PAGES

MISSING

THE CANADIAN ENGINEER

Published Weekly — Established 1893

ISSUED IN THE INTERESTS OF CANADIAN CIVIL, STRUCTURAL, RAILROAD, MUNICIPAL, HYDRAULIC, HIGHWAY AND CONSULTING ENGINEERS, SURVEYORS, MINE MANAGERS, ENGINEERING—CONTRACTORS AND WATERWORKS SUPERINTENDENTS.

Index to Volume 28

JANUARY TO JUNE, 1915

THE CANADIAN ENGINEER

Head Office, 62 Church St., TORONTO

MONTREAL WINNIPEG

EXPLANATORY NOTE.

NOTE.—The following table will be of assistance when reference to articles is desired. The pages of this volume are numbered from 101, to obviate ambiguity in the paging of the articles and advertising sections of the first number. The pages included in each of the 25 numbers are as follows:—

The Canadian Engineer, Volume 28.

No.	1—Jan.	7..........	pages	101-124
"	2— "	14..........	"	125-148
"	3— "	21..........	"	149-180
"	4— "	28..........	"	181-204
"	5—Feb.	4..........	"	205-228
"	6— "	11..........	"	229-252
"	7— "	18..........	"	253-276
"	8— "	25..........	"	277-302
"	9—Mar.	4..........	"	303-326
"	10— "	11..........	"	327-350
"	11— "	18..........	"	351-374
"	12— "	25..........	"	375-398
"	13—Apr.	1..........	"	399-422
"	14— "	8..........	"	423-446
"	15— "	15..........	"	447-470
"	16— "	22..........	"	471-494
"	17— "	29..........	"	495-518
"	18—May	6..........	"	519-542
"	19— "	13..........	"	543-566
"	20— "	20..........	"	567-590
"	21— "	27..........	"	591-614
"	22—June	3..........	"	615-638
"	23— "	10..........	"	639-662
"	24— "	17..........	"	663-686
"	25— "	24..........	"	687-710

INDEX TO VOLUME 28

JANUARY TO JUNE, 1915

AUTHORS.

EDITORIAL.

ARTICLES.

*Illustrated.

*Illustrated.

PERSONALS.

*Illustrated.

OBITUARY.

BOOK REVIEWS.

Volume 28 Toronto, January 7, 1915

Contents of this issue on page 3

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

DAM AND LOG SLIDE, HIGH FALLS, QUE.

REINFORCED CONCRETE STRUCTURES ON THE LIEVRE RIVER FOR THE JAMES MACLAREN COMPANY, LIMITED—PROVISION FOR FUTURE POWER DEVELOPMENT.

By Jos. Percy McRae,
Consulting Engineer, Ottawa, Ont.

HIGH FALLS is on the Lievre River, about thirty miles from its confluence with the Ottawa River, and about forty-five miles, in a direct line, from Ottawa City.

The James Maclaren Co., Limited, of Buckingham, P.Q., who own and operate the entire timber limit border-creased the difficulties of construction was the lack of transportation facilities. The nearest railway was at Buckingham, twenty-six miles away, which meant that all contractor's plant and cement had to be brought up by scows during the summer and by teams in the winter. Owing to the unfortunate proclivity to land slides of the

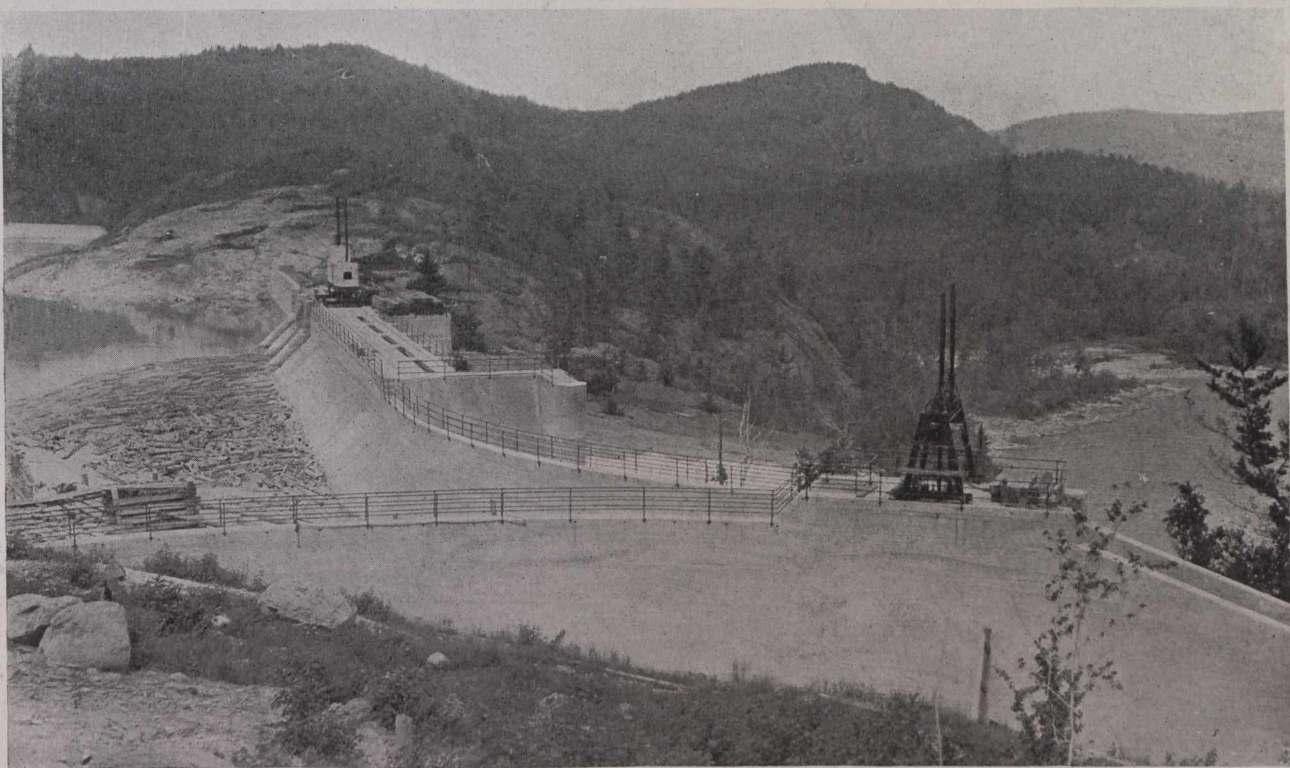


Fig. 1.—The Completed South Channel Dam at High Falls, Que.

ing both sides of the Lievre, had maintained and operated a timber dam and log slide at High Falls for a considerable time. Some five years ago, however, this old slide reached its allotted term of usefulness and it was decided to replace it with one of a permanent nature. It was further decided to incorporate the new slide with a dam which could, at a future date, be used in the development of the magnificent power available. Accordingly the designs hereinafter described were made and the work of construction carried to a successful completion.

One of the existing conditions which materially in-

clay belt through which the Lievre runs, several times during construction, work was held up while the government dredge cleared the channel.

A general plan of the site is shown in Fig. 2, which reveals the exceptional opportunities afforded for unwatering, a no small factor in working on a river whose flow varies from about 1,500 to 18,000 second-feet during an average year. As will be seen, the work consisted of a log slide, five power openings providing for the future development, three sluice openings and 200 feet of over-fall section in the south channel dam. Also a curved "over-fall" dam providing 100 feet of crest at elevation 205, the regulated level to which the water is to be held, and 200 feet of crest at 215 across the north channel. The crest of the over-fall section in the south dam is at 217. The reasons for these elevations will be given in the descriptions of the respective parts.

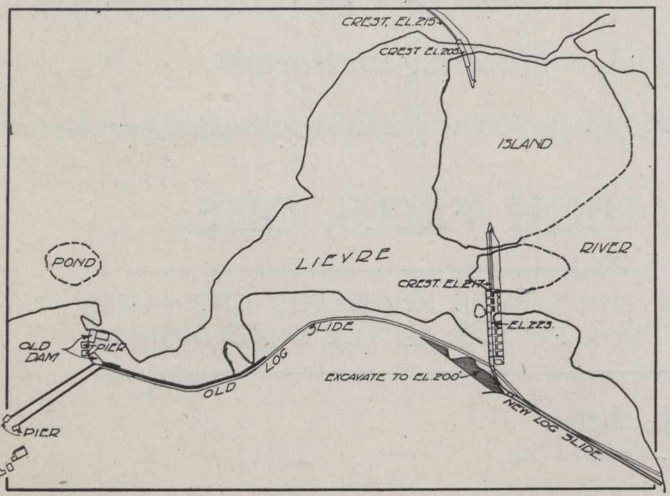


Fig. 2.—General Layout of the Lievre River Development.

The Log Slide.—One of the most interesting features of the design is the log slide.

Owing to the contemplated future development of the power, it was necessary to get a slide that would pass the greatest number of logs with the least amount of water, which appears to have been most satisfactorily accomplished. It is of the V type, with the lower 400 feet of its length of a uniform width of 6 feet. The upper 200 feet is of uniformly changing section from 6 feet wide at its lower end, to 10 feet wide at the stoplog checks. Thus the water is accelerated to its maximum velocity when it reaches the uniform section, a fact clearly shown in the uniformity of depth throughout the length of the slide. A series of observations taken when logs were running last spring, gave an average velocity of 55 feet per second in this lower section.

The girder spans of the lower sections are of rather especial interest. These are of 50 feet centres and some rather adverse criticism was given them during construction. However, when, after being given sufficient time

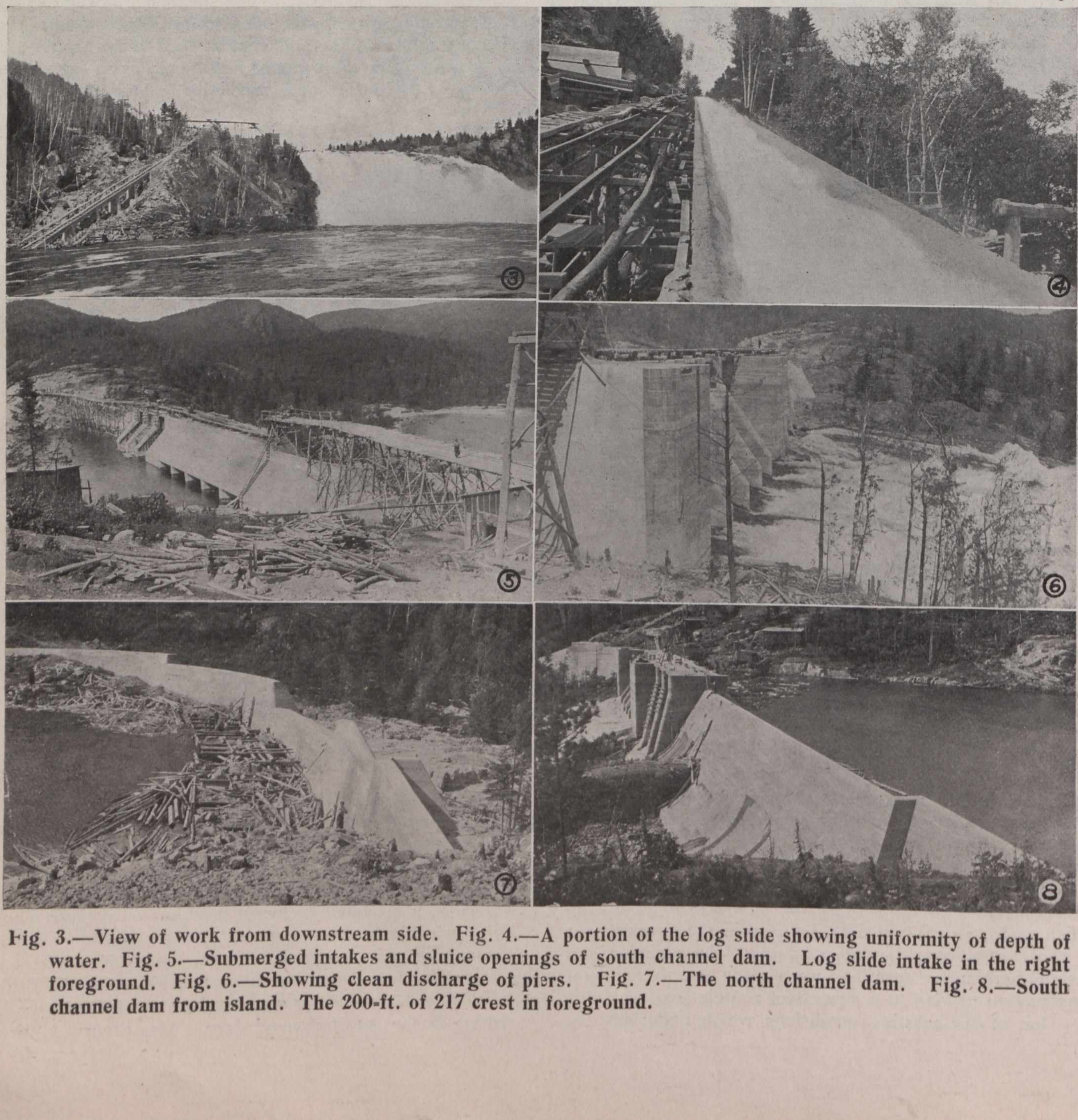


Fig. 3.—View of work from downstream side. Fig. 4.—A portion of the log slide showing uniformity of depth of water. Fig. 5.—Submerged intakes and sluice openings of south channel dam. Log slide intake in the right foreground. Fig. 6.—Showing clean discharge of piers. Fig. 7.—The north channel dam. Fig. 8.—South channel dam from island. The 200-ft. of 217 crest in foreground.

to allow the concrete to set, the wedges of the form-shoring were knocked out full length of the span and the centre ones then driven back, quite easily, to their former places. This criticism was proved to be without foundation.

Unfortunately a stronger proof of the great strength of this type of section was given, after the slide had been in operation a year.

Following more recent modifications in the design the original pier at the end of the slide has been replaced. The first carried the grade of the slide straight through, while in the second the grade line flattens out in a long radius curve. This change was made necessary by the fact that when, after a year's operation of the slide at but part of its operating head, it was made possible to run it full bore, due to the completion of the dam, two large eddies formed at the foot of it. These cut away the

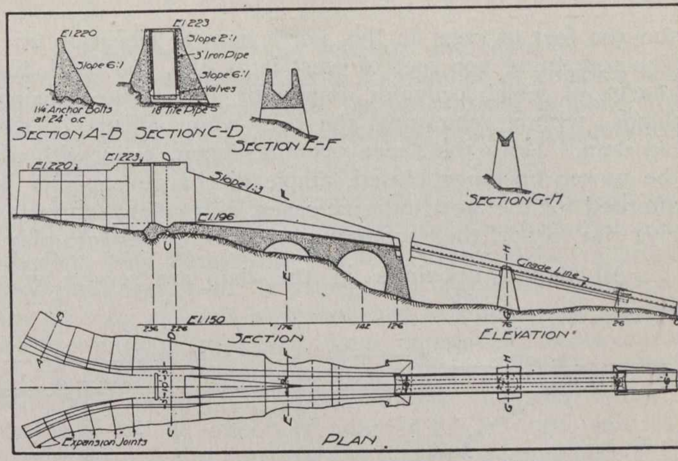


Fig. 9.—Details of Log Slide and Entrance.

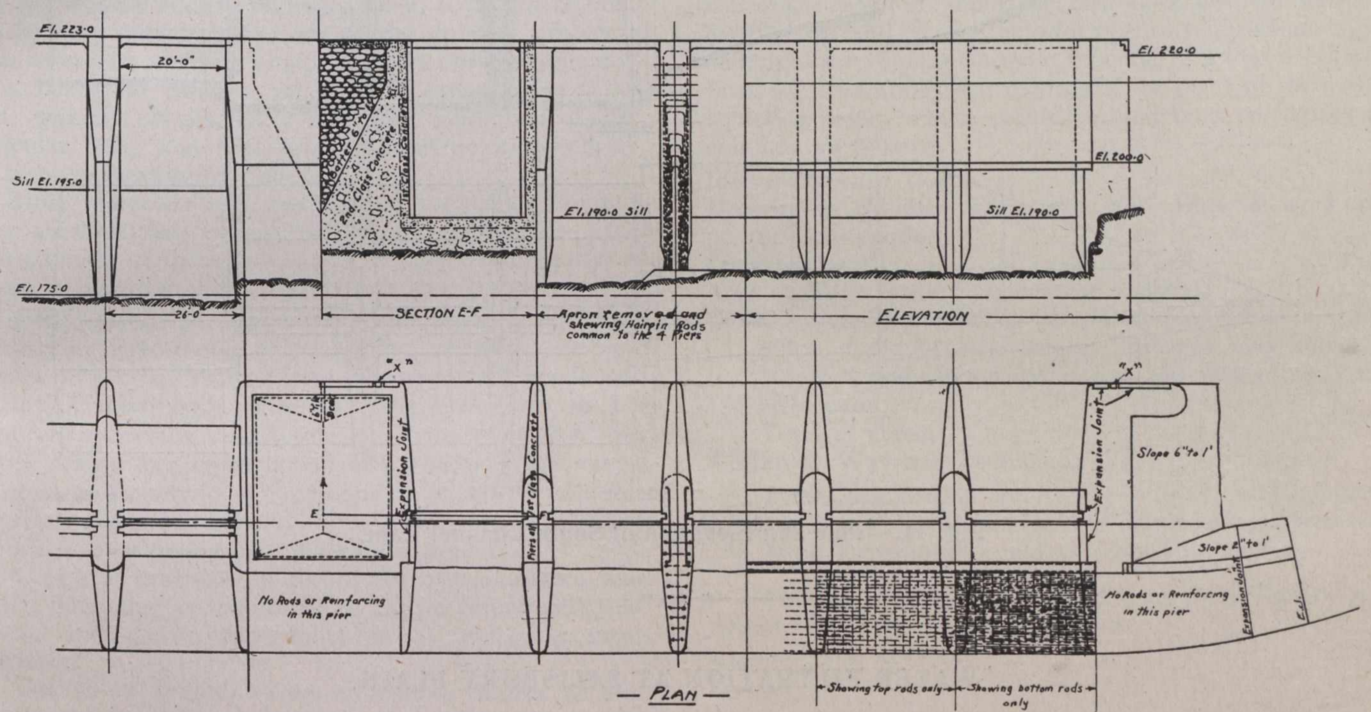


Fig. 10.—Plan and Elevation of Governing Dam.

gravel to such an extent that the pier began settling, breaking the slide about thirty feet up. The remaining twelve feet or so of the trough in the last section remained, not only holding the damaged part from slipping entirely out of place, but showing no ill effects from the enormously greater strains put upon it.

The repairs effected on this section were the removing of the lower damaged piece of trough, leaving the reinforcing rods protruding from the good section some 10 feet for the splice. The old pier was merely drilled and cracked, being left as a hearting for the new. A double row of piles were driven around the front, as shown, and the new pier built. The curving of the grade has made an enormous improvement, both in doing away with the eddy formations and in the delivery of the logs.

Six men can put through over 50,000 logs in a ten-hour day, whereas with the old slide, double that number of men had difficulty in handling 10,000 with the old wooden slide.

Power Intakes.—The first five openings of the dam are to be the future power intakes. Owing to the fact of the enormous amount of timber coming down the Lievre, these are protected against the entrance of such by a skimming apron clearly shown in Fig. 5. The piers of these openings, as well as the piers of the sluice openings, are tapered both up and down stream, and their efficient, clean discharge is well shown in Fig. 6. The head-gate house, and downtakes for the future power development, will be built on the comparatively flat rock back of these. Their sill elevation is at 195.

Sluice Openings.—These piers are somewhat heavier than those of the power openings, in order to stand the abuse of ice, etc. In general design they are identical, having, however, a double stoplog check. Their sills are at 190 and they will only be required for quickly dropping the pond elevation, as the spillway sections are designed to make the dam self-regulating as nearly as possible.

Two hundred feet of spillway section, with crest at 217, carry the south dam to the island.

North Channel Dam.—This dam is of rather peculiar interest insofar as it is designed to carry out the automatic regulation.

One of the conditions to be met was that the new dam should maintain, as closely as possible, the existing conditions imposed by the old dam. This accounts for the 100 feet of crest in this north dam at elevation 205. The remaining 200 feet of crest is at 215, the total discharge of which provides amply for all ordinary spring floods, without changing the back-water effects of the old dam. With the sluice openings open, even with all the power openings closed, ample discharge capacity is afforded for the most extreme cases, but should the water ever rise to 217, then 300 feet more crest comes into play.

All stoplog openings in the dam are served by a steam winch, shown clearly in Fig. 1. The stoplogs of the log slide are served by a suitable hand-operated winch. Both of these winches were built by the Victoria Foundry Company, of Ottawa.

The work, which was taken over from the contractors in the fall of 1913, was carried out by Haney, Quinlan & Robertson, of Montreal, to the designs and under the supervision of John B. McRae, consulting engineer, Ottawa.

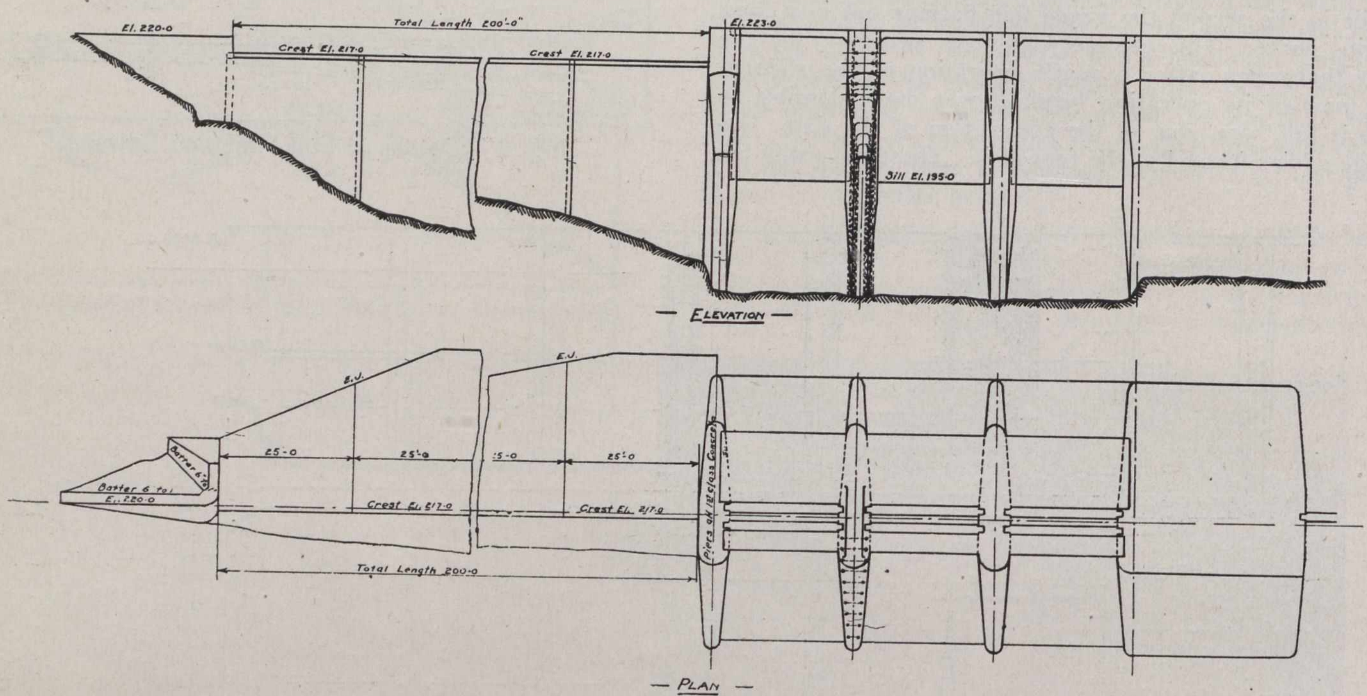


Fig. 11.—Plan and Elevation of South Channel Dam.

WATER FILTRATION AT SALISBURY PLAIN.

Our readers will be interested to know that the water supplied to the first Canadian expeditionary force now in training at Salisbury Plain, is purified by the Candy filter system, which has been selected by the War Office Department of H.M. Government for safeguarding the supply, which is from river and shallow wells.

Some remarkable results in the purification from pathogenic bacteria of public water supplies are being achieved in England by this Declor system. In it the destruction of objectionable bacteria is effected by the agency of a minute dose of chlorine. This material has long been known as efficacious against these organisms, but has not been generally applicable until the introduction of the above system, owing to the difficulty which has hitherto existed of removing the free chlorine which, unless eliminated, leaves an unpleasant taste and odor. In the system in question chlorine is applied in a most economical form by means of a simple automatic apparatus. A contact period (arranged to secure the bacteriocidal action) between the water and the chlorine is provided for and (what is of great importance) the total elimination from the water of the residual chlorine after it has performed its function of destroying the bacteria is ensured, the elimination being accomplished by means of a non-soluble agent in granular form within the filter.

The presence of the bacillus coli communis in water is always held to be indicative of intestinal pollution and such water should be looked upon with suspicion. Continuous bacteriological examinations of the water supplied to the Reading Corporation where a Declor filter has been at work since 1910 has shown that this bacillus was always present in 1 c.c and frequently in 0.1 c.c. of the river water which is used for the town's supply. After treatment by the process, it has invariably been absent in 100 c.c., a result which proves, under the frequent and critical bacteriological examination, that the bacillus coli has been totally destroyed. The capital cost of the filters at Reading was $11,000 and the cost of treatment 54 cents per million gallons. The success achieved by the system, which has the support of many well-known bacteriologists, has led to its adoption in many other towns, such as Reading, Hastings, Cardiff, Newport (Mon.), Tunbridge Wells, Harrogate, Cromer, Cowes, Isle of Wight, Torquay and others. Quite recently it has been adopted by the borough of Croydon for the purification of 4½ million gallons of water daily.

The Candy Filter Company, Limited, of Westminster, London, Eng., the makers, have appointed as agent for the provinces of Quebec, Ontario, New Brunswick and Nova Scotia, Mr. G. Maxwell Williams, B.Sc., M.R., San.I., operating under the name of "Maxwell Williams, Reg'd.," at 227 Coristine Building, Montreal.

BITUMINOUS MATERIALS FOR ROAD CONSTRUCTION.

At the annual meeting of the American Society of Civil Engineers to be held in January, 1915, an important progress report will be that of the special committee on materials for road construction and on standards for their test and use. This report appears in the proceedings of the Society for December, 1914. We extract from it the conclusions submitted by the committee on bituminous materials.

General.—The committee deplores the tendency, apparent in some quarters, to devote time and energy for the discovery of "The most satisfactory road surface," and expresses its conviction that there is no such thing as a "panacea" for all highway ills. It believes that, with the development of highway work, it should be constantly more apparent that one of the greatest problems to be solved by highway engineers is the proper selection of the particular material and form of construction to be used, which most efficiently meet the conditions of any particular case, and that progress will be hastened by complete recognition of this fact.

Most materials and methods of use of bituminous materials have their values, and the real problems are the determination of these values and of their adaptability or fitness to meet the conditions of any case properly.

A bituminous surface or pavement properly designed for carrying light motor vehicles may not be the one best adapted to horse-drawn vehicles, and one which is efficient for light horse-drawn vehicles may be most seriously injured by motor vehicles. A solution of the problem of the proper design and construction of a roadway for mixed traffic is, under any local conditions on which the solution ultimately depends, difficult, though facts are accumulating which may finally permit this solution.

It is still desirable to record the characteristics and details (including cost figures) of use of bituminous materials, and great concordance in so doing is most necessary.

Census of Traffic.—Your committee desires to emphasize the fact that experience has demonstrated the value of a traffic census taken both preliminary and subsequent to the construction of a highway.

The traffic census should be considered one of the most important variable factors in the solution of that important problem, the selection of that type of construction best suited to local conditions considered from the standpoints of both economy and efficiency. In connection with the census returns on any highway should be considered the traffic on cross and parallel highways and the effect of improvement of these highways on the traffic of the highway under construction.

It should not be taken for granted that the bald return of a traffic census should be the sole basis of the selection of the type of construction, but it should be considered a guide in determining the value of the type adopted.

Where motor traffic forms a considerable proportion of the total traffic likely to use a highway, the unit width of traffic lines should be considered as 9 or 10 ft., instead of 7 or 8 ft., as heretofore, because of the greater clearance required for the safe passing of the units of such traffic.

In considering the effect of traffic and its relation to the design and cost of maintenance, it is necessary to take into account the speed as well as the weight of the vehicles.

In view of the recent constant and rapid increase of traffic on the highways, both in number of vehicles and in wheel loads, it will be in the interests of economy for designs of highways to be made with proper consideration of further increases.

Collection and Standardization of Cost Data.—In the work of the committee, it has become apparent that conclusions may necessitate the use of cost data, recorded along uniform lines. It seems to be urgent that standards for arriving at costs be established and generally adopted as promptly as possible. Your committee therefore recommends to the attention of the profession this important feature of engineering work, with the hope that uniform methods will be generally adopted at an early date for reporting costs of construction and of maintenance.

The committee believes that, along the lines of standardization in reporting cost data and for general benefit, it would be advisable for highway departments, in making their regular periodic reports, to adopt a tabular form for presenting their records of the costs of their construction work, which should include data or figures in columns as follows:

Identification of Work;
Description (Width, Thickness, and Material or Form of Construction);
Length;
Area of Bituminous Pavement or Surface;
Construction Expenditures for: Preliminary surveys and plans, Grading, Surfacing, Bridges and culverts, Under-drains, Superintendence and inspection, Miscellaneous;
Total of above;
Rights of Way and Damages;
Total Construction and Rights of Way and Damages;
Administration, Legal and General Engineering Expenses;
Total Expenditures and Overhead Expenses;

For the maintenance expenditures there should be a tabular form showing, in columns:

Identification of work;
Length;
Area;
Maintenance Expenditures for: Labor, Material, Hire of teams and equipment, inspection and superintendence, Miscellaneous;
Total of above;
Administration, Legal and General Engineering Expenses;
Total Cost of Maintenance.

Each table, of course, should carry such foot-notes or text as might be necessary to supply the further information as to unusual rates of pay or other conditions advisable to be shown.

In compiling costs of any item of work done, the committee believes that it would be advisable and of great public bnefit if, hereafter, all such figures be compiled whenever practicable on the following basis:

Total Cost to be Reported per Unit for: Cost for materials delivered on site of work; Cost for labor and teams placing materials; Cost for machinery engaged in placing materials and in finishing the work; Cost for inspection and superintendence; Cost for general overhead charges.

In foot-notes or in the text such statements as may seem desirable in any case should be made concerning rates of pay, conditions, and circumstances.

Construction—General.—Your committee is agreed that: The use of any form of a bituminous pavement or bituminous surface does not preclude the necessity for the construction of a well-drained, thoroughly compacted, and adequate foundation. In fact, such improvement of the highway frequently attracts heavier traffic and thus increases the stresses on the sub-grade.

Within certain limits of traffic, the proper use of bituminous material should effect economy in the expenditures for the cleaning and maintenance.

The proper treatment of a broken stone, gravel, shell, or slag roadway with bituminous material, for the purpose of eliminating the so-called dust nuisance, will at the same time render even the best of such roadways more efficient for sustaining traffic, and such treatment with bituminous materials is usually preferable and more economical than sprinkling with water, or the use of hygroscopic salts.

An objectionable slipperiness of bituminous pavements or bituminous surfaces may be decreased or prevented by proper precautions during construction or by proper treatment thereafter.

The crown generally used in the construction of broken stone roadways is excessive when bituminous materials are used, and a crown of even ½ in. per ft. should be avoided when a lesser crown can be secured without detriment to the surface drainage.

Construction—Materials.—Your committee is agreed that: For the present, at least, whenever comprehensive specifications are to be prepared so as to admit a variety of types of bituminous materials, separate specifications as may be necessary should be prepared for each type.

Where bituminous pavements are laid, the edges should be protected and a sudden transition from the pavement to any softer shoulder material avoided by means of cement concrete or other edgings and such reinforcement of the shoulder material as may be necessary.

The character of the stone to be used may influence the choice of the bituminous material.

Whatever method may be used in any case, it is essential, as in water-bound construction, that a suitable quality of road metal be used.

By proper selection and use of the bituminous material, injury to property and deleterious effects upon animal and vegetable life may be avoided, and also considerable hygienic advantage may result from the use of such materials on the highways.

The maximum quantity of distillate up to 170° Cent. allowable in tars depends on the proportions of the other fractions in a tar, and on the conditions of use of the tar, and possibly on the conditions on the road surface after its construction, or on some other facts.

Construction—Methods.—Your committee wishes to emphasize the fact that the selection of the method of construction to be used in a given case will depend on the results of preliminary investigations, and that the recent and imminent development of, and the availability of, mechanical appliances, should affect the decision to a great degree.

Whatever method of construction is selected, the use of a bituminous material by no means justifies any lack of care in the ordinary details to be followed, but rather increases the need for thoroughness and skilled supervision.

The main principles underlying perfection in water-bound roads remain in full force when such roads are treated with bituminous material.

In all uses of bituminous materials in highway work, the use of proper machinery is preferable, wherever conditions make such practicable in any part of the process, to the use of hand labor.

The use or omission of a seal coat on bituminous pavements is dependent on one or more of the following points:

(*a*) The character of the bituminous material used,

(*b*) The method of construction,

(*c*) The density and quality of the work done, and

(*d*) The kind and amount of traffic to be expected on the completed highway.

The length of time that the finished pavement should be closed to traffic varies from a few hours to several days, dependent on the character of the bituminous material used, the method, and on climatic and other local conditions.

Construction—Mixing Methods.—Your committee is agreed that: Where the character of the traffic justifies the use of a bituminous concrete pavement, it also demands a correspondingly strong foundation.

The quantity of bituminous material to be used in any case will depend on the peculiar conditions of that case, such as the kind of road metal and of bituminous material, the character of the aggregate, the climatic conditions, etc.

The fluidity of the bituminous materials used should be sufficient to insure a proper coating of the mineral particles, and such fluidity may be obtained by heating—provided the degree of heat is not excessive or sufficient to injure the bituminous materials, and is reached through proper methods.

The bituminous material should possess adhesive and cohesive qualities sufficient to enable it to perform its purposes properly under the conditions of any case, and it should not be of a greasy character.

The adhesiveness, cohesiveness, resiliency, and elasticity of the material should have the greatest possible permanence.

The success of results depends largely on the use of proper sizes of the particles and on securing a proper density of the mixture for the local conditions.

The character of the mineral aggregate to be used may be controlled by local conditions, but the best results can only be obtained by the use of the best materials. Excessive sizes, or excessive variations in the size of the mineral particles, should be avoided, and the utmost care must be taken to avoid the segregation of particles of different sizes.

Mixing machines should be used, and hand-mixing methods should be avoided wherever practicable.

The success of results is greatly dependent on the degree of uniformity obtained in spreading the mixture and on the proper rolling and compacting of the mixture. Too heavy a roller should not be used.

Care should be taken in prescribing or laying any seal coat that invitation or excuse is not given for inferior prior work and its concealment by such a seal coat.

The use of fine sand on top of bituminous concrete is open to grave objections, and the use of clean stone chips or small gravel free from particles that will pass through a 10-mesh sieve seems preferable.

Trap rock in sizes greater than that passing a 2-in. screen should be used with caution in the construction of the upper course unless voids of the same are properly reduced, because of the likelihood of the individual stones to rock under traffic.

In the use of a heated aggregate for the construction of a bituminous concrete pavement non-uniformity or excess in the heating of stone should be avoided.

Construction—Penetration Method.—Your committee is agreed that:

An important factor for successful results is the proper compaction by rolling of the road metal before the spreading of the bituminous material.

The use of pressure distributors is to be preferred to hand-pouring applications.

The bituminous material should be sufficiently, but not excessively, fluid when used.

The bituminous material should be sufficiently adhesive and cohesive to carry out the purpose for which it is used, and should not be of a greasy character.

The essential characteristics of a bituminous material, such as adhesiveness, cohesiveness, resiliency, and elasticity, should have the greatest possible permanence.

The needed penetration of the material into the rolled stone is had when the bituminous material reaches to the bottom of the average sized stone in the course penetrated.

With the use of materials susceptible to heat, or fairly so, or otherwise of considerable fluidity during application or for a reasonable period thereafter at normal temperatures, the application of the bituminous material to the rolled stone can well be stopped on a line parallel to and within the edges of the stone, and reliance may be had for this border of the macadam becoming properly bound by the flowing of the bituminous material into it under heat and traffic. With the use of materials having the opposite characteristics, the application of the bituminous materials should be made fully to the edges of the rolled stone.

Present indications are to the effect that the use of bituminous materials in quantities of more than 2½ gal. per sq. yd., where the upper course of the macadam is to be 3 in. in thickness after compaction, is inadvisable under the penetration method, although sufficient data do not yet seem to be at hand to determine exactly in any case the value or possible advantage of using bituminous material in excess during construction in order to furnish a sort of reservoir by means of which to prolong the life of the surface of the bituminous pavement.

The use of fine sand on top of the bituminous material is open to grave objections, and clean stone chips or small gravel, free from particles that will pass through a 10-mesh sieve, is preferable.

Construction—Surface Treatments.—Your committee is agreed that:

The success of surface applications is proportionate to the adhesion obtained by the bituminous material to the old roadway surface, and such degree of cleanliness of the latter must be had, by means of sweeping or other methods, as will insure a proper degree of adhesion.

The roadway surface should be dry when the bituminous material is applied.

Whether or not the application of bituminous material is to be followed by an application of mineral material, and the length of time to be allowed to elapse between the application of bituminous material and a subsequent application of mineral material depends on local conditions and on the character and amount of the bituminous material used.

To be successful, a carpet must be able to absorb shocks sufficiently to prevent disintegration, by such shocks, of the surface to which it is applied.

The bituminous material should be sufficiently, but not excessively, fluid when used.

The bituminous material should be sufficiently adhesive and cohesive to carry out the purpose for which it is used under any conditions, and should not be of a greasy character.

The adhesiveness, cohesiveness, resiliency, and elasticity of a bituminous material used for this purpose should be of the greatest possible permanence.

The application of bituminous materials should in all cases be carried well over the outside edges of the rolled metal and on the shoulder far enough to protect the edges of the metalled surface.

The use of fine sand on top of the bituminous material is open to grave objections, the use of clean stone chips or small gravel, free from particles that will pass through a 10-mesh sieve, being generally preferable.

Attempts to construct and maintain by bituminous surface treatments a carpet of a greater total thickness than ½ in. have generally been unsuccessful, and in the construction of a successful carpet of a total thickness approximating ½ in. the materials should be applied in layers, at intervals, rather than by the construction of the total thickness in one application.

The quantity of bituminous material to be used depends on the local conditions in any particular case, but excess in any application is to be avoided, as a deficiency may be corrected by a subsequent application, whereas an excess in any application is difficult, if not impossible, of correction.

The success of results depends first on the condition of the surface to which the treatment is applied. Even the best surface treatment cannot correct defects in the original surface, though it may reduce or modify them.

The application of the bituminous material by means of a pressure distributer is, wherever practicable, preferable to gravity or hand-pouring methods.

Considerable evidence seems to make undesirable the presence of free carbon beyond a maximum, dependent on the distillate between 170° and 300° Cent., in tars for superficial treatments, in order at least to avoid brittleness at low temperatures.

The maximum quantity of residue allowable in an asphaltic oil used for superficial treatment should be as great as permitted by the physical conditions of its use, subject to certain limits in the penetration of this residue, and such limits in penetration should be:

A minimum which will ensure against undesirable hardness or slipperiness under travel at low temperatures,

A maximum which will ensure against undesirable softness or lack of body at the highest temperatures to be expected after use on the road.

Maintenance and Repairs.—Your committee is agreed that:

Repairs to bituminous pavements and bituminous surfaces should be made so as to secure immediately the greatest possible homogeneity.

It is even more necessary than with many other types of construction to carry out repairs on bituminous pavements and bituminous surfaces immediately the desirability for them appears.

PIPE WORK WELL AHEAD.

Last week the Burrard Engineering Company, contractors for the fabrication of the steel pressure pipe line for the Sooke Lake waterworks system, finished their work, and by the middle of January will have delivered the remaining portion of the pipe along the right-of-way between the city and Humpback Reservoir. Water Commissioner Rust is confident that by the end of February water from Humpback will be available for distribution in the city, and by the end of June the concrete flow line from Humpback Reservoir to Sooke Lake will also be completed and in operation.

LEGISLATION AND THE ENGINEER

PAPER READ BEFORE THE ANNUAL CONVENTION OF THE VICTORIA AND VANCOUVER BRANCHES OF THE CANADIAN SOCIETY OF CIVIL ENGINEERS AT VICTORIA, DECEMBER 12th, 1914.

By G. R. G. CONWAY, M.Can.Soc.C.E.
Chief Engineer, British Columbia Electric Railway Company, Limited. (Chairman, Vancouver Branch.)

At the outset we are confronted by the fact that the word "engineer" means so many things to so many different people as the field of his work is so broad that even the prefix "civil" does not define the exact scope of the work of the members of the Canadian Society of Civil Engineers.

"Civil Engineering," as understood by the three great engineering societies, i.e., the Institution of Civil Engineers of Great Britain, the American Society of Civil Engineers, and the Canadian Society of Civil Engineers, has been always considered in a very broad and catholic spirit and embracing within their scope civil, railway, municipal, mechanical, electrical and mining engineering, and the work of all these branches of engineering is so interwoven that it is difficult to draw a hard and fast line between any one branch. The work of the mining engineer may involve difficult construction work, such as tunneling and railroad building; the hydro-electric engineer is required to direct tunneling operations, the building of large dams, railroads, power houses, and electrical plants; the railroad engineer's duties involve every branch of engineering, and the same is true of the irrigation engineer or the municipal engineer, who may have to carry out great works of water supply and main drainage. No man, however, can be the master of all the separate branches of his profession, but the fundamental principles that underlie all engineering work are the same, and the recognition of this fact is thoroughly appreciated by the great engineering societies, in the requirements which they demand of engineers to qualify for studentship or corporate membership, and also by all of the engineering colleges in the training of the engineer to-day.

The principal object of the leading national engineering societies is to raise from time to time the standards of the profession so that only competent engineers shall be entrusted with the design and construction of engineering works, both public and private. Our object is not to attain that result by adopting the principles of the trades unions, although their efforts in co-operation for the benefit of their special trades might well have for us a useful lesson; but by increasing the value of our own society so that it will be recognized that corporate membership has such a standing in the engineering world that our public authorities will recognize the fact when entrusting the engineer to carry out public works.

In England the high standing of the Institution of Civil Engineers is such that the institution is consulted freely upon all great public questions; in fact, to-day in this great period of struggle, the president and council's services are eagerly sought after by the British government for recommendations as to satisfactory volunteer officers for both arms of the service. No Royal Commission is ever appointed on any matter connected with public works, or are government bills ever introduced on any subject where the engineer's advice is required, without the institution being the recognized adviser of the government. This confidence in the institution has been gained by the fact that all the leading engineers are faithful to it, and its long and honorable record has earned for it that commanding position. In the United States the American Society, too, has gained, though in a lesser way, a large and commanding sphere of influence. The influence of the Canadian Society of Civil Engineers, with its large membership spread over a continent—from the Atlantic to the Pacific—will, I think, if we all pull unitedly together, also have a great and powerful influence throughout the whole of Canada. It numbers among its ranks the ablest engineers in the country; men who have been prominent in building up all the provinces, and who have been responsible for engineering works that have no rival.

We have resident in the province, however, members of the Institution of Civil Engineers, and also of the American Society, who are not yet members of our own society, and I think we should all do our best to persuade these engineers to gain admission to our own ranks, as no matter to what other societies we may belong, it is our first duty to foster and develop our own national society.

I am not a believer that the present time is ripe for any proposals of a drastic nature in connection with the question of licensing or registering engineers; the subject is so complex that in my view much discussion and educational work is necessary before we as engineers can unitedly ask either the Provincial Government or the Dominion Government to legislate specifically in our favor. We realize the difficulties are great, and because of their existence the Manitoba Act which was passed in 1896, and the Quebec Act which was passed in 1899 have become a dead letter. This, though, I think, is partly due to the apathetic feeling of the engineers themselves, but in all young countries depending for their supply of engineers from new-comers, during periods of active development, there is a danger of specific legislation defeating the object we have in view.

We do not want to bolster up an engineer merely because he is a member of the society; we want the society to be recognized as, and actually to be, a group of well-trained and competent engineers, who collectively should have enormous influence with public authorities, and whose advice should be sought because they bear the honored rank of corporate membership.

The British Columbia members of the Canadian Society have been active in endeavoring to obtain in various government acts a definition of the function of the engineer as applied to work carried out under provincial legislation. In these activities we have already obtained, during the last session, the sympathetic ear of the members of the executive council, and a definition has been included in the Water Act of 1914. That is a step in the right direction, though quite inadequate to protect the public against incompetent advisers.

It has been suggested by a legislative committee of our two branches that a special act might be introduced with a view to its receiving legislative sanction during the present session, but the difficulties are so great that in my opinion it would be unwise to attempt anything of the kind at the present time.

In many public acts the looseness regarding what constitutes an engineer must be revised. I refer more particularly to the following acts: Ditches and Water-courses, Drainage, Dyking, Irrigation, Municipal, Public Works, Railway, Sewage, Water.

We all know the famous definition in the Water-courses and Ditches Act which naively defines "engineer" as: "Civil engineer, provincial land surveyor, or such a person as any municipality may deem competent and appoint to carry out the provisions of this Act."

Most of us have had experience of the ability of an elected alderman or a council to decide who is competent. I do not wish to say anything disrespectful regarding those gentlemen whom you and I as citizens give the power to run our local affairs; our object is rather to assist them so that municipal expenditure, for example, shall yield the greatest benefit, and the people's representatives have professional advisers who will see that waste is prevented, and that every dollar spent shall be spent with maximum efficiency.

Our chief object at the present time is to have the functions of the engineer defined in specific acts, so that first of all the public shall be protected against incompetency. This, in my opinion, must be the first step. The engineers employed by the government, the municipalities, and under the various public bodies, shall be competent engineers, and those engineers who have to design schemes of railroads, water powers, bridges, irrigation projects, water supply and drainage, that must, under the various acts, be submitted to the Provincial or Dominion Governments for approval, shall be so designated that it will be shown that they are entirely competent and trustworthy officers to their companies or local authorities. If that were so, we should be approaching the English system, which practically recognizes that plans submitted to parliament, in connection with parliamentary bills, or in connection with the local government board, if signed by a corporate member of the Institution of Civil Engineers, is a guarantee that the engineer is competent to design and construct those works.

The definition of engineer that we desire must be carefully thought out and worded. It must also be one that will be fair and just to all practising members of the profession; it should be a definition that will define the engineer referred to in any specific act as being a corporate member of the Canadian Society of Engineers, or of the Institution of Civil Engineers of Great Britain, or if the work is of a mechanical or mining nature, it must be such as recognizes the premier societies of those branches of the profession. In view of our proximity to the United States, it would also recognize the leading engineering societies of that country, although I do not think the broad and catholic spirit as shown in that case would ever be reciprocated by our cousins over the line, where all public and government works can only be designed and carried out by naturalized American citizens. For my own part, I think we have much to gain by association with our professional brethren across the border, but in these times it is necessary for our own countrymen to stand together in strong nationalism, when we are in the throes of a great world conflict, and say emphatically that our first duty is to our own people, and that our own people can, if our authorities will patriotically support them, find within the ranks of the Canadian engineers all the expert professional advice that Canada needs for her present and future development. That our own society is daily becoming more and more recognized, is shown by the fact that within the last eighteen months many practising engineers of great reputation in the United States have sought and obtained admission to our society. This cordial feeling, too, is also shown by the fact that many Canadian engineers are members of the American Society, some of whom have attained high place in its councils. I recognize quite fully that in some great public works it is necessary to get the best advice possible, without regard to geographical boundaries, and sometimes it is believed that experts should be obtained from over the border line. In this connection I do not think that we should insist that our government should be prohibited from obtaining the best advice possible, but I do think that any appointments of that kind should be in an advisory capacity only to a recognized official Canadian engineer. I have known cases in Canada, and I am not referring here to any action on the part of our Provincial Government, where an engineer was called in under special circumstances from a neighboring country in an advisory capacity, and who assumed almost autocratic power, and that power meant that many hundreds of thousands of dollars of good British capital were needlessly wasted. Had he, eminent man though he was, acted in an advisory capacity in collaboration with a Canadian colleague, or had he any sympathy with the building up of Canadian enterprises, much of this money would have been saved and could have been used to build up a genuine enterprise instead of hampering its development. I have also heard of a Canadian enterprise being completely abandoned because the promoters felt sure that a foreign engineer would be called upon to approve the design, and in view of his reputation, they were justly alarmed in entering upon an important piece of work, not knowing whither they would be led.

In British Columbia I think we are fortunate in having government officials who are most anxious to develop the province, and at the same time safeguard the interests of the public; and it is also a matter of congratulation that practically all these officials who are employed in various engineering capacities, are members of the Canadian Society. It is because of this fact that we hope to obtain a sympathetic hearing from the government, as their interests and ours are identical. We are also glad to know that many of the heads of various Dominion Government Departments take a deep interest in the welfare of the society, and are proud to be members and encourage its work.

I have merely touched upon one phase of the subject of the engineer and legislation, but the larger issue is one, as I have already stated, that the time is not yet ripe for its full fruition.

The question of licensing and registering engineers as doctors and lawyers are registered, is too early yet, and we must educate our young engineers and raise the standard of the society so that membership in its ranks will make any other registration unnecessary. During the past few years this subject has been discussed very prominently in the United States, and the difference of opinion there is very great. I think we are all agreed that the official recognition of the profession of the engineer is desirable, and that the regulation of the profession, both in the interest of the public and of the profession itself, is a worthy object to attain. We can advance no reason why a lawyer or a medical man should be licensed, or a land surveyor, sanitary inspector, or a plumber should be licensed or registered, and that an engineer should not be. There was a case I noticed recently in an engineering paper of a county surveyor in one of the neighboring States, who could not understand a transit, and yet was elected by an overwhelming majority by the wisdom of the people to fill the post!

It has been argued that laws governing admission into the ranks of the engineer will not make engineers anything more than fussy pedants, and that the engineer's duty is to mix more in public affairs and see that his talents are recognized by a public that needs them. This may be true, but we in British Columbia are endeavoring to disprove the argument of pedantry and are doing our best to educate public opinion on all important public questions where an engineer's advice is of value.

Perhaps one of the most interesting movements towards the licensing of engineers is that which has been in progress for some time past in Pennsylvania. In this State the governor has appointed a commission to consider the question of whether legislation regulating the practice of engineering was advisable in the public interest. This movement has also been strongly supported by an organization of engineering employees in New York, known as the "Technical League." This body had bills drafted and introduced into the New York legislature, which was the cause of a general protest from engineers. The American Society of Civil Engineers by a unanimous vote in 1911 decided against legislative restrictions, but the subject has again come prominently to the front as the result of the Engineers Commission appointed by the governor of Pennsylvania.

The draft bill now under discussion applies to persons who practise "professional engineering." That term includes every branch of engineering except military engineering, and provides that no person shall practise "professional engineering after 30th June, 1915, unless he is duly registered."

The bill provides a State Board of nine examining engineers to be appointed by the governor, each member to serve six years. The qualifications of the examiners that are necessary to serve on the board are:

(1) He must be a professional engineer of ten years' standing.

(2) Be of recognized good standing and repute in his profession.

(3) Have the qualifications of the highest grade of membership in the American Society of Civil Engineers, or American Institute of Electrical Engineers, or American Institute of Mining Engineers.

(4) Be at least 35 years of age.

(5) Must have been a resident of Pennsylvania five years prior to his appointment.

No person shall be examined for registration until he has paid a fee of $5.00, taken an affidavit that he is over 25 years of age, be of good reputation and had at least six years' experience, of which time he must have had charge as principal or assistant for one year. In lieu of this, an applicant may show he is a graduate of an engineering school of recognized standing, and have been engaged upon engineering work for four years, including one year as principal or assistant in charge.

If the results of such examination are satisfactory to the board, a certificate of registration will be issued to the applicant permitting him to practise as a "professional engineer."

Only the following persons shall be entitled to registration:

(1) Those who have passed the examination.

(2) Those persons registered from other States which require registration.

(3) Any person who shall before July 1st, 1916, submit proof that he has been practising professional engineering for ten years, and has been in charge as principal or assistant for two years.

The act makes it unlawful for any engineer to practise professional engineering unless registered, the penalty being a fine not exceeding $1,000, or not more than one year's imprisonment.

(1) The act does not apply to any professional engineer while working for the United States Government.

(2) To a professional engineer employed as an assistant to a registered professional engineer.

(3) To a professional engineer coming from another State and temporarily practising his profession.

This draft bill has aroused considerable opposition, particularly from a committee of the Philadelphia members of the American Society of Civil Engineers. Their view is that an act of this character, framed primarily in the interests of the public for the promotion of safety and the protection of life, health and property, cannot attain its object, and that other measures are more effective for its accomplishment.*

They claim that the examinations could not guarantee that engineering work would not be carried out by incompetent persons, and that the public could be adequately protected by state engineering departments and commissions whose duty it would be to enquire into all public works; e.g., in the same way as our own Provincial and Dominion departments are doing at present.

Conclusion.—There are therefore three phases of the subject to be considered:

(1) The protection of the public.

(2) The recognition of the society by the Provincial and Dominion Governments, and the public authorities.

(3) The licensing and regulation of engineers by a special act.

We can attain Nos. 1 and 2 by united action, and the third question is unnecessary at the present time.

Our object now should be to define the title "engineer" in specific acts, so as to avoid the unnecessary vagueness that obtains at present; this may be accomplished by the Provincial Government consenting to amend certain acts, or provide a general definition in the "Interpretation Act" of the Revised Statutes of British Columbia. Beyond attempting to do this, I do not think we should go at the present time; but our legislative committees should carefully watch the progress and discussion of the Pennsylvania bill, because I believe that whether that bill becomes law or not, all phases of the subject must be considered.

A further suggestion I wish to make is that our committee compile carefully a list of the references to the subject in the technical press, which has been quite voluminous during the last three years.

In conclusion, I think we as members of the society should, when signing all plans that have to be submitted to the Dominion and Provincial Governments, use our proper designation as corporate members of the society; and if we use our influence to add to the authority and dignity of the society, we need have no fear that the engineer will not get the recognition that is his due.

---

*See Eng. Rec., Oct. 31st, 1914, p. 485.

LINING LONG TUNNELS AND TUNNELS SUBJECTED TO HEAVY OR ECCENTRIC GROUND PRESSURE.

By E. Lauchli, Mem.Am.Inst.Min.Engrs.,
Civil and Hydraulic Engineer, 2 Wall Street, New York.

LITERATURE on this subject, in the English language, is meagre, and there is a wide divergence of opinions among engineers as to methods best adapted to the design and construction of tunnel linings and also the materials best suited for lining purposes.

The committee on roadways, of the American Railway Engineering and Maintenance-Of-Way Association has, however, made recommendations with reference to the shape and dimensions of tunnels, for single and double track tunnels, in connection with current tunnel practice. From an economical standpoint, these recommendations hardly apply, if at all, to long or deeply overlaid tunnels, or to tunnels subjected to intense or eccentric ground pressure. It is the purpose of this paper to outline the practice followed, and the methods advocated, in connection with the design and construction of such tunnels.

Height of Tunnel.—The practice generally followed in this country is to provide ample head room, to enable trainmen to stand on box cars, with safety, and in certain states this practice is made compulsory by statutory enactments. One familiar with train operation in long tunnels will, however, readily realize that, on account of smoke and gases, it is unadvisable to require brakemen,

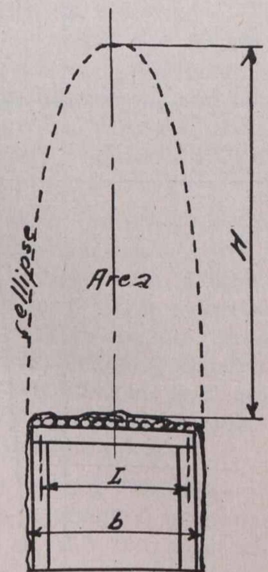


Fig. 1.

for instance, to stand on top of a box car in a tunnel 6 or 8 miles long, however well ventilated the tunnel may be.

In long tunnels it becomes evident that, for reasons of economy, the bore should have as small a cross-section as practicable, thereby reducing the amount of excavation and masonry lining, and also decreasing the intensity of ground pressure, both during and after construction.

The increasing tendency to use electric traction in long tunnels (Simplon, Loetschberg, Cascade, Roger's Pass, etc.) is another reason for decreasing overhead clearance. Furthermore, the progress attained with reference to capacity and efficiency of tunnel ventilating plants is also an incentive to reduce the area of tunnels necessitating artificial ventilation.

Tables I. and II. give the dimension of various tunnels, as actually built. It will be noticed that the height of single track tunnels vary from 18 to 19 feet,

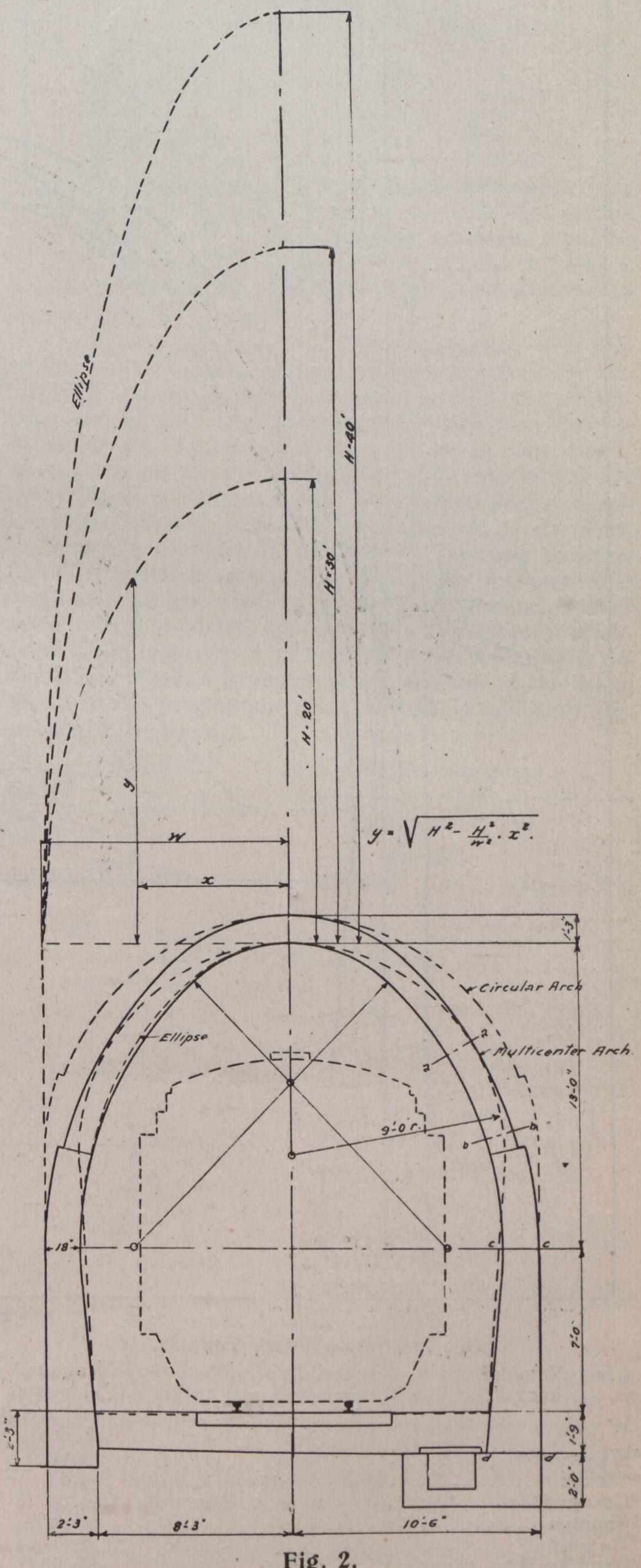


Fig. 2.

and that of double track bores from 19.7 to 21 feet (above base of rail). Generally speaking, the height of these bores has given rise to little comment. By keeping the roof of the bore as near as practicable to the floor, it becomes evident that the side-walls are thereby better fitted to resist lateral pressure.

Width of Tunnel.—The question of tunnel width is still the subject of much discussion. The committee on roadways, above referred to, recommends a width of 16 feet for single track tunnels. The standard width adopted

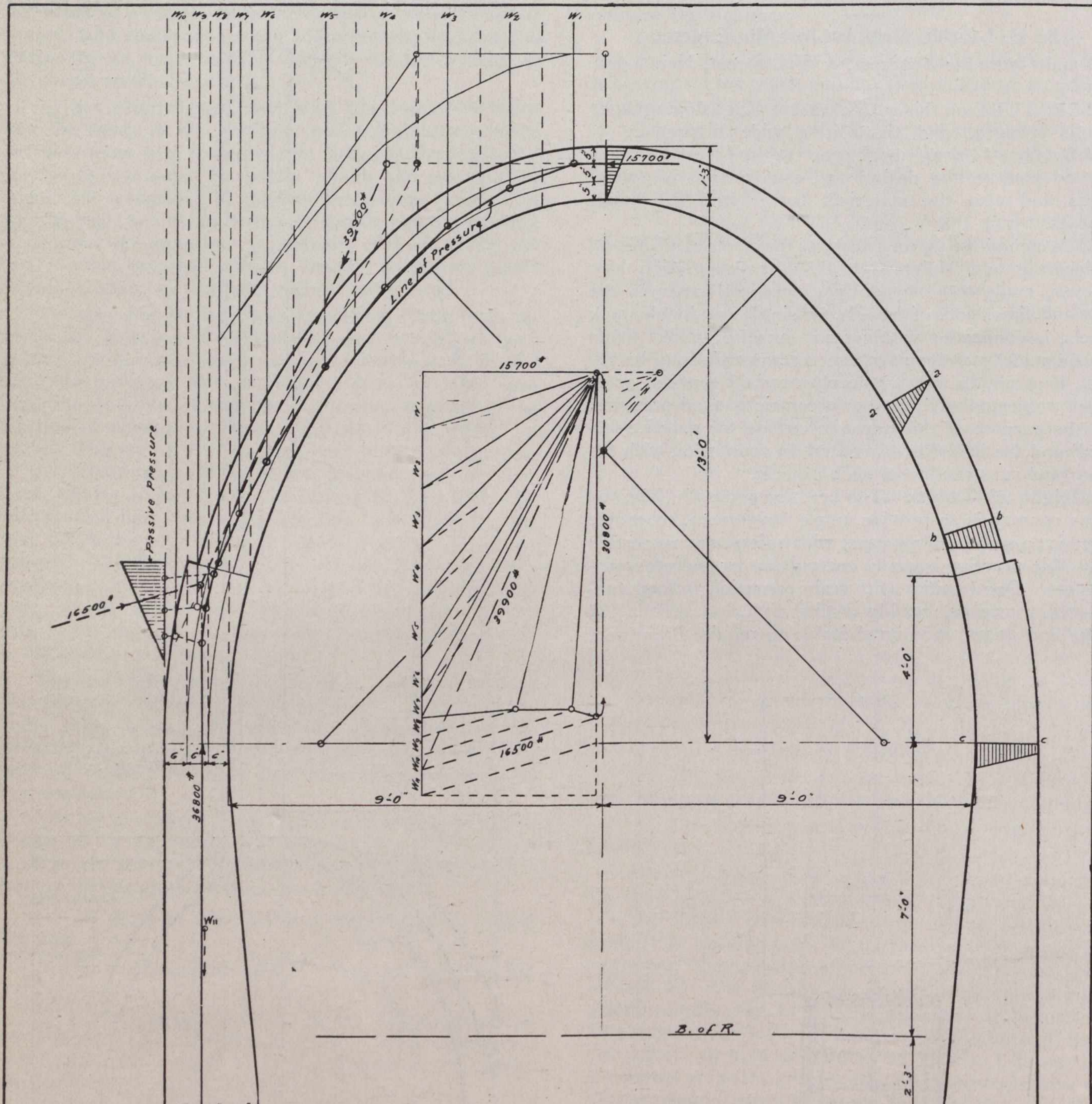


Fig. 3.

Table I.—Single Track Tunnels.

Name of tunnel.	Height of tunnel above base of rail. Feet.	Maximum width of tunnel. Feet.	Minimum thickness of tunnel arch. Feet.
*Weissenstein	18.04	15.74	1.31
*Ricken	19.00	17.16	1.00
*Granges	19.00	17.16	1.15
*Simplon	18.07	16.40	1.15
*Wasserfluh	18.35	17.00	1.31
*Austrian Alps tunnels	18.70	18.04	variable
*Kommerell (his book)	20.60	18.04	"
†Cascade	20.50	16.00	2.00

*Multicentre. †Circular.

Table II.—Double Track Tunnels.

Name of tunnel.	Height of tunnel above base of rail. Feet.	Maximum width of tunnel. Feet.	Minimum thickness of tunnel arch. Feet.
†Hauenstein	20.34	27.50	1.31
†Mont d'Or	20.07	28.30	1.98
†Loetschberg	19.68	26.24	1.50
*St. Gothard	19.70	26.90	1.77
*Austrian Alps tunnels	21.00	26.90	variable
*Kommerell (his book)	24.70	29.20	"

for the Austrian Alpine tunnels is 18.04 feet, and Kommerell, in his book on tunnel linings, advocated also the same width. Karl Brandau, a member of the contracting firm driving the Simplon tunnel, and well known for his connection with difficult tunnel work, recommended that the width of the second bore of the Simplon tunnel be made 18.04 feet, in order to better resist lateral pressure. Incidently, this would be of material assistance in the work of maintenance and repair.

Thomas H. Johnson, Mem.Am.Soc.C.E., consulting engineer, speaking of the Pennsylvania Lines, says: "Experience in maintenance has shown us that there is need of additional height and width to provide ample room for centering when repairs to the arch are needed, as will be the case from time to time, and sufficient allowance for this should be made, over and above the clearance allowed for trains."

The experience gained in driving long tunnels, and especially tunnels subjected to heavy ground pressure, shows that economy in reconstruction can be effected by increasing the width of a tunnel, and that 18 feet will give adequate clearance for reconstruction or repair work, without interruption of traffic.

Tunnel Cross-section.—In this country the circular arch has been adopted almost exclusively for short and even relatively long single track tunnels (Cascade, St. Paul Pass and Stampede tunnels), whereas in Europe it is the current practice to make use of polycentre arches or roofs, nearing the shape of a semi-ellipse.

For double track tunnels, the committee on roadways recommends an arch with the central portion constructed on a long radius and with short radii to connect the central portion with the side-walls. The European practice favors circular arches for double track tunnels; in certain instances, however, multi-centre arches for double track tunnels have been used, and only in those tunnels not subjected to ground pressure, and where a lining has been provided merely to prevent falls of rocks, flat tunnel arches have been used.

It is not proposed to discuss here the most economical tunnel section best adaptable to resist the many cases of ground pressure acting upon a bore, yet, an example illustrating a case most liable to occur has been selected to show that, even under the most favorable case of loading, a multicentre arch, having nearly the form of a semi-ellipse, is more economical and more stable than a circular arch, for single track tunnels, both from a theoretical and practical standpoint.

Formulae for Ground Pressure.—It has been observed that when a cave-in occurred in an earth or rock tunnel, or when a sand or rock bin, or a silo filled with grain would be emptied from the bottom, the void resulting from the cave-in, or from the material extracted, would take a vaulted shape, nearing that of a parabola. The height of the vaulted space was found independent of the depth or weight of the overlying material, but, on the other hand, was dependent on the width of the excavation and of the cohesion of the material under consideration.

Several formulae that serve the purpose of determining the height of the parabola that represents the overlying weight acting on a bore have been devised, but as it is beyond the scope of this paper to present and discuss all of these, the Kommerell formula only is given here.

Let d represent the settlement or deflection observed in a tunnel roof; let C have the value given in Table III., and H be the height of an ellipse substituted with sufficient accuracy for all practical purposes, to the parabola above the tunnel roof, then:

$$H = \frac{100 . d}{C} \quad (d \text{ and } H \text{ expressed in feet.})$$

Table III.

Material penetrated.	Value of C.
Fine sand, dry	1.0
Sand, gravel	1.5
Earth, loam, etc.	2 to 4
Marl	4 to 5
Shale	6 to 7
Harder rocks	8 to 15

Kommerell's formula is based on the deflection of the roof of a bore or tunnel, and, as for the same kind of material, the deflection due to bending increases with the width of the bore, the height of the parabola becomes a function of the tunnel width and of the kind and cohesion of the overlying material.

In tunnels subjected to ground pressure, it is advisable and often necessary to know approximately the intensity and direction of same, and to this effect, valuable information will be obtained by observing the behavior of the temporary timbering, such as caps, posts, etc. Close results can be obtained by substituting for timber, over a short distance, in pressure zones, structural steel shapes, as for instance I-beams, or channels, the strength of which is known with sufficient accuracy for all practical purposes. Assuming, for instance, that in a tunnel 18 feet wide, 15 in. @ 42 lbs. I-beams, spaced 2 feet centre to centre, are used for the purpose of ascertaining the intensity of ground pressure, and that a deflection of 2 inches is observed at the centre of the beam, then, on the assumption that the load is uniformly distributed over same:

$$W = \frac{76.8\, E.I.d}{L^3} = \frac{76.8 \times 29{,}000{,}000 \times 444 \times 2}{200^3} =$$

250,000 lbs. or, for one lineal foot $\frac{250{,}000}{2} = 125{,}000$ lbs.

$$A = \frac{W}{w} = \frac{125{,}000}{160} = 780 \text{ sq. ft.}$$

$$H = \frac{A}{.7854 . b} = \frac{780}{.7854 . 18} = 55 \text{ feet.}$$

in which: E = modulus of elasticity of steel.
I = moment of inertia of steel section.
d = deflection of beam, in inches.
L = span of beam, in inches.
A = area of ellipse (see Fig. 1).
W = weight of overlaying material (within ellipse).
w = weight of overlying material (per cu. ft.).
b = width of tunnel, in feet.
H = height of ellipse, in feet.

Having determined approximately the weight acting on a tunnel lining, the next step is to select the type of cross-section best suitable to resist the stresses borne by same. Theoretically, there is but one tunnel section that is most economical, corresponding to a given condition of loading; in actual practice, however, it would be unpractical to change the tunnel section very often; furthermore, certain clearance lines for the rolling stock and for other purposes have to be strictly observed; it is also desirable that the masonry forms and tunnel centres be made as uniform as possible. For the above reasons, it is usually the practice to design a few types of lining sections, the strength of which is determined a priori, adapting same where found necessary, to conditions of loading.

An exact treatment of the problem involves the theory of the elastic arch, but, inasmuch as many of the factors entering into same are of a very uncertain nature, the application of this theory is hardly warranted in the determination of stresses in a tunnel arch. If a pressure line can be made to pass within the middle third of the arch and sidewalls, and if the stresses are kept within a conservative limit, then it is generally accepted that, other things being equal, a tunnel lining designed along these lines will be stable.

In Table IV. are given the stresses in a multicentre arch (Fig. 2) 15 inches thick, due to a burden of 20, 30 and 40 feet,' and in Tables V. and VI. the stresses in circular arches 15 and 18 inches thick respectively, due to similar loads. The graphical solution of the problem for one case of loading is shown in Fig. 3. The weight of the overlying material is taken at 170 lbs. per cu. ft. It has been assumed that the arch was built of concrete blocks, and the side-walls of concrete masonry. An inspection of the stresses shows that:

1. The thrust at the arch crown is least in the multicentre arch.

2. The stresses in the arch are least in the multicentre arch.

3. The stresses at the springing lines are higher in the multicentre arch.

4. The stresses at the side-wall footings are higher in the multicentre arch.

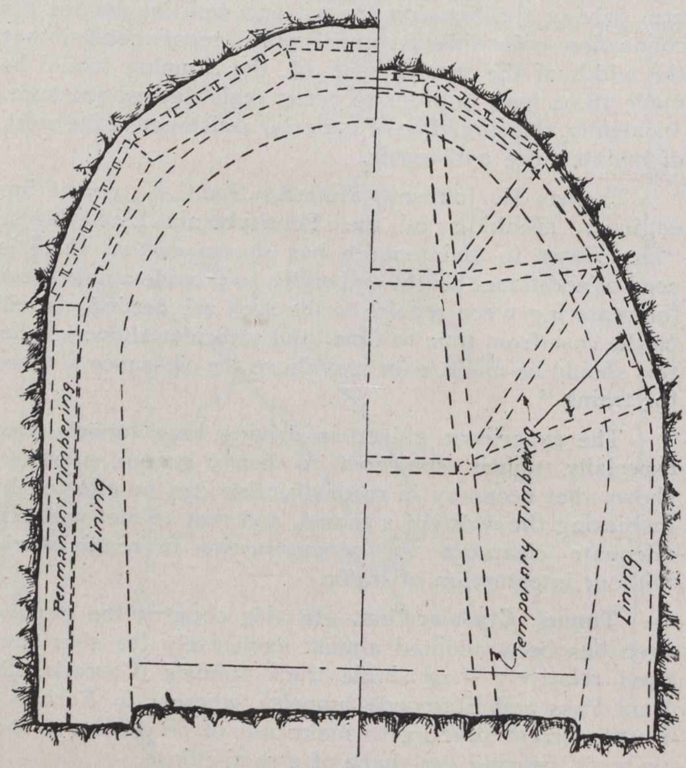
Items 1 and 2 result in decreasing the thickness of the arch, thus reducing the yardage of excavation and lining; items 3 and 4 have for result to give more stiffness to the side-walls, against lateral pressure, should such develop after construction. Allowing unit stresses of 500 and 400 lbs. per sq. in. for 1 : 2 : 4 concrete arch blocks, and 400 lbs. for 1 : 2½ : 5 concrete side-walls, it will be seen from Table IV. that a multicentre arch 15 in. thick will carry a burden represented by a semi-ellipse 30 ft. high, whereas it would require an 18-inch circular arch to carry the same load without exceeding the allowable stresses.

In tunnels subjected to heavy ground pressure, and in long tunnels also, this advantage alone deserves due consideration. In shorter tunnels not subjected to heavy ground pressure this advantage is lessened, for in such cases reasons of construction usually dictate the minimum thickness practicable.

Materials Suitable for Lining Purposes.—The materials used for lining purposes are brick masonry, concrete, concrete blocks, rubble and cut stone masonry. In this country, concrete and brick linings are used very extensively, although cut stone masonry has been used also in several instances.

In Europe, where labor is cheaper relatively, rubble and cut stone masonry, and, of late, concrete blocks, have been used very extensively, almost to the exclusion of concrete and brick linings, in connection with long tunnels, or else bores subjected to ground pressure. Opinions as to the kind and quality of materials best suitable to line tunnels, all aim towards the same results, i.e., toward material that will reach its maximum strength soon after being used, and that possesses a high compressive strength, together with great resistance against action of water, heat, frost, and gases from locomotives. The question of strength is obvious, for the thicker the lining, the wider the bore, and the greater the amount of excavation and masonry.

On account of the low compressive strength of brickwork, the use in recent practice, in deep tunnel work, of brick lining has been closely limited. In short tunnels,



CIRCULAR ARCH. MULTICENTER ARCH.

a. b.

Fig. 4.

Quantities per Lineal Foot.

Excavation..	21 cu. yds.	Excavation..	17 cu. yds.
Lining......	3.55 cu. yds.	Lining......	3.0 cu. yds.
Timbering...	315 ft. B.M.	Timbering...	95 ft. B.M.
Packing.....	0.5 cu. yd.		

not subjected to pressure, and necessitating a lining merely to prevent falls of rocks, hard burned bricks for the arch and concrete or rubble masonry side-walls are found satisfactory and economical. One chief disadvantage of brick arches lies in the cutting out of the mortar by the blast from the locomotive stacks and also the cutting action of the bricks from sparks from the locomotive.

Such defects can be partly remedied by substituting an arch segment of rich concrete above the centre of the track, or else by using hard burned vitrified bricks laid in a rich mixture of cement mortar.

There is a wide divergence in the opinion of railroad men with reference to concrete linings, and it is the writer's opinion that at the present time no definite conclusion can be drawn as to the efficiency of concrete linings (reference being made here to concrete poured into forms, in the tunnel) owing to the fact that the use of such linings in connection with tunnel work is very recent. From observations thus far made, concrete linings have in several instances not lived up to expectations, especially where lateral movements have taken place after their completion.

When such occurrence takes place in a brick masonry, concrete block or cut stone masonry tunnel arch, slight deformations are easily taken care of by the joints of the masonry, usually several of these opening slightly in a radial plane perpendicularly to the direction of the thrust, thereby resulting merely in throwing additional stresses on the individual elements of the arch. On the other hand, concrete linings, poured into forms in the tunnel, are rigid, and their lack of flexibility causes cracks to open at the slightest deformation or movement of the lining. Unfortunately, these cracks do not open in radial

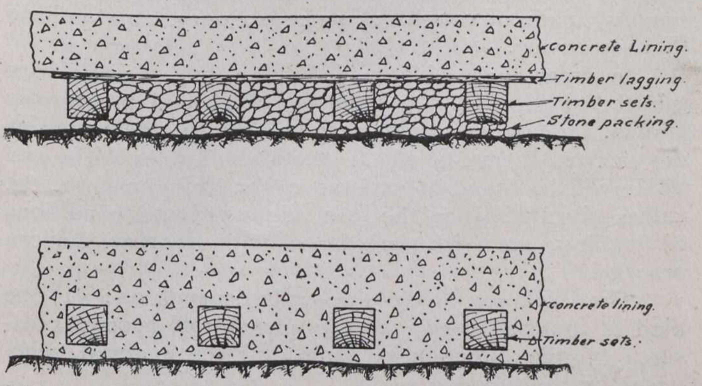


Fig. 5.—Horizontal Sections Through Side-wall of Tunnel Illustrating Two Different Methods of Construction.

planes, but in any direction, usually in horizontal planes (the concrete being usually deposited in layers, especially near the arch crown, where spading cannot be done easily) thereby creating sliding surfaces parallel to the line of thrust. Besides, concrete possessing a relatively low compressive strength has the same disadvantages as rubble masonry, i.e., the maximum strength is reached only long after being laid, and in wet sections or in heavy pressure zones, both of these materials have proved to be rather unsatisfactory. In dry sections, and where the

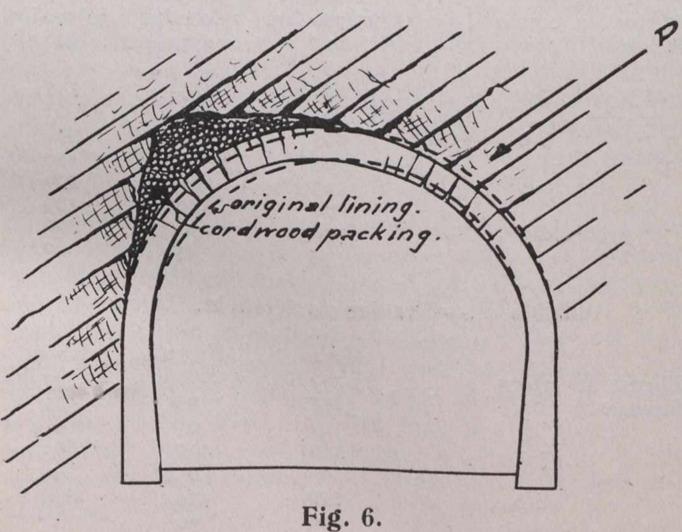


Fig. 6.

lining merely answers the purpose of preventing falls of rocks, concrete will usually be found cheaper than rubble or cut stone masonry.

One advantage incurred by using concrete for lining purposes, is the possibility of inserting steel reinforcement within the lining to take care of tensile and shearing stresses, in heavy ground subjected to lateral pressure; however, stresses such as these can be taken care of very efficiently by giving the lining an appropriate shape.

Allowable Stresses.—Owing to the fact that a tunnel lining is constructed usually under unfavorable conditions, when compared with other masonry structures, a relatively large factor of safety should be used in proportioning its various elements.

In a tunnel concrete or rubble masonry reach their ultimate strength long after having been laid, especially in wet sections; therefore, as a lining built of such materials is called to carry heavy loads soon after completion, it is obvious that low unit stresses should be specified. On the other hand, concrete or artificial masonry blocks can be made in advance so that when used they possess already a high compressive strength and thus higher unit stresses can be allowed.

For arch bridges, Prof. Melan allows the following unit stresses:

Rubble masonry	355-427 lbs. per sq. in.
Stone masonry, in courses	427-570 lbs. per sq. in.
Stone masonry made of granite or crystal rocks	710-850 lbs. per sq. in.

The Austrian specifications for stone masonry bridge work allow for:

Cut stone masonry	427 lbs. per sq. in.
Coursed stone masonry	214 lbs. per sq. in.
Rubble masonry	142 lbs. per sq. in.

no distinction being made with reference to the kind of stone used. Kommerell, in his book on tunnel lining, allows 285 lbs. per sq. in. for hard burned bricks.

Bierbaumer, in his book bearing on the dimensioning of tunnel linings, suggests the following unit stresses:

Tunnel arch made of rubble masonry (flat stones) and side-walls of coursed rubble masonry	285 lbs. per sq. in.
Tunnel arch made of rough cut stone and side-walls of coursed rubble masonry	355-430 lbs. per sq. in.
Tunnel arch made of rough cut stone masonry and side walls of coursed masonry	570 lbs. per sq. in.
Tunnel arch made of first-class cut stone masonry and side walls of rough cut stone masonry	710-850 lbs. per sq. in.

The specifications covering the lining of the Granges tunnel called for concrete blocks having an ultimate compressive strength of 3,700 lbs. per sq. in. The first bore of the Simplon tunnel was lined with concrete blocks having a strength of 1,200 to 2,000 lbs. per sq. in., and the specifications covering the concrete blocks of the second bore of the Simplon tunnel and of the double track Hauenstein tunnel called for concrete blocks having, when placed, 70% of a guaranteed ultimate strength of 2,844 lbs. per sq. in.

From the above, and from the experience gained with reference to the behavior of old tunnel linings, the following unit stresses will be found conservative when proportioning the elements of tunnel linings:

1 : 2 : 4 concrete (blocks cast in advance)	500-600 lbs. per sq. in.
1 : 2½ : 5 concrete	350-400 lbs. per sq. in.
1 : 3 : 6 concrete	250-300 lbs. per sq. in.
Hard burned brick masonry	250-275 lbs. per sq. in.
Ordinary brick masonry	175-200 lbs. per sq. in.
Rubble stone masonry	250-300 lbs. per sq. in.
Rubble stone masonry in courses..	350-400 lbs. per sq. in.
Roughly dressed cut stone masonry.	500-600 lbs. per sq. in.
First-class cut stone masonry....	700-800 lbs. per sq. in.

Thickness of Lining.—Several formulae serving the purpose to ascertain the proper thickness of tunnel linings have been published by various authors; these are either wholly empirical, or else derived from theories applied to masonry arch bridges, as, for instance, Rankine's formulae. In general, such formulae give but very approximate results at best, and often they are valueless for practical purposes.

The minimum practical thickness of a tunnel lining depends generally upon the material used and the method of construction. For instance, a brick masonry lining is given usually a thickness of about 18 inches (the width of 3 bricks) for a single track bore; that of a concrete lining 18 to 22 inches. On the other hand, tunnel linings made of concrete blocks or cut stone masonry, 14 to 15 inches thick have answered the purpose.

Bierbaumer, in his book on tunnel linings, gives the following dimensions for tunnel arches:

I.—No apparent ground pressure. Material: rubble masonry:
Thickness t = 19.7 to 23.6 in. for single track tunnels.
t = 19.7 to 31.5 in. for double track tunnels.

II.a—Light ground pressure. Material: rubble masonry:
t = 27.6 to 31.5 in. for single track tunnels.
t = 35.5 to 47.3 in. for double track tunnels.

II.b—Tunnel arch made of rough cut stone masonry; side-walls of rubble masonry:
t = 19.7 to 23.6 in. for single track tunnels.
t = 27.6 to 31.5 in. for double track tunnels.

III.—Heavy ground pressure. Tunnel arch made of rough cut stone; side-walls of rubble masonry:
t = 31.5 in. for single track tunnels.
t = 47.5 in. for double track tunnels.

IV.—Very heavy ground pressure. Arch made of first-class cut stone masonry; side-walls of rough cut stone:
t = 31.5 to 35.4 in. for single track tunnels.
t = 47.3 to 55.0 in. for double track tunnels, with masonry invert.

For tunnel linings made of hard burned bricks, Kommerell, in his book, gives the following dimensions (allowable unit stress for brick masonry 285 lbs. per sq. in.):

Single Track Tunnels.

Thickness of arch: 17.4 inches for burden of 50 feet.
" " 22.6 " " 61 "
" " 27.4 " " 73 "
" " 31.9 " " 84 "

Double Track Tunnels.

Thickness of arch: 17.4 inches for burden of 26 feet.
" " 22.6 " " 32 "
" " 27.4 " " 38 "
" " 31.9 " " 44 "

From the above, it will be noted that single track tunnels are capable of carrying approximately double the load supported by double track tunnels, for the same thickness of lining. The minimum thickness of the lining of the single track Weissenstein tunnel, built of rough cut stone masonry, is 1.31 ft. That of the single track Ricken tunnel, built of cut stone masonry, 1.00 ft. The minimum thickness of the lining of the Granges tunnel is 1.15 ft. (concrete blocks). That of the first bore of the Simplon tunnel 1.15 ft. for cut stone masonry, and the same thickness for the concrete blocks of the second bore. The minimum thickness of the concrete blocks forming the lining of the double track Hauenstein tunnel is 1.31 ft. That of the Mont d'Or and Loetschberg double track tunnels, made of rough cut stone masonry, 1.98 and 2.0 ft. respectively.

In order to be able to determine the stresses in a tunnel lining, when the intensity of ground pressure is known, it is necessary to assume first the dimension of the various elements of the section. Tables VII. and VIII. will be found of assistance for this purpose, the values given being on the safe side for normal conditions of loading, and in accordance with current modern practice.

The thickness of the side-walls depends on: (1) the kind of material used; (2) the intensity of ground pressure; (3) the direction of same; (4) the material penetrated by the tunnel.

When the side-walls are built of a material possessing a low compressive strength it is obvious that their thickness will be greater than if built of stronger materials. Also, when eccentric or lateral pressure is to be guarded against, the side-walls are made heavier than those sustaining vertical pressure only. The thrust, at springing line elevation, due to the load carried by the arch, causes passive pressure which must be resisted by

STRESSES IN MASONRY—(See Fig. 2).

Table IV.—Multicentre Arch 15 in. Thick.

	H=20′	H=30′	H=40′
Thrust at crown	15,700 lbs.	23,000 lbs.	30,500 lbs.
Stresses " "	175	255	340
	0	0	0
" " a-a	280	425	555
	0	0	0
" " b-b	265	430	590
	115	110	150
" " c-c	215	290	390
	70	100	130
" " d-d	170	230	300
	35	45	60

Table V.—Circular Arch 15 in. Thick.

	H=20′	H=30′	H=40′
Thrust at crown	23,700 lbs.	33,600 lbs.	45,500 lbs.
Stresses " "	255	375	505
	0	0	0
" " a-a	340	495	665
	0	0	0
" " b-b	370	570	820
	40	30	0
" " c-c	180	250	350
	60	85	115
" " d-d	150	205	275
	30	40	55

Table VI.—Circular Arch 18 in. Thick.

	H=20′	H=30′	H=40′
Thrust at crown	23,700 lbs.	33,600 lbs.	45,500 lbs.
Stresses " "	220	310	425
	0	0	0
" " a-a	300	410	550
	0	0	0
" " b-b	260	365	500
	85	130	180
	60	85	115
" " d-d	150	205	275
	35	40	60
" " c-c	180	250	350

the material adjacent to the lining, as shown in Fig. 3; in hard and solid rock, this passive pressure will be amply taken care of, even with thin side-walls, but when the material penetrated is soft, and lacks cohesion, as for instance earth, loose rocks, gravel, etc., the passive pressure, which is to counterbalance the thrust of the arch, can no longer be taken care of by the material adjacent to the masonry, and thus it becomes necessary to give the side-walls a greater thickness in order to provide the tunnel arch with rigid abutments. The thickness of the side-walls at springing line elevation in a tunnel lining whose purpose is merely to prevent falls of rocks, is usually made 1 to 1.25 times the thickness t of the arch. In pressure zones, 1.25 to 1.50 t. In soft materials 1 to 2 t, according to the hardness and cohesion of the material penetrated and the direction and intensity of ground pressure.

The latter has been over-estimated in many instances, and there is no doubt that more money has been wasted by constructing too heavily designed tunnel linings rather than by the failure of too lightly built ones.

The direction of ground pressure plays a far more important part than its intensity, and here especially the skill of the engineer will find a broad field for application. The cohesion of the material penetrated, the plans of rupture along fault lines, or lines of stratification, the possibility of the floor to bulge, etc., are all factors bearing directly on the design of tunnel linings.

Methods of Construction.—In this country, reasons of original economy of construction has created the segmental arch timbering system of tunnel lining, which in due time had to be replaced with a more permanent type of lining, often without interruption of train traffic. Thus the old timbering was embedded or encased within the masonry lining, and this has created a most extravagant method of timbering and lining, the use of which has gradually been extended to long tunnels, then standardized and now used indiscriminately in connection with tunnels driven through hard and soft materials.

Referring to Fig. 4a, representing a single track tunnel lined with a circular concrete arch, and timbered with 12 by 12-in. arch sets, spaced 5 ft. centre to centre, and referring also to Fig. 4b, illustrating a single track tunnel lined with a multicentre concrete lining and timbered during construction only, with sets spaced 6 feet apart, used three times over again, as done in actual practice, we find that: (1) The amount of excavation in tunnel "a" exceeds that of tunnel "b" by 23.5%; (2) the amount of masonry lining is in excess by 18.3%, and that of timber by 231%.

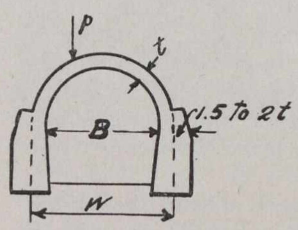
In a short tunnel of, say, a few hundred feet long, these excesses have apparently little bearing on the total cost of the bore, but in long tunnels they run high, as shown in the table below. For instance, in a six-mile tunnel the excess in cost would be close to a million dollars.

Length of tunnel, ft.	15,000	20,000	30,000	40,000
Excess excavation, cu. yds.	60,000	80,000	120,000	160,000
Excess masonry, cu. yds.	8,250	11,000	16,500	22,000
Excess timbering, ft. B.M.	3,300,000	4,400,000	6,600,000	8,800,000

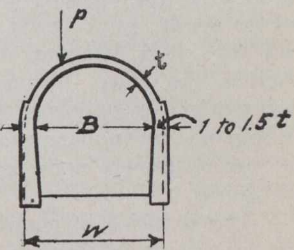
Another disadvantage incurred by this method of construction, especially in heavy ground, is the increased width of two to three feet, necessitated by the timbering left in place.

Figures 5a and 5b illustrate the practice generally followed in lining tunnels in this country. For the purpose of effecting a saving in masonry, timber lagging one to two inches thick is provided against the vertical posts of the timber sets, and the concrete is thus confined within

Table VII.—Single Track Tunnels.



Soft Material.



Hard Material.

$B = 18' 0''$ $\qquad t = \dfrac{C.P.W.}{s}$

Unit Stress, Lbs. per Sq. In.	250	300	350	400	500	600	700
Unit Stress, Lbs. per Sq. Ft.	s= 36,000	s= 43,200	s= 50,400	s= 57,600	s= 72,000	s= 86,400	s= 100,800
Ground Pressure "p" per Sq. Ft.	Thickness of Arch, "t" in inches.						
1,000 lbs.	18	18	15	15	14	14	14
2,000 "	18	18	15	15	14	14	14
3,000 "	18	18	15	15	14	14	14
4,000 "	18	18	15	15	14	14	14
5,000 "	18	18	15	15	14	14	14
6,000 "	21	18	15	15	14	14	14
7,000 "	25	21	17	15	14	14	14
8,000 "	30	25	21	18	14	14	14
9,000 "	35	29	24	20	16	14	14
10,000 "	..	32	27	23	18	15	14
11,000 "	..	35	30	26	20	16	15
12,000 "	..	..	35	29	22	17	15
13,000 "	..	..	..	32	25	20	16
14,000 "	..	..	..	35	28	22	18
15,000 "	..	..	..	..	31	24	20
16,000 "	..	..	..	..	34	26	22
17,000 "	..	..	..	..	..	28	23
18,000 "	..	..	..	..	..	30	25
19,000 "	..	..	..	..	..	32	27
20,000 "	..	..	..	..	..	34	28
21,000 "	..	..	..	..	..	..	30
22,000 "	..	..	..	..	..	..	32
23,000 "	..	..	..	..	..	..	34

Table VIII.—Double Track Tunnels.

$B = 28' 0''$

Unit Stress, Lbs. per Sq. In.	250	300	350	400	500	600	700
Unit Stress, Lbs. per Sq. Ft.	s= 36,000	s= 43,200	s= 50,400	s= 57,600	s= 72,000	s= 86,400	s= 100,800
Ground Pressure "p" per Sq. Ft.	Thickness of Arch, "t" in inches.						
1,000 lbs.	22	22	20	20	18	18	18
2,000 "	22	22	20	20	18	18	18
3,000 "	22	22	20	20	18	18	18
4,000 "	24	22	20	20	18	18	18
5,000 "	28	24	20	20	18	18	18
6,000 "	34	28	23	20	18	18	18
7,000 "	..	33	28	23	18	18	18
8,000 "	..	38	33	28	22	18	18
9,000 "	..	..	38	33	25	20	18
10,000 "	..	..	..	37	28	22	19
11,000 "	..	..	..	..	31	25	21
12,000 "	..	..	..	..	35	28	23
13,000 "	..	..	..	..	..	31	25
14,000 "	..	..	..	..	..	34	27
15,000 "	..	..	..	..	..	..	31
16,000 "	..	..	..	..	..	..	34

two forms. The space between the inside lagging and the timber sets is packed with spalls (Fig. 5a). Now, it is a well-known fact that the use of seasoned timber, on account of its scarcity, is very limited, especially in tunnel work; also, when concrete is poured into wooden forms the latter swell when coming in contact with wet concrete. Therefore, the wooden lagging between the concrete and the vertical posts, as well as the timber sets, occupy first a greater space than they do after drying, so that, after shrinking naturally, or through the heat developed by the surrounding ground, possibly also by dry rot or decay, etc., voids are created back of the lining, and the latter becomes then a mere shell, standing by itself in the bore. Years may be required to accomplish this work; nevertheless, features of this kind have been anticipated by modern tunnel builders, and now it is considered extremely poor practice to leave timbering within the lining.

The practice of running concrete around the timbering, as shown in Fig. 5b, would be a noted improvement if it was not for its high cost, due to the fact that the masonry yardage is almost doubled. Likewise, cordwood packing is very objectionable, for the reason that it is difficult to pack timber very tightly, and also because cordwood packing shrinks rapidly in dry tunnels.

Fig. 6 illustrates the possible result gained by using cordwood packing in a tunnel subjected to eccentric pressure, the latter developing only after the lining has been completed, as is often the case.

The practice used or advocated by modern builders is to use timbering for temporary purposes only, and to pack the space left between the walls of the bore and the lining, either with rubble masonry or concrete, or also with spalls, grouting these if necessary. Packing with spalls, when well done, is an expensive procedure, involving much labor, and during the past few years there seems to be a tendency to use a lean mixture of concrete instead of stone packing.

AN UNDEVELOPED FIELD IN WATERWORKS MANAGEMENT.*

By Paul Hansen.

THOSE who have had an opportunity to visit large numbers of small waterworks, as well as a variety of other small public utilities, more particularly in the smaller communities, cannot fail to be impressed with the generally unsystematic, unscientific and slipshod methods of operation. Among several hundred small waterworks, i.e., in cities under 25,000 population, with which the writer has acquaintance, there are but a very few where good operating records and financial accounts are maintained, and where a commendable technical skill is shown. The writer is obliged to say that these exceptions are very nearly all among the privately owned plants, though he is far from being committed to any definite stand on private versus municipal ownership.

The result of poor management is generally poor service, or good service purchased at cost much too high. The fault is not always, or even generally, that of the man in charge, because it is ordinarily not possible to obtain a man for the salaries offered, or even for the salaries that might reasonably be paid, who is a thorough waterworks expert; nor is it possible, in connection with the more complex waterworks installations, to find in one man the diverse knowledge necessary to secure the most effective and economical service in all departments. The most logical, the simplest, and the most readily available method of overcoming these difficulties is that of retaining the services of competent consulting engineers, on an annual basis, to supervise operation. As such work, once it is well initiated, can be carried on with but a small expenditure of time, it may be rendered at small expense, probably not exceeding $600 per annum. This procedure is not new or novel, but is seldom resorted to, whereas it should constitute a general custom. Large works do not need it, generally speaking, because such works are supervised by full-time employees, who are specialists in various lines of waterworks design and operation; yet it is significant that, when difficult problems arise in connection with large waterworks, the management is quick to avail itself of outside expert services.

Three factors enter into the supervision which a consulting expert exercises, viz.: Operating records; financial accounts, and technical skill.

Operating records relate to physical facts such as yield and quality of source of supply, performance of pumping stations, and the condition of the distribution system and reservoirs.

Financial records should permit of readily making a complete analysis of costs of operation and maintenance, and, to this end, should include fully itemized capital, maintenance, repair, replacement, sinking fund, depreciation and interest accounts. Unit costs should also be prepared on all material purchased and work done.

Technical skill should be possessed in a pre-eminent degree by the consulting engineer, that he may instruct those in direct charge in the proper manipulation of the waterworks equipment, and that he may correctly interpret the significance of the records that are maintained under his direction.

A plan such as outlined will not only improve operation, but will also improve waterworks design, for it will give consulting engineers an opportunity to ascertain how their own designs "work out," an opportunity strangely lacking at the present time. Design and operation must go hand in hand, for the engineer cannot be proficient in the one without being proficient in the other. If once this system is fairly tried, it is difficult to believe that it will not grow in favor.

*From the Journal of the American Waterworks Association.

Mr. E. D. Casseday, chief engineer of the Barnett-McQueen Co., Limited, engineers and general contractors, Fort William, Ont., calls our attention to a statement made in our article descriptive of the new government elevator at Vancouver in our issue of December 17th, 1914. It was there remarked that the headquarters of the company are at Minneapolis, with a branch office at Fort William, Ont. Mr. Casseday advises us that the company is strictly a Canadian firm, and that Fort William, Ont., is their headquarters.

In the annual report of Mr. C. P. Edwards, General Superintendent of the Dominion Government radiotelegraph service, it is stated that there was an increase of 46 in the number of radiotelegraph stations established in Canada and on Canadian ships during the year ending March 31st, 1914. The total number of stations then in operation was as follows:

	1912-13.	1913-14.	Increase.
Government commercial stations	..	1	1
Coast stations	37	42	5
Government ship stations	16	21	5
Licensed ship stations	36	50	14
Licensed commercial stations	6	8	2
Licensed amateur and experimental stations	28	47	19
	123	169	46

Editorial

ENGINEERING IN 1914—AND 1915.

Since the publication of last week's issue, the year 1914 has stepped out of the present and is now casting its shadows across the devastated plains of the past. It has been a year of incidents that are casting longer shadows than those to which we are accustomed. The "Empress of Ireland" disaster gave birth to a world-spread sadness that will mark in history, for all time, the first half of the year. The second half has given us an European war that is destined to be without precedent in the annals of world powers. Its influence is felt in the remotest corners. The scar which commerce and civilization will carry as a result, centuries of Science's best nurture and tuition will hardly efface.

Canada, voluntarily, with the regard for right and honor so characteristic of Great Britain and her colonies, and with a full sense of duty, let the cost be what it may, has entered the conflict, and the history of the war cannot be chronicled without at least a worthy mention of this country's participation in the struggle that means so much to human-kind.

That the war would heave a formidable obstruction in the path of engineering progress was inevitable even at the outset. The crucial moment found engineering flying signals of revival after some months of considerable depression. The result of the blow is everywhere in evidence. The influence of the war upon engineering has been great. Any other phase of national development that has been subjected to a more pronounced depredation is certainly a subject for consolation. Engineers, however, are accustomed to carrying out problems under conditions which, from a distance, appear to make those problems insurmountable, and the problem of the coming year, being one of co-operation rather than the survival of the fittest, will undoubtedly be treated in an engineering way, insuring successful solution.

Reflecting upon the work of the year that has just closed, engineering activities have been remarkable, considering the financial situation, and it is to be noted that a balance characteristic of the most progressive years of our history was largely maintained throughout the country. The enumeration of a few of the projects that have been under way, may emphasize this. Large contracts have been let by Victoria and Winnipeg for the construction of water supply systems of great dimension. Montreal's progress in this respect, Toronto's filtration plant extension, and Port Arthur's completion of a new system, are to be noted as typical of many. The tunneling of Mount Royal and of Roger's Pass has brought Canada East and West prominently before the eye of railroad engineers. Material progress on the Quebec bridge has been recorded in a recent issue. Large bridges constructed by the C.P.R., G.T.P. and C.N.R., and by municipal and highway authorities have proceeded. Work is about to commence on the Bloor Street Viaduct, Toronto; the St. Paul Street Viaduct, St. Catharines, and other bridges. Navigation was improved during the year by remarkable progress on the new Welland Ship Canal, new contracts on the Trent Canal, large terminals at Halifax, shipbuilding dock construction at Lauzon and Prince Rupert, while several mammoth schemes have crystallized into near-realities for Vancouver and Owen Sound. General harbor work at various points on the Pacific and Atlantic coasts and in the St. Lawrence and Hudson's Bay, has made substantial progress. Railway construction has proceeded to the extent of over 2,100 miles. Elevator construction has not lapsed; interior elevators have been completed and a large terminal elevator at Vancouver put under contract. Road work in practically every province of the Dominion has gone ahead, receiving, in many localities, an impetus in the closing months of the year in order to alleviate unemployment. Power development has been marked by the recent introductory operation of the Cedars Rapids plant, while the Laurentide plant on the St. Maurice experienced speedy construction during the spring and summer. The Hydro-Electric Power Commission of Ontario put into operation at Wasdell's Falls its initial power-producing plant, and its second plant at Eugenia, on the Beaver River, is on the eve of being put into commission. A great many municipalities throughout the province have experienced for the first time the opening of a new year with new possibilities backed by electric light and power. Sewerage construction has had, perhaps, the least curtailment of all, and innumerable projects, large and small, are under way.

These are but a few of the many activities that have been successfully furthered during the year. The greater majority of them are still far from completion. Similar projects are still on paper. From an engineering viewpoint, 1914 has given us much to be thankful for, while 1915 gives promise of as much or even more activity.

There is no getting away from the fact that the most serious impediment is lack of funds, or that it is vital. As this journal has several times observed, in times of extreme trade depression governments should spend as largely on public works as proper economy dictates, and at this particular time the Dominion Government might well employ substantial sums upon certain public works. Its credit is better than that of any of its industrial or municipal institutions, and Canadians are not likely to oppose certain measures to provide employment, production and necessary construction work. In this respect there is much encouragement in the assurances of the government that its policy of continuing all possible public works, is unshaken. It fosters optimism within our boundaries and has a tendency to loosen the grip on money bags, both within and without.

The Canadian Engineer has this New Year wish for its readers: That 1915 may hold greater engineering development within itself than the most optimistic of us have been able to foretell.

THE GOVERNMENT AND THE NICKEL EXPORT.

In view of what *The Canadian Engineer* had to say last week on the controversy which had arisen over Canada's export of nickel, a metal highly sought by manufacturers of armor plate and war munitions, our readers will no doubt be interested in the following memorandum issued by the Dominion Government after the editorial had gone to press.

"Various criticisms have appeared in the press with regard to the export of nickel matte from Canada to the United States.

"The whole subject has been under careful consideration and investigation by the government of Canada since the commencement of the war, and they have been in frequent communication with the British government as to the precautions which should be taken to prevent export to Germany.

"The books of the company in New York are inspected at short intervals by a thoroughly trained and experienced accountant, who goes into all exports most thoroughly and reports to the Canadian government.

"In addition to this, by an arrangement between the company and His Majesty's government, certain control is exercised in London through the company's British representatives. The company is not under German control, but is controlled altogether in the United States, where the vast majority of its stock is held. There may be a few German shareholders, but the proportion is insignificant, and there are no German directors.

"The steps taken by the government of Canada have the entire approval and sanction of the British government, who express themselves as entirely satisfied with the precautions that have been taken.

"It must be borne in mind that nickel exported from Canada to the United States is used in a large number of industries in that country, and prohibition of the export, except for the most urgent reasons, would be undesirable, as it would produce great business disturbance in a country, whose sympathies are very strongly with the cause of the allies.

"Moreover, the government is informed that there is an output of nickel in Norway controlled by German interests which could furnish a sufficient supply for German requirements during the present war."

A 100,000,000-GALLON CENTRIFUGAL PUMP.

A 100,000,000 gal. turbine driven centrifugal pump has been installed by the DeLaval Steam Turbine Co. in the Ross pumping station at Pittsburg. The pump was described by Mr. Geo. H. Gibson, in a recent issue of "Power." It operates against a total head of 56 feet including an 18 ft. suction lift. It was guaranteed to give a duty including all steam and power used by auxiliaries of 115,000,000 foot pounds per 1,000 lb. of dry steam at 150 pounds gauge pressure. The pump is of the double suction type with 48 in. inlet and outlet openings. The casing is split horizontally and both suction and discharge openings are in the bottom part. The casing cover can be removed without disturbing the suction and discharge connections. The impeller is of bronze and is mounted on a steel shaft, protected by bronze sleeves which abut against the impeller. The pump complete is 11 feet long over the shaft and 10 feet high. The space occupied by the turbine is 12½ feet long and 9½ feet high. The turbine shaft runs 3,600 r.p.m. and is connected by a flexible coupling to the pinion of the double helical reducing gear which in turn drives the pump at a speed of 350 r.p.m.

In a 10-hour test for duty and capacity a duty of 119,500,000 ft. lb. was developed. The steam per hour was 17,506 pounds, indicating a steam consumption per water horsepower of 16.59 pounds per hour. The corrected capacity was 102,610 gal. per 24 hours. The quality of the steam in the test was only 0.977 so that the duty corrected for quality of steam would be 122,300,000 foot pounds and the steam per water horsepower 16.2 making the additional consumption on account of the circulating and hot well pump motors 263 pounds per hour or a corrected duty of 120,500,000 ft. lb. with dry steam including all auxiliaries.

Under normal conditions at the makers' works the pump showed a delivery of 108,000,000 gal. per 24 hours running at 345 r.p.m.

PROPOSED HYDRO RADIALS FOR WESTERN ONTARIO.

The Hydro-Electric Power Commission of Ontario has presented to the municipalities in the western peninsula of the province, comprising what is known as the Aylmer district, a report bearing upon the cost of a proposed system of electric railways for that section. The report includes traffic statistics and a synopsis of seven different routes that have been surveyed and estimated. These seven schemes are as follows:—

The first scheme considers a line from a point designated as Westminster Junction on the London and Port Stanley Railway through Belmont, Lyons, Springfield and Brownsville to Tillsonburg and from St. Thomas through New Sarum to Port Burwell, and also with a tie line between Aylmer and Lyons. Rolling stock would consist of five passenger motor cars, five trail cars, three express motor cars and 220 freight cars. Sub-stations would be located near Springfield and Mount Salem. Westminster Junction is situated about eight miles south of London or halfway between the present Westminster and Glanworth stations on the L. & P. S. Total distance of this scheme would be 53.36 miles.

Scheme 2 considers route and location of sub-stations exactly similar to scheme 1, with the exception that no connection is provided between St. Thomas and Aylmer. Rolling stock would consist of four passenger motor cars, four trail cars, two express motor cars and 20 freight cars. Total distance would be 47.13 miles.

Scheme 3 considers a route exactly similar to scheme 1, except that no connection is provided between St. Thomas and Aylmer, and also between Aylmer and Port Burwell. Rolling stock would consist of four passenger motor cars, two trail cars, two express motor cars and 10 freight cars. One sub-station only would be necessary, and it would probably be located near Lyons or Aylmer. Total distance would be 32.77 miles.

Scheme 4 considers a line from St. Thomas through New Sarum, Aylmer, Mount Salem, to Port Burwell, and from Aylmer northward to the M.C.R. station and hence easterly through the villages of Springfield and Brownsville to Tillsonburg. Rolling stock would consist of four passenger motor cars and four trail cars, two express motor cars and 20 freight cars. Sub-station would be located near Springfield and Mount Salem. Total distance would be 44.44 miles.

Scheme 5 considers a line from St. Thomas through New Sarum to Aylmer and hence northeast to Springfield and hence easterly on the south side of the M.C.R. to Tillsonburg. Rolling stock would consist of three passenger motor cars, two trail cars, two express cars and 10 freight cars. One sub-station would be provided and would be located near Springfield. Total distance would be 27.33 miles.

Scheme 6 considers a line from St. Thomas through New Sarum, Aylmer, Mount Salem to Port Burwell. Rolling stock would consist of three passenger motor cars, two trail cars, two express motor cars and 10 freight cars. One sub-station would be located at Mount Salem. Total distance would be 25.84 miles.

Scheme 7 considers a line from St. Thomas through New Sarum to Aylmer. Rolling stock would consist of three passenger motor cars, two trail cars, one express motor car and eight freight cars. No sub-station would be required. Total distance, 11.23 miles.

In presenting the report to the municipalities it is pointed out that in schemes 1, 2 and 3 it has been assumed that express motor cars, hauling freight trains when necessary, would make two round trips per day over the L. & P. S. R. between Westminster Junction and London.

In schemes 4, 5, 6 and 7 provision has not been made for hauling express or freight from St. Thomas to London, as this service could readily be transferred to the L. & P. S. Railway at St. Thomas, although such service could not be properly arranged for at Westminster Junction.

A considerable saving in capital cost of sub-stations has been made by considering that the L. & P. S. Railway will supply power to the trolley wire at Westminster Junction and St. Thomas. As the 1,500-volt D.C. system has been assumed, it will be possible to supply scheme 7 with power entirely from St. Thomas.

The figures given for permanent construction cover the cost of the right-of-way track, overhead construction, station buildings, etc., while the figures given for joint equipment cover the cost of rolling stock, sub-stations and other similar items that are used in common by all the municipalities. This division has been made so that each municipality may take care of the cost of permanent construction within its own boundaries and share in the cost of joint equipment in proportion to mileage.

The following is a summation of the estimates of the different proposals:

Cost.

No.	Miles.	Permanent construction.	Joint equipment.	Subsidy.	Net capital cost.
1	58.36	$1,640,643	$316,825	$373,504	$1,583,964
2	47.13	1,224,453	269,675	301,632	1,192,496
3	32.77	882,540	221,950	209,728	894,762
4	44.44	1,264,555	274,850	284,416	1,254,989
5	27.33	843,437	200,100	174,912	868,625
6	25.84	775,418	151,800	165,376	761,842
7	11.23	416,191	116,740	71,372	461,059

Revenue.

No.	Annual revenue.	Total annual charges.	Annual deficit.	Annual surplus.
1	$196,381	$249,038	$52,657	....
2	177,190	207,486	30,296	....
3	151,805	151,144	......	$661
4	153,914	193,283	39,369	....
5	130,835	136,304	5,469	.....
6	87,257	128,030	40,773	....
7	65,536	79,347	13,811	....

In submitting the report, Sir Adam Beck, chairman of the Commission, points out that increased use of power will lower the cost to all municipalities. The estimates have considered a road constructed with 65-pound rails and 45-ft. steel cars with four 100-h.p. motors. This type of equipment is deemed sufficiently heavy to handle the traffic.

Using any pig iron in solution, an iron can be obtained of the following average composition, after removal of the gases by annealing: C, 0.004; Si, 0.007; S, 0.006; P, 0.008. The metal deposited from the solution is extremely brittle and hard, due to occluded hydrogen.

Aluminum is subject to two kinds of corrosion, one resulting from a uniform attack all over the surface, the other being localized in scales and spots. The second type is usually found on drawn or rolled metal. The metal must be exposed to air and moisture at the same time. Either alone will not produce it. Worked aluminum scales off in the direction in which the mechanical action has been carried on.

THE DEVELOPMENT OF A CANADIAN CHEMICAL INDUSTRY.

By W. H. Smith, Mining Engineer, Tweed, Ont.

At no other time in the history of Canada has such a valuable opportunity occurred for the establishment of a great and permanent industry and the utilization thereby of the country's vast natural resources. The closing out of the German factories with their enormous outputs of both heavy and small chemicals, combined with the difficulties now being experienced in ocean transportation have advanced the prices of a number of chemical products to abnormal figures. Many manufacturers who are more or less dependent on the chemical trade for their supply of materials are finding it increasingly difficult to obtain their needs, and it is certainly time that Canada turned her attention to the development of what is beyond any doubt the foundation of the majority of other important industries.

The country possesses certain unique advantages that should enable it to produce many chemicals at a much lower cost than can be done either in the United States or Europe.

The principal of these advantages are: 1. The immense extent and richness of her mineral resources, more especially those classed as non-metallic. 2. The enormous amount of water-power available in many districts and the exceedingly low figures at which electrical energy can be supplied to the consumer in either large or small quantity. 3. The excellent transportation facilities provided by three great transcontinental railways, their branches and other smaller lines, together with the Great Lakes and their connecting channels leading to tidewater and the markets of the world. 4. An abundance of cheap land located within short distances from the sources of raw material and adjacent to the water-powers and transportation routes referred to. 5. An ample supply of intelligent English-speaking labor obtainable at very reasonable rates.

Very little has hitherto been attempted in the way of the production of chemicals in the Dominion, the public, and to some extent the consumers of these substances, being largely ignorant on the subject. Within the last three months the writer has received numerous enquiries from the users of chemicals and even raw minerals, whose supply had been obtained from abroad and was now cut off.

In many cases these firms could have obtained an equally good article at a lower price in their own country, but were ignorant of its existence here. And few of them realize how, with a small and comparatively inexpensive plant, they could supply themselves with cheap home-made chemical material derived from Canadian resources.

There are few manufacturing concerns to-day that are not to a certain extent dependent on the chemical industry for a portion of their material, and it may be confidently asserted that the establishment of each and every chemical plant would mean the starting up of two other outside enterprises.

The foundation of all chemical industry is the production of an ample supply of cheap sulphuric acid. Following this in order of importance comes the alkali industry, this term being now generally restricted to the manufacture of sodium compounds from common salt. Coal tar and ammonia products take the next place, together with the alcohols (both ethyl and methyl), and chemicals derived from the distillation of wood. The combination of the sulphuric acid and alkaline products furnishes hydrochloric acid, bleaching powder, calcium chloride and salt cake, all consumed in large quantities and constituting the base for hundreds of other operations. With the addition of imported sodium nitrate (Chilè saltpetre), nitric acid and nitre cake are produced. For the manufacture of sulphuric acid the country can supply an excellent grade of pyrites in ample quantity and the only other raw material necessary in this branch of the trade is the Chilian nitrate of soda. The utilization of the sulphurous fumes from Sudbury and other smelting works would assure a supply of acid far in excess of all demands for years to come.

In the manufacture of coal tar products and more particularly the aniline colors, large quantities of concentrated and fuming (Nordhausen) sulphuric acid are essential, and it is necessary that these be obtainable at a reasonable price.

The following list of chemicals will give some idea as to the extent of the industry that it is possible to develop, and indicates roughly the raw materials from which the products are derived, all of which may be procured in the country.

From coal, distilled in bye-product coke ovens and also from gasworks: Coke, gas carbon, coal tar, ammoniacal liquor, pitch, sulphate of ammonia, liquor ammonia or ammonia hydrate, ammonia carbonate, muriate chloride, nitrate, and sal ammoniac.

Cyanides of sodium and potassium, ferro and ferri cyanides (red and yellow prussiates), benzole, tolnole, solvent naphtha, creosote oils, grease oils, naphthalene, anthracene, nitro-benzol, aniline oil, xylole, cresylic acid, carbolic acid (cresol and phenol), picric acid, trinitrotalual, dinitrochlor benzol, alpha and beta naphtols, saccharine and the numberless aniline colors and synthetic compounds used in medicine.

From common salt, pyrites, limestone, quartz and ammonia: Caustic soda, soda ash, soda crystals, pure sodium carbonate and bicarbonate, ammonia alkali, silicate of soda (water glass), calcium chloride, bleaching powder, sodium peroxide, liquid chlorine gas, sodium sulphate (salt cake), and hydrochloric acid.

From onthoclase or potash felspar, sulphuric acid, hydrochloric acid, lime, gypsum, apatite, common salt and salt cake: Potassium sulphate and chloride, fertilizing salts, potash alum, alumina, di-calcium silicate, phosphoric acid and certain phosphates.

From magnesite, dalomite and serpentine, sulphuric acid, hydrochloric acid, lime and common salt: Magnesia, magnesia alba, magnesia sulphate (Epsom salts), chloride and carbonate, with liquid carbonic acid gas.

From cordwood and mill refuse, lime and other bases, with sulphuric and hydrochloric acids: Methyl alcohols, methyl acetate, acetone, wood tar and its derivatives, creosote oil, acetates of lime, lead, iron, alumina, soda, potash, chromium and copper, acetic and pyroligneous acids, oxalic acid and salts of the latter.

From chromite, molybdenite, walfram, scheelite, apatite, limestone and coke by electrothermic treatment: Ferro-chrome, ferro-tungsten, ferro-molybdenum, phosphide of iron and phosphorus, calcium carbide, cyanamide, and nitrate of lime, cyanides of sodium and potassium.

From chromite, tungsten ores, molybdenite and apatite by chemical treatment: Bichromates of soda and potash, chromic acid and chromates, tungsten acid and tungstates, molybdic acid and ammonium molybdate, phosphoric acid, phosphorus and sodium phosphate, superphosphate and other fertilizers.

From barytes: Chloride, nitrate, carbonate and sulphate of barium blanc fixe, barium peroxide and hydrogen peroxide.

From fluorspar, sulphuric acid, ammonia and soda salts: Ammonium and sodium fluoride, hydrofluoric acid and hydroflusilicic acid.

From arsenical pyrites and nickel and cobalt arsenites: White arsenic, arseniates of lead and soda, arsenite of potàsh and arsenic acid, Paris green, sheep dips, weed killers, insecticides and spraying mixtures for agricultural and horticultural purposes, cobalt and nickel oxides and other salts of the same metals including nickel plating salts.

From manganese: Sulphate and borate of manganese, permanganates of sodium and potassium, and sodium manganate.

Other lines of manufacture that might be found profitable are: Ethers and chloroform, ethyl chloride, iodoform, amyl compounds, carbon bisulphide, formaldehyde, sulpho-carbolates and cresyalates, chloral hydrate, cream of tartar and tartaric acid, preservatives, antiseptics and disinfectants, salicylic and benzoic acids, sulphurous acid, sulphites and hyposulphites, metallic resineates and linoleates and drying compounds.

The chemical processes of to-day are largely electrolytic or electrothermic ones and outside of Norway no other country than Canada can offer such a cheap and abundant supply of electrical energy.

The fixation of atmospheric nitrogen, together with the production of nitric acid, nitrates, and cheap fertilizing material is a most attractive field for Canadian enterprise, which on account of the growing demand for fertilizers from our great Northwest must be seriously considered.

Synthetic ammonia is another possibility which has to be taken into account. The Badische Analin and Soda Fabrik in Germany were producing on a large scale when hostilities commenced, the results being highly profitable. The German works have absolutely no advantages that cannot be found in this country and, given the necessary experience in operating, Canada should prove a successful competitor.

The electrothermic production of ferro alloys is another suitable enterprise for the country to undertake, with its extensive deposits of chromite, molybdenite and tungsten.

The manufacture of the aniline or synthetic dyes is now a popular theme for discussion, but it must be remembered that there are some difficulties to be surmounted before this industry can become a reality here.

As previously mentioned, the business demands a large quantity of both ordinary concentrated sulphuric acid and the fuming or Nordhausen variety which must be obtainable at a cheap figure. A good deal has been said both in Great Britain and Canada as to allowing the manufacture, duty free, of ethyl alcohol for industrial purposes. While both ethyl and methyl alcohols, together with ethylic ether, are largely used in the production of the synthetic dyes it is not their cheapness alone that has given Germany the control of this market. There are many complicated operations involved between the recovery of the primary coal tar products and the finishing process of any one single color to obtain which plant costing up to $50,000 may be necessary. Some kind of government protection or assistance is needed which might either take the form of a protective tariff or the abolition or reduction of patent royalties now and for a reasonable period after the war. In Great Britain the firms engaged in this branch are now combining into a strong organization to which the state will furnish financial assistance.

The first step to be taken in this country is the recovery of more bye-products from the coke ovens and gasworks. At present there is only one concern operating by-product ovens on Canadian coals, the majority of the mines adhering to the old beehive oven or at the best utilizing the gases for steam raising. The recovery of these valuable coal tar and ammonia compounds at every coke oven plant would be a great step forward in national conservation.

Among the salts the alkaline bichromates and cyanides offer a good opening, together with the compounds of magnesia, the latter being largely employed in the manufacture of jointless floorings and the cyanides finding an extensive market in our gold milling plants.

Small chemicals and pharmaceutical products, synthetic perfumes and essences, formerly of German origin, are a fascinating branch and one that English manufacturers are now giving close attention to. There are a large number of what are called organic intermediate products obtained from coal tar by chemical transformation and apart from the dyes. Aspirin and other salicylic acid derivatives may be particularly referred to as being in great demand, and there are many other compounds of which the same might be said.

It can be seen that there is ample opportunity for both the large and small producer in heavy and in small chemicals. The consumers of large quantities of chemical material should follow the lead of the British firms and themselves become producers, owning their independent resources of raw material.

The practical operation of all plants should be controlled solely by skilled technological chemists, with whom research work for improvement of treatment must, as in the foreign factories, become a part of their daily routine. The status of the technical engineer or chemist in this country is, as a rule, entirely disproportionate to his skill and training, the business man being paramount in most undertakings. The technical man should be raised from his present position as an academic adjunct and given a full voice in the control of all technical enterprises.

BRITTLENESS IN SOFT STEEL.

The extreme brittleness brought about in soft steel by working at a blue heat, that is, from about 400° to 650° F., is a well-known phenomenon. It is often so great that insignificant causes, especially light blows and shocks, are sufficient to cause fracture. There are no exact figures, but according to experiments made by Dr. E. Preuss, of the University of Darmstadt, a small elongation of soft steel at a blue heat is sufficient to bring about remarkable increase in brittleness. In all cases the higher temperature gives the worst results. The brittleness increases very rapidly with increase in the amount of elongation given. It is the more extraordinary because no change in structure can be found, even with the highest magnification. If this were not the case it would be easy to separate the brittle material by microscopic examination of a small piece the removal of which would not injure the material. The only difference found was that often the larger slag inclusions were broken, but this is also seen in pieces stretched to the same extent at ordinary temperatures.

A reinforced concrete pontoon for a landing stage for ferry service, has recently been put into use in Sydney harbor, Australia. The pontoon is 160 feet long, 43 feet wide at one end and 68 feet wide at the other, seven feet nine inches deep and has a freeboard of 22 inches. The bottom of the pontoon is flat and the sides and ends are sloped to an angle of 70 degrees.

Coast to Coast

Fredericton, N.B.—The St. John Valley Railway has been taken over by the Intercolonial Railway Co.

Vancouver, B.C.—Train service has been established on the entire line of the newly-completed Kootenay Central Railway. It is 160 miles long.

Victoria, B.C.—Canadian Northern rails are en route for Victoria from Sydney, Cape Breton, via the Panama Canal. The Gladstone, 3,087 tons, sailed from Sydney in November, and is expected to arrive in Victoria in a few days.

Sydney, N.S.—The Nova Scotia Steel and Coal Co. will shortly be working at full capacity. An important order in hand is that for the manufacture of war material for the government, and consists chiefly of manufacture of steel cases for shrapnel shells.

Vancouver, B.C.—Less than 100 miles of track will now complete the British Columbia divisions of the Canadian Northern Railway. Steel bridge work between Lytton and Kamloops has been completed. A tunnel 330 ft. long is being bored at mile 128 north of Kamloops.

Point Grey, B.C.—W. B. Grier, municipal engineer, in his annual report, states that there are in the municipality 16.155 miles of paved streets, 49.75 miles of macadam roads, 29 miles of cement sidewalks, 78 miles wooden sidewalks, 53.5 miles of sewers, 10 miles of storm sewers, and 104 miles of water mains. He estimates the cost of necessary work for 1915 at a little over $152,000.

Montreal, Que.—The work of linking up the new Cedars Rapids Power and Manufacturing Company's development with Montreal was completed last week, the company being now ready to deliver power to both the Montreal Light, Heat and Power Co. and to the Aluminum Co., under contracts, which date from January 1st, 1915. It is significant to note that despite the mishap which occurred a month ago the new company is ready to operate in advance of the stipulated time. Mr. J. E. Aldred is president of both the Shawinigan and Cedars Rapids Companies.

Hamilton, Ont.—The industrial situation has brightened remarkably of late. The Steel Co. of Canada has a million dollar order for special steel for Great Britain and France, and will shortly commence running full blast. The Canada Steel Goods Co. is also working full time. Large orders for shells are keeping busy the plants of the Canadian Westinghouse Co., Otis-Fensom Elevator Co., Chadwick Brass Co., Hamilton Brass Co., and others. The Hamilton Bridge Co. is rushing the work on the steel for the Don section of the Bloor Street viaduct. The Royal Connaught Hotel and the Proctor-Gamble building are being proceeded with.

Montreal, Que.—The board of control has before it a proposal to construct a tunnel under the Lachine Canal at the Wellington Street bridge for the greater convenience to the Point St. Charles populace and avoidance of delay in navigation on the canal. The Federal government and the Montreal Tramways Co. will be asked to contribute toward the cost of construction, which is estimated at $750,000. The tunnel, if proceeded with, will be built about 50 ft. below the present water level. The approach at the west end would be at Bridge Street, and at the east end near Murray Street. A sum of $1,500 was voted toward the preparation of plans. At that point the canal is about 20 ft. in depth, and provision has been made in the estimate to provide room for deepening it further, as contemplated by the government.

PERSONAL.

J. W. PURCELL has been appointed manager of the branch office just opened at 1206 Union Trust Building, Winnipeg, by the firm of F. H. Hopkins and Co., Montreal.

CHAS. SHERGOLD, second Lieutenant in the corps of the Royal Canadian Engineers, has been the recipient of a medal for distinguished service in the field at Tour de Passy.

S. B. WASS has just been appointed assistant superintendent of the St. John and Quebec Railway, in charge of station service, train service and track, with office at Fredericton, N.B.

E. A. STONE, Ma. E., M. Can. Soc. C.E., consulting engineer, with offices in Vancouver, B.C., has recently accepted a professorship in structural and municipal engineering at the School of Mines, Queen's University, Kingston, Ont.

A. P. COLEMAN, professor of geology in the University of Toronto, has been elected president of the Geological Society of America, which met in Philadelphia last week in connection with the annual convention of the American Association for the Advancement of Science.

J. J. McMANUS has been appointed assistant superintendent of the National Transcontinental Railway, between Harvey Junction and Parent, Que., in charge of station service, train service and track, with office at Harvey Junction, P.Q.

GRANT HALL has been appointed vice-president and general manager of the Canadian Pacific Railway Company at Winnipeg, of lines west of Port Arthur. Since 1911 he has been assistant general manager of western lines of the C.P.R., previous to which date he was for some years superintendent of motive power of western lines.

E. V. BUCHANAN has been appointed to take full charge of the work of the Public Utilities Commission of London, Ont., relieving General Manager H. J. Glaublitz and Assistant Manager Hunt of their duties while the latter are engaged in a special investigation. Mr. Buchanan has been attached to the Commission as electrical engineer.

CLIFFORD SIFTON, chairman since 1909 of the Commission for the Conservation of Natural Resources, Canada, has received the title of Knights Bachelor from the King. He has spent many years in public service, and in 1903 was agent for the British Government before the Alaska Boundary Tribunal.

J. W. LEONARD, assistant to the president of the Canadian Pacific Railway Company, is resigning the position to become superintendent of the Toronto Terminal Company, the organization in charge of the construction of the proposed Union Station and terminal developments for the city of Toronto. Mr. Leonard has been in railroad work since 1872.

GEORGE JOSEPH DESBARATS, deputy minister and comptroller of naval service, and formerly deputy minister of marine and fisheries, Canada, has been honored by the King with the rank of C.M.G. (Companion, St. Michael and St. George). The recipient of this distinction is a graduate of Laval University, and holds the degree of B.A.Sc. He has had an extended experience in public service as engineer on canal construction and other works. In 1901 he rebuilt and enlarged the Government shipyards at Sorel, Que.

HERBERT SAMUEL HOLT, M. Can. Soc. C.E., president of the Montreal Light, Heat and Power Company, and President of the Royal Bank of Canada, has had the title of Knights Bachelor conferred upon him by the King. Sir Herbert came to Canada as a civil engineer in 1875, and has acted successively as engineer for the Credit Valley, Victoria, Lake Simcoe Junction, Ontario and Quebec and other railways in Ontario. In partnership with Messrs. Ross, Mackenzie and Mann he built in 1889-92 the Regina, Qu'Appelle and Long Lake and the Calgary and Edmonton Railways, aggregating 550 miles. Since 1892 he has devoted his time largely to finance and banking, becoming associated with many successful enterprises.

OBITUARY.

The death is reported from Vancouver, B.C., of Mr. George Herbert Webster, civil engineer, formerly with the Canadian Pacific Railway, and a member of the Canadian Society of Civil Engineers since 1887.

AMERICAN INSTITUTE OF CONSULTING ENGINEERS.

The annual meeting of American Institute of Consulting Engineers, Inc., will be held Tuesday, January 19th, 1915, at the City Club, 55 West 44th Street, New York City, at 8 p.m. Three members of the Council will be elected Reports of the Council and of special committees will be presented. Ballots will be canvassed also for the adoption of amended constitution and by-laws as prepared by the special committee appointed at the last annual meeting. Eugene W. Stern, C.E., 101 Park Avenue, New York, is Secretary of the Institute.

AMERICAN FORESTRY ASSOCIATION.

The annual meeting of the American Forestry Association will be held at the Woolworth Building, New York City, on Monday, January 11th. Dr. Henry S. Drinker is President, and Mr. P. S. Ridsdale, Washington, D.C., is Secretary.

ADVANCEMENT OF SCIENCE.

Section D—Engineering, of the American Association for the Advancement of Science, held its annual convention in Philadelphia, December 30th and 31st. Dr. Fredk. W. Taylor, Vice-President of the Section, presided. Prof. Arthur H. Blanchard, of Columbia University, New York City, is Secretary.

CANADIAN FORESTRY ASSOCIATION.

The 16th annual business meeting of the Canadian Forestry Association for the consideration of reports, passing of accounts, dealing with business arising out of the same, the election of officers, etc., will be held in the assembly hall of the Carnegie Public Library, Ottawa, on Tuesday, January 19th, at 8 o'clock p.m. Though the war takes up most of the national attention and energy, yet work so vital to the continued well-being of the nation as the protection of our natural resources should be pressed forward as vigorously as circumstances permit, so that after the war our people will have the raw material out of which to build up renewed prosperity. That all who can attend and take part will do so is the request of Mr. William Power, M.P., President, and Mr. James Lawler, Secretary.

The Commission of Conservation holds its annual meeting on the mornings and afternoons of January 19th and 20th, in its offices opposite the Carnegie Library, so that those attending can participate in both meetings.