Cohen's opinion, would be a rearrangement, not a transformation of state, and an irreversible, but also infective, process. On the other hand, Professor Cohen emphasized that the tin pest was characteristic of the pure metal, and he felt sure—though he was, of course, anxious to investigate the point—that some exceptionally pure tin, which Mr. G. T. Holloway had obtained from Nigeria, would also be liable to the pest; the natives run this tin into straws or reeds, and it does not appear to contain any impurities except traces of iron. That the grey tin always contains some oxide does not disprove Professor Cohen's assumption. For the fine grey powder would naturally oxidize more readily than the compact white tin. This oxidation may prevent the ready reconversion by heat of the grey tin into ordinary white tin; but re-fusion of the grey tin with the addition of some carbon to reduce the oxide always yields good white tin again.

NEWS ITEMS.

It is stated that the new hydraulic forging plant of the Nova Scotia Steel & Coal Company is almost completed.

The Canadian Iron Corporation contemplates erecting a gas plant in connection with its works at Fort William.

The report of the American Iron and Steel Association shows that the Independent Steel Companies have gained much more in percentage of output during the period 1902 to 1911 than have the Steel Corporation.

In pig iron the "independents" gained 57.1% in production while the Corporation only gained 48.3 per cent.

DISTRIBUTION OF STRESS.

The meeting of the Physical Society at Finsbury Technical College, England, recently was remarkable for a number of exceptionally brilliant experiments relating to surface-tension, acoustics, and optics; but the matter of chief importance in its practical bearing was the demonstration by Professor Silvanus Thompson and Professor E. G. Coker of the use that can be made of polarized light in solving engineering problems in regard to the distribution and amount of the stresses in tension members. It has of course long been known that a plate of glass when submitted to a bending or twisting stress exhibits changes in its properties in respect to polarized light. In the present experiments the investigators have developed the apparatus to such an extent that comparatively large specimens of transparent material can be brought into the field of vision, with the result that celluloid models of parts of girders and other structures can be examined optically while being subjected to known mechanical stresses. By this means, the distribution of stress in proximity to rivet holes and notches can be clearly observed, and by an ingenious device quantitative estimates can be made of the forces acting at all points throughout the specimens. This device consists in providing an auxiliary strip of the same material, but without holes or notches, and observing in the same apparatus the successive changes of color of the transmitted light corresponding to known changes of tension. By comparing the colors in the case of this strip with those obtained with the specimens, the numerical values of the stresses throughout the specimens can be mapped out and recorded. The applications of such an apparatus are almost limitless; is should, for example, afford a means of answering many of the vexed questions relating to masonry dams. In general, it is entirely representative of the modern tendency of research in engineering science, which consists in appealing to experiments upon models for the fundamental principles of design to be applied to large structures.

THE BRITISH FIRE PREVENTION COMMITTEE'S PUBLICATIONS.

The British Fire Prevention Committee have decided to publish early next year an important illustrated tabular summary of the results of their official fire tests with sixty fire resisting doors. These important results cover an experimetal period of 12 years and practically embrace every type of door from different varieties of ordinary wood and hardwood doors to the most modern forms of composite doors or roller shutters. The summary will be published at $10.22 (net).

Later next year a similar summary dealing with 15 different types of fire resisting partitions will be published at $2 52 (net).

These publications will be issued over and above the usual reports and well known "Red Books" of the committee.

It should be pointed out that new subscribers to the committee's publications enrolled at this period, i.e., November and December, 1911—whereby their subscription ranks until the end of 1912—will have the benefit of a number of valuable publications of quite exceptional importance, as well as the useful publications regularly issued by the British Fire Prevention Committee in the ordinary course, and it may thus be of advantage to public authorities, professional men and others to notify the committee of their intended subscription at this stage.

The subscription to the publications, which figures at $10.22 per annum, allows for use of the committees enquiry office as also of obtaining back issues of the 150 "Red Books" already issued at special figures, as far as they are still in print, as also of the summarized results of 28 fire tests with fire resisting floors, otherwise only obtainable at $5.11 (net).

Enquiries as to publications should be addressed in writing to the Assistant Secretary of the British Fire Prevention Committee, 8 Waterloo Place, London, S. W., England.

PERSONAL.

Mr. C. McN. Steeves, assistant engineer in St. John district, has been appointed engineer in charge of the new wharf on West Side, Ottawa, Ont.

Dr. Frederick T. Dunlop has been appointed provincial bacteriologist for the province of New Brunswick. He occupies the office of Dr. W. Warwick, who recently resigned.

Mr. Francis W. Frost, formerly secretary and treasurer of the Engineering News Publishing Co., of New York, U. S.A., has been elected to the office of vice-president and treasurer of Suffern & Co., 96 Wall Street, New York City.

Mr. Frank Cooper, for some time resident engineer of the C.P.R., at London, Ont., has been transferred to the Montreal terminals.

Mr. E. S. Prentice was a recent visitor to Vancouver, B.C. Mr. Prentice is a member of the Institute of Civil Engineers, of London, and late consulting engineer to the Transvaal government and the Central South African Railways. He invented a device to gauge the water capacity of hydrants while he was engaged as engineer of the old Metropolitan Board of Works and the London County Council.

Mr. R. D. Brown, A.M. Inst. C.E., of the City Engineer's office, Toronto, has been appointed city engineer of St. Catharines, Ont. Trained under the borough engineer of Clydebank, Scotland, he served seven years as assistant to the city engineer of Glasgow, and afterwards one year looking after the Scottish interests of the Considerè Reinforced Concrete Construction Co., Ltd., of Westminster. Mr. Brown is an associate of the Institution of Municipal and County Engineers, (London, Eng.), and a member of the Sanitary Association of Scotland.

Mr. David M. Shaw has left Montreal, P.Q., to assume a position in connection with a large hydro-electric development in Barcelona, Spain, which is being organized by Dr. F. S. Pearson, of New York. Mr. Shaw was born and educated in Montreal and was for many years in the employ of the Montreal Street Railway Company. He later entered the employ of the Montreal Light, Heat & Power Company in connection with their construction work at Chambly, and from there he went to Mexico in the employ of the Mexican Light & Power Company. Latterly, he has been identified with the Canadian Light & Power Company's development, being employed by one of the contractors on that work.

CANADIAN SOCIETY OF CIVIL ENGINEERS.

The Toronto Branch of the Canadian Society of Civil Engineers held their annual meeting at the Engineers' Club, Toronto, on November 30th. Mr. John H. Jackson, Supt. of the Queen Victoria Niagara Falls Park, addressed the meeting on the Niagara Boulevard, taking up the engineering features in connection with this work. His address will be published in the columns of The Canadian Engineer.

A meeting of the Mechanical Lectures was held on Wednesday evening, December 6th, at the society's rooms, Montreal, at which Mr. Alexander Allaire, A.M. Can. Soc. C.E., Montreal, manager of the Foundation Co., of New York, read a paper on "Pneumatic Caisson Foundations for Tall Buildings."

MEETING OF THE ENGINEERING ALUMNI OF THE UNIVERSITY OF TORONTO.

The Engineering Alumni of the University of Toronto held their annual fall meeting at the Engineers' Club, Toronto, on the evening of November 30th. Mr. W. E. Douglas, the president, was in the chair and addresses were delivered by Professor A. G. Christie, of the University of Wisconsin, and Dean Galbraith.

Prof. Christie's address dealt with engineering education at the University of Wisconsin; the text of his paper will be found in another column of The Canadian Engineer.

APPEAL FOR THE HOSPITAL FOR SICK CHILDREN.

Mr. J. Ross Robertson, chairman of the trustees of the Hospital for Sick Children, Toronto, has written to The Canadian Engineer asking that the needs of this institution be brought to the attention of our readers.

In his letter he states:—I make this direct appeal to the people of Ontario, for the fathers and mothers of Ontario, outside the city of Toronto, have precisely the same claim for their sick children as regards the privileges of the hospital, as parents who reside in the city of Toronto.

In brief, the sick children from any place in Ontario whose parents cannot afford to pay, is, on certificate from a municipal officer of any city, town, village or township, treated free.

This is a privilege not granted by any hospital in the Dominion, or on this continent.

Any reader wishing to contribute toward the upkeep of this worthy cause may send his contribution to Mr. Douglas Davidson, Secretary-Treasurer of the Hospital, Toronto.

COMING MEETINGS.

THE ENGINEERS' CLUB OF TORONTO.—Dec. 13, 96 King Street West, Toronto Luncheon at 1 p.m. Address by the Hon. Mr. Justice William Renwick Riddell. R. B. Wolsey, Secretary.

THE CANADIAN PUBLIC HEALTH ASSOCIATION.—Dec. 13-15. Montreal. F. C. Douglas, M.D., D.P.H., Secretary, 51 Park Avenue, Montreal. (The date of the meeting has been changed from Nov. 21-23 to Dec. 13-15)

PROVINCE OF QUEBEC ASSOCIATION OF ARCHITECTS.—Tuesday, Dec. 19th, 1911, lecture by Dr. T. A. Starkey, of McGill University, Professor of Hygiene, on "Ventilation of Public Buildings." No. 5 Beaver Hall Square, Montreal. J. E. Ganier, Secretary.

THE CANADIAN FORESTRY ASSOCIATION.—February 6, 7 and 8, 1912. Annual Meeting, Ottawa. James Lawler, Secretary.

ENGINEERING SOCIETIES.

CANADIAN SOCIETY OF CIVIL ENGINEERS.—413 Dorchester Street West, Montreal. President, C. H. Rust; Secretary, Professor C. H. McLeod.

QUEBEC BRANCH—
Chairman, P. E. Parent; Secretary, S. S. Oliver. Meetings held twice a month at Room 40, City Hall.

TORONTO BRANCH—
96 King Street West, Toronto. Chairman, H. E. T. Haultain, Acting Secretary; E. A. James, 57 Adelaide Street East, Toronto. Meets last Thursday of the month at Engineers' Club.

MANITOBA BRANCH—
Secretary E. Brydone Jack. Meets every first and third Fridays of each month, October to April, in University of Manitoba, Winnipeg.

VANCOUVER BRANCH—
Chairman, Geo. H. Webster; Secretary, H. K. Dutcher, 319 Pender Street West, Vancouver. Meets in Engineering Department, University.

OTTAWA BRANCH—
Chairman, S. J. Chapleau, Ottawa; Secretary, H. Victor Brayley, N. T. Ry., Cory Bldg.

MUNICIPAL ASSOCIATIONS.

ONTARIO MUNICIPAL ASSOCIATION.—President, Chas. Hopewell, Mayor, Ottawa; Secretary-Treasurer, Mr. K. W. McKay, County Clerk, St. Thomas, Ontario.

UNION OF ALBERTA MUNICIPALITIES.—President, H. H. Gaetz, Red Deer, Alta.; Secretary-Treasurer, John T. Hall, Medicine Hat, Alta.

THE UNION OF CANADIAN MUNICIPALITIES.—President, W. Sanford Evans, Mayor of Winnipeg; Hon. Secretary-Treasurer, W. D. Lighthall, K.C., Ex-Mayor of Westmount.

THE UNION OF NEW BRUNSWICK MUNICIPALITIES.—President, Councillor Siddall, Port Elgin; Hon. Secretary-Treasurer, J. W. McCready, City Clerk, Fredericton.

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