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THE GARRISON CREEK STORM OVERFLOW SEWER IN THE CITY OF TORONTO.

By RAY R. KNIGHT, C.E.*

The occurrence and recurrence of flooding during heavy rain-storms, due to the inadequate provision of sewers in many parts of Toronto, necessitated a complete system of storm relief sewers. The sewer department of the city engineer's office took the matter up and a scheme was laid down and estimates provided for the purpose of putting a by-law before the ratepayers on January 1st, 1911.

The scheme, which has been partly carried out, follows mainly the lines of the original lay-out. Some deviations, however, were found advisable when details and construction matters were gone into.

The sewerage of Toronto is on the combined system. The general topography of the city is a steadily rising, fairly even surface from Lake Ontario at the south to the ridge about 2½ miles north. The surface is intersected at intervals by natural creeks running from north to south in more or less direct lines, the notable exception being Rosedale Ravine, which follows a southeasterly course to the Don. Steps were not taken in the past to reserve, for purposes of main sewers, these natural creeks, excepting the Garrison Creek and Rosedale Ravine; the general sewerage scheme consisted of a number of sewers flowing into the lake and bay along streets running north and south. The Garrison Creek sewer, however, provided a good example of the treatment which could have been adopted in other parts of the city, with King, Queen, College and Bloor Streets as intersecting parallels. The Garrison Creek sewer is, at the present time, inadequate for the removal of the storm water from the

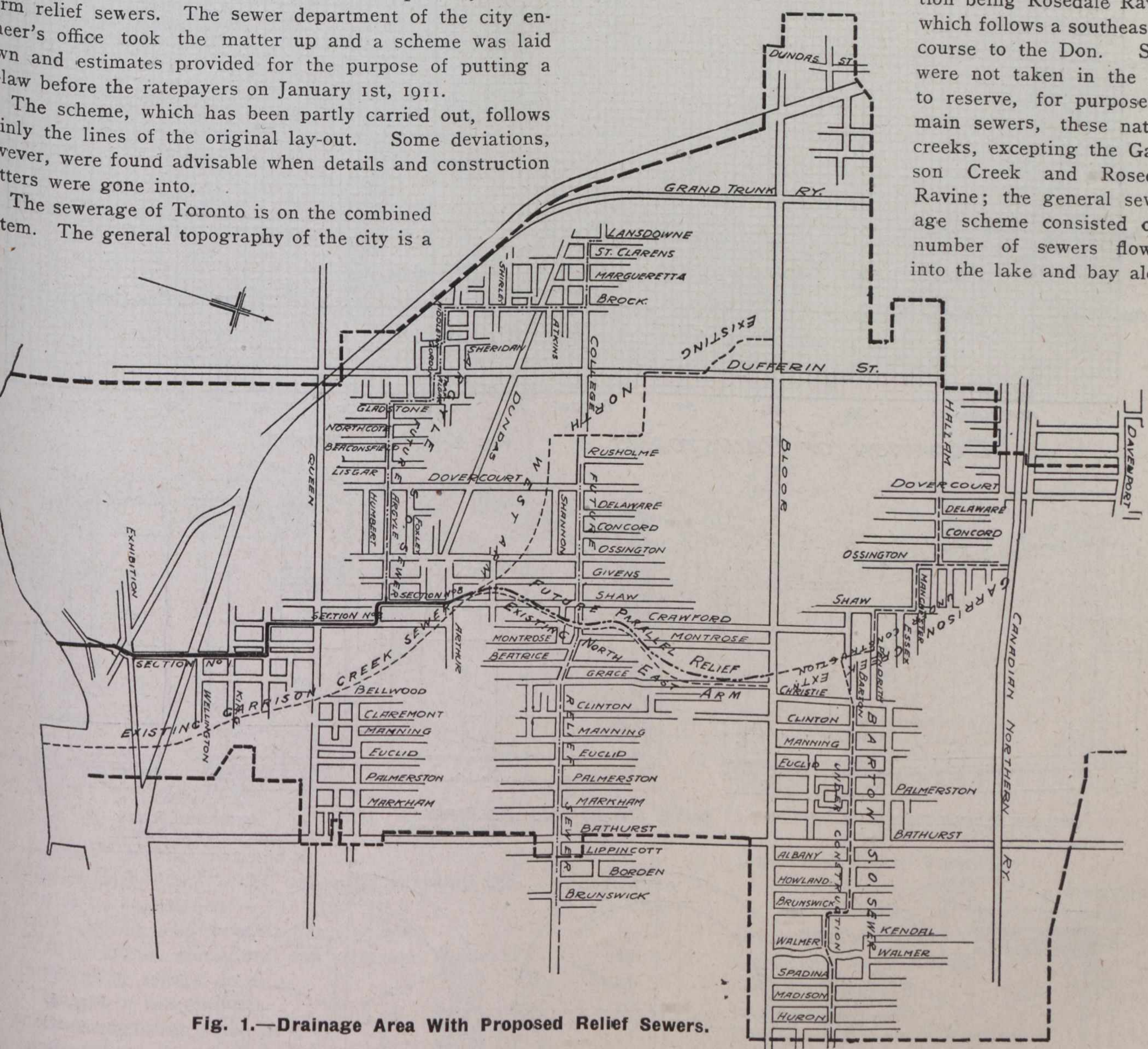

Fig. 1.—Drainage Area With Proposed Relief Sewers.

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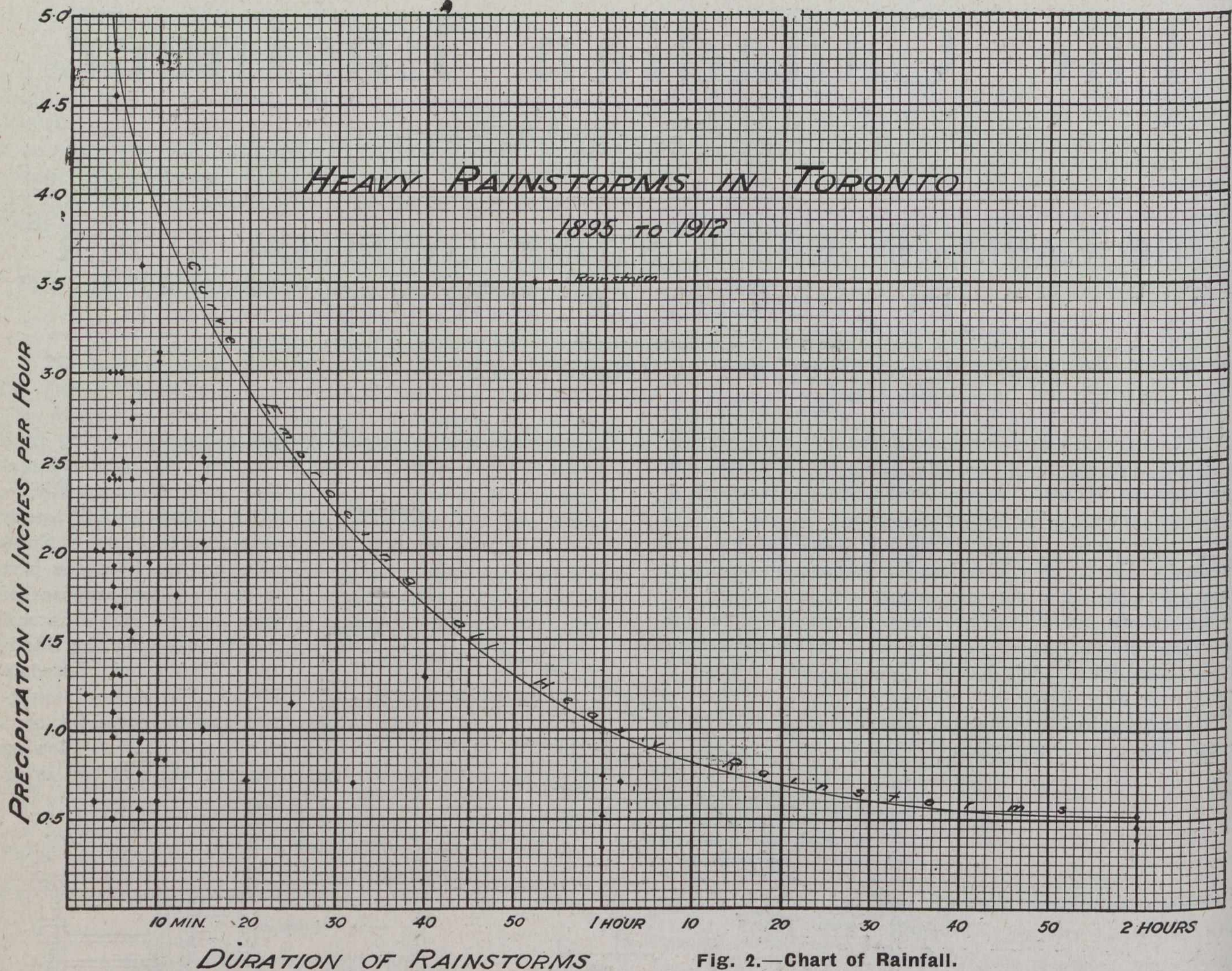


Fig. 2.—Chart of Rainfall.

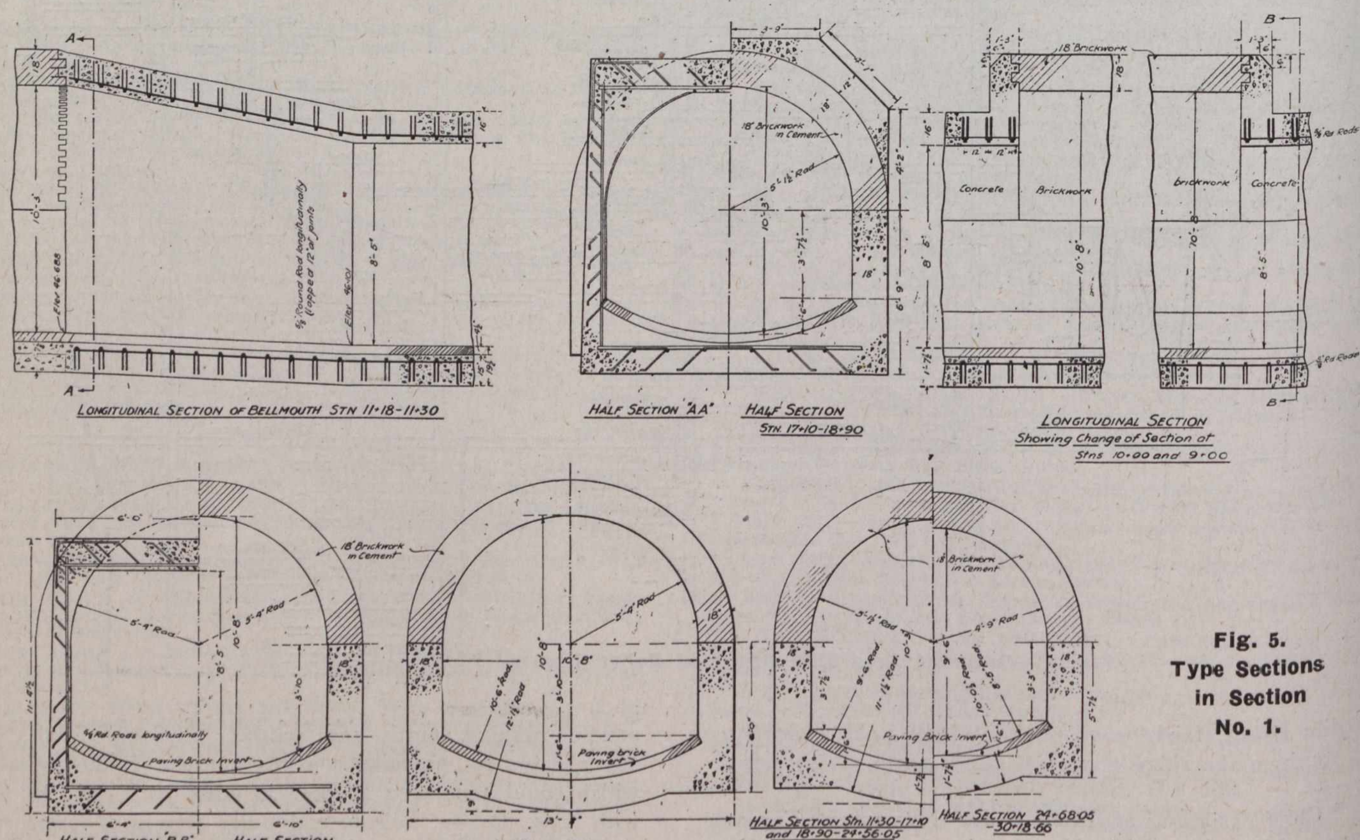


Fig. 5. Type Sections in Section No. 1.

drainage area which has from time to time been extending both northerly and westerly. The outcome being the backing up and flooding of the parallel intercepting sewers, themselves much overtaxed, and the consequent flooding of tributary sewers.

Relief had to be provided before the northerly areas were developed and sewered. It was, therefore, decided to relieve the Garrison Creek sewer at its bifurcation to the northeast and northwest, just north of Arthur Street.

It is the intention of this article to describe the design of this relief sewer, called the main Garrison Creek storm including all drawn in. It was found that 45 minutes was a fair average for concentration in the intercepting parallels, and that being the case, reference to the chart will show that a rate of 1½ inches per hour is indicated on the curve drawn. This rate was taken in all calculations for the storm sewers.

Rate of Absorption.—The rate of absorption was fixed arbitrarily for certain areas of the city from general knowledge of the localities, based upon a series of actual surveys, made for the purpose of ascertaining the proportional relation of impervious to pervious areas. The result of these surveys is given below:—

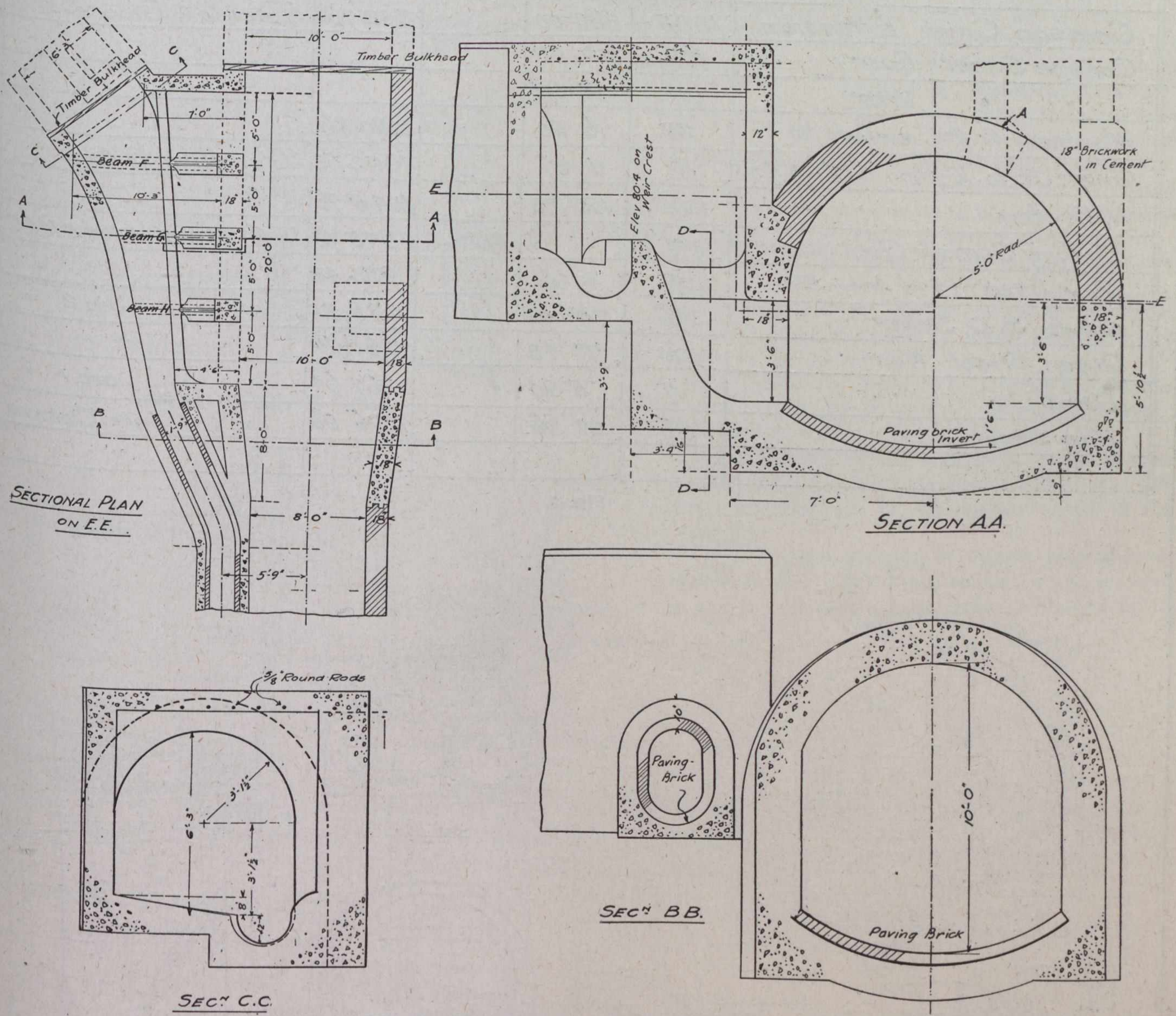


Fig. 8.—Weir Chamber, Argyle Street.

overflow sewers. Sections 1, 2 and 3.

In order to design the relief sewer the following particulars had to be ascertained:—

(1) The existing and probable drainage area.

(2) The locations, elevations and drainage areas of parallel intercepting sewers.

(3) The rate of precipitation.

(4) The rate of absorption, etc.

(5) The probable discharge due to heavy rainstorms.

Drainage Area.—Fig. 1 shows the drainage area with the proposed relief sewers.

Rate of Precipitation.—In order to fix upon a rate of rainfall for which provision would be necessary, the diagram shown in Fig. 2 was prepared. The heavy rainstorms since 1895 are plotted by "diamonds" on this chart, and a curve

Impervious Areas—Toronto.

Population per acre.	Remarks.	Impervious area.
19	Open, good property	.19
24	Shops and old dwellings	.43
25	Good new property	.21
30	Good new property	.19
30	Good property, small gardens	.37
36	Good new property	.37
37	Good new property	.36
42	Good new property, large gardens	.26
50	Ordinary terrace houses	.36
55	Good new property	.37
60	Good new property	.33
65	Old terrace houses	.43

	Acres	Rainfall in C.F.S.	Sub Totals	Summation of Rainfall	Remarks
Bloor Street East	120	61.47			
" " West	238	119.29			
Garrison Creek Extension	1338	668.00		848.76	Total at Bloor St.
College Street East	169	119.68			
" " West	166	95.92			
Montrose Av & Crawford St	29	16.50		1080.86	
College St. to Junction N.E. & N.W. Arms	18	11.67		1092.53	Total for N E Arm
N. W. Arm	285	153.23		1245.76	
Existing Garrison Creek sewer to take out			300.00	945.76	Total at end of Sec. 3 M.G.C.
Shaw Street (S of Arthur St)	7.	4.66		950.42	
Argyle S. O. Sewer	375	237.89		1188.31	" " " " Sec 2 "
Queen Street West	106	73.43		1261.74	
Defoe "	7	5.90		1267.64	" " " sec. 1 "
King Street	36	29.26		1296.90	" " Lake Ontario

Fig. 3.

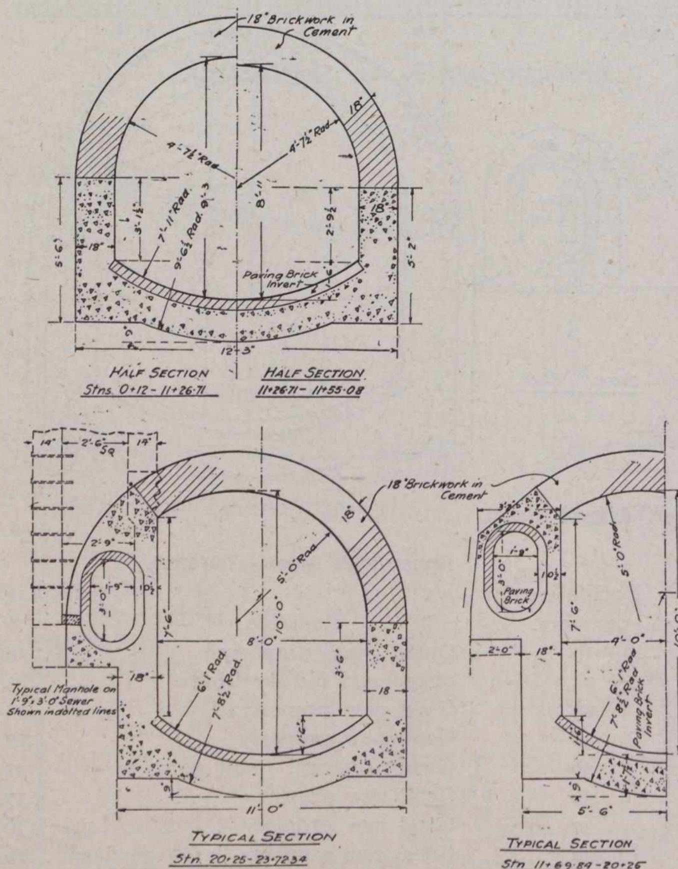


Fig. 6.—Junction Chamber, Section No. 2.

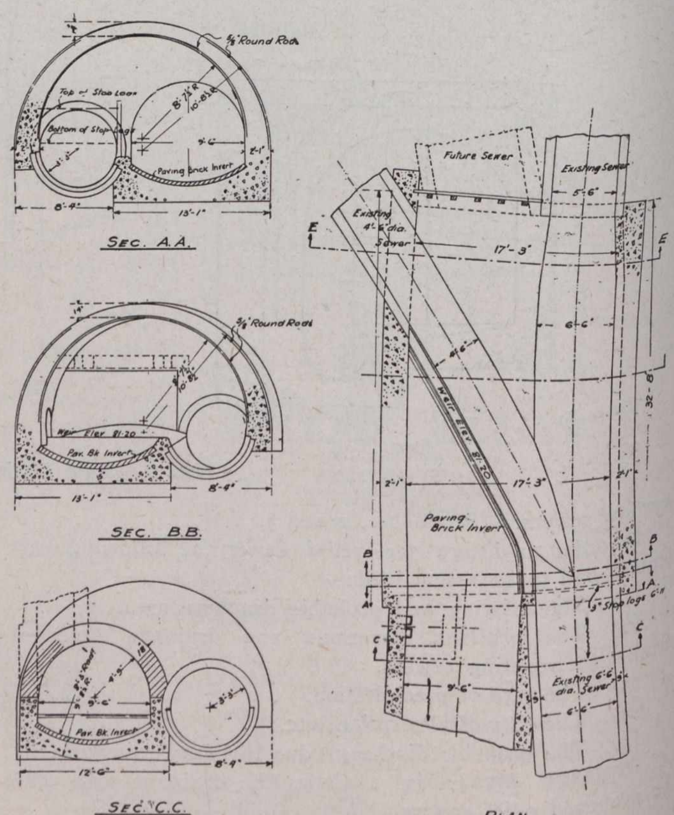
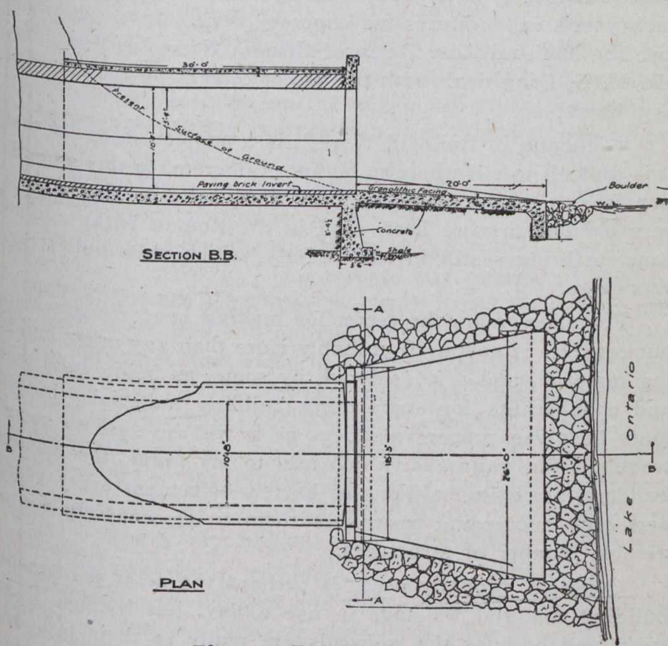


Fig. 9. Junction Chamber, Section No. 3.

Discharge Due to One and One-half Inches Rainfall.—The diagram shown in Fig. 3 was prepared showing the discharge in cubic feet per second at all points along the line of the proposed storm relief sewer, due to a rainfall of 1½ inches per hour with absorption varying between 30 per cent. and 50 per cent.



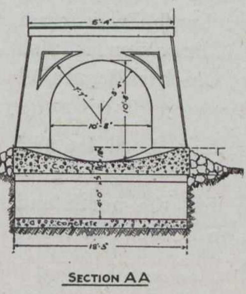
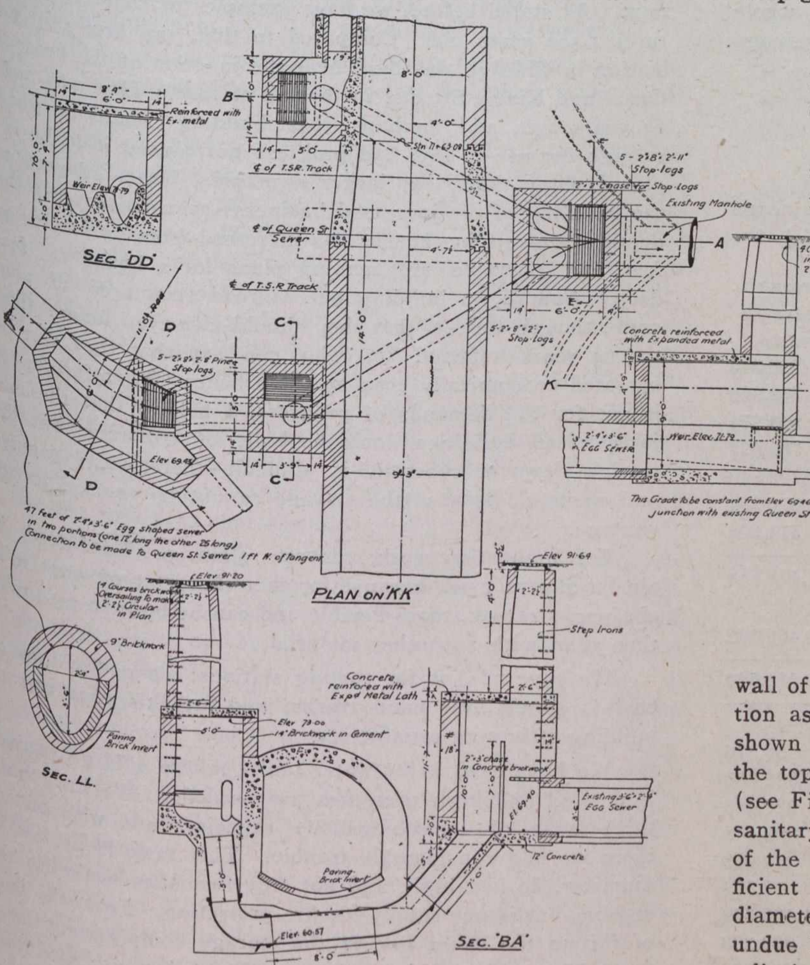


Fig. 4.—Details of Outlet.



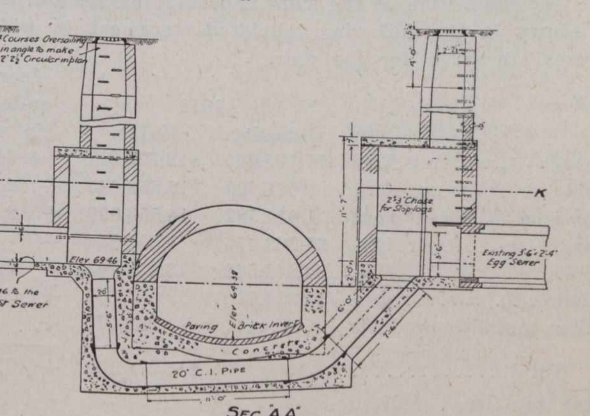


Fig. 7.—Syphons at Queen Street.

Design of the Relief Sewer.—At the point selected for relief of the existing Garrison Creek sewer it was found that a quantity equal to 945.76 cubic feet per second had to be taken by the relief sewer which, on its course to the south, receives additional discharges until at its outlet a capacity of 1,296.90 cubic feet per second is required.

Generally speaking, grades are good, and give high velocities—much above the orthodox sewer requirements. However, these sewers are idle most of the time, so that matters of wear and tear, due to high velocities, do not figure.

Starting at the lake (south end) at the 0+00 of Section No. 1, a headwall is provided for the 10-ft. 8-in. by 10-ft. 8-in. arch and invert culvert. This headwall with the apron is not designed as a permanent structure in view of a probable future extension into the lake to the sea-wall limit. Fig. 4 gives the details of headwall and apron. Fig. 5 shows the type sections adopted in Section No. 1. The flat top section was necessary in order to pass under the railway tracks and to get a minimum 4 feet of cover from top of sewer to base of rail, as required by the Railway Board, order No. 13494.

With the exception of the portion across the railway tracks the culvert was designed for tunnel work, and is being executed in that manner.

At King Street the high level interceptor had to be crossed, and special invert castings provided in order to keep grade in both sewers.

The existing sewers and proposed relief sewers draining into Section 2 presented difficulties which have been overcome in the manner shown in Figs. 6 and 7.

Fig. 6 shows the type of culvert adopted in this section of the work. From station 11+54 to 23+73 it will be seen that a small sewer is "tucked in" the wall of the culvert. This sewer has a flow in the same direction as the culvert, but as at a smaller grade. The type shown is for tunnel execution, the complete arch section of the top exterior being the main feature. At Queen Street (see Fig. 7) two syphons had to be constructed to take the sanitary sewage across the line of storm sewer. The grade of the existing Queen Street sewer did not permit of a sufficient hydraulic head being given so that excessively large diameter syphons had to be designed so as to permit any undue loss of head. A small overflow chamber is shown relieving the Queen Street sewer at this point.

At Argyle Street and Shaw Street (the end of Section 2) a large weir chamber is provided, as shown in Fig. 8. This is the overflow chamber for a proposed intercepting combined sewer, the sanitary flow from which is taken in the small sewer in the wall of the culvert to Queen Street and discharged there into the existing sewer via the syphon (to the north) shown in Fig. 7.

Section 3 completes this sewer and comprises a culvert, as before, with an overflow chamber at the existing Garrison Creek sewer. This chamber is shown in Fig. 9. The outlet of the existing sewer is throttled by adjustable stop-logs, so as to prevent any excess of storm water passing down. The sanitary sewage is prevented by the weir from running into the storm overflow sewer. Provision is also made in this chamber for a future sewer, which will parallel the existing one from the north.

Contracts for the whole of this work have been let and work is in progress all along the line. Tunnelling is general throughout, although it is probable that the north end of Section 3 will be executed in open-cut on account of made ground which is revealed by the borings.

Alternative tenders were called for brickwork arch, concrete arch of same dimensions as brick, and reinforced concrete arch. In every case the concrete arch (without reinforcement) was adopted as lowest in cost.

The borings throughout gave indications of good hard clay. In Section 2 water was revealed in small quantities and shale is reached.

The total contract cost of the sewer, which is 6,909 feet long, is $318,000.

Provision of the sum of $125,000 has just been made for the paralleling of the existing Garrison Creek sewer from the north end of the work described here to Bloor Street, completing the necessary relief and connecting up the whole system of storm overflow sewers for this particular drainage area.

CANADA'S MINERALS.

The production of the more important metals and minerals is shown in the following tabulated statement in which the figures are given for the year.

	1912 Quantity.	1912 Value.	Increase or decrease in value.
Copper ....Lbs.	77,775,600	$12,709,311	+$ 5,822,313
Gold ....Ozs.	607,609	12,559,443	+ 2,778,366
Pig iron ....*Tons	1,014,587	14,550,999	+ 2,243,874
Lead ....Lbs.	35,763,476	1,597,554	+ 769,837
Nickel ....Lbs.	44,841,542	13,452,463	+ 3,222,840
Silver ....Ozs.	31,931,710	19,425,656	+ 2,070,384
Other metallic products	....	982,676	+ 571,344
Total..............		$75,578,102	+$17,478,958
Less pig iron credited to imported ores	987,232	14,100,113	+ 2,406,392
Total metallic		$61,177,989	+$15,072,566
Asbestos and asbestic ....Tons	131,260	2,979,384	+ 36,276
Coal ....Tons	14,699,953	36,349,299	+ 9,881,653
Gypsum ....Tons	576,498	1,320,883	+ 327,489
Natural gas	....	2,311,126	+ 393,448
Petroleum ....Brls.	243,336	345,050	— 12,023
Salt ....Tons	95,053	459,582	+ 16,578
Cement ....Brls.	7,120,787	9,083,216	+ 1,438,679
Clay products	....	9,343,321	+ 983,388
Lime ....Bush.	7,992,234	1,717,771	+ 200,172
Stone	....	4,675,851	+ 347,094
Miscellaneous non-metallic	....	3,364,017	+ 1,221,175
Total non-metallic..		$71,949,500	+$14,833,929
Grand total		$133,127,489	+$29,906,495

*Short tons throughout.

CONCRETE IN RAILROAD WORK.

The railways of Canada, in their yearly expansion in road buildings, have had, among other things, to add to each year's expenditures for concrete work. In a paper before the National Association of Cement Users, at Pittsburg, Mr. M. S. Long deals with the use of cement by the railways as follows:—

"Concrete in Railroad Work," is a subject so broad that it is difficult to tell where to begin. Concrete, to this generation, seems a new material, but history tells us that it is a very old one, having been used in the Roman baths and in concrete bridges still in use in Italy, which were built 1,500 years ago.

For many years the secret for making concrete was lost, but concrete is now used probably more than any other building material, and is considered, by some, as being infallible and a substitute for every other building material; but it must be given proper treatment or it will be sure to cause trouble. The railroads, which are, to my mind, the master builders, are using millions of barrels of cement every year, and each succeeding year sees them using concrete for a greater number of structures.

Concrete, properly used, is perhaps the most permanent building material we have in use to-day, but because it is such, and because the railroads are really in their infancy, there are some structures they hesitate to make too permanent. As stated before, we have examples of concrete structures 1,500 years old. Compared to that, the first railroad station in Chicago was built near the junction of the present Canal and Kinzie Streets, in the fall of 1848. That was only 64 years ago, and perhaps that building would be good enough for use to-day, had progress not caused it to be replaced many times by larger structures, better adapted to the handling of the increased business—even in 12 years the depth of our engine houses has increased from 75 feet to 95 feet, and now we are making plans for a house 115 feet deep. And so, in building our railroad structures of concrete, though we feel that they should last even longer than the 64 years referred to, who can say that they can be operated economically even 25 years hence. Therefore, were it not for the demands of progress, I believe that the majority of all buildings would be built of concrete; but the tearing down of concrete is difficult—therefore, expensive and wasteful, because the salvage cannot be re-used to advantage.

For foundation work, concrete plain or reinforced, is almost always used, because for that character of work it is cheaper, stronger, more flexible and can be built in a shorter time than with any other material.

We have used it for coaling stations, where 800 tons of coal is stored over main tracks, and for this character of building it is very satisfactory.

We have used it for water tanks, where a large storage is desired and high pressures are needed. We have built three tanks of 100,000 gallons capacity, and with one of them we had considerable trouble. This tank is 24 feet in diameter, 80 feet high, and not only furnishes water for the engines but is our supply for fire protection. From the base of rail to the water line in the storage compartment is 50 feet. This tank was finished late in December, and was filled to within 4 feet of the top a few days after it was completed, and on the day it was filled the temperature fell to zero. It so happened that orders were not issued for engines to take water at this tank until about two days after it was filled. We found that, in the meantime, a layer of ice had formed—it being about 18 inches thick around the sides but in the centre it was not more than 1 inch thick. The water was used until the gauge showed the tank empty, and about this time the weather had moderated and the ice fell. In breaking loose, it tore the waterproofing off and this allowed the water to percolate through the walls and freeze on the outside—the ice collecting in chunks weighing a ton or more. When the weather moderated, this ice fell off and we found that the walls were damaged very little, and with an application of waterproofing on the inside and a coating applied to the exterior with a cement gun, the tank held water satisfactorily, and we have had no trouble with it since.

From the experience we gained, we would recommend that concrete structures of this character be coated inside and outside with waterproofing, and be allowed to cure before water is put in. Our trouble was caused, no doubt, by the concrete not being protected until it had thoroughly cured, and as there was still moisture in it when the zero temperature struck it, the water in the concrete froze, and when it thawed it left pores through which the water could escape.

The other two tanks are 53 feet high, and we have two reinforced concrete reservoirs, 55 feet in diameter, 12 feet high, built on the ground—the latter each hold 200,000 gallons and are giving satisfactory service. They are, each one, coated inside and out with waterproofing compound.

We have built reinforced concrete cinder pits, where hot cinders are dumped and then drenched with cold water. Here we find that concrete must be faced with vitrified brick, as alternate heat and cold cause it to spall. We have tried using slag as a substitute for stone in these pits, and find it an improvement, but it is not altogether satisfactory.

We have built pump houses, where the pumps are placed in a water-tight compartment below the water level on the outside.

Also, subways for passengers going from one platform to another. The one I have in mind being below the water level, so that it was necessary to waterproof against the water pressure. In this instance, we kept the water down by pumping and laid a cinder concrete base to receive the "Membrane" method of waterproofing. After the work was completed, the water developed a greater head than we had figured and some leaks developed. In repairing them we found that the cinder concrete, which was made from soft coal cinders, had not set up. We have since learned that others have had experience similar to ours, and upon testing it, we find that the soft coal cinders contain a great deal of sulphur. This is not true of hard coal cinders, and the latter are the only kind that should be used in concrete.

We have built one reinforced concrete engine house, as we are reasonably sure that this structure will be permanent, but we used a wood roof, as we felt that the escaping steam would condense on the cold concrete ceiling and drip off on the engine jackets.

We have built a reinforced concrete grain elevator for the storage of grain, and although the concrete was mixed rather wet, we had considerable trouble with dampness at times during hard, steady rains. We applied waterproofing to the outside of the walls and since that time have had no trouble from dampness.

We are now building an eight-story reinforced concrete warehouse in New York City, and do not expect to waterproof the exterior walls above the ground line in any way, for we believe that in a structure of this character that by careful mixing and careful placing and working the mass into place it can be made sufficiently waterproof of itself.

In conjunction with the Lake Shore & Michigan Southern Railway, we built a passenger station at Gary, Ind., which is practically all concrete. The building is Classic in design and the lines and shapes are the same as if cut stone was to be the material used.

During the past year we found that we could buy watch boxes and telephone booths, of reinforced concrete, cheaper than we could build them of wood, and we have now adopted the concrete ones as our standard.

In making plans for some small shop buildings, within the past year, we specified wood construction, also steel frame covered with metal lath, plastered both sides with cement mortar, making the concrete wall, approximately two inches thick, and were agreeably surprised to find that the bids for the steel frame and concrete were as cheap as the wood construction, and, of course, concrete was adopted.

In our track elevation work at Chicago, concrete is the principal material used, and the results obtained are very satisfactory, and the design and general appearance of that part of the work through the parks has been very favorably commented upon by the Park Board.

There are many reasons why concrete is chosen by the railroads in preference to other materials, some of them being as follows:—

1. Its rigidness, especially in buildings containing machinery.—Vibration in a properly constructed concrete building is negligable.

2. Its low cost of maintenance.—With a good concrete structure the maintenance should be very low, as the structural parts should last indefinitely.

3. Its fireproofness.—We consider our reinforced concrete structures so nearly fireproof that we carry little or no insurance on them. We do, of course, carry insurance on the contents.

4. Its waterproofness.—Reinforced concrete, when properly mixed, can be made practically waterproof against small pressures. It should be mixed wet and well worked into place to obtain this result.

5. And perhaps most important, is the cost.—Compared to a structural steel fireproof building, its cost is lower but it is more expensive than ordinary mill construction, and it is up to some of you to design a flexible form that will help cheapen the cost—a form that can be used over and over again and flexible enough to fit any wall or column.

There are a number of other things that you, who are making a life work of concrete in its various phases, should give consideration. It would be universally used as a wearing surface for freight house floors, passenger platforms, etc., were it not for the fact that its surface is so likely to become chipped and broken, and once broken it wears very fast. We are now making some tests with ironite worked into a rich mixture for wearing surface, and while this increases the wearing qualities, it is not as satisfactory as we would like. We also find that concrete floor surfaces dust badly, and it is necessary to resort to the use of linseed oil and shellac, or to hot silicate of soda, which eliminates the dust for a time.

Another adverse feature of concrete is contraction cracks. As concrete cures it has a tendency to crack, and this gives it the appearance of having veins, especially so where moisture has had a chance to enter through these small cracks. Where the mass of concrete is waterproofed this is a serious proposition, and we would like very much to have this problem solved, as I am sure many more buildings would be constructed with a concrete wearing surface, were it not for the fact that these incipient cracks ruin the appearance of the structure. A great deal of this is, no doubt, caused by finishing the surface with a very rich mixture—should it be necessary to patch voids in the surface we specify that the mixture should be no richer than the mass. We specify our concrete surfaces to be finished by rubbing with a concrete brick. We also find that where cracks occur the moisture entering the mass starts a chemical action which results in the surface being ruined by efflorescence.

Another step forward in the use of concrete would be to make it in colors. This does not mean by painting, but the coloring matter should be mixed, or probably ground, with the cement, and great care must be taken to get each batch properly proportioned. This is only a suggestion, as chemical action may make this a hard problem to solve.

I have tried coloring on two different structures. This coloring was brought about by the use of sand. On one structure we used a sand that had a reddish-brown tinge—this gave a rich, warm buff color. On another structure we used a sand similar, except that it was lighter, and this gave a color a little darker than cream. Am quite sure that concrete will have many more friends, especially in residence work, when you can produce it in colors that are warmer than its natural one.

Concrete is so lasting that you must be doubly sure to get a pleasing design and, in my opinion, your success lies in handling it in large surfaces. Don't try for too much detail, such as you see in some structures built of cement blocks.

These remarks are based on practical experience, and I trust that they will help to stimulate the discussion of the many interesting features of this broad subject.

ROAD CONSTRUCTION.

Ontario, more so than any of the provinces, has spent money and endeavored to make its road system modern and equal to present day traffic requirements. W. A. McLean, Provincial Engineer of Highways, in carrying out of the plans of the province, has had opportunities of studying and knowing the requirements of roads in a way that makes his report to the government particularly interesting. Writing, as regards road construction, he states:

A perfect roadmaking material, or a single type of road, possessing every desirable quality for service, durability, and cost, has not been found, and from natural reasons, cannot be expected to exist. Roads must be adapted to the traffic they are to carry, and since traffic differs greatly in character, road construction must be varied accordingly. The problem in general is, to use local materials to the best advantage.

Motor traffic is leading to important requirements and modifications, but gravel roads, and broken stone roads substantially as advocated by Tresaguet in France, and Telford and Macadam in England, continue to be the mainstay of road-building.

All roads are important and each deserves a type of construction and system of maintenance in keeping the traffic over it. Some roads have only an occasional vehicle passing over them; others may have an average of 1,500 vehicles of all descriptions. Some carry light single-horse vehicles principally; others have a greater proportion of heavy teaming. The amount of motor traffic varies from roads which have few automobiles to those which have a large number of motors and few horse-drawn vehicles. A gravel road will give good service to a considerable amount of light driving; and an oiled gravel road will serve a very large motor traffic if there is a small proportion of horse-drawn vehicles. A water-bound macadam road is easily maintained under a considerable amount of heavy teaming and light driving, but if even a small proportion of rapid motor traffic is added, the cost of maintenance is much increased; and if motor traffic is of large amount, an asphalt or tar binder becomes necessary, or a durable pavement should be considered. Painting with tar or asphalt will give good service where motor traffic is heavy, with few horse-drawn vehicles; but if proportions of travel are reversed a bituminous paint coat is much less effective. These examples suggest some of the factors entering into the design of a road.

Road Classification.—The roads of Ontario may, for a consideration of construction, be broadly divided into three classes; one grade merging into another, however, at the arbitrary dividing line. It is estimated that in the organized counties of old Ontario there are 50,000 miles of road, and a classification would be approximately as follows:

1. Trunk roads connecting the large towns and cities	5%	or	2,500 miles
2. County or leading market roads	12%	or	6,000 miles
3. (a) Main township roads	50%	or	25,000 miles
(b) Secondary township roads	33%	or	16,500 miles
Total	100%	or	50,000 miles

In the foregoing classification, the roads described as "Trunk Roads" are, with the exception of a few connecting links, among the most important of the county roads, and are heavily travelled for local market purposes, but they carry as well an increasing amount of through inter-urban traffic. The heavy and complex nature of this traffic requires, as a rule, construction of the most durable type varying from a concrete, brick, or other durable pavement to first-class macadam. The classes one and two, including trunk roads and leading market roads, thus include two divisions of what would be the main county roads of the Province. These comprise 17 per cent. or 8,500 miles in all, which if properly selected and constructed should carry 80 per cent. of the traffic of the Province.

The main township roads comprise principally the concession roads on which numerous farms front and which converge into and create the traffic of trunk or county roads. The more important of these should be metalled with gravel or broken stone, if available. Secondary township roads include the little travelled connecting roads which should be graded and given such further treatment as circumstances may permit. The first need for the roads classified as township roads is thorough grading, draining and bridging, and systematic maintenance with the log drag.

Gradients adopted, amount of camber or crown, width and depth of metal, foundation if any, drainage, binding material, and other details, should, as suggested, be largely dictated by the degree of traffic. A good road attracts and creates traffic so that the construction of any one road is very likely to raise it from one class to a higher grade, a matter which should not be lost sight of in planning improvement. Methods of construction should be as simple and direct as proper results will permit. There should, for true economy, be a well adjusted average between maximum service and minimum cost.

Trunk Roads.—Broken stone roads of the best class have been reduced to a few well-defined types, through more than a century of experience in England, France, Germany, and on this continent. The true macadam road has a well-defined and crowned earth sub-grade, over which is spread a uniform coating of finely broken stone of about 2½ inches diameter. The Telford road has a foundation of flat quarry stones, placed by hand, on edge, the angular points being chipped off by hammer and wedged into the interstices; and over all is spread a coating of finely broken stone, in thickness about one-third of the total depth of the stone surface. The earth sub-grade is flat and larger stones are used at the centre of the road, with smaller at the sides, to give the desired camber. The roads built by Tresaguet in France, were substantially the same as the Telford road and are usually included with it. In the former, the sub-grade was cambered, and the foundation stones of uniform depth. A distinct type of foundation is that developed in Massachusetts in which there is a slightly V-shaped sub-grade with a filling of cobble or field stone, a method which is claimed to give more effectively than other types, a desirable underdrainage.

Experience has shown the superiority of roads with a foundation, such as the Telford type, in reducing the cost of maintenance under heavy traffic. Settlement is more uniform, and defective drainage is less destructive. If the natural sub-soil is strongly supporting, such as a dry, well-cemented gravel, the foundation may be omitted with saving of cost. Whether the Telford or Massachusetts type of foundation be allowed, the local material suitable for either should largely govern.

The width of roadway between gutters or drains, and the width of stone should be guided by the amount and character of traffic, and should ordinarily be less in strictly rural districts, increasing as roads converge into city streets. A minimum width of grade for trunk roads should be 24 feet with metal in the central 12 feet, and earth or gravel shoulders six feet wide on each side. Maintaining shoulders at six feet, and a maximum width of metal at eighteen feet, the maximum width of grade need not exceed thirty feet.

The camber on roads of heavy travel should be the least possible, consistent with good surface drainage, factors to be considered being the quality of road metal, class of binder, and gradient of the road. As is well known, roads with a sharp crown encourage travel in one central line of wheel-tracks, while a flatter surface permits more uniform wear.

A hard rock such as trap, or a bituminous binder, requires less camber than soft material and an inferior binder, while a steep grade requires an increased camber to drain the wheel tracks. Trunk roads of the best class may be given an average crown of one-third or one-half an inch per foot from centre to gutter.

County or Main Market Roads.—Roads of this class cannot as a rule follow closely English, French, German, or other standard, but must be built with a view to the particular needs of this continent, and of the locality. The immediate need is a long mileage, to be built as rapidly as possible, through districts where population is comparatively sparse, often where there may be little or no road-making material, and the available expenditure necessarily restricted by these and other conditions.

European engineers would, undoubtedly, if it were possible to reconstruct many of their roads, lay them with foundations, but the cost is prohibitive. No more is it practicable on this continent to build any but the most heavily travelled roads with expensive foundation. Instead, it is necessary to depend on good drainage, carefully maintained to keep the sub-soil dry and strong enough to sustain the road surface.

Road-beds should have sufficient drainage for the severest test, which in northern countries is that period of thaw in the early spring, lasting usually for two or three weeks; just as bridges have to be strong enough for the maximum load, and with waterway enough for the maximum freshet. If sub-soil drainage is sufficient for the test of spring, no break-up of the road crust need be feared at other seasons.

Old specifications for roads built before the period of railway construction in Ontario, required open drains on each side of the road, with bottom at least two feet below the crown of the road. In most cases the drain was deeper; and hills or spouty places were under-drained with trenches filled with field stone. Such roads have stood the test of time, and may be accepted as the standard of drainage required for the north; except that tile under-drains are taking the place of open ditches where they would otherwise be dangerous, unsightly or difficult to maintain. Drains of porous farm tile keep the sub-soil at its driest and prevent uneven settlement of the road crust into mud which is as destructive to a road when below the surface as when on the surface. Some counties of Ontario are using tile drains the full length of all their roads. Others use them only on wet and spouty hills; on level land which is exceptionally wet and retentive; and where the open drain would otherwise have to be dangerously deep to give sufficient fall and outlet. In the last case, the tile may carry some surface drainage, receiving it in catch-basins.

Closely associated with drainage is the grading of the road. Before a road is surfaced it should be brought to grades that ensure permanence. Hills should be cut down, low places filled, and the earth work brought to a substantial turnpike. The road surface will need renewal, but the grade, if properly made, will outlast even the bond issue. On roads of a secondary class elaborate surveys are unnecessary. A good foreman can obtain easy flowing gradients by grading from point-to-point, and would probably disregard stakes and profiles except in cases of extensive cuts and fills, new locations, tile drains, or doubtful surface drainage, which should always be staked by an engineer.

Roads laid on an earth foundation should be given a higher crown when newly constructed, than is desirable for perfect condition. Settlement will assuredly occur, and unless the road is too high to begin with it will become too flat. A road of a secondary class which in two or three years has settled to the desirable camber will give the greatest degree of durability, with least expense for maintenance. One inch to the foot from centre to gutter or edge of shoulder, for a completed, rolled road, will meet ordinary conditions; with a circular cross-section, the greatest part of the fall is on the earth shoulders.

The cost of a road, unless earthwork and drainage is of an exceptional kind, will depend on the width and depth of broken stone used. Wide flat roads are desirable, but narrow roads with a good camber cost less to build, and much less to maintain, unless a highly organized system of maintenance is created. For this class of road and earth grade twenty-four feet wide, shoulder to shoulder, will meet most conditions; but may be reduced to eighteen or twenty feet for least traffic. With shoulders six feet wide, the stone is put on from eight to twelve feet wide.

The consolidated depth of metal on roads is based on 8 inches for a moderately strong clay or sand sub-soil. This is modified according to the anticipated amount of traffic and quality of stone to resist wear; the maximum concentrated wheel loads; local tire widths and wheel diameters; bond of road metal and consequent distributing effect of the stone crust; the supporting strength of the sub-grade and opportunity for drainage.

Bituminous binders may be justified on heavily travelled suburban or motor roads of this class, but present practice in Canada tends to oiling as a preservative and dust preventive, owing to the less first cost of water bound macadam.

Township Roads.—Reduction of cost to meet township conditions requires that townships have as their ideal, the cheaper class of roads adaptable for main county roads. Grading is cheap, and should be perfected before metal is applied. Neglect to provide easy flowing gradients, and to sufficiently drain and turnpike are mistakes fatal to any road. Minor municipalities can make no mistake in creating the perfect earth road as their ideal base for such metal surfacing as their resources will permit. An earth-grade from eighteen to twenty-four feet shoulder to shoulder should be made, and a single track laid eight feet wide, of gravel or broken stone.

Binder.—The durability of a road is largely dependent on the binder, and the cementing qualities of the stone dust, in producing a waterproof surface,—if tar, asphalt, rocmac or other special binder is not used. Stone screenings are more preferable than sand. Very rarely can gravel or sand, sufficiently clean, coarse and sharp, be found to make a binder equal to limestone screenings. The superior cementing qualities of limestone, make it a better road metal than its degree of toughness would justify. Limestone screenings are also exceedingly useful with water washed gravel, or with broken granite or trap, all of which are deficient in good bonding qualities.

Coursing Stone.—A uniform grade of stone, rather fine, is desirable in finishing the surface of a road, and is necessary where a very hard stone such as trap is employed; but this may be sought at considerably increased cost, and is not always necessary to suitable results. It adds to the cost of a road to spread the stone in several layers. Municipalities using portable crushers particularly, will find a rotary screen with two sizes of mesh very satisfactory. This will produce, (1) "Tailings," or the stone too large to pass through the screen; (2) the middle course, a uniform grade to form the main body of the road; and (3) screenings to bond and finish the surface. The tailings should be spread in the bottom of the road, and covered to the required depth with the uniform grade; and this, after rolling, may be lightly coated with screenings and rolled. If a very tough stone such as trap, the screenings may be such as will pass a one-half inch mesh, or a one inch mesh if limestone; and the uniform grade of stone may be two inches for trap, and two and one-half or three inches for limestone, with the screenings removed. Crushing and handling are cheapened by the system, and for water-bound roads, a smooth surface results.

Trap or other tough rock brought from a distance by rail in preference to the use of soft local material, is justifiable for surfacing heavily travelled main roads; but it is a safe rule, if applied with discretion, that local material if it exists, should be used.

Gravel Roads.—Gravel in general is inferior to broken stone as a road material, but if of a reasonable quality, is suitable for township roads, and for many county roads but, unless of exceptional quality, is deficient for extremely heavy traffic. The rounded pebbles do not take the mechanical clasp that pertains to fragments of broken stone, while the sand which it usually contains is not equal to stone screenings as a binder. It may contain lime or iron, improving its bonding qualities, but as a rule it is not water-proof, and ruts readily in wet weather, especially if it contains sand, clay or loam in excess.

The best quality of gravel is of varying sized grain up to 2 inches in greatest dimension, with only sufficient fine material to fill the voids between pebbles. It should be clean and made up largely of a uniform grade of pebbles—qualities rarely found in natural pit gravel. Gravel pits containing a mass of large stones and boulders should be treated as rock, and put through a crusher. Gravel which is not coarse, but which is "dirty" or contains fine sand, should be screened to remove the excess of sand or clay. A rotary screen may be used, operated by steam power. The gravel can be drawn in wagons to an elevated platform, dumped into a hopper from which it passes through the rotary screen, and from the screen to an elevated bin, from which the screened gravel is again loaded into wagons to be taken to the road. By means of the elevated bins the expense of shovelling into wagons is saved, the time of teams and teamsters is saved, and a well arranged plant will, under favorable circumstances, pay for crushing and screening. This is particularly the case if a pit near the work can be used rather than to team better material a long distance.

Methods.—The methods of construction will largely determine the cost. Machine work is cheaper than manual labor. The cross section adopted should, therefore, permit the maximum amount of machine construction. Particularly for the cheaper class of roads, the grading machine, in treating with old locations, should do most of the earthwork, supplemented with wheeled and drag scrapers. A cheap and good plan is to make the earth sub-grade, shoulder to shoulder between ditches, almost flat, or with a central rise of about three inches for a 24 foot grade. When this is rolled, the stone is spread to the desired width in the centre, then with the grading machine, earth is drawn from the shoulders to support the stone, thus completing the camber. The stone is first rolled dry to level and partly compact the surface, the screenings are then spread, sprinkled and rolled till consolidated. To grade the road and then excavate a central channel to receive the metal is a more expensive method, and is apt, for roads without a foundation, to place the stone too low for good drainage, producing what may be termed a "water-logged" road. Instead of the camber and turnpike being high enough to allow for settlement, it is apt to be made too low and flat.

Rolling.—As distinguished from earlier road-making, modern construction has been largely influenced by machinery, especially grading machines, rock crushers, and road rollers. The smaller municipalities of Canada commonly use graders and crushers, but the purchase of a steam roller is too often delayed. It is to be pointed out that the cost of a roller is by no means an additional expense, since rolling effects economy in several ways. Coarser stone can be used in a road that is rolled, so that the cost of crushing is reduced. With coarser stone, the road is stronger to resist wear, and is more securely bonded than if first rutted and mixed with mud. Less stone is required in a rolled road, as loose stone is largely forced down into the mud before the surface becomes waterproof, or is knocked to the ditches by traffic. Without rolling, roads demand attention for one or two years, to rake the stone to place from time to time; the earth shoulders have to be restored and levelled where cut up and destroyed by traffic, new material has to be added to fill hollows and ruts. By rolling the sub-grade, the wet or weak spots are developed, which can be drained or filled with earth and again rolled to produce a uniform foundation; thereby reducing the stone which the road would otherwise absorb. Long lines of loose stone left for traffic to consolidate are a most objectionable obstruction to travel, and bring road-building into disrepute. On the other hand, a road built with a heavy roller is a complete work, in perfect condition when finished. Rolled roads are a revelation to those who have been accustomed to and who expect only old-time methods and results. For both economy, service, and to popularize the work, rolling should be regarded as essential for every class of gravel and stone roads.

The process of melting abstracts or renders latent a definite quantity of heat, and it is the loss of this heat in the melting of ice that gives it its refrigerating value. This heat, which is used up in the melting of ice, is the latent heat of fusion of ice, and it amounts to 142 heat units per pound of ice. When one pound of ice changes to water the heat that is abstracted is equivalent to what would be required to raise one pound of water 142 degrees Fahrenheit, or required to raise 142 pounds of water one degree Fahrenheit This quantity of heat is considerable, and accounts for ice being a better cooling agent than ordinary cold water, or even water at 32 degrees Fahrenheit. One pound of ice in melting has, therefore, 142 times the cooling value of one pound of water in passing from 32 degrees to 33 degrees Fahrenheit.

PROPOSED SOUTH SASKATCHEWAN RIVER DIVERSION CANAL.

In the issue of *The Canadian Engineer* of March 6th, 1913, there was an article on the Moose Jaw water supply, by Mr. Gillespie, associate professor of Applied Mechanics, University of Toronto. In this article Mr. Gillespie mentioned that the ultimate source of the water supply at Moose Jaw, if the city increased its population, must be the Saskatchewan River. We publish below a report by the Commissioner of Irrigation, F. M. Peters, on the proposed South Saskatchewan River Diversion Canal. This scheme, if carried through, will be the probable source of water supply for both the city of Regina and Moose Jaw. The estimates of costs given will be of interest to engineers and contractors.

The height of land of Aiktow Creek in township 24:—

High-water level in river	1,632 feet
Height of land, head of Qu'Appelle River	1,720
Difference of elevation	88

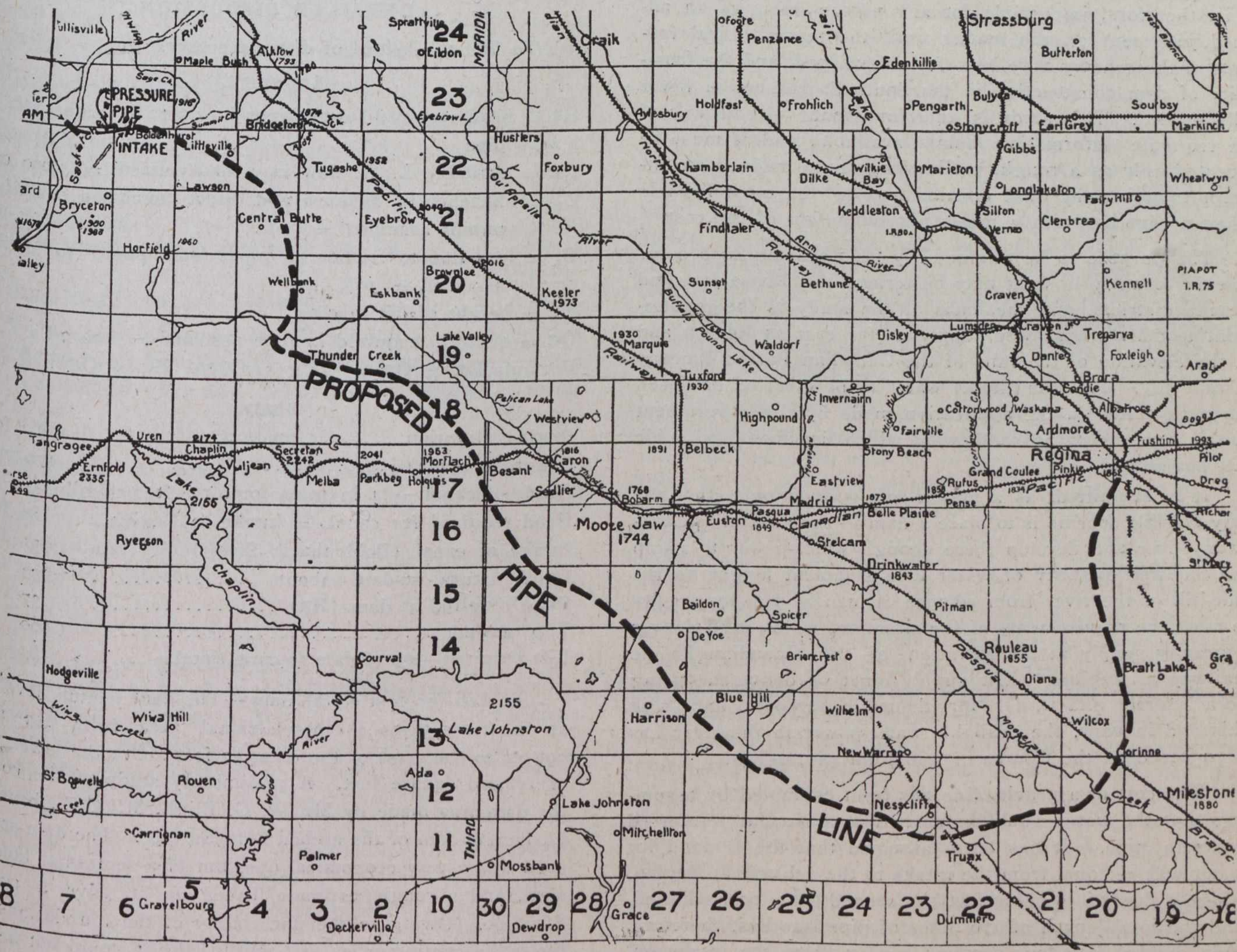
The height of land of Sage Creek in township 23:—

High-water level in river	1,644 feet
Height of land, head of Summit Creek	1,916
Difference of elevation	272

The height of land of Shellstone Creek in township 21:—

High-water level in river	1,672 feet
Height of land, head of Thunder Creek	1,975
Difference of elevation	303

All the elevations given above are to the datum of the Canadian Pacific Railway levels.



Map of Proposed Diversion Canal. Scale 1" = 16 miles

A proposition in connection with this scheme, which has been looked upon with some favor is the proposition to pump water out of the South Saskatchewan River over the height of land and deliver it into the head-waters of the Qu'Appelle River. The work was confined entirely to developing the critical elevation along these lines and consisted of running a series of level lines over several heights of land which showed possibilities of feasibility. Mr. Russell was at this work for one month and had the assistance of only one rod man and a team and driver.

The results of all Mr. Russell's work is plainly set forth on the plans and profiles submitted in connection with this report, but for purposes of convenient reference the results may be set forth as follows:—

It should be noted that the pumping of water over the height of land of Shellstone Creek would allow the water to run by gravity down to the city of Moose Jaw and from there down into the Qu'Appelle River.

The project of pumping the water over the Aiktow Creek height of land and allowing it to flow down the Qu'Appelle River would probably be useless, as it would deliver the water into Buffalo Pond Lake at an elevation of 1,627 feet, which is about 117 feet below the elevation of the city of Moose Jaw. Then, allowing a grade in the Qu'Appelle River of two feet per mile, as the crow flies, the elevation of the water in the Qu'Appelle River at a point southeast of Regina (about twenty miles from Buffalo Pond Lake) would be about 1,587 feet or 275 feet below the elevation of the city of Regina. The bed of the Qu'Appelle River is, moreover, of such a character, viz., black swamp earth, that any water turned into it for domestic purposes would be badly polluted.

Mr. Russell also developed a cross-section of the South Saskatchewan River at a point about midway between the mouths of Aiktow and Sage Creeks for the purpose of making a preliminary study of the cost of a dam. This section will give probably as small a cross-sectional area for a dam as any section that can be found on the river in this vicinity. It was also ascertained that the fall of the river water-service in townships 21 to 24, a distance of 31 miles, is 40 feet, or an average fall of 1.3 feet per mile.

Study of Pumping and High Level Gravity Scheme.—Before proceeding with this short study it may be stated that this scheme is a very large one and will be very expensive. It is, therefore, impossible for any person to give an advised judgment on the matter until the topographical features of the country have been fully developed, and the feasibility of dam construction in the South Saskatchewan River fully probed. This study is, therefore, made without any of the requisite information being available, and it must be accepted only as a rough, preliminary study made in an attempt to point out what appears to be the most feasible scheme, together with a rough approximation of the cost.

The purpose to be attained by this scheme is to serve that dry country in what may be termed the Moose Jaw and Regina districts, and the basis of the study is the requirement to deliver a gravity supply as far east as Regina and at the elevation of the rails of the Canadian Pacific Railway in that city. The quantity of water to be diverted has been taken as stated in the application made by the government of the province of Saskatchewan, which is about 200 cubic feet per second.

It is submitted, as a matter of opinion only, that the only feasible scheme is to place a dam in the South Saskatchewan River and develop there enough water-power to pump the required quantity of water to a sufficient height on the side-hill of the river from whence it can be run by gravity to meet the requirements of the situation, which is to deliver a gravity supply at the elevation of the Canadian Pacific Railway at Regina. The supply must be delivered during both summer and winter for domestic purposes, and, with this end in view, the available water-power in the river has been based on the figures of minimum winter-flow.

The cost of a gravity line has been estimated by assuming that the water would be carried in a circular reinforced concrete pipe. It has been assumed that the demand for water will be equal from the intake to the delivery at Regina, where a flow of 50 cubic feet per second has been allowed, and the total length of 170 miles of pipe line has, therefore, been divided into four sections having, from the intake on, carrying capacities, respectively, of 200, 150, 100 and 50 cubic feet per second. The excavation cost has been based on a level section cut for the trench sufficient to bury and cover the pipe everywhere with six feet of earth. In computing the cost of the dam the section used is that one taken in township 24 between Aiktow and Sage Creeks, but, in order to suit the assumed scheme, the dam must be placed somewhere in townships 22 or 23. One fact alone which is liable to make the estimate of the cost of the dam seriously in error is that the bottom of the South Saskatchewan River is known to be most treacherous for the foundations of any structure, and no definite information whatsoever has been gained on this point.

The small-scale map accompanying this report shows the position of the dam and the location of the proposed pipe line, while the calculations following hereafter have been made in such a way that they may be read through understandingly by any person who has followed this preliminary discussion. The unit prices assumed in the estimate are understood to include the cost of many small details and incidentals which have not been calculated. For example, it will not be possible to obtain the minimum excavation section for the pipe line throughout, which will make the quantity of excavation much higher than that calculated.

In conclusion attention may again be drawn to the fact that this study is only a rough approximation and that nothing further can be attempted until the many controlling elements of the scheme have been fully developed by the carrying out of the proper surveys and also river borings to develop the possibilities of a dam foundation.

DETAILED DISCUSSION.

To find the height of dam necessary.

Argument.

H_R = head required for turbines in river to pump Q_C into pipe

Q_R = available L. W. flow in river assumed = 3,000 c.f.s.

C_1 = efficiency of turbines and direct connected centrifugal pumps assumed = 52%.

C_2 = loss due to friction in pipes from pump to delivery assumed = 10%.

H_C = height of lift to pipe.

Q_C = quantity required in pipe assumed = 200 c.f.s.

Formula $H_R \times Q_R \times C_1 \times (1\text{-}C)_2 = H_C \times Q_C$

Study.

Regina elevation	1,862 feet.
Length of canal	170 miles.
Grade of canal = 1 in 10,000 or 0.528 ft. per mile.	
Head required for canal = intake to Regina..	89 feet.
Intake of canal (Boldenhurst Street) elevation	1,951 "
L. W. natural at dam (about)	1,653 "
Head required at dam (H_R)	37 "
Top of dam	1,690 "
Lift required—top of dam to canal intake	261 "

To find the cost of the dam.—The dam section developed on the river gives a cross-sectional area from the river-bottom to the crest of the dam, 37 feet above the lower pool, of 118,000 square feet. A preliminary study of the cost of the dam was made by Mr. W. G. Bligh, M.I.C.E., based on a concrete dam of the arched buttress type. The dam-section used was a very economical one, but of a somewhat bold design, and a rough estimate based on it gave a cost of $600,000. Owing to the uncertainty of the foundations and the many contingencies that might arise it would not be safe to estimate the cost of the dam at any less than $1,000,000.

To find the cost of turbines and pumps.

Theoretic H.P. required = .001892 Q.H. = 12,600.

Allow cost at $15 per H.P. = $189,000.

To find the cost of pressure pipes from pumps at dam to intake of concrete pipe line.

Q = 200 cu. ft. per second.

V = 3 s.f.

A = 67 sq. ft.

R = 4.6 feet (one large pipe).

Area plates required, including laps, 29 sq. ft. per ft. run.

Half-inch wrt. iron plates, weight per foot run, 580 lbs.

Cost, at 6 cts. per lb., about $35 per foot run.

Cost for 1 mile, $184,800.

To find the cost of concrete pipe.

Argument.

1.30 bbl. cement at $3.00	$ 3.90
0.44 cu. yd. sand at $1.25	0.55
1 cu. yd. stone at $1.50	1.50
Total cost ingredients 1 cu. yd. concrete	$ 5.95
Cement and stone	$ 5.95
55 lbs. steel at 3 cents	1.65
Forms, labor, and materials	1.85
Mixing and placing concrete, labor	0.85
Placing steel at 0.2 cents	0.11
Bending steel at 0.06 cents	0.03
Moving forms	0.30
Cost in place, 1 cu. yd. concrete	$10.74
Superintendence, plans, contingencies, etc.	1.26
Total cost in place, 1 cu. yd. concrete	12.00

To find the cost of excavation.

Argument.

Excavation, cu. yd.	$0.30
Back fill, cu. yd.	0.10
Cost per cu. yd.	$0.40
Superintendence, plans, contingencies, etc.	0.05
Total cost, 1 cu. yd. excavation	$0.45

To find cost of pipe line.—The grade throughout has been figured at 1 in 10,000 and the discharge of the pipe has been calculated by the Chezy-Kutter formula, using 'N' = .012.

Study.

Section No. 1, length 42 miles, capacity 200 c.f.s.

243,714 cu. yds. concrete at $12.00	$ 2,924,568
Cost per mile, $69,632.	
1,576,935 cu. yds. excavation at 45 cents	709,621
Cost per mile, $18,834.	
Total cost	$ 3,715,586

Total cost per mile, $88,466.

Section No. 2, length 42 miles, capacity 150 c.f.s.

222,192 cu. yds. concrete at $12	$ 2,666,304
Cost per mile, $63,481.	
1,576,935 cu. yds. excavation at 45 cents	709,621
Cost per mile, $16,895.75.	
Total cost	$ 3,375,925

Total cost per mile, $80,379

Section No. 3, length 43 miles, capacity 100 c.f.s.

152,633 cu. yds. concrete at 12	$ 1,831,596
Cost per mile, $42,595.	
1,354,915 cu. yds. excavation at 45 cents	609,712
Cost per mile, $14,179.34.	
Total cost	$ 2,441,308

Total cost per mile, $56,774.34.

Section No. 4, length 43 miles, capacity 50 c.f.s.

127,912 cu. yds. concrete at $12	$ 1,534,944
Cost per mile, $35,696.37.	
1,164,715 cu. yds. excavation at 45 cents	524,122
Cost per mile, $12,206.70.	
Total cost	$ 2,059,066

Total cost per mile, $47,885.25.

Total cost of pipe line laid, 170 miles $11,591,885

Summary of estimate of cost.

Cost of dam	$ 1,000,000
Cost of turbines and pumps	189,000
Cost of pressure pipes	184,800
Cost of concrete pipe line	11,591,885
	$12,965,685
Total cost, about	$13,000,000

FIRING OF STACKED COAL.

Every now and then some firm which has a quantity of coal on hand finds itself bothered from its coal pile having caught on fire. The question has been discussed lately in a paper read before the Manchester District Institution of Gas Engineers. Mr. Kendrick, who owns gas works of his own, relating his experience with them, stated that at Stretford they have had three serious fires in four years, and many cases of overheating. No. 1 store of coal held 1,800 tons, and was an old retort house partly roofed, with and partly without louvres. No. 2 store holds 1,400 tons and has no louvre. No. 3 holds 800 tons, and has a two-span roof of corrugated iron. In the first two, coal is delivered by conveyors. In No. 3 it is hand-stacked, 14 ft. high. In the other stores it is piled in pyramids 24 and 20 ft. high, the top of the cones being 8 ft. across. No. 1 shed had given most trouble. The finest slack is usually sent direct to the retorts, but much fine stuff still gets into the store and fills the middle part of the piles, and to this dust and small coal the fire trouble is due.

As a result of what was observed, after each boat had been discharged, the fine dust was dug out and spread over the heap, and pipes were put in at intervals to enable the interior of the pile to be watched. Three years of immunity led to laxity, and the small stuff had not been fully dug out, and a fourth fire occurred. It was again the small coal which heated, but was not the immediate cause. Some old screened coal was buried under the new coal, and the store was filled, in about six weeks, to its utmost capacity. On emptying the shed, the rough coal under the slack was quite carbonized and fire was creeping under the slack. Apparently air had reached the new coal through the old tongue of open rough coal. The temperature in the tubes rose slowly to 90 deg., then quickly to 110 deg., with a quick jump to 300 deg., and it required a week to reach the fire, which had then spread considerably. As this coal was stored in the hot month of May, 1912, and was stacked quickly and was dustier than usual, these causes appear to have been active in producing fires.

The colliery agents attribute the numerous fires of that year to the fact that after the strike, coal was much crushed at the face, and was very small, and it was not clean, being hurried away quickly for use, and more probably fresher coal than usual was stacked. Freshly-wrought coal is more prone to heat, especially if fine.

Coal as received is warmer than the atmosphere, as much as 2 deg. to 12 deg. in summer, and 4 deg. to 20 deg. in winter. Since a pit may have a temperature of 90 deg., coal must start from the pit fairly warm, and if stacked too soon, too high, or in too large mass, it is prone to heat. Also, coal mined first after the strike would be damper than usual, and dampness seems to engender fire.

Coals absorb from one to three times their volume of oxygen, and this produces heat, and if it can occur in a thick mass the heat accumulates. Stacking in cone shape from a conveyor causes the fines to accumulate at the apex, and these are apt to fire. This system of storage is thus to be regarded with suspicion. Coal owners suggest 11 to 15 ft. as the height of coal stacks, or a mean of 13 ft. Gas works practice is to stack 10 to 30 ft. Since coal under cover cools less slowly, it should be stored in less depths than when out of doors, whereas the reverse is the usual practice. The question of ventilation is a disputed one. Some men say ventilate freely and carry off the heat. Others say keep out all hot air and no heat can be generated. If this is so it would be quite safe to store in closed bunkers, exhausting the air at the top and admitting CO_2 at the base to fill the voids between the coal. In practice it appears that coal will be reached by air enough to make it become hot. Therefore, supply ample air to carry off the heat, for the oxidation will be less if the coal is cold. Yet in mines ample ventilation to remove gas has caused heating in the gob, and the checking of the air current has stopped the heating.

If a heap fires, very much water is needed to quench it, for water sets up air currents to fan the fires. At Stretford they treat affected coal with strong ammoniacal liquor and only put water on unaffected coal. The summing up is that coal from different seams should not be mixed, nor should coal of different classes.

Fine slacks should not be stacked at all, nor damp coal under cover. Large heaps are the more dangerous. Lumps, nuts and fines should be well mixed in stacking. Limit heights to 20 ft. in the open, and 16 ft. under cover. Avoid external sources of heat, leaking roofs, &c. Keep temperature records of coal as received and in stock, and if the heat rises to 90 deg. or 100 deg., remove the top layers and watch carefully. Do not disturb a fired heap by pushing in bars. Do not apply water to a fire, but ammoniacal liquor. Remove and use heated coal promptly.

From remarks made during the discussion, it would seem that if coal is screened and stacked it does not become hot. This indicates the smalls as the cause of trouble. But it also indicates the need for good air circulation, for it is the fines that prevent this. It seems impracticable, as a rule, to gain safety by excluding all air, as that would undoubtedly prevent fire, for to produce fire there must be oxygen. The question is, can coal absorb oxygen, as oxygen which shall only begin to work when the coal is stacked? With present-day large stacks of coal, the subject becomes important.

MINERAL PRODUCTION BY PROVINCES.

The subdivision of the mineral production in 1911 and 1912 by provinces for Canada was approximately as follows:

Province.	1911. Value of Production.	1911. Per cent. of Total.	1912. Value of Production.	1912. Per cent. of Total.
Nova Scotia	$15,409,397	14.93	$18,843,324	14.15
New Brunswick	612,830	0.59	806,584	0.61
Quebec	9,304,717	9.01	11,675,682	8.77
Ontario	42,796,162	41.46	51,023,134	38.33
Manitoba	1,791,772	1.74	2,314,922	1.74
Saskatchewan	636,706	0.62	909,934	0.68
Alberta	6,662,673	6.46	12,110,960	9.10
British Columbia	21,299,305	20.63	29,555,323	22.20
North West Territories	4,707,432	4.56	5,887,626	4.42
Dominion	103,220,994	100.00	133,127,489	100.00

CONSTANCY OF VOLUME ACCELERATED TESTS IN PORTLAND CEMENT.

At the meeting of the International Association for Testing Materials, amongst the discussions that arose the questions regarding constancy of volume accelerated tests in Portland cement were eagerly discussed. Professor Max Gary, in a paper discussing accelerated tests in Germany, states the accelerated test for volume constancy was discussed as far back as the Zurich meeting of the International Congress for Testing Materials. At that time, Dr. P. Prüssing exhibited samples containing 50 per cent. of highly expansive constituents, but so finely ground that they slaked readily, without expansion, on being stirred up with a large volume of water, though when mixed with only a little water, for the production of cement ware, considerable expansion occurred. Thus, even at that time, proof existed that a test in which the cement is mixed with much water does not always cast suspicion on such dangerous cements as those in question; and a desire arose for the introduction of some method of testing with specimens made up with only a little water (earth-damp or dry).

Experiments with various testing methods failed at that time to lead to the desired result; and in course of time other proposals were made in succession for the rapid testing of cement in order to detect any tendency to expansion. Among these may be mentioned: The Drying test at 100 degrees C. (Darrprobe), the Heintzel ball test (calcination test), the Michaelis boiling test, the Von Tetmajer ball test, the Maclay hot water test and the Prüssing pressed block test.

All these tests met with opposition, and in 1891 the Association of German Portland Cement Manufacturers gave expression to the following opinions:—

(1) The test for standard constancy of volume in Portland cement is sufficiently decisive and perfectly adequate for practical purpose, if performed with care.

(2) The accelerated tests, hitherto published, for ascertaining inconstancy of volume in Portland cement are not adapted to enable the consumer to form a reliable judgment on the cement, it being found that some Portland cements which fail to pass the accelerated tests, prove thoroughly constant in volume when in use.

On the other hand, there were loud expressions of opinion, particularly by Von Tetmajer, Bauschinger, Dr. Michaelis and C. Prüssing, to the effect that the standard tests were insufficient for judging cement, especially when the cement was intended to be exposed to the air during setting in pactical use. His opposition to its views induced the association to appoint a committee entrusted with the solution of the following question:—

Does the standard test for constancy of volume in Portland cement enable an accurate judgment to be formed on the behavior of a cement in use, or is this object attained in a more reliable manner by any of the proposed (accelerated) tests?

Without delay, the committee began operations in collaboration with the Royal Mechanico-Technical Laboratory at Charlottenburg.[1] The laboratory procured ten cements which, according to the users, had behaved satisfactorily in practice, though failing to pass the boiling test. All the cements were tested by the laboratory and by the members of the committee separately, as regarded their general properties, changes of volume in the Bauschinger tester, tensile strength and behavior under the above-mentioned tests for constancy of volume. Moreover, reliefs and conduit covers were made from the cements at the cement works for the purpose of being exposed to the air, subject to all changes in the weather during setting.

It is impossible here to go into the details of the experiments, but it must be specially mentioned that none of the so-called "accelerated" testing methods tried (drying test at 100 deg., Heintzel ball test, Von Tetmajer ball test, Maclay hot water test and Prüssing pressed-block test) appeared calculated to enable a rapid and reliable judgment to be formed in all cases as to the suitability of a cement for practical use.

The experiments showed that all ten cements which passed the standard test also exhibited constancy of volume (in the practical sense) when used for making test pieces and cement ware. The practical utility of the cements was also demonstrated by the increased tensile strength of the test pieces when allowed to harden in water and in the air.

The assumption that the standard test for judging a cement is inadequate, especially when the cement is intended, in practice, to harden in the air, failed, therefore, to obtain any confirmation through the experiments of the committee. That body, however, expressed its willingness to carry out additional experiments, and publicity requested the adherents of the accelerated methods of testing to place at its disposal sufficient quantities of such cements as passed the standard test, but failed to pass the accelerated tests and were found to expand in practice. Cements of this kind were to be forwarded to the Charlottenburg laboratory. In spite of the long term appointed, no response has been received on this matter by the laboratory, and no experimental material for testing in the above-mentioned manner has been furnished.

This might have been considered as settling the matter; but the laboratory has gone further, and has continued for years to keep under observation the cements (and the articles made therefrom) characterized as highly suspicious from the results of the accelerated tests without, however, finding any alteration in the result.

Accordingly, the assumption that the so-called accelerated tests for constancy of volume enable, in general, a more accurate judgment to be formed on the suitability of a cement than is done by the standard test should be dismissed as erroneous. Following on the experiments, however, the laboratory requested a large number of officials to keep under observation the constructional works carried out by them with cements which, according to the accelerated tests, ought to be of a suspicious character; and the results of such observations have been compared with the results of the accelerated tests on constancy of volume. This comparison established in an unimpeachable manner that numerous cements of different origin and methods of preparation, which had partially or entirely failed to pass the accelerated tests for constancy of volume, were found to have fulfilled their purpose completely, irrespective of the conditions of the mixtures, during an observation period of 34 to 18 months, without giving rise to the smallest objection in connection with their constancy of volume.

Furthermore, it has been established by a circular inquiry among more than 200 users of cement that the dubious value of the darrprobe and boiling test in particular has already been recognized in practice, and that there is no longer any need for such tests. In numerous instances it was found that testing in the standard manner sufficed completely to reveal the inferiority of a badly prepared cement. Six cements, which, on the basis of the boiling test and drying test at 100 deg. C. ought to have ranked as quite useless, have been employed, officially, for a variety of building purposes, e.g., in building a fire station; for concrete and masonry in harbor work; in abutments and circumvallation work in a fortress; in building a high-level water tank; in the piers of a large railway bridge; for concrete floors and ceilings, etc. In all cases the work has remained under observation for several years, but in no case, however, has the work given rise to complaint on the score of changes in volume, or in any other respect, although the constancy of volume of all these cements, as determined by the darrprobe, calcination test and boiling test, was open to the gravest suspicion, and although remarkable phenomena were exhibited at the end of one and two years by the test blocks in air and water. No injurious effect could be observed in practice—in a very thick concrete wall—even in the case of a cement which was completely disintegrated by the boiling test, and showed reticulated and edge cracks at the end of two years in a test block immersed in water. The thoroughness of these observations and determinations is probably unsurpassed.

After the publication of these results the question of accelerated tests for constancy of volume slumbered for some years, so far as Germany was concerned, until Le Chatelier proposed to fill the cement paste into split brass rings fitted with needles and test the expansion by measuring the distance between the needle points after treatment in hot water. Hence the Le Chatelier test is an improved form of boiling test.

Quite recently Dr. G. Hentschel has proposed a modified boiling test for cement. Instead of performing the boiling test after the block has been hardened for 24 hours, he proposes a preliminary treatment to accelerate the hardening before applying the test. The block is to be left for 15 to 20 minutes on a highly absorbent gypsum plate, and then be heated, on an iron plate, over a naked flame until no more water vapor is given off. After cooling, it is immersed for ten minutes in water at room temperature, and is then exposed to the air for three hours, being finally boiled. It should be remarked that one cannot expect this test to furnish any essentially different information from that given by the old darrprobe and boiling test; and it will prove unreliable and misleading for the same reasons as the older tests.

Greater attention was bestowed on the Le Chatelier test, mainly because, in contrast to the other methods, it furnished values which were regarded as mutually comparable. The British Standard Committee took up the Le Chatelier test; and from England this test was laid before the International Association and caused to be accepted by the Copenhagen Congress, 1909, as a commendable accelerated test for constancy of volume, although a number of expert members protested against this decision. The protest was entered in the minutes of proceedings, and is now brought to remembrance again.

In justification of this protest, reference was made at Copenhagen to the aforesaid unfavorable experiences with the boiling test. It must be reiterated that the Le Chatelier test is a boiling test, and therefore must also be judged, like the old boiling test, on the basis of the comprehensive experiments already referred to. Moreover, it is necessary to point out the opinion in which this test is held even in England.

At a meeting of the Concrete Institute in 1910, Mr. Butler read a paper on tests for constancy of volume, which paper was followed by an extremely animated discussion. The reader of the paper supplemented a historical review of the development of the existing tests by an exposition of the theoretical advantages of the Le Chatelier test; but on the basis of many thousand experiments with the Le Chatelier needle came to the conclusion that, owing to the often contradictory results in cases where the cements would have to be condemned on account of failure to pass the Le Chatelier test, the results must not be interpreted too strictly. He also demonstrated that divergent results could be obtained in different localities, and that the results also differed even when the tests were performed at one and the same place and under perfectly identical conditions. It is highly interesting and characteristic of the lack of practical value of the test that the results of Butler's experiments entirely coincide with the experiments (to be mentioned later) carried out by the Association of German Portland Cement Manufacturers. Butler found:

In the first place, that with three operators working in the same place and with the same molds, the results of the tests showed extreme divergences. One operator found considerable expansion of the cement, whilst the other two found much less expansion. According to the result of the one test, the cement would have to be discarded as not being constant in volume; whereas, on the basis of the results obtained by the other two, under precisely equal conditions, the cement was not open to objection.

In the second place, Butler found that an extraordinary influence on the results was exerted by the use of different kinds of needles, whether brass or copper, old or new.

Thirdly, he found that on many occasions the test pieces gave higher expansion values after the cement had been exposed to the air for 24 hours or 6 days than when the same cement was used in the original conditions. He points out that, in the English method, the expansion during the first 24 hours—which in many cases is far greater than the subsequent expansion—is entirely neglected by the boiling test, and that leaving the cement 24 hours to harden before boiling is quite an arbitrary procedure.

At the conclusion of the paper, the author said that, whatever good reasons might exist, either in favor of or against accelerated tests for constancy of volume, he could vouch, from his personal experience, for the fact that not 90 per cent. of the Portland cement made in England or elsewhere less than 20 years ago would have been able to pass the boiling test under the conditions laid down. If this test were indeed an accurate one for constancy of volume, the evident conclusion would be that 90 per cent. of the total cement used 20 years ago was not constant in volume. This would be a somewhat surprising assumption when it was remembered that hundreds of thousands of tons had been used for important structures in different parts of the world; and in view of the excellent present condition of these structures, the assumption could not be seriously brought forward.

This paper was read at a meeting under the chairmanship of Mr. Blount, the advocate of the Le Chatelier test at Copenhagen. Mr. Blount's criticism of the paper was that he did not agree with Mr. Butler. This terse but unfortunately, merely ex parte opinion was, however, not shared by a large number of well known English cement manufacturers, who expressed their agreement with Mr. Butler. Among others, objections were raised against the Le Chatelier test by Messrs. Bamber, Cooper, Tristam, Watson and Roberts.

So far as the Association of German Portland Cement Manufacutrers is concerned, the Le Chatelier test was first tried, in 1909, by a special committee, under the chairmanship of Director Schindler. It appears from the comprehensive report that, as was found by Butler, there was no harmony between the results obtained at different testing stations. The experiments were continued, on a larger scale, in 1910 with six cements. The results were most contradictory, one and the same cement giving expansions varying between 0 and 10.7 mm. of needle divergence at different stations. Schindler's report contains all the individual values and careful drawings of the results at ten testing stations.

At the Royal Laboratory for Testing Materials, experiments were carried out in 1911 with six Le Chatelier needles, of different kinds of brass and copper, and the experiments, like those of Butler, show that the results of the Le Chatelier test vary according to the kind of material and method of making the needles.

Consequently, the apparatus is, in itself, uncertain and unreliable.

Finally, under the chairmanship of Dr. Strebel, committee No. V. of the German Association for Testing Materials, made a thorough investigation of the Le Chatelier test, and Dr. Strebel presented his report to the twelfth general meeting of that association held in Düsseldorf on October 7, 1911.

The experiments led to the following conclusions:

(1) It has been found that the Le Chatelier test characterized as constant in volume a cement which exhibited a decided tendency to expansion in cold water. Even if the cement in question be one of abnormal composition, it was, nevertheless, bought in the open market; and consequently the buyer of such cement would, if he relied on the results of the Le Chatelier test, have incurred risks by using the cement in practice.

(2.) It was also found that the results obtained in testing one and the same cement in different testing stations varied in such a manner that in quite a number of instances a cement would pass the test in some stations but not in others. The risks arising from such unreliability on the part of an extremely important test do not need to be enlarged upon. The matter is rendered more serious by the fact that the tests in question were performed by skilled operators exclusively, and in strict accordance with the prescribed conditions.

Owing to the coincidence of these results with all those obtained in the previous experiments, the committee—comprising not only manufacturers, but also a large number of the most prominent cement experts in Germany—decided to invite the German association to adopt the following resolutions:—

(1.) The German Association for Testing Materials rejects the Le Chatelier test as an accelerated test for constancy of volume.

(2.) The Association requests the International Association for Testing Materials to set aside the resolutions adopted at Copenhagen with reference to the Le Chatelier test.

At Copenhagen it was evident that the German cement industry would have to fight shy of the introduction of the Le Chatelier test, and that the resistance offered to this test by the German members was based on that circumstance. On the other hand, it should be mentioned that already in 1909 experiments with the Le Chatelier test were carried out in the laboratory of the Association of German Portland Cement Manufacturers, as reported by Dr. Framm in 1910. According to the English regulations, the expansion of the test pieces (cement not exposed to air) should not exceed 10 mm. after six hours' boiling. This condition was fulfilled by 83 samples out of 88 German commercial cements, originating from 88 different makers, 79 of the samples giving an expansion of less than 5 mm. and only 4 samples one, between 5 and 10 mm. The mean expansion of the entire set of samples, including those which failed to pass the test, was only 3.5 mm. This shows that if the Le Chatelier test gave reliable results, the Germans need not fear its introduction. It is, however, rejected because the result of the test is uncertain and bears no relation to the other properties of the cement.

Basing on the foregoing unassailable facts, I arrive at the following conclusions:—

The decision of the Copenhagen Congress to commend the Le Chatelier test as accelerated test for constancy of volume is not borne out by the facts of the case. The Le Chatelier test is misleading and should therefore be discarded.

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CONTENTS OF THIS ISSUE.

THE SMOKE PROBLEM.

A most difficult problem to satisfactorily solve in cities is the pollution by smoke of the atmosphere. It may be merely an unpleasant and jarring note on the beauty of the scenery to the suburban residents, but it has an added and more serious meaning to those living in the smoke area, and that usually means a majority of the citizens.

A certain amount of dust and impurities from the streets will always of necessity be found in the city atmosphere. The presence of such is a menace to health, and every added pollution by smoke only further endangers the public's well-being. All these points are well known, and pressure has in a way been brought to bear on the scientist to in some way abate the nuisance.

Legislation, it would seem, is the only way to cure the evil, and that involves the interruption and interfering with of long-used rights. Without knowledge and accurate data of the exact amount of smoke pollution in our towns, legislation on the subject is extremely difficult, and there must ultimately devolve on engineering shoulders the task of gathering these data.

Any attempt so far at the abating of the smoke nuisance or of obtaining information on the subject seems to have been local and confined to independent municipal effort. There is no organized effort in Canada to systematize and collect smoke information. Vancouver, for instance, in a recent report to the City Council, by a Smoke and Sawdust Abatement Society, recommended as follows:—

That the offer of a public service corporation to supply the city electric light, heat and power for consumers by developing electricity and steam heat from lumber refuse be accepted. The franchise to the company was to be for thirty years. Besides relieving the city of part of its smoke, consumers were to be supplied with energy at the following rates: electricity at eight cents per kilowatt hour, and subsequently seven and six cents; heat at $1.00 per 1,000 pounds of steam pressure development. The company was to pay the city one per cent. of gross earnings the first ten years, two per cent. gross the next five years, and two and a half the succeeding five years. The company was also to start operations within fifteen months and to expend $50,000. Now the above contract is very interesting, and might help Vancouver in its smoke trouble, but it is questionable whether a remedy on such lines would be practicable in other cities. Vancouver in being a city of many lumber mills has possibly sufficient waste product available for fuel to make such an attempt possible. The majority of Canadian cities and towns have not that resource. It is legislation that will help all municipalities that must be hoped for as the desired goal.

In England a committee of scientists have been appointed who have formulated a plan of investigation that ought to lead to more definite information of the pollution of atmosphere than we have yet had. All the principal local authorities of the United Kingdom are to be communicated with in the hope that they will co-operate in an organized attempt to collect reliable data as to the degree of the pollution of the atmosphere in different places. No co-ordinated effort has ever previously been made to estimate the amount of suspended matter in the air. A standardized method of examination of the atmosphere is to be adopted, and the result ought to be the collecting of much useful information. The standardized method of investigation is to be (a) a form of enlarged rain gauge, with catch area of four square feet, and a large bottle is provided to collect rain, soot, or other deposits falling. The bottle is removed periodically and the amount of solids estimated. This is a method for use over long periods.

(b) A measured volume of air drawn through filter paper is the method for measurements of solids from day to day or hour to hour.

One cannot help feeling that such a systematized course of investigation should be inaugurated in Canada as well as Great Britain. It is only through reliable knowledge of conditions gained by such means that we can ever hope to be able to effectively handle the problem. It is only when the exact amount of the pollution of atmosphere we are undergoing is known; when we have some idea based on facts of the amount of injury to health dwellers in the cities are risking. It is only then that corrective legislation will be properly balanced.

Tampering with rights of usage and time by regulations which might seriously affect vested capital is too serious a problem to be encouraged without full knowledge of the conditions to be remedied. We would probably either allow more pollution than is good for us, or go to the other extreme and be unnecessarily harsh in our regulations if we approached the subject in any other manner. Active steps should be taken in Canada to gather information and data on smoke pollution similar to those being carried on in the United Kingdom. It is a step towards better laws that we should all hope to see.

SPONTANEOUS COMBUSTION.

The liability of coal in bulk to take fire from spontaneous combustion is generally known among the engineering profession. The chemistry and cause of the action may not be so familiar to many of our readers. Possibilities of fire due to chemical action taking place between the air and the coal is well understood by chemical engineers and by those accustomed to handling or using coal in bulk. It is a question which has been well treated in an article on another page of this issue by the owner of gas works who had suffered considerably in a business way due to fires brought on by spontaneous combustion. The subject, moreover, has peculiar significance just at present, due to the recent catastrophe at Baltimore, whereby a ship that was loading dynamite was blown up and forty or fifty people killed. While there is no official version of the cause of the explosion, it was apparently due indirectly to fire generated by spontaneous combustion in the coal bins. Accounts that come of the length of time between the discovery of the fire until the actual explosion took place lead one to believe that the dynamite was not the original source of trouble. Moreover, fire otherwise located than in the bottom of the coal bunkers, would probably be quickly observed and extinguished before it was too late to prevent the explosion of dynamite. Everything considered, it seems reasonable to blame the coal bunkers and spontaneous combustion as the cause of the catastrophe. One can be glad that reason and charity go together to support the belief that unforeseen and unguarded chemical actions were the cause of the accident rather than pure human carelessness.

The whole subject of the explosion can be understood by a study of the previously mentioned article. Coal, it appears, absorbs from one to three times its volume of oxygen. This produces heat, and, occurring in a thick mass, the heat accumulates, and ignition is the result. It seems a disputed point, according to Mr. Kendrick, whether free ventilation should be aimed at to prevent combustion, or whether the method whereby no warm air is to be allowed near the coal, and so no heat generated, should be adopted. The latter method being true, it is quite safe to store coal in closed bunkers, exhaust the air at the top and fill the voids between the coal from below with carbon dioxide.

Coal of large size with few fines in it will ordinarily not take fire. Nevertheless, Mr. Kendrick claims that in coal mines ample ventilation has sometimes caused heating in the gob (waste fillings in mine), and choking off the air current has stopped the heating. Water is not very satisfactory for quenching coal piles that are on fire if in small quantities, and may, if so used, only increase the combustion and heat. One can understand, therefore, how, in a ship loaded with dynamite, fire, once well started in a coal bunker, might be inextinguishable when discovered before the serious danger of the fire had extended to the dynamite.

Knowledge has forearmed man sufficiently against spontaneous combustion, so that, ordinarily speaking, he should be able to guard himself against serious danger from it. With proper attention during loading, or with a proper system of inspection afterwards, a ship carrying dynamite could be made safe from such an occurrence as spontaneous combustion. It is unfortunate that it is usually tramp steamers that carry the most dangerous cargoes around. The officers and crew may not be in a position to either know how or to be able to enforce intelligent and scientific orders and inspection for the prevention of accidents. It will be interesting to note what steps, if any, will be taken to prevent a re-occurrence of such an accident as that brought about by spontaneous combustion occurring in coal bins of a ship loaded with dynamite.

EDITORIAL COMMENT.

The arrival of Easter brings to end one of the mildest winters Ontario has ever experienced. The corollary follows that it has been an exceptionally fine winter for those trying to carry on outdoor work or building construction. Winters of such a mild nature as that just past are always welcome to engineers. The cold is a serious drawback to all forms of construction, and the arrival of spring, we hope, heralds the approach of a summer of unexampled activity in all engineering lines. Railroads under construction and extension; the Welland and Georgian Bay Canal schemes; harbors in almost all our Canadian cities under plans for improvements and increased shipping accommodation. All these items and many smaller ones go to make up a gigantic programme to prepare for and consider in an engineering way.

LARGE WIRE ROPE.

A large cable which has been used for 18 months in lowering 50-ton trucks down an incline into a mine in Cuba has been tested at Lehigh University, Pa. A portion of the worn cable withstood a test of 300 tons. The cable itself is believed to be unique in wire rope manufacture; it consists of six strands, each having 19 wires, placed around a wire rope centre, and the centre is composed of six strands of 19 wires each twisted around a hemp rope. The length of the cable was 7,810 feet, and it weighed over 125,000 lbs.

ELECTRIC RAILWAY STATISTICS.

The growth of electric railways throughout Canada is well shown in the following statistics, published by the Department of Railways and Canals, Ottawa. Two companies failed to make their annual report to the Department for 1912, i.e., the Montreal Tramways and the St. John Electric, consequently, in the statistics given for 1912 it has been necessary, as regards the above-mentioned companies, to assume the figures from their 1911 reports as applicable to the following year.

Operations for the year show growth in all departments and a general extension of the electric railway interests.

Mileage.—Track mileage for the past four years is shown in the following table:—

Length of Tracks.	1910. Miles	1911. Miles	1912. Miles
Length of first main track	1,049.07	1,223.73	1,308.17
Length of second main track....	242.39	259.74	294.50
Total length of main track.....	1,291.46	1,483.47	1,602.67
Length of sidings and turnouts..	91.39	103.54	120.84
Total, computed as single track.	1,382.85	1,587.01	1,723.51

It will be observed from the foregoing that there was an increase of 84.44 in first track mileage, and of 34.76 in second track mileage—a total for 1912 of 119.20. The increase in sidings and turnouts amounted to 17.30 miles. The actual gain for the year in trackage of all sorts was 136.50 miles.

For purposes of comparison, the following table shows first track mileage since 1910:—

1910	1,047.07
1911	1,223.73
1912	1,308.17

Improperly included double track and sidings.

Capital Liability.—There was an increase for 1912 of $11,309,599 in capital liability, which brought the total up to $122,841,946.

The facts with respect to capital liability since 1910 are as follows:—

	1910.	1911.	1912.
Stocks	$ 58,653,826	$ 62,251,203	$ 70,829,118
Funded debt	43,391,153	49,281,144	52,012,828
Total	$102,044,979	$111,532,347	$122,841,946

The foregoing statement does not include cash subsidies to the amount of $493,346 received from governments and municipalities.

Earnings and Operating Expenses.—Gross earnings from operation in 1912 totalled $23,499,250.31—an increase of $3,142,298.61 as compared with 1911.

Following were the sources and items of gross earnings for the year:—

Car earnings—	
Passengers	$22,007,750.15
Freight	1,025,371.93
Mail and express	78,818.66
Other car earnings	67,022.30
Total car earnings	$23,178,693.04
Miscellaneous earnings—	
Advertising	$ 71,226.65
Rent of land and buildings	21,228.39
Rent of tracks	13,836.70
Rent of equipment	56,239.74
Sale of power	37,083.98
Other miscellaneous earnings	120,671.81
Total miscellaneous earnings	$ 320,287.27
Gross earnings from operation	$23,499,250.31

A comparative statement of car earnings for the past three years shows the following result:—

Gross car earnings.	1910. $	1911. $	1912. $
Passengers	16,125,944.72	19,130,376.22	22,007,750.15
Freight	575,536.84	744,179.11	1,025,371.93
Mails and express	68,604.11	88,233.13	78,818.66
Other earnings ..	51,241.07	100,930.12	67,022.30
Total	16,821,376.74	20,063,718.58	23,499,250.31

An outstanding feature in the foregoing statement is the steady rise of earnings from freight. In 1904 there had been an increase to $182,143, and in 1906 to $288,105. In 1912 the earnings from freight reached $1,025,372—showing the extent to which that aspect of public service had grown in twelve years.

Table 4 will afford details with respect to earnings.

Following is the balance sheet for 1912:—

Earnings and income—		
Gross earnings from operation		$23,499,250.31
Operating expenses		14,266,674.63
Net earnings		$ 9,232,575.68
Miscellaneous income		1,617,017.78
Gross income		$10,849,593.46
Deductions from income—		
Taxes	$1,581,802.81	
Interest—funded debt	1,570,202.02	
Interest—floating debt	193,068.26	
Other deductions	188,582.57	
	$3,533,655.66	
Undistributed	1,378,906.56	4,912,562.22
Total net income		$ 5,937,562.24

The undistributed amount given above relates to the British Columbia Electric Railway Company, which operates, in addition to an electric railway, a lighting and power plant. A separation is not made in the balance sheet of that company of items which would establish the real net income of the electric railway interest by itself.

If the undistributed income had been added to net income, as was done in preceding years, the amount of the latter for 1912 would have been $7,315,937.80, as compared with $6,592,535.30 in 1911. It would not, however, be strictly correct to do that, since it represents a total from which proper deductions had not been made. The definitely known net income is the sum given in the balance sheet, although it is probably below the actual amount.

The amount of dividends and bonuses paid during the year was $4,229,005.75. These payments were equal to 5.9 per cent. of the total stock issue.

Following is a comparison of deductions from income for the past three years:—

	1910.	1911.	1912.
Taxes	$1,311,953.65	$1,437,045.07	$1,581,802.81
Int. on funded debt	1,449,152.48	1,622,780.11	1,570,202.02
Int. on floating debt	156,546.16	157,843.38	193,068.26
Other deductions ..	36,106.97	155,149.97	188,582.57
Total	$2,953,759.26	$3,352,818.53	$3,533,655.66

Operating expenses for the year totalled $14,266,674.63 as against $12,096,134.22 in 1911.

The ratio of operating expenses to gross earnings was 60.71 per cent., as compared with 59.42 in the preceding year.

Following was the distribution of operating expenses in 1912, with a comparison for 1911:—

Operating expenses.	1911.	1912.
Maintenance of way and structures	$ 920,874.93	$ 1,228,972.10
Maintenance of equipment	1,758,289.10	1,859,939.21
Operations of power plant	2,001,543.00	2,535,573.10
Operation of cars	5,768,085.10	6,770,560.47
General	1,610,098.62	1,871,626.75
Total	$12,096,134.22	$14,266,674.63

Following is a comparative statement of the items comprising operating expenses for the past three years:—

	1910.	1911.	1912.
Maintenance of way and structures—			
Track and roadway.	$ 590,363.28	$ 693,498.75	$ 857,796.61
Electric line	152,874.47	163,108.91	227,562.04
Build'gs and fixtures	54,657.28	64,697.11	143,613.40
Maintenance of equipment—			
Steam plant	38,305.93	46,504.31	50,137.15
Electric plant	45,148.10	65,145.02	87,570.70
Cars	692,276.38	790,609.02	916,755.20
Electric equipment of cars	481,301.83	546,276.52	630,521.52
Miscellaneous equipment	58,815.63	99,831.25	86,053.80
Miscellaneous shop expenses	202,591.58	192,608.03	67,493.89
Transportation—Operation of power plant—			
Power plant wages.	178,389.69	207,118.54	205,858.34
Fuel for power	271,410.36	332,584.89	315,019.83
Water for power	21,398.33	21,947.47	13,979.30
Lubricants and waste for power plant	10,538.93	10,702.75	11,006.39
Miscellaneous supplies and expenses	17,916.34	29,126.20	22,051.25
Hired power	1,087,273.72	1,390,810.05	1,901,757.49
Transportation—Operation of cars—			
Superintendence	192,567.60	250,459.73	319,399.37
Wages of conductors	1,749,916.70	2,070,624.01	2,423,060.35
Wages of motormen	1,697,096.68	2,024,115.38	2,371,529.39
Wages, miscellaneous car service	152,950.35	294,498.67	339,771.00
Wages, car house employees	393,998.76	287,441.56	400,967.61
Car service supplies	94,486.16	151,489.64	161,895.17
Miscellaneous car service expenses	183,526.94	306,931.96	304,898.48
Hired equipment	42,136.56	55,278.55	73,876.17
Cleaning and sanding track	65,200.30	80,302.13	86,514.84
Removal of snow and ice	238,881.58	246,943.47	285,662.53
General—			
Salaries of general officers	236,575.70	279,819.40	327,451.09
Salaries of clerks	202,712.98	250,902.23	274,832.47
Print'g and stationery	33,634.34	44,284.36	53,073.13
Miscellaneous office expenses	44,336.11	34,944.72	54,474.14
Stable expenses	30,817.44	33,047.06	47,931.82
Store expenses	33,841.10	37,876.19	43,908.89
Advertising and attractions	47,411.04	49,948.03	39,706.15
Miscellaneous general expenses	133,752.32	165,707.31	154,432.11
Damages	342,120.26	357,279.67	536,273.01
Legal expenses	8,784.32	9,107.93	4,406.14
Miscellaneous legal expenses	54,336.64	63,311.08	53,089.47
Rent of land and buildings	20,936.74	28,310.05	29,651.68
Rent of track and terminals	98,753.70	110,846.74	90,751.33
Insurance	118,930.80	144,713.85	148,309.34

Public Service.—During the year 488,865,682 passengers were carried, exclusive of 125,453,320 transfers, showing an increase of 62,568,890 as compared with 1911.

The carrying of these passengers involved a car mileage of 80,402,089.* Freight, mail, and express business had a car mileage of 1,667,975. There was an increase of 8,867,961 in passenger car mileage, and 583,297 in freight car mileage, over 1911.

The following statement shows the growth of passenger traffic since 1910:—

1910	360,964,876
1911	426,296,792
1912	488,865,682

The number of tons of freight hauled was 1,435,525, as compared with 1,228,362 in 1911. Owing to an erroneous return in 1911 by one of the Ontario companies, the figures published in that year in relation to freight tonnage were considerably exaggerated.

Equipment.—The following statement will show the number and classes of cars in service in 1912, with the figures for the two preceding years:—

Classes of cars, etc.	1910.	1911.	1912.
Passenger, closed	1,795	1,985	2,049
Passenger, open	994	990	866
Passenger, combination	337	455	574
Freight	282	357	483
Mail, express and baggage	25	33	33
Combination, passenger and freight	–	5	7
Work	8[illegible]	108	10[illegible]
Snow ploughs	6[illegible]	60	57
Sweepers	97	106	112
Miscellaneous	103	225	194
Total	3,789	4,325	4,478

Employees.—The number of employees in the service of electric railways on June 30, 1912, was 14,760, as compared with 13,671 in 1911.

The total of salaries and wages for the year was $9,261,370.26, as against $8,559,215.04 in 1911.

Salaries and wages in 1912 were equal to 64.91 per cent. of the operating expenses, as compared with 70.76 in the preceding year.

The following comparative table will show the number and classes of employees in 1912 and 1911:—

Employees.	1911.	1912.
General administration—		
General officers	163	159
General office clerks	694	744
Maintenance—		
Superintendents	89	90
Other employees	4,546	4,922
Transportation—		
Superintendents	111	118
Other employees	8,157	8,727
Total	13,671	14,760

WESTERN CANADA POWER COMPANY'S HYDRO-ELECTRIC PLANT AT STAVE FALLS, B.C.

One of the most important hydraulic installations Messrs. Escher Wyss and Co., of Zurich, Switzerland, have installed in Canada is the Stave Falls plant of the Western Canada Power Company. The power station is located about 35 miles from Vancouver at the Stave River Falls and utilizes a fall of about 100 feet.

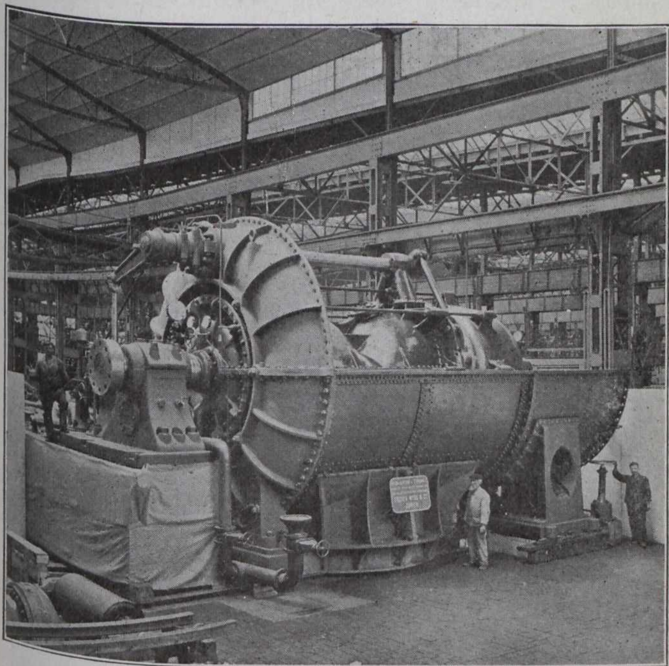


Fig. 1.—13,000 H.P. Turbine, rear view.

By building two dams at the upper side of Stave Falls a large reservoir has been created reaching to the upper end of Stave Lake, a distance of 16 miles, with an area of 18 square miles; this storage capacity, together with the flow of the river, is sufficient for 28,000 h.p. continuously, and for a peak load of 50,000 h.p.

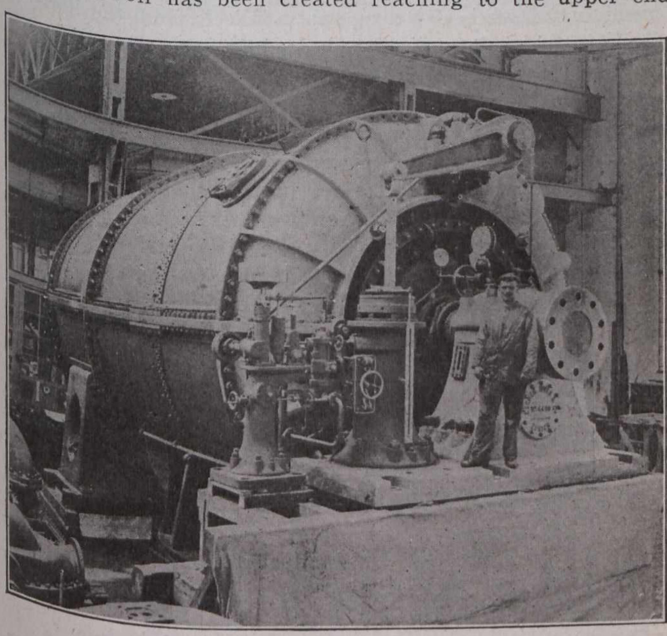


Fig. 2.—13,000 H.P. Turbine, Front View.

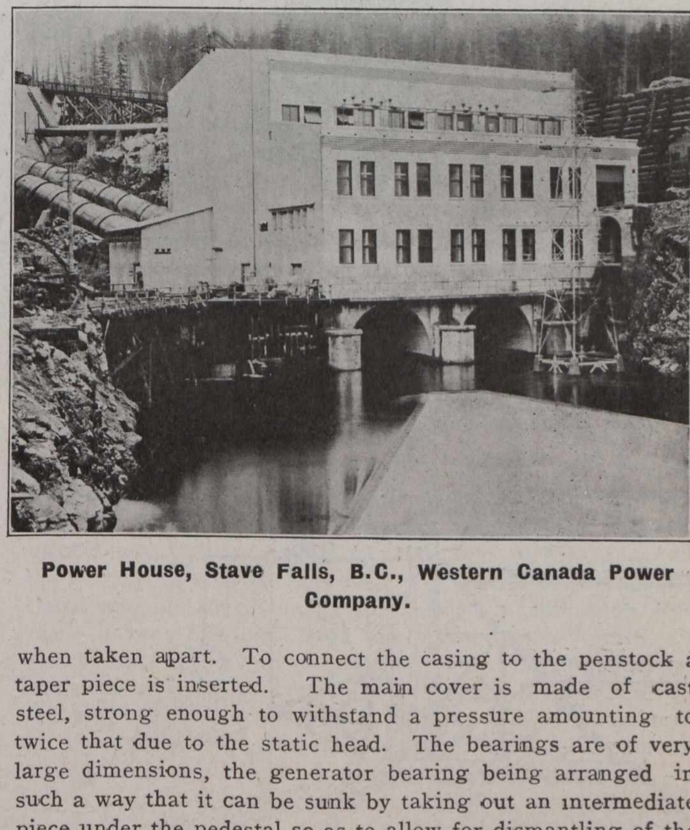
By raising the dams additional storage can be obtained and the plant be brought up to the full capacity of 100,000 h.p.

At present 26,000 h.p. are developed and two units of 13,000 h.p. are installed. The water is taken from a forebay by means of two penstocks, each having 14'6" diameter and a total length of 150 ft. The penstocks for the two exciter turbines are 4 ft. in diameter.

The design of the main turbines is shown on figures 1 and 2. These turbines are of the Francis type with horizontal shaft, double wheels and central discharge, delivering through a short draught tube formed in concrete to the tail-race. The level of the water in the tail-race is kept constant at elevation 110 ft. The level of the water in the forebay varies from a minimum of 210 ft. to a maximum of 230 ft., the head varying thus from 100 ft. to 120 ft. The average head is 110 ft. Under this head the turbines have to give a maximum power of 13,000 h.p. on the shaft when running at a speed of 225 r.p.m.

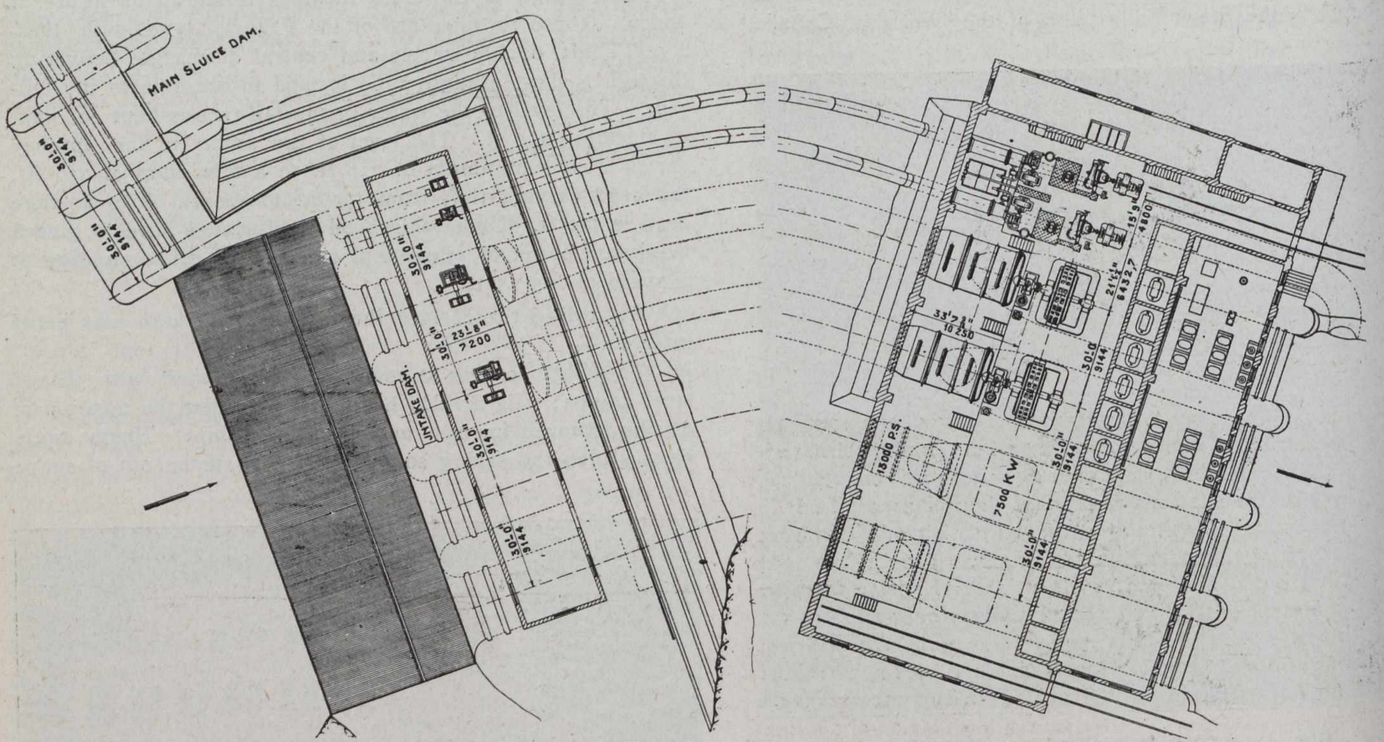
Regarding the design, the following remarks may be of interest:—

The wheel casing is made of steel plates with heavy steel angles; it is divided horizontally so that the upper part can be removed for easy access to the turbine. Heavy angle irons stiffen the casing so that it cannot spring out of shape when taken apart. To connect the casing to the penstock a taper piece is inserted. The main cover is made of cast steel, strong enough to withstand a pressure amounting to twice that due to the static head. The bearings are of very large dimensions, the generator bearing being arranged in such a way that it can be sunk by taking out an intermediate piece under the pedestal so as to allow for dismantling of the shaft. The outer bearing is protected by a housing, into which access is allowed by means of a steel tube. It will be noted that a considerable distance between the two bearings is allowed, but Escher Wyss and Company consider this arrangement better than to have a third bearing inside the draught chest which is not free to inspection and thus means a weak point in the design. The shaft is made in one piece and of sufficient thickness at the centre to revolve without the support of a middle bearing and without undue deflection. The half couplings are forged on both the generator and the turbine shaft. A strong cast iron foundation frame supports rigidly the draught chest and cover. No steel girders are used as foundation, but the whole is grouted in concrete. The runners are made entirely in cast steel. Considerable difficulty was experienced by the steel foundries to cast these runners, but in the end faultless casts were obtain-

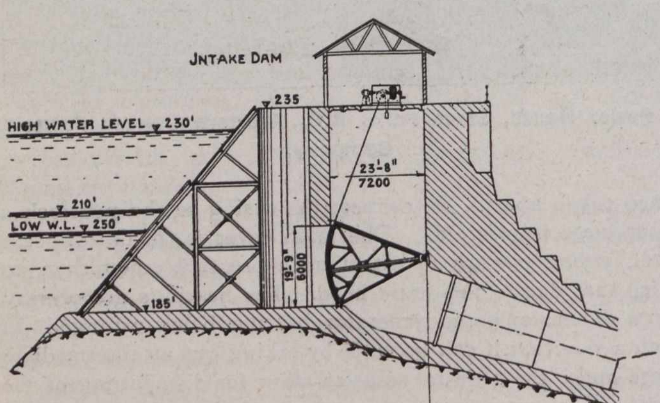


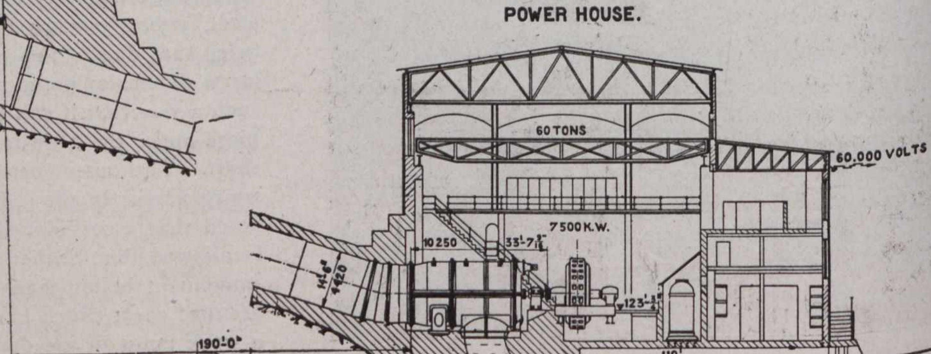
Power House, Stave Falls, B.C., Western Canada Power Company.

ed and the high efficiency these runners have shown gives high credit to the designers. The guide vanes are of cast steel, and all steel bolts are provided with suffing boxes and bronze bushings so as to guarantee smooth working and possibility of dismantling. The regulating rings have been given a profile of maximum possible resistance and stiffness, which in this case is of great importance, as the diameter of the ring is 9 ft. These rings, as well as all covers, stuffing boxes, etc., are split horizontally. A regulating shaft of 10 inches diameter, supported by white metal bearings mounted on the draught chest, operates the regulating rings. The shaft, on the other hand, is operated direct from the servo-motor working under oil pressure supplied by an oil pumping plant. The speed governor is driven by belt from the main shaft. The servo-motor consists of a differential cylinder, which, by means of pressure oil from the air vessel produces the power required for moving the governor gearing of the turbine. Pipes from wither side of the piston connect to the controlling valve mounted on the casing. This valve contains several chambers communicating with the respective servo-motor chambers and oil tank. The spring pendulum contains fly-weights loaded by compressed springs. The larger springs are supported by the pendulum casing, the smaller ones by the movable discs, which latter are adjustable in the radial direction, whereby the compression of the springs and therewith the speed of the pendulum is varied. The speed can be regulated by turning a handwheel on the governor or from the switchboard by means of a small electric motor mounted on the pendulum. The pendulum shaft is driven by worm wheels from the horizontal shaft, which latter is driven by belt from the turbine shaft. The movement of the fly weights in the pendulum is transmitted to the regulating lever. A relay consisting of a dash pot serves as second compensation device. Governing by hand can be effected by means of a hand governing valve, which admits pressure to one or the other side of the servo-motor piston. The oil pressure necessary for the governors of both turbines is supplied by an independent plant. It consists of two complete units, each unit being capable of supplying under normal conditions the necessary pressure oil for the governors of the two main and the two ex-



C.—General Plan of Hydraulic Development at Stave Falls, B.C., Western Canada Power Co.



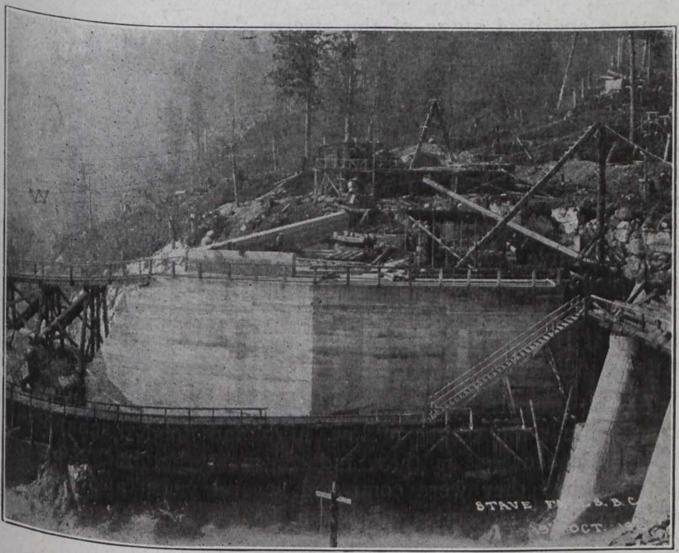


D.—Elevation and General Plan of Hydraulic Development at Stave Falls, B.C., Western Canada Power Co.

citer turbines. Each unit consists of an impulse wheel direct connected to a three cylinder single acting oil pressure pump which draws the oil from an oil tank and forces it into a strong air chamber, whence the governors of the turbines are fed. After leaving the governors the oil is flowing back to the oil tank passing an oil filter. The impulse wheels receive water through pipes connected to the exciter pipeline.

The exciter turbines are single wheel Francis turbines with horizontal shaft in spiral casing, each designed for 500 b.h.p. when running at a speed of 500 r.p.m. They are fitted with Escher Wyss and Co.'s patent universal oil pressure governor of the standard type, and are direct connected to two exciters.

The electrical equipment of the power station, which was supplied by the Canadian General Electric Co., consists of 2 generators having a nominal capacity of 7,500 k.w. each and 2 exciters rated at 250 k.w. each. They are capable of giving a continuous overload of 25 per cent. and are producing continuously 9,375 k.w. at a power factor of 85 per cent. The normal voltage is 4,000, periodicity 60 cycles. They are guaranteed to run at a speed of 75 per cent. in excess of the normal.



Intake of Stave Falls Plant, Western Canada Power Co.

The transmission lines from the power house to the receiving station is designed for 60,000 volts.

The weight of the water-wheels is 165 tons per piece, while the generators weigh 160 tons each.

The plant was first started up in December, 1911, and, according to a statement made by the Western Canada Power Co., not the slightest difficulty was experienced, neither on the hydraulic nor the electrical machinery. It has during the fourteen months run given full satisfaction in every respect.

Modern research has brought to our industries, at a marvellous rate, not only new compounds but even new elements. Prof. H. T. Kalmus, of Toronto, calls attention to the fact that of the fifty metallic elements now known only seven were in commercial use 2,000 years ago and until 100 years ago the rate of addition was less than one metal for each two centuries. Within the last twenty-five years about fourteen metals have been added to commercial use—an addition at more than one hundred fold the previous rate.

IRRIGATION SURVEYS AND WATER POWERS.

The magnitude of the work which the Commissioner of Irrigation for the Dominion Government of the Provinces of Alberta and Saskatchewan is doing may not be altogether realized by readers who have not come in direct touch with this department. The work is carried on under the Director of Forestry, and the annual publication of the department contains many interesting details submitted by the Commissioner, F. H. Peters, A.M. Can. Soc. C.E., D.L.S. Those portions of his report which are likely to be of interest to our readers are condensed in the following paragraphs:—

The irrigation office may be said to be the guardian of the water resources of the provinces of Alberta and Saskatchewan, and this naturally carries with it great responsibilities. Much of the work done by this office must necessarily be for the benefit of future generations, and this, unfortunately, does not tend to make the work popular with the people of to-day. This is especially true of the work of stream measurement that is being carried on, and, because there is plenty of water for everybody to-day, even the most interested parties, who are themselves licensed by the government to use water, do not appreciate the work and do not realize that a perfect system of stream measurement means a perfect safeguard to their water-rights in the future, and that every dollar spent to-day in prosecuting this work means many dollars saved in the future in the prevention of litigation that must arise if the load that is placed on every stream is not carefully guarded to-day. Our neighbors to the south have learned this lesson by costly and bitter experience, and we may, if we will, profit by their experience and avoid the mistakes which they made during the earlier days of irrigation development.

General Information Regarding Irrigation in Alberta and Saskatchewan.—The irrigation office has jurisdiction over all water-grants made in the provinces of Alberta and Saskatchewan (except grants for water-power purposes, which are handled by a separate branch), and it can be easily understood that the patrolling of this vast area requires a large staff and a sound organization.

The remarks here following relate almost entirely to the work of irrigation inspections. The work done by this office naturally divides itself into two separate branches: irrigation inspections, together with reservoir site surveys, etc., and the stream measurement work. The two are closely associated and must go hand-in-hand, but are submitted separately in order to keep down the bulk of each volume, and also because the report of progress of stream measurements is nearly all composed of tables of gauge-heights and discharges, and is more fittingly published in a separate report for convenience of reference; a brief, general report on stream measurements is, however, appended hereto.

In order to give an idea of the extent to which irrigation is now being carried on in the western provinces the following brief summary is given:—

The total amount of water granted by the Dominion Government in the two provinces is 23,865 cubic feet per second. Of this total amount 23,536 c.f.s. have been granted for purposes of irrigation, leaving 329 cubic feet per second divided up between the other three classifications; that is, domestic, industrial and other purposes.

In Alberta the total amount of water granted for irrigation purposes is 23,114 c.f.s., or enough to irrigate 3,467,100 acres of land, according to the authorized duty of water, which is 2.023 acre-feet per acre.

Of this quantity four large companies have 22,500 c.f.s., leaving 614 c.f.s. divided up among 320 individual users; excluding from these twenty-four applicants who each have an average grant of about eight c.f.s., we get figures for the average individual water-user, viz.: 414 c.f.s., divided up between 296 individual users, which gives each one 1.40 cubic feet per second, or enough to irrigate 210 acres of land.

Of the four large companies mentioned above, the following facts may be stated: The Canadian Pacific Railway Irrigation Company has been granted from Bow River, near Calgary, 3,000 c.f.s. at low-water stages, 13,000 c.f.s. at high-water stages, and 15,000 c.f.s. at flood stages. It has approximately one million acres of irrigable land, and already has issued over 1,500 agreements to furnish water to settlers within this tract.

The Alberta Railway and Irrigation Company has been granted from Belly River 500 c.f.s. at all stages of flow, from Milk River 500 c.f.s. at low-water and 1,500 c.f.s. at high-water and flood stages, and from St. Mary River 500 c.f.s. at low-water and 2,000 c.f.s. at high-water and flood stages. It should be noted, however, that the total amount of the grants from Milk River and St. Mary River have been somewhat modified under the terms of the International Waterways Treaty recently made between Canada and the United States. This company has already issued water agreements to over 800 water-users.

The Southern Alberta Land Company has been granted from Bow River 2,000 c.f.s. at high-water and flood stages, and from the South Saskatchewan River 1,000 cubic feet per second at all stages. This company has developed a very large reservoir for the storage of flood waters, in order to utilize its high-water and flood license from Bow River. The works are not yet completed, and, therefore, the company has not as yet entered into any agreement to supply water to actual users. The company controls about 400,000 acres, about half of which is irrigable.

The Alberta Land Company, operating as a subsidiary company to the last-named company, and diverting water through its works, has a grant of 500 c.f.s. from the Bow River at high-water and flood stages. The works of this company are not yet completed.

In the province of Saskatchewan irrigation has not been undertaken to nearly the same extent as in the province of Alberta, and it has no large irrigation companies. There has been granted to date in Saskatchewan, for irrigation purposes, 423 cubic feet of water per second, and this quantity is divided among 241 individual users. This gives each one an acre of 1.75 cubic feet per second, or enough to irrigate 262 acres.

Licenses are granted by the Dominion Government, under the administration of the Minister of the Interior, for the use of water, under the following classification:—

1. Domestic uses.
2. Industrial uses.
3. Irrigation purposes.
4. Other purposes.

The procedure followed in granting water-rights is, briefly, as follows:—

Any applicant for a water-right must first submit a memorial setting forth the purposes for which the water is required, and, accompanying this, must be general and detail plans showing where, and how, and for what purpose, he intends to use the water and what works he intends to construct or install. The next step is an inspection of the scheme by one of the government engineers, who reports upon the feasibility of the scheme, the question of water-supply and the character of the works to be constructed. The proposed scheme is then advertised in a local paper for six weeks, in order to give the local public notice of what is proposed and what water-supply and lands will be affected. Any protests which may be made against the proposed scheme are carefully investigated. Authorization is then issued for the construction of the necessary works, and a limit of time is placed within which the construction must be completed. The Department's engineers inspect all schemes periodically during construction, and, finally, after the works have been satisfactorily completed and inspected, the water license is granted.

The work of inspection is divided into two districts, within which the bulk of the work lies, viz.: the Maple Creek district and the Calgary district; the other schemes, which are widely scattered, are inspected by so-called special inspectors.

The Maple Creek district is under the especial charge of a division engineer, who has under his control two assistant engineers, each with a field party working under his direction. The Calgary district is patrolled by one district engineer with a small party.

Determination of the Low, High and Flood Discharge of Streams.—In order that the following may be intelligible it is necessary to explain the procedure in granting water-rights against any stream or other source of supply. The procedure is to consider that every stream has three separate stages of flow; that is to say, low-water stage, high-water stage and flood stage, and each water-license is issued against a specified stage of the stream flow.

In order that, under average conditions, there may always be enough water in the stream to fulfil the obligations of all the licenses issued, it is clear that the records of this office must show definitely the quantity of water in the stream, under such average conditions, at the three stages above mentioned. It is also clear that it is a most difficult matter to determine accurately the flow of the stream at the three respective stages; in fact, these figures can only be determined with even a fair degree of accuracy after a long series of stream measurements has been carried on on each stream. It is at this point that the work of stream measurements is indivisible from the work of irrigation inspections.

At the present time the quantities for all the streams, shown against the stages of low, high and flood discharge, are most inaccurate, as they, indeed, must be, because at the time when they were computed several years ago practically no continued series of stream measurements had been made.

During the present winter the matter of determining these quantities with some degree of accuracy is being actively taken up. The Department now has fairly complete records of stream-flow on several streams from the year 1908 to the year 1911, inclusive, and on most of the important streams used for irrigation purposes the records of stream measurement date back to 1909. The procedure being adopted is as follows: A separate sheet is being prepared for each stream, and on this is being plotted as a profile the mean monthly discharges for all the years during which records have been obtained. The profile for each year is plotted with a different colored ink, so that the different years can be readily distinguished. After a careful study of each sheet two horizontal lines are drawn across the profiles showing the three stages of flow as arbitrarily determined from the study. The horizontal lines are drawn only in pencil, so that at some future time, when more records of stream-flow are available, they may be shifted if necessary to more accurate positions as shown by the increased length of the period over which the stream measurements have been gained.

This arbitrary determination of the stage of the streams is a most important matter, as, if these determinations are in error, the streams will either be over-recorded or under-recorded. In the first case, the existing rights of the first license will be jeopardized, and, in the second case, applications will be refused when sufficient water is really available and might be put to beneficial use for irrigation or other purposes.

The rivers must be regulated for all beneficial purposes in order to develop their maximum potentiality; so should the regulation of all the beneficial purposes be carried out by one department so that in studying any scheme of conservation every beneficial use may be given due consideration. Forestry, irrigation and drainage are at present in one branch of this department, under the Director of Forestry, but the investigation and regulation of power production is a separate branch. It is most important that this work should be included in the work of the irrigation office, or at least placed under the direction of the same head, the Director of Forestry. The water-power branch has its headquarters at Ottawa, far removed from the scene of its work, and it has no organization in the West with which to carry out the necessary investigation. The irrigation office, on the other hand, has its headquarters at Calgary, and has a well-organized establishment and a staff of engineers familiar with western conditions. In concluding this topic the case of the Bow River is most illustrative. The government anticipates reservoiring the waters of this river, and in doing so it must consider the claims of irrigation, and also of power production. The claims of these two industries are antagonistic, in that irrigation requires the stored waters for use in the summer and power production requires the stored waters for use in the winter. The two demands have to be adjusted and balanced, and it would be waste of space to further explain that this question can far better be studied and adjusted within the confines of one branch of the department than by two separate branches, neither of them responsible to the other.

The people in the United States have, after long years of bitter experience, come to the conculsion that these matters are indivisible. Cannot we save all the inevitable blunders and heart-burnings of the future by profiting by their experiences and having this matter adjusted at once?

GOOD ROADS IN ONTARIO.

Last month the Ontario Good Roads Association held its annual meeting in Toronto. On that occasion W. A. McLean, Chief Engineer of Highways for Ontario, gave an address before the Association, an abstract of which we are now pleased to present to our readers.

The roadways constructed under the county road plan last year, aggregating 240 miles, and if placed in a continuous line, would extend from the city of Toronto to Ottawa, a fairly good stretch of highway. If we keep improving in the future as in the past, the prospects are very favorable for a good system of highways throughout Ontario. During the past few years, the cost of highway construction in Ontario has greatly increased. Highway construction is not made up of the cost of material in the pit, or stone in the quarries, nor by the cost of machinery, but rather by the cost of grading and drainage, of operating machinery, of getting material out of the pit and out of the quarry, crushing and preparing it for the roads and putting it in place. That means that the principal cost of road construction goes into wages of men and teams. Ten years ago, the cost of labor was $1.25 for men, and teams could be had for $3.50 per day. I have seen, this year, instances of men being paid $3 a day, and teams $6 a day, with a fair average over Ontario of $2.50 per day for men and $4.50 and $5 for teams, which means that the cost of road construction is practically twice as much to-day as it was ten years ago.

To meet the situation, we shall have to dispense, as far as possible, with horses and manual labor, and turn our attention to road building through the use of machinery. But, to build roads with economy by the use of machinery, we must keep the machinery steadily employed. We must stop the annual patching of roads by men and teams, and expand the county road plan; not to build roads in short, scattered sections, but rather in long stretches.

Road Drainage.—Last season one of the striking features of the year was the heavy rainfall, and from all sides we heard that the roads were badly worn. Where our roads went to pieces, under the influence of last season's heavy rainfall, it means largely, a lack of drainage; that sufficient precaution had not been taken to put a proper crown on the road, open ditches, and put in culverts where they ought to be. We have got to drain in Ontario, not for the ordinary summer weather, but for the heavy rainfalls which come periodically; and for the Spring time.

We have a standard type of roadway in Ontario. The width between the shoulders is 24 ft., the crown depending upon the width of stone, and varying from half-an-inch to an inch per foot between the shoulder and the top of the road. Below the shoulders, there should be 18 inches or two feet of drainage. The stone in the centre should depend upon the traffic over the road, ranging from 8 to 16 feet wide.

Everybody wants good roads, but few want to pay for them. They do not want to pay for them with half the zeal with which they ask for them. It is extremely important in entering upon any scheme of construction to have an equitable system of distributing the cost. The people of this country will not object to pay a reasonable price for good roads if the cost is equitably placed upon those who should pay for them. My experience is that, while the people at the commencement are often opposed to good roads, when they begin to see results, they say "That is the road we want, and will pay what it should cost."

The increase in the price of property along highways which have been recently constructed, indicates the real service good roads are to a country. We talk about the service good roads do socially, commercially and otherwise; but getting to practical dollars and cents, we find that property along a good road is increased to the extent of $500 to $2,000 for each one hundred acre farm. Increase in the value of property is a pretty good indication of the service these roads are to the people of the country. Just think what that means. Every one hundred acre farm is increased in value to the extent of $500 to $2,000. With eight farms fronting on each mile of highway, it means an increase of from $4,000 to $16,000 per mile of road. With that increase, property can pretty fairly be assessed for the cost of a great portion of the roads. When you take from that cost the proportion the province is paying under the Highway Improvement Act, it looks like a pretty good proposal for any part of the country to construct good roads.

In proposing the construction of a main highway between Toronto and Hamilton, the people along that highway said, "If you will construct it, we will pay an annual frontage tax of one and a half cents per foot for thirty years." The people on that highway have consented to the plan, and it indicates that the principle, if extended and made applicable to certain other of the most important highways, could be serviceable and acceptable, and would help to create the fund necessary to construct good roads.

It is also argued, and very properly so, that the automobile should be specially taxed. I will not go into the question of the destruction of the roads from the use of automobiles. They unquestionably do considerable injury to the highways, especially heavy cars which travel at high speed over stone roads. But it is a notable fact that the automobile owners have consented to pay such a tax; which will no doubt be imposed.

Now the population of the towns and their assessment throughout Ontario is practically equal to the population and assessment of the townships; therefore, I take it that the people of the towns and cities are paying one-half of that one-third, or one-sixth of the cost of the good roads constructed under the Highway Act at the present time. One-sixth, I think you will agree with me, is not sufficient.

The Highway Improvement Act has been before the people of Ontario for some time. For over ten years, counties have been offered one-third of the cost of constructing main roads, and all of them have not yet jumped at the chance. I do not know just why they have not.

The Highway Act is extremely simple in its operation. The county is empowered to take over and maintain the main roads of the county highways used by the people of that county, and serving the market requirements of the people of the county. They appoint their own superintendent or engineer to direct construction for the county council. At the end of the season they send us their statement of expenditure and we pay them one-third of it. Up to the present time we have not had any serious trouble with any county. Sometimes they say we are a little slow, but we get there just the same, and they always feet sure of their cheque. The county council controls these main highways in the same way as a township council would manage their roads. By concentrating our efforts and energies on a special system of highways we follow a principle that is absolutely essential in any similar form of organization. In any line of construction you must concentrate sufficient energy on a fixed object to accomplish that object; to complete it and then go on to the next.

I have referred to organization. Organization, I am convinced, is the key-stone of the situation. If you get your organization as it should be, everything else will take care of itself. The superintendent should practically take the place, with county council, of a contractor. He should be the type of man who would be a successful contractor.

Another important part of the organization is the foremen. Part of the qualification of the superintendent should be that he is able to select and get to work for him, and with him, good and capable foremen. What is a foreman? The word "foreman" explains itself. It means the first man: the head man on the work, carrying out the instructions which have been given to him, and whose special duty it is to get the men, the teams and machinery to give fair and honest service on the road. Between the superintendent and the foremen, you have the essential features of an organization, and too much car cannot be taken in the selection of these men.

It is part of the duty of the superintendent to plan his work, and every foreman should be the first man on the job, with the day's operations well planned. Not only should the superintendent plan for carrying out the construction, but the foreman should come to his work each day with a clear understanding of what he is going to do. These are some of the features of the organization that we should try to build up.

Contract vs. Day Labor.—I am sometimes asked if it would not be well to construct roads by contract instead of under the county road superintendent and his foremen. In road construction, in my experience, in order to get as good results from a contractor as from your own foreman, you must spend too much on surveys and engineering supervision to get the contractor to carry out the work. Specifications must be so complete that they frighten the contractor and increase the amount of his tender. The contractor's risk is also greater than that of the municipality. I have seen sections where contract work had been carried out very close to day work, and going over those two sections, we could point out the parts which had been built under the county superintendent and those under the contractor. The time is approaching when, I believe, we can construct highways by contract, but for the simpler class of work, the best and cheaper results will come through carrying out the work under the superintendent and foreman. When we come to make provincial highways, such as are constructed as state highways, I can understand where the plant of the contractors can achieve excellent results, and his organization can be made of good use. But, up to that stage, I believe that the best and cheapest results can be obtained by doing the work under your own superintendent.

Freight Rates on Stone.—It is important to get stone, in a great many parts of Ontario, as cheaply as possible. There are parts of the province where there is plenty of stone. where the people would like to exchange it for some of the good soil of Essex County and Elgin. Down in Leeds and Frontenac there are points where they have so much stone that they do not go off the highway to procure it. But in certain parts of Ontario the only way we can build roads is to ship stone by rail. That is expensive; and there has been a feeling among the counties that the freight rates ought to be reduced. I believe so too, and we have placed the matter before the railway corporations from time to time. The last negotiations entered upon were the most hopeful I have yet undertaken, and I hope we may be able to get the freight rates on stone reduced. But we cannot control two ends of the string at the same time. The point has been raised that if we get the freight rates reduced, we are merely creating an opportunity for the quarry owners to increase their price for stone. If we can in any way get the cost of hauling the stone reduced, we shall expect to look after the other end of the problem.

It is the fact that in every township, if you have not good main roads at the present time, as soon as a good road is constructed, it becomes a main highway, it draws the heavier traffic from other roads. From this cause, townships can construct an inferior type of highway for branches from the main road, which will serve equally as well the traffic over them. My view is that every road in Ontario, travelled to any extent, should receive a due degree of care, and by proper organization in our townships, this can be done.

To get a system established in the townships, there are some essential steps. One is that you place your system on a cash basis. Collect what you require as a special levy on the assessment of the township, what your people can afford. When that sum is a sufficient amount, say $3,000 or $4,000, you should have a foreman appointed under the township council to take charge of the expenditure. By starting early in the year, he can, with the grading machine, grade the roads at the time of the year when earth is in a suitable state to be handled. We often see grading in progress on clay roads when they are as hard as bricks. That is a mistake. Road construction should go on at the time of year that is most suitable. The foreman should be out early in the Spring as soon as the soil is fit, to do all the grading that is required for the year. By using the log-drag on the roads after grading, for maintenance you do not have to repeat the grading operation and it becomes permanent. But the log-drag is useful only as you make it part of a system, and the organization of that system ought to be the duty of the township foreman. After the grading of the year is done, when the streams are low and the ditches dry, that is the time for him to build the small bridges and culverts. Gravelling, if there is gravel in the township, can be let by contract, and carried in when the grading is finished. In the fall, drainage should be completed. By employing a permanent foreman you create in him an experienced employee who will be able to bring that skill to play upon your highways such as other countries have found necessary.

On page 440 of last week's issue, in connection with the report of the Canadian Society of Civil Engineers, Mr. V. J. Elmont's name appeared as Mr. Almonte. The mistake was made as a result of the compositor following the copy as supplied by the verbatim report of the discussion.

STEEL FORMS FOR CONCRETE CONSTRUCTION.

The application of steel forms to conduits, culverts and drains is dealt with in the following article by William Mayo Venable. From his experience of many years on reinforced concrete sewage and drainage systems he is well qualified to write on this subject. In "The Cement World" of January, 1913, dealing with the use of steel forms as above, he writes:—

From the very earliest days of concrete construction until the present, the use of steel for building forms has been constantly increasing in favor. In the earlier days steel was resorted to occasionally by individual contractors who designed and built their own equipment to meet particular conditions, or by builders experimenting to ascertain some more economical method of providing for their centering.

The use of corrugated steel, either plain or galvanized, to support floor loads, both as temporary centering and to be left in place permanently, represented one of the earlier attempts to employ steel for concrete construction. This particular material, corrugated steel sheets, has continued in use for the same purpose, but has found a much wider field of recent years as lagging to support concrete floors of flat slab construction in those cases where the appearance of the corrugations on the ceiling is not considered objectionable. This is probably the most conspicuous instance of an early type of steel centre which has come into common use. The low price of corrugated steel and the ease with which it may be placed and moved on work of this kind without appreciable damage makes it the material which appeals to building contractors generally.

The application of steel in the construction of forms for engineering work generally, however, has been brought about largely through the efforts of a few concerns that are specializing in this line. The reasons for this are that the fabrication of steel cannot conveniently be carried on by individual contractors with the facilities which they possess, and that contractors generally are not usually sufficiently familiar with the requirements of steel form designing to be able to design their own forms and have them built for them. Aside from the fact that there are certain fundamental patents on steel forms, there is another reason which likewise has operated to cause the steel form business to be developed as a separate industry, and that is the very great advantage that accrues to the user of the form by being able to lease apparatus suitable for this work, instead of being obliged to pay the full price of having the forms made for his particular job.

Steel forms are in more extensive use in the construction of sewers, drains, conduits, tunnels and such engineering works than in any other kind of construction. Works of this kind possess certain characteristics that are not common to other types of work upon which concrete is extensively employed. They extend from considerable distances without change of section, and they are always, in whole or in part, composed of curved surfaces. A form to construct a sewer or an aqueduct must be designed so that it can be used over and over again very many times. It is not at all uncommon for a form to be used as many as 30 times over in the construction of a single sewer, while in building construction it is unusual for a form to be used over more than 3 or 4 times on one building. Thus, it is readily seen that the form for a conduit should be made much more durable than is necessary for a form which is not expected to be re-used more than a very few times. The use of steel for forms for conduit of all kinds provides a form which is not injured at all by depositing the concrete, but which will retain its shape indefinitely. This, however, is but one advantage of the use of steel on such work. In conduits of all kinds it is necessary to economize space in order that there may be room for the workmen inside of the conduit and also room for shifting the forms themselves. Wooden centres, in order to secure the necessary strength, occupy so much room with their bracing and other frame-work that it is very nearly impossible to arrange to shift them with the necessary degree of economy.

In conduit work there are two different methods by which the work may be carried on so far as the forms are concerned. Forms for one section may be set up, concrete deposited about them, and the forms then removed and carried forward for another section, the process being repeated thus until the entire structure is finished. If the work is carried on in this way it is not necessary to pull one set of forms through the conduit which is occupied by another set. The other method of conducting the work is to provide the forms for a given length of conduit and constantly to convey the forms from the portion of the conduit which is completed through the portion of the conduit which is being constructed, and to set them up in front, where the conduit is to be extended. It may readily be seen that with wooden forms the first of these methods implies taking the forms apart into many pieces, carrying these out of the ditch and assembling them again in a new position; while the second method implies taking the wooden forms apart in panels and conveying these panels forward through the bracing which supports the panels upon which the concrete is being placed. These are both extremely laborious and expensive processes with wood. With the use of steel forms they are rendered extremely easy.

On conduits of moderate size, where the depth of the excavation is not very great, it is usually found more economical to shift the forms from one position to another without conveying them through forms already set up. Steel forms when used in this way are provided with a carrier of some kind, usually a series of small wheels attached to the sides of the form, by which they may be conveyed forward without being taken apart at all. Thus 100′, or over 200′ of centering for a sewer may be moved at one time, it merely being loosened from the concrete by means of turnbuckles, lowered upon wheels and pulled out with a line to the new position in which it is raised to the proper height and braced to the proper width. This is called pulling the forms "en train."

Where a section is circular the same form may be used to form the invert as is subsequently used to form the arch, but usually the form for the invert is kept separate from that for the arch, the invert being built first and the arch built subsequently. In circular conduits a centre for either invert or arch consists of plates bent to a little more than half a circle, stiffened by angle-irons running longitudinally, joined together at intervals by simple fasteners so as to form a continuous trough, and placed in such a position that it may be collapsed or stiffened, if necessary, by means of turnbuckles.

A circular section is by no means adopted for most of the larger sewers or drains. In some of these structures the bottom, or invert, is made with sides having only sufficient inclination to keep them free from deposit when the conduit is in use. The side walls are often perpendicular for some little distance, and the arch semi-circular. This form of conduit can be built in three operations, viz., the invert, the side walls, and the arch; or may be built in two operations, consisting of invert and portion of side walls, and the balance of the side walls and the arch together. Modifications of this design are very common, in some cases the side walls being slightly curved. Egg-shaped and flattened elliptical conduits are often required, and these, as well as the circular, lend themselves to the use of steel in their construction. It is, of course, obvious, however, that the circular and semi-circular sections, being in such common demand, can usually be constructed much more cheaply than other sections, because forms for them can be used on many different contracts in succession throughout the country. Engineers are generally well aware of this fact, and take advantage of it in making their designs. There is scarcely an important sewer system which has been constructed in this country in recent years upon which the half-round collapsible centre has not been used to a considerable extent.

Generally speaking, it is more economical for the contractor to build a sewer in two sections, the invert first and the arch subsequently, no matter what the cross-section of the sewer may be, than it is for him to pour the entire structure in one operation. It is also generally preferred by engineers that the invert shall be constructed and the forms removed for inspection before any work is done on the arch, and where sewers are reinforced with steel, the splice of the steel is generally made about the springing line of the invert. By dividing the work in this way the engineer is able to inspect the most important part of it, the invert, which carries the actual flow of water, without having to enter the finished conduit. It is also often preferred that the men should work in daylight rather than by artificial light to do any work requiring close inspection. There are, however, numerous occasions upon which it is considered essential that the structure shall be poured as a monolith, and in such cases it is necessary to build the form so as to make a complete circle, which may still be collapsed and removed conveniently, care being taken that the joints are so made that one or the other of the sections may be removed first. If the design is not very carefully worked out with this object in view, a full round centre is likely to bind, and become extremely difficult to shift.

Half-round centres to be pulled "en train" have been made and used of all diameters, from 2′ up to 25′. Usually however, the length of time that a centre must be left in place on a conduit of the larger size, and the necessity of arranging the work so that the concrete can be deposited every day, render it necessary on large work to design the centres so that they may be collapsed and pulled through one another. Just when it will be more economical to pull a centre "en train," and when it will be more economical to collapse it and carry it forward in sections ought to be determined in connection with each particular construction after careful consideration of the local conditions, the depth of the excavation, the arrangements for depositing concrete and the liability of the work to interruption or injury on account of having a greater or less amount of open ditch at one time. Wherever it is practicable to stretch out the work over a long distance without incurring any liability to damage, there will be a certain advantage in arranging the work in several sections and pulling the forms "en train," rather than in collapsing them and carrying them through one another; but on the largest work it is very seldom practicable to spread the work out in this way, and usually where the conduit is more than 8′ or 10′ in diameter more economy will be secured by building the centre in sections and collapsing one or two or three sections at a time and conveying them forward through the assembled sections of form to the new position.

On the large concrete sewers, aqueducts and drains built in recent years, it has been almost universal with contractors to collapse the centres sufficiently to convey them through other centres which are supporting concrete which has not yet set sufficiently to permit the centres to be moved. The best example of this method of working is found on the new Catskill aqueduct which supplies the city of New York with water. This aqueduct is 90 miles long. Throughout most of this length water is conveyed in a horseshoe conduit 17′ 6″ wide and 17′ high, built at a grade which permits the water to flow without completely filling the aqueduct. Other parts of the work are in tunnel, or on viaducts; while that portion of the work which enters the city of New York is in many places at a great depth from the surface of the ground. Practically all of this concrete has been cast on steel forms.

Where the work is conducted in open cut, these forms are collapsed and supported upon carriers in the finished aqueduct, and they are conveyed through the portion of the work which is yet under construction and expanded into position in front. The same method of handling the forms has been employed on the new sewerage systems at Louisville, Baltimore and East St. Louis.

Very large forms adapted to collapse and move forward in large units have been used on the locks of the Panama Canal and for the pressure tunnel of the Ontario Power Co.

In tunnel work, it is sometimes possible to utilize forms that collapse and pull through in units similar to those used in sewer work, but very frequently on account of the difficulty of getting concrete into place in tunnel work, it is necessary to carry on this work with a series of panels which are attached to ribs as the concrete is deposited. This method is extensively employed in tunnel work for railways and while not nearly so easy to handle as the form that can be moved in large units, it has proved to be eminently practical and economical in work of this class.

In all such work it is customary to build the forms especially to fit the design of the particular structure in view, and not to attempt to consider the form problem at all in the design of the concrete structure. Wherever the length of the conduit is sufficient, this is the most economical practice, but where the lengths of the conduit is not great it will be found more economical to use circular or modified circular forms upon which a standard steel form can be used,—a form which can be leased for the moderate rental—than to adopt a peculiar shape which will require a form built to order, and consequently an unnecessarily heavy expenditure for the form work. It should be remembered that where forms are made of wood to meet any particular conditions, they cost 12c. to 16c. per sq. ft. of form surface, and that if the walls of the concrete structure be thin, this amounts to over $5.00 to $10.00 per cu. yd. of concrete in place. In fact, the cost of forms on very many concrete structures exceeds the sum of all other costs entering into the concrete. The saving that may be made by adopting sections which will lower the cost of the forms is so great that every engineer should consider it in making his designs, more especially upon those parts of the system he is designing which are too short to justify the manufacture of special apparatus for constructing them.

The cost of a system of concrete storm sewers may very easily be reduced by 15 per cent. or 20 per cent. of what it might otherwise be by having careful consideration given to the cost of the form work, and so laying out the system before construction is commenced as to secure the greatest economy in this item.

All collapsing and conveying methods used on forms similar to those described for circular and horse-shoe shaped conduits are adapted to rectangular or box-shaped culverts such as are commonly employed in flat lands where it is necessary to build drains of large capacity without deep excavation. Box-shaped forms for drains with flat slab covers should be designed so that the same forms can be used on the various sizes of drains in any common drainage system, beginning with the largest on the main line of the system and extending to the smallest laterals. Forms of this kind are readily made in such a manner as to permit the removal of panels of various width so as to change the width and height of the conduit wherever necessary.

HIGH-SPEED BEARINGS.*

By John C. K. Balfry.

When considered in connection with the subject of this paper, the term "high speed of revolution" is somewhat misleading, for one should speak of the speed of journal surface rather than of speed of revolution. For example, take the case of a De Laval steam turbine having a shaft 10 mm. diameter revolving at 30,000 revolutions per minute, and compare the surface velocity of it with that of a steam turbine shaft of 100 mm. diameter revolving at 3,000 revolutions per minute. The surface velocity of each is about 51.6 feet per second, but the speed of revolution of the first is ten times that of the second.

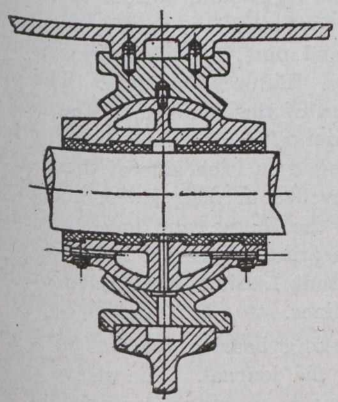


Fig. 1.

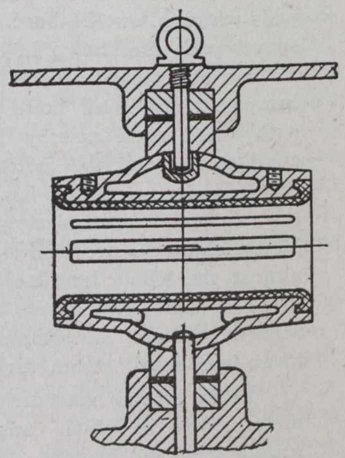


Fig. 2.

With rotary machines of the turbine or electrical kind, it may be considered that surface speeds of 50 feet per second are quite ordinary, and 100 feet per second as high. Pressures, per unit area of projected bearing surface, in common use with the kinds of bearings under consideration are small when compared with those met with in, e.g., modern railway practice, where 300 lb. per sq. in. of projected bearing surface is not at all exceptional in the case of driving axle journals; but the conditions under which these work are very different. Briefly, 50 lb. per sq. in. of projected bearing surface may be considered ordinary, and 90 lb. per sq. in. high for bearings of the class being dealt with.

Steam Turbine Bearings.—These may be grouped under three heads: (1) Rigid bearings; (2) swivel bearings; (3) concentric ring bearings.

1. By a rigid bearing is meant one wherein the shell is held rigidly in the housing or pedestal surrounding it. It is adaptable where shaft deflection is very small, the slight slackness or clearance between the journal and the bearing, and also the presence of a film of oil around the journal, being taken advantage of. Obviously, these bearings are of use only where journal centres are comparatively small.

2. The swivel bearing is no doubt the most widely used kind in turbine practice to-day. Its name indicates one of its outstanding features. It is adaptable practically to all kinds of turbines and generators. It allows itself to radiate in the housing about its centre, thus accommodating itself to the deflection of the shaft, so that its use with shafts having great length between journal centres is almost universal. It is easy to design the shell in such a way that lateral and vertical movement, required for alignment when bearings are being set at a considerable distance apart, is readily attained.

3. The concentric ring bearing has characteristics which are set forth in the description of it which appears further on.

The shell of the "rigid" type of bearing is usually made of good, close-grained cast iron, and is lined on the inside with white metal; babbitt, delta, or magnolia metals are found suitable for this purpose. It is turned on the outside of the shell to fit the pedestal, in which it is prevented from rotating by means of dowels engaging in holes in the cap or cover of the housing; a flange at each end prevents end movement. There are, of course, other methods of preventing rotation and end movement, but the above is perhaps the simplest. If it is found necessary to water-cool such a bearing, the problem is much simpler than that which presents itself when the same treatment is desired for a bearing of the swivel type.

A bearing of the rigid type is fitted to a 2,000 kw. steam turbine of the A.E.G. type. In this instance the shell is made of brass, and is lined with white metal. Among the interesting features it possesses may be mentioned that the oil, before being admitted to the journal, is passed around the space between the housing and the shell to render the oil thinner before use. This appears to have a double effect on improving conditions of working—the shell is cooled by the circulating oil, and the friction losses in the bearing are reduced by the higher oil temperature. The surface speed of the journal is said to be 96 ft. per second.

The Swivel type is illustrated in Figs. 1, 2, 3, 4 and 5. Fig. 1 is used with a Melms Pfenninger steam turbine of 3,000 h.p. at 1,500 revolutions per minute. It is 180 mm. diameter by 380 mm. long, and the journal surface speed is 46 ft. per second. The shell, which is made in halves, is of cast iron, and is lined with white metal. The temperature of the bearing can be kept below the danger point by circulating water through the chamber shown. A cage is provided giving ample bearing surface for the shell. The housing is, of course, on the outside, the cage being provided with lugs to prevent end movement. Dowels prevent cage and bearing from rotating. Oil is fed under pressure into the annular space in the housing, through a hole in the bottom of both cage and shell, into a partly annular space around the journal.

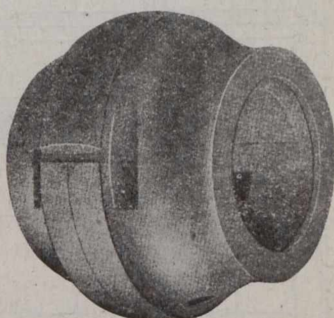


Fig. 3.

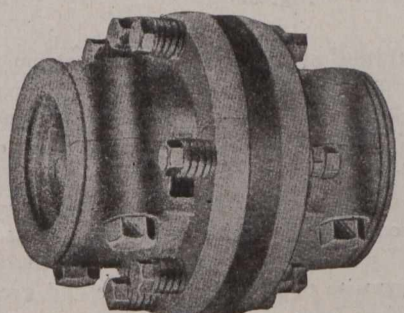


Fig. 4.

Fig. 2 illustrates a bearing used with a 1,500 kw. 1,500 revolutions per minute steam turbine made by the Brush Electrical Engineering Company. The shell is hollow, and is lined with white metal. The diameter of journal is 5 in., and length 15 in. The bearing is capable of being easily aligned both vertically and laterally, shinplates being provided between the cage, which is immediately without the shell, and radial pads which are screwed to the cage. Both shell and cage are made in halves, and both are prevented from rotation in

*Paper read before the Rugby Engineering Society.

the manner shown, end movement being prevented by the flanges forming part of the housing. It is interesting to note that the oil, before being admitted to the journal, is passed through the hollow shell. Grooves arranged longitudinally, and well chamfered on their edges, are provided in the top half of the bearing surfaced. The surface velocity is about 33 ft. per second.

The kind fitted to a Zoelly steam turbine of 200 h.p. at 3,000 revolutions per minute is of cast iron, lined with white metal. Lubrication is effected by six rings arranged in two chambers containing three rings each. The bearing is water-cooled, water being supplied to and returned from the hollow shell through two unions screwed into the top half of the shell; these are not illustrated. The ringed shaft is provided for expansion purposes, and keeps the shell and shaft always together. This bearing is 60 mm. in diameter by 250 mm. long, the surface speed being 31 ft. per second. Oil, after being carried to the upper surface of the journal by means of the rings, is distributed to the surfaces along grooves in the white mdetal. These grooves or channels "take in" at the top on both sides of the ring chambers and spread away spirally, returning again to the chamber farther round the shaft. By this means an effective method of lubrication is obtained.

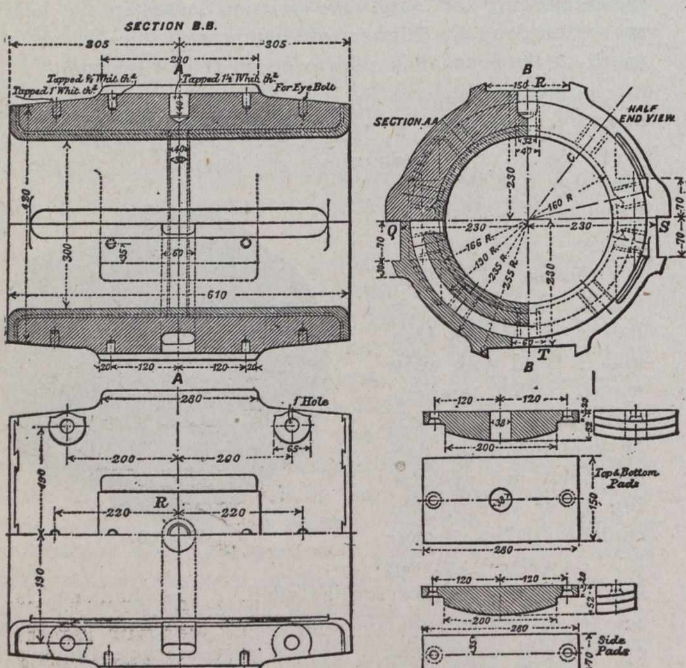


Fig. 5.

Fig. 3 is an illustration of a bearing fitted to steam turbines made by the British Thomson-Houston Company, Limited. It possesses several interesting features, among them being its "clean" finish and simple design. It consists of a cast-iron shell lined with babbitt metal; the shell has spherical seats, and the bearing is made in halves. Oil is delivered into a groove in the white metal and along the horizontal centre line, and is drawn down by the rotating shaft. On the side opposite to the oil inlet a second groove is provided, but it differs from the groove on the inlet side in being open at its ends thus allowing oil that has passed under the shaft and has become heated to pass easily away at the ends of the bearing. Lubrication and cooling of the upper surface of the journal is effected by means of grooves leading from the inlet groove diagonally.

Fig. 4 shows a bearing which has important characteristics. It is fitted to generator shafts at the exciting end of the rotor. When a turbo-generator is passing through a critical speed there is a tendency for the shaft to "whip." In order to destroy this action anl ensure that the shaft will pass through a critical speed with absolute safety, the bearing sleeve is permitted a small amount of radial play between friction collars. This bearing, it will be noticed, is made in halves, and the radial sideplates or collars are bolted in an elastic manner to the shell. It is made by the British Thomson-Houston Company, Limited.

A bearing such as is fitted to turbines of 7,000 kw. capacity when running at 750 revolutions per minute is illustrated, together with its accessories, in Fig. 5. It consists of a cast-iron shell to which is secured at four positions the pads which allow the bearing to swivel about its centre. The swivel pads are shown in the right-hand bottom corner. It will be seen that the shell is made in halves, secured by comparatively small bolts and nuts. The interior is lined with white metal cast by the "Eatonia" process. The oil is conducted from the bottom of the shell along the two oil-ways shown up to the horizontal centre line; there it feeds the two wide channels arranged on each side of the bearing. These channels are well bevelled at their sides, and extend almost the whole length of the lining, and have a sealing piece at each end. These bearings represent a design which Messrs. Willans and Robinson, Limited, have used on both large and small steam turbines.

The Parsons concentric-ring bearing consists of a gun-metal sleeve in which runs the journal. The sleeve is surrounded by two or more gun-metal rings arranged in sets, and separated by an oil or lantern ring. The whole is mounted within a heavy cast-iron outer sleeve, to which the innermost sleeve is lightly secured at one end. This outer sleeve is spigoted to the housing only, and not to the cap, by means of a loose cast-iron half-ring which fits in the groove stem at the bottom.

If it is desired to remove the bearing, the cap is first removed, and the half-ring rotated until it is free of the pedestal and bearing. It is then possible to slide the bearing endways off the shaft. There is a clearance of a few thousandths of an inch between the rings and sleeves. Oil finds its way into these spaces, tnd thus there is a hydraulic cushion which dampens those vibrations which are inseparable from shafts having speeds of rotation.

COAST TO COAST.

Toronto, Ont.—At a meeting of the Hydro-Electric Power Commission held recently an important change in policy was decided. Hereafter the Commission will not acquire easements for right-of-way but will expropriate the necessary strip, 66 feet wide, required for transmission lines. This departure will apply to the extension of the Niagara transmission line from St. Thomas to Windsor as well as other contemplated extensions in the Midlands district and in eastern Ontario.

Montreal, Que.—In the course of the work of the Mount Royal tunnel many interesting speciments of rock have been met with and definite proof of the volcanic origin of Montreal's mountain obtained. The indications, according to the engineers, show that the mountain was at one time either an active volcano or that lava forced its way up a central orifice, bursting and breaking the summit of the mountain, but possibly never actually spouting forth as an eruption. Numerous fossils have been found and also a particularly fine specimen of crystallized calcite. Copper and iron pyrites are also evident in some of the rock.

Montreal, Que.—The experts working on street car congestion of this city have prepared their report for the Montreal Tramways Company. These plans cover a gradual development designed to be spread over the next couple of years, and eventually the development will care for the population for the next ten or twenty years.

It is stated if the proposals of street extensions, etc., are carried out, the company will find it necessary to order 200 cars in addition to the 200 now on order. The total expenditure will amount to from $8,000,000 to $10,000,000, which the company is fully prepared to make.

Providence, R.I.—The Narragansett, the first of the Grand Trunk boats for Atlantic coastwise trade, from the shops of Harlan and Hollingsworth, Wilmington, Del., has been launched recently. The Manhattan, a sister ship, will be launched later. Both have been designed by Mr. Kirby, of New York and Detroit, a well-known marine architect, who has designed some of the largest steamers on the Great Lakes. These vessels have been built for the Central Vermont Transportation Co., and were financed a year ago by the sale of $1,500,000 bonds. The Narragansett is of steel, and has a capacity for 700 passengers and 500 tons of express freight. The Narragansett and Manhattan will ply between Providence and New York.

Sarnia, Ont.—Wireless machinery is being installed in the wireless station at Point Edward by the Canadian Marconi Company, which will be in charge of the station and will operate it for the government on a percentage basis. The apparatus consists of two sets of dynamos connected engines, so that if one machine with two eight-horsepower gasoline breaks down, the operator will have a second generator to fall back on. The sending radius of the machines will be 300 miles and will enable the station to work with the Soo on the west, or Ottawa on the east. The receiving machines will be able to take a message from any of the high tension stations on the continent as long as the sending station is strong enough to send out the waves this far. The station will be used by the government as well as for sending telegrams for the public. The charges will be considerably lower than those of wire lines.

British Columbia.—Work has been begun by the Northern Construction Company on the Lulu Island branch of the Canadian Northern Pacific Railway. The first camp has been established six miles below New Westminster and a second will be located a mile further west. The latter will undertake the construction of the two miles of trestling across the muskeg which exists here and for which two million feet of lumber will be required. According to Mr. J. M. Mercer, general manager of the construction company, this line will be completed by the end of May. The line from Port Mann to Yale is now nearing completion but it is not expected that a train service will be operated until about midsummer. All the stations from Port Mann to Yale have been named and the contract for their construction will be let in a few days. These stations will be Port Mann, Langley, Glen Valley, Mount Lehman, Matsqui, Sumas, Mountain, Chilliwack, Rosedale, Popkum, St. Elmo, Floodville, Hope, Trafalgar, Yale.

Washington, D.C.—The failure of Congress to enact legislation at the session just closed to extend the Burton Act which limits the amount of water diverted on the American side of Niagara Falls for power development to 15,600 feet, means that the Americans can increase the amount of water used for this purpose and that they may import more power generated on the Canadian side.

The treaty between the United States and Canada provides that 25,000 feet per second of water may be diverted for power purposes for each government. The Burton Act restriction, which was originally demanded by the American Civic Associations and other organizations, who feared unrestricted use of Niagara's waters would ruin the beauty of the Falls, has been extended twice.

Several American companies are preparing to import power from Canada and use the plants and machinery that have been idle since the enactment of the Burton law. Governor Sulzer states that in the absence of federal legislation the jurisdiction of the extra 4,450 feet of water permitted under the treaty with Canada, automatically passes to New York State.

Ottawa, Ont.—Mr. Clyde Leavitt, Chief Fire Inspector for the Railway Commission, and Forester for the Commission of Conservation, is now preparing a statement showing how the installation of the use of crude oil for generating locomotive power in stead of coal, may prove more advantageous to railways from a financial standpoint.

The Canadian Pacific Railway is now using oil-burning engines on its main line between Kamloops and Field, B.C. The Grand Trunk Pacific and some of the Canadian coast steamships also burn oil, while the new system is now in use on many of the railroads in the United States. The greatly decreased smoke, the decrease in the number of firemen required, the economy particularly in intermittent service, and the fact that three boilers heated by oil will give the same amount of steam as the same number heated by coal, all tend to make this new system popular.

The oil is obtained from the oil fields of California, and if future discoveries in Alberta and British Columbia make this oil more plentiful its use will be largely extended on Canadian railroads.

The use of this new fuel would greatly lessen the necessity for forest protection from flying sparks and cinders, and greatly decrease the loss experienced annually by the country from this cause.

Vernon, B.C.—This city recently opened a splendid new power house with a demonstration in which several hundred citizens participated.

The chief point of interest was the new Diesel oil engine which has just been installed, and the operation of which will enable the city to give the citizens the lowest lighting rate in British Columbia, and power rates unequalled by any city of its size in Western Canada.

The oil plant will be used continuously, the steam plant being used for auxiliary during the hours when the load is heaviest, until another 50 h.p. engine is installed and which the increased demand for power necessitates.

PERSONAL.

MR. F. N. NEWMAN, manager of The Canadian Fairbanks-Morse Co., Limited, of Toronto, is on a trip to England.

MR. F. J. ANDERSON, B.A.Sc., O.L.S., of the firm of Anderson and Berry, engineers, has been appointed city engineer of Niagara Falls, Ontario.

KESTER BARR has resigned his position with Manning, Maxwell and Moore, Inc., of New York, to take the position of manager of the Lumen Bearing Co., West Toronto, to succeed Mr. Fred Ganderton, resigned.

ARTHUR H. BLANCHARD, M.Can.Soc.C.E., Professor of Highway Engineering, Columbia University, has been appointed by Governor Sulzer a member of the Advisory Commission on Highways for the State of New York.

MR. H. M. MORROW, formerly assistant manager of the Asbestos Corporation of Canada is now in the employment of The Canadian Fairbanks-Morse Co., Limited, at Montreal, and will be associated with the motor truck department.

V. J. ELMONT, A.M. Can. Society C.E., read an interesting paper on "Trusses without Diagonals in Reinforced Concrete," before the Canadian Society of Civil Engineers on the evening of March 6. Following the reading of the papers and the showing of a number of lantern slides, a discussion took place in which Prof. Mackay, J. A. Jamieson and others took part.

OBITUARY.

GEO. H. PEDLAR died suddenly at his home in Oshawa while preparing for a business trip to Chicago. Deceased was 70 years of age, and was president and manager of the Pedlar People, Limited, a company he established over 50 years ago, and which through his ability, became a flourishing concern, having at present offices in Toronto, Montreal, Ottawa, London, Chatham, Winnipeg, and Vancouver. He was throughout his busy life actively interested in public and social affairs and a generous giver to all charities.

SOCIETY NOTES.

At a meeting held March 14th, the following officers of the Engineering Society of the University of Toronto were elected: President, F. E. Mechin; 1st vice-president, F. S. Rutherford; 2nd vice-presidents, R. E. Laidlaw, K. A. Jefferson, C. K. MacPherson.

COMING MEETINGS.

CANADIAN ELECTRICAL ASSOCIATION.—Annual Convention will be held in Fort William, June 23, 24 and 25. Secretary, T. S. Young, 220 King Street W., Toronto.

THE INTERNATIONAL ROADS CONGRESS.—The Third International Roads Congress will be held in London, England, in June, 1913. Secretary, W. Rees Jeffreys, Queen Anne's Chambers, Broadway, Westminster, London, S.W.

THE INTERNATIONAL GEOLOGICAL CONGRESS.—Twelfth Annual Meeting to be held in Canada during the summer of 1913. Secretary, W. S. Lecky, Victoria Memoriam Museum, Ottawa

ENGINEERING SOCIETIES.

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

KINGSTON BRANCH—Chairman, A. K. Kirkpatrick; Secretary, L. W Gill; Headquarters: School of Mines, Kingston.

MANITOBA BRANCH.—Chairman, J. A. Hesketh; Secretary, E. E. Brydone-Jack, 83 Canada Life Building, Winnipeg. Regular meetings on first Thursday of every month from November to April.

OTTAWA BRANCH—
177 Sparks St. Ottawa. Chairman, R. F. Uniacke, Ottawa; Secretary, H. Victor Brayley, N.T. Ry., Cory Bldg. Meetings at which papers are read, 1st and 3rd Wednesdays of fall and winter months; on other Wednesday nights in month there are informal or business meetings.

QUEBEC BRANCH—Chairman, A. R. Décary; Secretary, A. Amos; meetings held twice a month at room 40, City Hall.

TORONTO BRANCH—96 King Street West, Toronto. Chairman, E. A. James; Secretary-Treasurer, A. Garrow. Meets last Thursday of the month at Engineers' Club.

VANCOUVER BRANCH—Chairman, G. E. G. Conway; Secretary-Treasurer, F. Pardo Wilson, Address: 422 Pacific Building, Vancouver, B.C.

VICTORIA BRANCH—Chairman, F. C. Gamble; Secretary, R. W. MacIntyre; Address P.O. Box 1290.

MUNICIPAL ASSOCIATIONS

ONTARIO MUNICIPAL ASSOCIATION—President, Mayor Lees, Hamilton. Secretary-Treasurer, Mr. K. W. McKay, County Clerk, St. Thomas, Ontario.

SASKATCHEWAN ASSOCIATION OF RURAL MUNICIPALITIES.—President, George Thompson, Indian Head, Sask.; Secy-Treasurer, E. Hingley, Radisson. Sask.

THE ALBERTA L. I. D. ASSOCIATION.—President, Wm Mason, Bon Accord, Alta. Secy-Treasurer, James McNicol, Blackfalds, Alta.

THE UNION OF CANADIAN MUNICIPALTIES.—President, Chase. Hopewell, Mayor of Ottawa; Hon. Secretary-Treasurer, W. D. Lighthall, K.C. Ex-Mayor of Westmount.

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

UNION OF NOVA SCOTIA MUNICIPALITIES.—President, Mr. A. S. MacMillan, Warden, Antigonish, N.S.; Secretary, A. Roberts, Bridgewater, N.S.

UNION OF SASKATCHEWAN MUNICIPALITIES.—President, Mayor Bee, Lemberg; Secy-Treasurer, W. F. Heal, Moose Jaw.

UNION OF BRITISH COLUMBIA MUNICIPALITIES.—President, Mayor Planta, Nanaimo, B.C.; Hon. Secretary-Treasurer. Mr. H. Bose, Surrey Centre, B.C.

UNION OF ALBERTA MUNICIPALITIES.—President, F. P. Layton, Mayor of Camrose; Secretary-Treasurer, G. J. Kinnaird, Edmonton, Alta.

UNION OF MANITOBA MUNICIPALITIES.—President, Reeve Forke, Pipestone, Man.; Secy-Treasurer, Reeve Cardale, Oak River, Man.

CANADIAN TECHNICAL SOCIETIES

ALBERTA ASSOCIATION OF ARCHITECTS.—President, R. W. Lines, Edmonton; Hon. Secretary, W. D. Cromarty, Edmonton, Alta.

ASSOCIATION OF SASKATCHEWAN LAND SURVEYORS.—President, J. L. R. Parsons, Regina; Secretary-Treasurer, M. B. Weeks, Regina.

ASTRONOMICAL SOCIETY OF SASKATCHEWAN.—President, N. McMurchy; Secretary, Mr. McClung, Regina.

BRITISH COLUMBIA LAND SURVEYORS' ASSOCIATION.—President, W. S. Drewry, Nelson, B.C.; Secretary-Treasurer, S. A. Roberts, Victoria, B.C.

BRITISH COLUMBIA SOCIETY OF ARCHITECTS.—President, Hoult Horton; Secretary, John Wilson, Victoria, B.C.

BUILDERS' CANADIAN NATIONAL ASSOCIATION.—President, E. T. Nesbitt; Secretary-Treasurer, J. H Lauer, Montreal, Que.

CANADIAN ASSOCIATION OF STATIONARY ENGINEERS.—President, Wm. Norris, Chatham, Ont.; Secretary, W. A. Crockett, Mount Hamilton, Ont.

CANADIAN CEMENT AND CONCRETE ASSOCIATION.—President, Peter Gillespie, Toronto, Ont.; Secretary-Treasurer, Wm. Snaith, 57 Adelaide Street, Toronto, Ont.

CANADIAN CLAY PRODUCTS' MANUFACTURERS' ASSOCIATION.—President, W. McCredie; Secretary-Treasurer, D. O. McKinnon, Toronto

CANADIAN ELECTRICAL ASSOCIATION.—President, A. A. Dion, Ottawa; Secretary, T. S. Young, 220 King Street W., Toronto.

CANADIAN FORESTRY ASSOCIATION.—President, Hon. W. A. Charlton, M.P., Toronto; Secretary, James Lawler, Canadian Building, Ottawa.

CANADIAN GAS ASSOCIATION.—President, Arthur Hewitt, General Manager Consumers' Gas Company, Toronto; John Kelilor, Secretary-Treasurer, Hamilton, Ont.

CANADIAN INDEPENDENT TELEPHONE ASSOCIATION.—President, W. Doan, M.D., Harrietsville, Ont.; Secretary-Treasurer, Francis Dagger, 21 Richmond Street West, Toronto.

THE CANADIAN INSTITUTE.—198 College Street, Toronto. President J. B. Tyrrell; Secretary, Mr. J. Patterson.

CANADIAN MINING INSTITUTE.—Windsor Hotel, Montreal. President, Dr. A. E. Barlow, Montreal; Secretary, H. Mortimer Lamb, Windsor Hotel, Montreal.

CANADIAN PEAT SOCIETY.—President, J. McWilliam, M.D., London, Ont.; Secretary-Treasurer, Arthur J. Forward, B.A., 22 Castle Building, Ottawa, Ont.

THE CANADIAN PUBLIC HEALTH ASSOCIATION.—President, Dr. Charles A. Hodgetts, Ottawa; General Secretary, Major Lorne Drum, Ottawa.

CANADIAN RAILWAY CLUB.—President, A. A. Goodchild; Secretary, James Powell, P.O. Box 7, St. Lambert, near Montreal, P.Q.

CANADIAN STREET RAILWAY ASSOCIATION.—President, Patrick Dubee, Montreal; Secretary, Acton Burrows, 70 Bond Street, Toronto.

CANADIAN SOCIETY OF FOREST ENGINEERS.—President, Dr. Fernow, Toronto.; Secretary, F. W. H. Jacombe, Department of the Interior, Ottawa.

CENTRAL RAILWAY AND ENGINEERING CLUB.—Toronto, President, G. Baldwin; Secretary, C. L. Worth, 409 Union Station. Meets third Tuesday each month except June, July and August.

DOMINION LAND SURVEYORS.—President, Mr. R. A. Belanger, Ottawa; Secretary-Treasurer, E. M. Dennis, Dept. of the Interior, Ottawa.

EDMONTON ENGINEERING SOCIETY.—President, J. Chalmers; Secretary, B. F. Mitchell, City Engineer's Office, Edmonton, Alberta.

ENGINEERING SOCIETY, TORONTO UNIVERSITY.—President, F. C. Mechin; Corresponding Secretary, A. W. Sime.

ENGINEERS' CLUB OF MONTREAL.—Secretary, C. M. Strange, 9 Beaver Hall Square, Montreal.

ENGINEERS' CLUB OF TORONTO.—96 King Street West. President, Willis Chipman; Secretary, R. B. Wolsey. Meeting every Thursday evening during the fall and winter months.

INSTITUTION OF ELECTRICAL ENGINEERS.—President, Dr. G. Kapp; Secretary, P. F. Rowell, Victoria Embankment, London, W.C.; Hon. Secretary-Treasurer for Canada, Lawford Grant, Power Building, Montreal, Que.

INSTITUTION OF MINING AND METALLURGY.—President, Edgar Taylor; Secretary, C. McDermid, London, England. Canadian members of Council:—Prof. F. D. Adams, J. B. Porter, H. E. T. Haultain and W. H. Miller and Messrs W. H. Trewartha-James and J. B. Tyrrell.

INTERNATIONAL ASSOCIATION FOR THE PREVENTION OF SMOKE.—Secretary R. C. Harris, City Hall, Toronto.

MANITOBA ASSOCIATION OF ARCHITECTS.—President, W. Fingland, Winnipeg; Secretary, R. G. Hanford.

MANITOBA LAND SURVEYORS.—President, George McPhillips; Secretary-Treasurer, C. G. Chataway, Winnipeg, Man.

NOVA SCOTIA MINING SOCIETY.—President, T. J. Brown, Sydney Mines, C. B.; Secretary, A. A. Hayward.

NOVA SCOTIA SOCIETY OF ENGINEERS, HALIFAX.—President, J. N. MacKenzie; Secretary, A. R. McCleave, Assistant Road Commissioner's Office, Halifax, N.S.

ONTARIO ASSOCIATION OF ARCHITECTS.—President, C. P. Meredith, Ottawa; Secretary, H. E. Moore, 195 Bloor St. E., Toronto.

ONTARIO PROVINCIAL GOOD ROADS ASSOCIATION.—President, N. Vermilyea, Belleville; Hon. Secretary-Treasurer, J. E. Farewell, Whitby; Secretary-Treasurer, G. S. Henry, Oriole.

ONTARIO LAND SURVEYORS' ASSOCIATION.—President, J. S. Dobie, Thessalon; Secretary, L. V. Rorke, Toronto.

TECHNICAL SOCIETY OF PETERBORO.—Bank of Commerce Building, Peterboro. General Secretary, N. C. Mills, P.O. Box 995, Peterboro, Ont.

THE PEAT ASSOCIATION OF CANADA.—Secretary, Wm. J. W. Booth, New Drawer, 2263, Main P.O., Montreal.

PROVINCE OF QUEBEC ASSOCIATION OF ARCHITECTS.—Secretary J. E. Ganier, No. 5, Beaver Hall Square, Montreal.

QUEEN'S UNIVERSITY ENGINEERING SOCIETY.—Kingston, Ont. President, W. Dalziel; Secretary, J. C. Cameron.

REGINA ENGINEERING SOCIETY.—President, A. J. McPherson, Regina; Secretary, J. A. Gibson, 2429 Victoria Avenue, Regina.

ROYAL ARCHITECTURAL INSTITUTE OF CANADA.—President, H. C. Russell, Winnipeg, Man.; Hon. Secretary, Alcide Chausse, No. 5, Beaver Hall Square, Montreal, Que.

ROYAL ASTRONOMICAL SOCIETY.—President, Prof. Louis B. Stewart, Toronto; Secretary, J. R. Collins, Toronto.

SOCIETY OF CHEMICAL INDUSTRY.—Wallace P. Cohoe, Chairman, Alfred Burton, Toronto, Secretary.

UNDERGRADUATE SOCIETY OF APPLIED SCIENCE, McGILL UNIVERSITY.—President, W. G. Mitchell; Secretary, H. F. Cole.

WESTERN CANADA IRRIGATION ASSOCIATION.—President, Duncan Marshall, Edmonton, Alta. Permanent Secretary, Norman S. Rankin, P.O. Box 1317, Calgary, Alta.

WESTERN CANADA RAILWAY CLUB.—President, R. R. Nield; Secretary, W. H. Rosevear, P.O. Box 1707, Winnipeg, Man. Second Monday, except June, July and August at Winnipeg.