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Volume 25 Toronto, Dec 4, 1913
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The Canadian Engineer

*A weekly paper for engineers and engineering-contractors*

# RAILWAY ECONOMICS

## IMPORTANT FACTORS OF THE SUBJECT AS APPLIED MORE PARTICULARLY TO THE RAILWAYS OF CANADA—QUESTIONS AFFECTING LOCATION AND CONSTRUCTION, REVENUE ESTIMATES AND OPERATING COSTS

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RAILWAY economics is a subject to which much attention has been given by railway engineers in recent years. There has been so much construction undertaken by the different railways latterly, that a great amount of data has had to be compiled on the subject of economics. The following table is illustrative of the amount of work that was undertaken and completed by the larger railways in Canada during the year 1912:

| | | |
|---|---|---|
| Canadian Northern Ontario Railway ........ | 195 | miles |
| Canadian Northern Railway ................ | 304 | " |
| Canadian Pacific Railway .................. | 360 | " |
| Grand Trunk Pacific Railway .............. | 608 | " |
| Intercolonial Railway .................... | 17 | " |
| Timiskaming and Northern Ontario Railway.. | 30 | " |
| National Transcontinental Railway ......... | 358 | |

making a total of 1,872 miles of railway in one year.

The problem of transportation in this Dominion is one peculiar to itself, and is made more difficult to deal with on account of the lack of precedent. The conditions cannot well be compared with those in the United States, either as they are now, or as they were when the large transcontinental railways were first developed on the south side of the border, consequently the subject has to be dealt with largely from first principles.

**Economics of Location and Construction.**—This branch of the subject deals with the relations between the cost of operation and the cost of construction, of any particular section of railway and finding the best location, of that section of railway, which will give the most economical combination of cost and operating expenses and at the same time give the maximum revenue.

There are two classes of location, one being the location of a new line of railway between two points hitherto unconnected, the other being the relocation of an existing piece of railway in order to give more economical and better financial returns.

In the case of an entirely new project it is usual to make a preliminary examination of several different routes and then make a comparison of the following estimated features:—

Probable revenue from each line.
Cost of construction.
Annual traffic—gross tonnage.
Cost of handling such traffic,

and, in addition to these specific items, the effect of future changes in traffic or operating conditions must be considered. This latter is one of the most important items in this country as the railways, more particularly in the Western Provinces, have built and are building lines through practically unsettled districts basing their estimates of the volume of traffic and sources of revenue on the future settlement of the districts adjacent to the railway, the general effect of railway development being to increase the population of that part of the country served by the new line, due to better transportation facilities.

In the case, however, of the relocation of an existing line, besides taking into account the increased efficiency obtainable by the new route or line (which can be computed more accurately than in the case of an entirely new line) allowance has to be made for the possible injury to existing facilities and also for the value of the facilities on the old route which have to be abandoned. In this instance the net income has to be increased to such an extent that a proper return will be obtained on the capital outlay necessary to make the entire change.

**Probable Revenue.**—There are several methods of estimating the probable revenue or the volume of traffic of a section of proposed railway. The first method is to make a comparison between the whole population of the country and the gross earnings from the operation of all the railways, and then to assume a similar amount per capita for the projected railway. This method is quick and easy, but is very approximate and is really more suitable for a country more developed than Canada, such as the United States, but it is of interest to note that the gross earnings of Canadian railways average about $29 per capita per annum of the whole population of Canada.

A second method is to estimate the probable earnings per mile of railway by a comparison of the earnings per mile of some existing railway or railways similarly situated. The gross earnings per mile is a very variable quantity on different railways and only a very approximate idea can be obtained by this method, but the following table illustrates this more clearly:

TABLE I.

| Name of railway. | Gross earnings | Mileage. | Gross earnings per mile. |
|---|---|---|---|
| Intercolonial .... .... | $ 11,003,410 | 1,462.89 | $ 7,520 |
| Canadian Northern ..... | 20,860,093 | 4,272.92 | 4,811 |
| Canadian Northern Ont. . | 881,953 | 492.35 | 1,792 |
| Canadian Northern Que. . | 1,327,534 | 369.27 | 3,597 |
| Canadian Pacific ...... | 116,233,812 | 10,813.70 | 10,748 |
| Grand Trunk ......... | 35,801,975 | 3,105.82 | 11,526 |
| Canada Atlantic ....... | 2,173,363 | 459.26 | 4,766 |
| Halifax & South Western | 478,031 | 378.32 | 1,264 |
| Timiskaming & Northern Ontario ......... | 1,935,421 | 302.28 | 6,408 |

The above railways are selected from those with a greater mileage than 300, but the following table gives similar figures for five of the smaller roads:

TABLE II.

| Name of railway. | Gross earnings. | Mileage. | Gross earnings per mile |
|---|---|---|---|
| Algoma Central and Hudson Bay .......... | $545,054 | 134 | $4,067 |
| Bay of Quinte .......... | 238,333 | 89 | 2,689 |
| Kingston & Pembroke... | 225,936 | 109 | 2,054 |
| Midland Ry. of Manitoba | 61,155 | 98 | 624 |
| New Brunswick & P.E.I. | 37,726 | 36 | 1,048 |

A third method is that of estimating the receipts per head of tributary population. This method is only applicable to those parts of the country where a fairly accurate estimate can be made of the location and magnitude of the population. In Eastern Canada maps can be obtained from the Dominion Government giving the location of all existing railways, highways, buildings, etc., on a scale of one mile per inch. These are a great help in making the population estimate. The proposed road will usually pass through some territories in which it may reckon on obtaining all the traffic. An example of this is where a new railway location is through a valley separated from other railways by intervening hills. The new railway can, in a case like this, assume that it will receive all the traffic from that district. In the case of a new railway passing through a town or village already served by a railway, it cannot expect to obtain half the traffic from that town, but only a proportion of it, depending on the relative importance of the two railways, the transportation facilities to and from the depots, distance from the centre of population, nature of the roads, convenience of the train service and sundry other features.

A fourth method is to make a comparison of the production or the producing character of the country which the railway will tap and that of some territory as nearly similar as possible, and note the revenue of the railway serving that territory. An even better way is to combine the third and fourth methods and compare the new and existing roads by means of their tributary population and by dividing the gross earnings of the existing line by its tributary population, a fair approximation is obtained to the probable gross earnings per capita of tributary population of the proposed route. Allowance has to be made, however, for the different character of the locality served by the existing railway.

The fifth and last method of estimating the probable revenue is probably the most accurate. This method is to make a very close estimate of the amount of business that will be obtained from all the different sources of revenue. This requires a great deal of careful study of all the manufactories, mines, lumber mills, farms and every industry located near the proposed route. It is not difficult to make such an estimate when the railway is being built through a country well populated and not previously served by a railway. But in a great many parts of Canada an estimate of the revenue cannot be based on the existing conditions but only on the future estimated conditions of the country after it has been developed by the railway itself. A factory may also be located in the country to be served and it is usually safe to assume that its business will be increased by the advent of the railway. With regard to farms, an experienced man can make a close estimate of the business to be obtained from them, and the distances their produce will have to be transported to the nearest market. In making this estimate other transportation facilities for the farmers have to be considered. Each proposed station on the route will have to be studied independently and information of each source of revenue gathered together, and also information as to the probable markets for the products at each point. The following table gives the percentages of the different sources of revenue for freight traffic for all the railways in the Dominion of Canada and also for the United States.

TABLE III.

| Sources of revenue. | Percentage Canada. | Percentage U.S. |
|---|---|---|
| Products of agriculture .............. | 19.33 | 8.13 |
| Products of animals ................ | 3.53 | 2.10 |
| Products of mines .................. | 35.20 | 56.23 |
| Products of forests ................. | 15.82 | 11.67 |
| Manufacturers .................... | 18.16 | 14.42 |
| Merchandise ...................... | 3.03 | 3.69 |
| Miscellaneous ..................... | 4.93 | 3.72 |
| | 100.00 | 100.00 |

The relations between freight and passenger earnings varies for different parts of the country, but is approximately the same for all the roads in the same locality. The following table gives the proportions of freight, passenger and other earnings on different Canadian railways:

TABLE IV.

| | Freight revenue. % | Passenger revenue. % | Other revenue. % |
|---|---|---|---|
| Alberta Ry. and Irrigation Co. | 71 | 25 | 4 |
| British Yukon Railway ...... | 75 | 24 | 1 |
| Intercolonial Railway ....... | 65 | 32 | 3 |
| Prince Edward Island Railway | 48 | 50 | 2 |
| Canadian Northern Railway.. | 74 | 19 | 7 |
| Can. Northern Ontario Ry... | 68 | 29 | 3 |
| Can. Northern Quebec Ry.... | 72 | 26 | 2 |
| Canadian Pacific Railway .... | 68 | 30 | 2 |
| Central Ontario Railway .... | 68 | 29 | 3 |
| Dominion Atlantic Railway... | 57 | 42 | 1 |
| Grand Trunk Railway ....... | 63 | 35 | 2 |
| Halifax & South Western Ry. | 51 | 48 | 1 |
| Kingston & Pembroke Railway | 72 | 29 | 1 |
| Ottawa & New York Railway. | 54 | 43 | 3 |
| Quebec Central Railway ..... | 68 | 31 | 1 |
| Quebec & Lake St. John Ry.. | 63 | 34 | 2 |
| St. Lawrence & Adirondack Ry. | 60 | 39 | 1 |
| Timiskaming & Nor. Ont. Ry. | 56 | 39 | 5 |
| Vancouver, Victoria & Eastern Railway ........... | 66 | 32 | 2 |

Whatever method is used for estimating the volume of traffic there are always a number of conditions which affect this volume in different ways. For instance, the proximity to the probable source of traffic is a feature to which great attention should be paid. In Eastern Canada where there is keen competition between different railways the locating engineer must subordinate all other requirements to that of locating the road where it will be in a position to obtain the maximum of business. It is always advisable to spend more money on freight and passenger facilities in the cities and towns served by the road, even at the expense of cheaper construction on the line between the cities. There are some good local examples of railways going to great expense to reach the heart of the business districts of the towns and cities where there is or is likely to be competition from other railways. The Campbellford, Lake Ontario & Western

Railway (C.P.R.) has constructed its new line of railway through the busiest part of Trenton, Belleville and other towns of Ontario in order to be in a better position to obtain the local traffic from these towns than the Grand Trunk Railway, which is already established, in many cases, on the outskirts of the towns. Another important instance of this is the construction of the Mount Royal Tunnel by the Canadian Northern Railway at Montreal. This great undertaking will bring the lines of the C.N.R. right into the heart of the hotel and shopping district of the city, to a passenger terminal, and will also give access for the freight traffic to the warehouse and business districts of the city. This question of terminal facilities naturally depends on the limit of capital which may be expended on the terminals without financially wrecking the whole undertaking. The proposal to defer the time of building into the heart of a city is one which should not be considered as it invariably becomes a more and more expensive undertaking as time advances.

**Cost of Construction.**—In Canada—where there are long stretches of thinly populated country on all transcontinental lines—it was only natural that originally many miles were built of the cheapest construction possible without very much attention being paid to the future requirements, but even though the traffic from these sections is practically nil and they are non-revenue producing, they form links in the chain across the continent and the lines should be built in such a way as to ensure economy of operation for the heavy through traffic. Great sums are now being spent by the Canadian railways improving the grades and alignment on some of the non-revenue producing sections in order to reduce the cost of operation of the whole system.

The type of construction to be adopted naturally will depend entirely on the estimated volume of traffic. If the traffic expected is light, then it would not be a good policy to build the railway at great expense in order to reduce the operating expenses, thus having very high fixed charges, but if the traffic over the road is to be very heavy, then a greater expense of construction per mile would be warranted in order to give a high operating efficiency, i.e., to keep the cost of hauling trains over the road at a minimum. The interest and maintenance charges for a poorly located and constructed road may be $2,500 per mile per annum or more, and the direct cost of hauling one ton over a mile of that road will be nearly a cent. Increasing the efficiency of the location and construction of the railway will necessarily increase the annual interest and maintenance charges, but the cost of hauling each ton will be reduced in greater proportions due to the increase in possible train loads over the better grades of track. There has been, due to these circumstances, a demand for every improvement in location and construction which would enable a railway to conduct transportation more economically.

Having made the preliminary surveys of the alternative routes between any two points, an estimate of the cost of construction of the different lines is made by collecting all the materials of a kind under one head and obtaining unit prices for all the different classifications. A form somewhat similar to the following may well be used for making these preliminary estimates of cost—spaces being left on the right hand side for filling in the actual completed cost of the work, thus serving as a better guide for future estimates.

| Item. | Quantity. | Price. | Estimated cost. Subtotal. | Total. | Cost completed. Total. | Price per unit. |
|---|---|---|---|---|---|---|
| | | | | | | |

The road may be built entirely by contract or by day labor under charge of the engineer or superintendent. The contract method is more usual. The chief engineer will have the entire charge of the work of construction and will, with the assistance of the attorney of the company, after consultation with the officers of the company, draw up all the specifications and contracts for the work. The following table gives the approximate percentages of the different items that go to make up the total cost of building a mile of a standard single-track railway suitable for heavy traffic.

Table V.—Percentage of Cost.

| | | |
|---|---|---|
| 1. | Right of way | 5.5 |
| 2. | Proportionate expense of terminals | 13.9 |
| 3. | Bridges and culverts | 11.0 |
| 4. | Grading | 33.0 |
| 5. | Track laying | 19.4 |
| 6. | Ballasting | 8.4 |
| 7. | Fencing | 1.4 |
| 8. | Telegraph service | 0.5 |
| 9. | Stations and water supply | 3.3 |
| 10. | Engineering | 1.9 |
| 11. | General and legal expenses | 1.7 |
| | | 100.0 |

Considering these items separately, the cost of right-of-way is one that is naturally extremely variable and will often depend on the publicity given to the whole scheme before the right-of-way agents are able to get the necessary options on the lands. Frequently right-of-way can be obtained cheaper by a carefully studied location. For instance, if the railway is so located that it cuts through farms at right angles to their length the danger is not so great as in the case where the railway locates right down the centre of a long and narrow farm, leaving two even narrower strips on either side. When possible, the best location through cultivated or pasture land is parallel and adjacent to the lot lines.

The second item is one which varies with the nature of the railway and the towns it serves. It is higher for locations where there are large cities and towns comparatively close together, requiring greater expense on terminal facilities per mile of road than in places like the Western Provinces, where the towns are far apart. But even in some of the small western towns large terminals are being built to take care of the increased traffic induced by the growth of the country.

Items three to seven are ones in which considerable economies can be made if necessitated by the financial status of the company. For example, it has already been stated that money should be expended on first-class terminal facilities, even at the expense of cheaper construction between the terminals. This can be quite satisfactorily done by using more or less temporary construction for some of the smaller bridges and culverts which can be built cheaply, without sacrificing the operating efficiency of the road, and they can easily be replaced by permanent structures when this expense is warranted by the earnings of the road. Similarly in the case of the grading, temporary wooden trestles can be built instead of heavy embankments, but it is not advisable to put in heavier grades in order to save earthwork unless it is absolutely necessary. These trestles can be filled in eventually at a cheaper cost per cubic yard owing to the track being already laid from which the filling can be readily dumped from side dump cars by a rapid unloader. In the case, however, of there being a large cut immediately adjacent to the proposed fill, it is, of course, more economical to use the material from the cut to make the fill when the road is first constructed.

Economies can be made in the tracklaying and ballasting items without seriously effecting the cost of operation, but the maintenance charges will necessarily be higher with light rails and poor ballast. The expense of replacing the light rails and re-ballasting the line will not be disproportionately great.

The other items in the cost of construction are comparatively small percentages and big reductions in them do not make very much reduction in the total cost per mile, but large economies in any of them are apt to cause, indirectly, greater expenses in some of the larger items, or a loss of revenue to the road. That it is a false economy to cut down engineering and legal expenses is becoming more generally recognized among the larger railways. Thousands of dollars may be saved on the construction of a road by having well-organized and equipped engineering staffs working under the guidance of competent men. Similarly economies in station buildings, freight sheds, etc., are apt to adversely affect the revenue of the line.

**Annual Traffic—Gross Tonnage.**—A comparison of the annual traffic and gross tonnage must be made of the different routes under discussion. The amount of the gross tonnage has to be estimated in a way similar to that already described as the fifth method of estimating probable revenue. The probable gross tonnage must be carefully analyzed so as to obtain figures which will not only apply to the whole route but also to the sections between the intermediate towns. It will be as well to note at this point that it is desirable in estimating gross revenue and gross tonnage to be on the safe side by keeping the figures on the low side in the case of the former and on the high side for the latter. This will prove to give the most satisfactory results in the long run.

**Cost of Handling the Traffic.**—The features controlling this item are distance, curvature and grades, and we will deal with each of these features in the order named.

*Distance.*—This is the item on which the rates chargeable for passenger and freight services are based. This is apt to be rather contrary to the value of the service rendered and also to the cost of rendering that service. If the railway adopts a very costly construction in order to reduce the distance betweeen any two points it will be able to give a better and quicker service both for passenger and freight traffic between these points, but, by a strict mileage rate, the actual compensation would be lower than for a longer and cheaper route. On some of the roads in the States serving the large business centres this feature of the increased value of short routes and quick service is illustrated by the fact that an extra charge is made on the fast passenger trains over and above the regular fares between the two points. The actual value of the transportation to a passenger who wishes to go from, say, Montreal to Toronto, is inestimable. If he is travelling purely for pleasure, or for a whim, the money value to him approaches nothing, but if he has to attend to important business the actual value to him of being able to attend to it personally may be many times the cost of his ticket.

The cost of transportation between any two points is only slightly influenced by small changes of distance as it is ruling grades and curvature of the line which most seriously affect this cost, as will be shown later. The effect of change of distance on maintenance of way charges (except in the case where it is a change of a few feet only) is fully proportional to the amount of that change. The expenses of labor and material, etc., will naturally be proportionately increased because it is assumed that in the case of a shorter route there will only be employed sufficient section gangs to properly take care of that line. If the length is increased, either additional gangs will have to be employed or else the existing ones would have to be reinforced.

The cost of bridges, road crossings, culverts and other fixtures of this nature would have to be considered separately for each route, as in some cases the number of bridges, etc., would be identical on the different routes, hence there would be no effect on the cost of structures by a change of distance. With regard to the maintenance of equipment any added train mileage will naturally increase the depreciation of rolling stock and increase the shop expenses, repairs and renewals. The actual mileage run by locomotives, passenger and freight cars is only one of the contributory causes of their deterioration. They deteriorate with age, strains due to stopping and starting, etc. The following table illustrates the effect of large and small change of distance on operating expenses:

TABLE VI.

| | Normal average. | Cost per mile p.c. large. | small. |
|---|---|---|---|
| Maintenance of way and structures ............ | 20.09 | 18.11 | 15.53 |
| Maintenance of equipment... | 22.74 | 9.18 | 8.50 |
| Traffic expenses ........... | 3.08 | 0.00 | 0.00 |
| Conducting transportation .. | 50.54 | 21.69 | 9.21 |
| General expenses ......... | 3.65 | 0.00 | 0.00 |
| | 100.00 | 48.98 | 33.24 |

In the above calculations it has been assumed that the business done by the road is fixed and invariable and would be unaffected by any changes in the length of the line. A change of length in order to reach a possible source of traffic would naturally affect the tonnage and consequently the number of trains required to handle it, but the rest of the line might be so burdened by an excess haul that the traffic might be discouraged. A saving in time between two points by a reduction of distance is—except in a very few cases—not to be effected except by a great expenditure which can hardly be justified by the time saved. The reduction in distance will have no effect on the freight business so far as the small saving in time is concerned, and may tend to reduce the rate considerably between the two points under discussion. The effect on the passenger traffic (except in the case of competing lines between large business centres) is comparatively small and the speed of trains is controlled to a large degree by the curvature and grades of the line.

*Curvature.*—Curvature increases the resistance to traction and, when uncompensated on grades, may be said to increase the rate of grade. When a curve is located on the ruling grade it has a controlling effect on the length of trains. Insofar as passenger traffic is concerned, curvature has very little effect beyond limiting the speed of trains when the sharpness of the curves is over a certain amount varying with different conditions. On competing lines, however, this may be a serious matter, not only on account of time lost, but also due to the apprehension of danger, and because the curvature may produce rough and unpleasant riding. These objections to curvature may be almost entirely eliminated as regards the number of trains required to handle the traffic as the only feature which might control this is the possible increase of a ruling grade by an uncompensated curve, and this may readily be eliminated by compensating curves on ruling grades. On minor grades uncompensated curvature has but little effect, as it merely increases the rate of grade, and unless the original grade plus the increase in grade due to curvature does not exceed the ruling grade it will not limit the tonnage of trains in any way. If, however, the combined effect would be to make the resistance more than that due to ruling grades, then trains loaded up to the maximum for those grades would be liable to stall on the curve.

Grades on the lower side of a stopping place need not be compensated for curvature, because the resistance due to the curve will reduce the work required in braking the trains. When a curve occurs above a stopping place it should be compensated in an even greater degree than ordinarily.

Curves should evidently be compensated an amount equal to that grade which would produce the same resistance as the curve. The resistance due to curvature being a variable quantity depending on the speed of trains, compensation for fast passenger trains may be made quite low, but for slow and heavy freight trains, which are the most important, it must be gradually increased. Webb advises 0.04% to 0.05% per degree for ordinary degrees of curvature. The maximum degree of curvature permissible on any road is a matter on which opinions differ considerably. Some roads limit their engineers to a maximum curvature of 6 degrees, others leave this to the judgment of the engineer. There is no serious objection up to a certain limit to a few sharp curves where the amount saved may be sufficient to justify their introduction. One limiting feature of the maximum curvature is the ruling grade. For instance, where the ruling grade on a line is 0.4% and the rate of compensation has been fixed at 0.4% per degree of curve, it is obvious that a ten-degree curve is the maximum permissible, as this degree has theoretically the same resistance as a .4% grade, and if the 10-degree curve was located on a ruling grade to be correctly compensated the grade would have to be eliminated entirely.

Curvature has a very marked effect on the maintenance and operating expenses of a line. Rails on curves wear much more rapidly than those on tangents; it has been computed that the wear on a rail on a 10-degree curve is 226% of the rail wear on a tangent, under similar conditions of traffic, and that it is approximately proportional to the degree of curve. Ties are also adversely affected by curvature owing to increased rail cutting, and they need more frequent respiking. Wellington states that the deterioration of ties is also proportional to the degree of curve. That part of the roadbed under sharp curves has to be more frequently reballasted, especially when the superelevation is high. The expense of repairs and renewals becomes greater owing to the harder wear on locomotive tires and wheels, thus increasing shop expenses.

The increase of tractive resistance due to curvature naturally tends to increase the fuel consumption of locomotives. Webb charges 44% of the average cost per train mile for an addition of 528 degrees of central angle into a mile of track. In some mountainous regions where a number of sharp curves are unavoidable operating expenses may be sometimes increased by locating these curves in deep cuts, thus necessitating the use of watchmen to warn trains of obstructions due to snow slides, etc., or, as an alternative, the speed of trains must be reduced as they pass these places.

The following table (abbreviated from Webb) gives some idea of the items affected by curvature, being based on the addition of 528 degrees of central angle into a mile of track.

Table VII.

| Item. | Normal average. | Cost per mile per cent. |
|---|---|---|
| Maintenance of way | 20.09 | 5.93 |
| Maintenance of equipment | 22.74 | 28.70 |
| Traffic expenses | 3.08 | 0.00 |
| Conducting transportation | 50.44 | 5.02 |
| General expenses | 3.65 | 0.00 |
| | 100.00 | 39.65 |

It will be seen from this table that an addition of 528 degrees of central angle into a mile of track increases the expenses per train mile by 39.65% of the average cost per train mile. Assuming that the increased expense is directly proportional to the amount of curvature, which, in the majority of cases, is very nearly true, then one degree of additional central angle per mile would increase the train expenses by .075%. If, again, we assume that the average cost per train mile to be $1, the cost per annum per daily train would be 27.375c. This result is, of course, entirely approximate but will give a better idea of the value of a proposed change than any unbased estimate, and will show whether the improvement will be justified, due to possible increase in business.

*Grades.*—The effect of grades on train expenses is of the greatest importance. Tonnage of trains is fixed by the ruling grade on the section of line under consideration, a heavy ruling grade necessitates shorter trains and consequently more of them. Gross receipts from traffic is a fixed quantity regardless of the number of trains necessary to handle it, while the cost of handling the traffic will be nearly proportional to the number of trains. A reduction of ruling grade, on the other hand, reducing as it does the number of trains and therefore the operating expenses, will justify a large expenditure to accomplish this result. Where the line runs through comparatively level stretches of country with light grades, very little can be done to favorably affect the grade, but humps and sags in otherwise uniform grades may be eliminated. No figures on the resistance to movement of a train on straight level track can be considered accurate for all cases, as they depend on speed, length of trains, character of cars, and condition of weather and roadbed, but 10 lb. per ton is frequently taken for average conditions and velocities. This is equivalent to the retarding effect of a 0.5% grade.

The rate of ruling grades are necessarily limited by the general character of the road. A road designed to meet the requirements of light traffic would naturally not be justified in a large expenditure to reduce the rate of ruling grade, whereas on a road built for heavy traffic this would be of prime importance. Methods of operating the trains will, to a large extent, minimize the effect of ruling grades, the road being divided into divisions, at the termini of which sorting yards may be located, and the trains increased or decreased when the grades on the next division make this advisable. If the road has necessarily to pass over a summit between two points and the natural grade is very high it may be advisable to use pusher engines on this high grade, a lower rate can then be used for the ruling grade.

On most roads the ruling grades affect only the heavier class of freight trains, the lighter freight and passenger trains being usually well under the maximum tonnage capacity of their locomotives. The cost of operating is dependent on the number of trains and not on their tonnage, and an extra train means an extra locomotive, train crew, etc., and this extra engine and train will also increase the maintenance of way charges due to the additional wear and tear of the track.

A small saving is made by having fewer cars per train due to the lighter work on the engines, when hauling over the minor grades and level sections. The following table gives an idea of the effect on different items of operating (n + 1) trains on heavy ruling grades compared with the cost of operating "n" trains on light grades, the tonnage being the same in both cases:

TABLE VIII.

| Item. | Normal average. | Cost per mile per cent. |
|---|---|---|
| Maintenance of way | 20.09 | 7.45 |
| Maintenance of equipment | 22.74 | 5.88 |
| Traffic expenses | 3.08 | 0.00 |
| Transportation | 50.44 | 28.30 |
| General expenses | 3.65 | 0.00 |
| | 100.00 | 41.63 |

In estimating the probable train mileage of a new road the estimated tonnage, ruling grades and the type of engine to be used must all be taken into account. It is possible to get an approximation of the hauling capacity of any type of locomotive over the ruling grades. In practice the engine is not loaded up to capacity, the reduction being dependent upon the rate of grade and its length. In general, this reduction will be as follows:

Grades of 0.3% to 0.6%, reduction 25% to 16%
Grades of 0.7% to 1.0%, reduction 14% to 10%

Dividing the estimated tonnage by the hauling capacity of the engine and multiplying by the length of the line will give the train mileage. Multiplying this by the cost per train mile will give the yearly cost of operating. The saving resulting from adopting a lower ruling grade or using pusher engines in isolated cases of heavy grades may thus be determined.

The last of the 92 leaves for the miter gates of the Panama Canal locks was lowered into place on its hinge pintle on Thursday, October 30th. This was the side wall leaf of the lower operating gate in the east flight at Miraflores Locks. The lower operating gates at Miraflores are the largest in the Canal construction, each of the lower leaves being 82 feet high and weighing over 700 tons. The swinging of a leaf means the completion of its erection, sheathing, and most of the riveting and reaming, but it is a step toward final adjustment. The work of lining up and babbiting the nickel steel bearing plates at both ends of a leaf can be completed only after the leaf is swinging in operating position, and the leaves are yet to be tested, painted inside and out, and fitted with foot-walk and handrail.

## ELECTRIC LOCOMOTIVES FOR MOUNT ROYAL TUNNEL.

VARIOUS features of the tunnelling of Mount Royal, by the Canadian Northern Railway, in order to reach a terminal in the centre of the city of Montreal, have been described in *The Canadian Engineer* during the past year. Attention is directed to Jan. 16th issue, outlining the essential engineering aspects of the scheme; to Feb. 6th issue for an article descriptive of the early operations and the plant equipment; to Feb. 27th issue dealing with the precise survey work in connection with its location, and to the issue of June 12th, where mention was made of the remarkable speed with which operations were progressing. In Oct. 9th issue the announcement was made of the contract for the electrification of the tunnel having been let, as, in the design, considerations of cleanliness and health pointed to the use of electricity as the motive power. The present article contains a few points of interest with respect to the design of the locomotives selected.

The equipment for the electrification of the tunnel and terminals, for which the Canadian General Electric Company, Limited, has the contract, includes 6 electric locomotives designed for an operating potential of 2,400 volts with overhead trolley construction. Two of these locomotives, operated and controlled as a single unit, will have ample capacity and suitable speed requirements for handling the heavy transcontinental passenger trains—1,130 tons trailing load—within the Montreal terminal zone. A single locomotive will successfully handle the freight trains—1,000 tons trailing load—and the local passenger service—500 tons trailing load.

**Locomotives.**—The general type of the locomotive proposed is that known as the box cab, articulated running gear type of locomotive. Its estimated weight is 83.0 tons. The locomotive has four axles with all of the weight upon the eight driving wheels, thus securing the maximum adhesive weight on drivers. The running gear consists of two 4-wheel trucks, articulated together by a heavy hinge. The equalization of the trucks is accomplished by a heavy locomotive type semi-elliptic leaf spring over each journal box, connected through spring hangers to the frame and to the equalizer bars. Practically a 3-point suspension is thus supplied through the side equalization of one of the trucks and both side and cross equalization of the other truck. With the Miner friction draft gear mounted in the end frame casting of the truck, this type of construction restricts the hauling and buffing stresses of the truck side frames and articulated joint, instead of through the cab centre plate. This relieves the cab and apparatus from the effect of severe shocks.

Both the box cab and platform are built of plates, sheets, angles and heavy channels, and are thoroughly reinforced throughout. The box cab is divided into three compartments: the apparatus compartment in the centre and the two operators' compartments at the ends. Each operator's compartment has a full complement of apparatus, consisting of controller, control switches, meter, air brake control apparatus, air gauges, pantagraph control and heaters, thus providing the locomotive with a complete double-end control. All apparatus subject to 2,400-volt potential is located in the centre apparatus compartment and properly screened to protect against accidental contact. The location and general arrange-

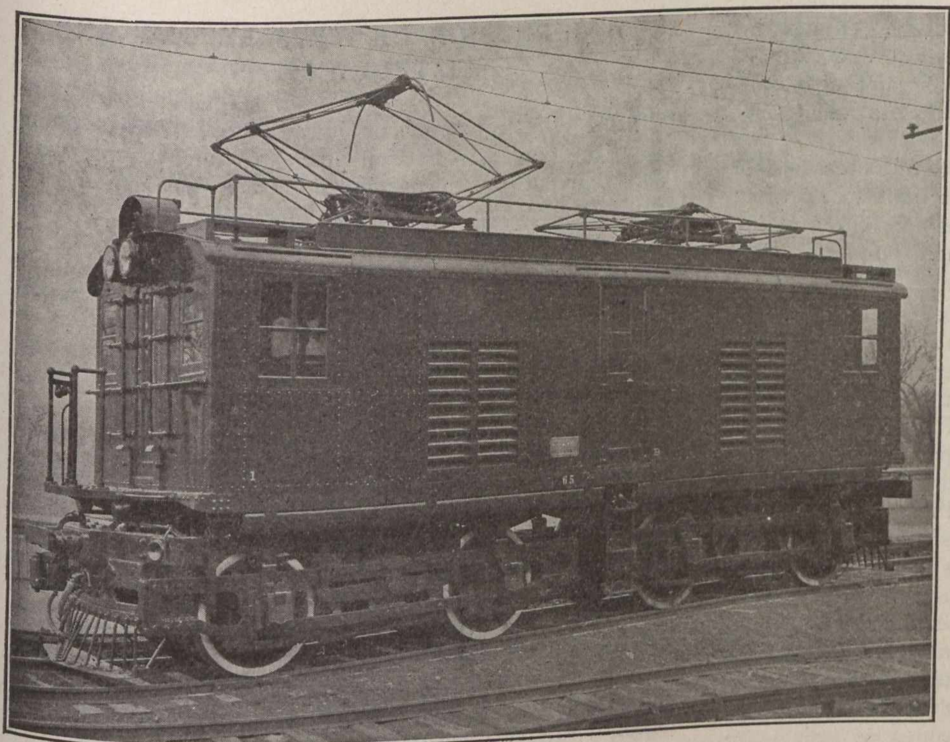

Fig. 1.

so as to distribute the duty upon all the compressors in the train.

**Operation of Motors.**—The motors will be operated by the Sprague-General Electric Type "M" two-speed control arranged to operate the motors in series and series-parallel. The external regulating resistance is divided into two parts, each part being directly connected to a pair of motors permanently connected in series. The two pairs of motors, with their resistances, are all connected in series on the first point of the control, the resistance being varied through the first nine points on the controller and finally short circuited on the tenth, or running point. The two pairs of motors are then similarly operated in series-parallel and all resistances cut out on the last or full speed running point.

A special electro-pneumatically operated change-over switch is used to make the transition between series and series-parallel so that there will be no appreciable

ment of this apparatus is such as to provide easy access from all sides for inspection, cleaning and repairs.

**Control Equipment.**—The Sprague-General Electric Type "M" multiple unit double-end control equipment is proposed for the locomotives, all the control points being proportioned and adjusted so as to secure a smooth and even acceleration, at all times, corresponding to a current consumption near the slipping point of the wheels. The transition between series and series-parallel is effected by a special electro-pneumatically operated change-over switch and the motor fields will always be on the ground side of the armature.

A motor generator set will supply 125-volt energy for the operation of the control and a 2,400-volt air compressor of 100 cubic feet free air piston displacement is provided as part of the air brake equipment. Two air-operated roller pantagraphs and a properly insulated bus line are located upon the roof. The bus line will supply power to two or more units from the pantagraphs of any of these units.

The motor equipment consists of four C.G.E. -229 commutating pole type motors wound for 1,200 volts and insulated for 2,400 volts, so that two may be connected permanently in series and operated on a 2,400-volt circuit. These motors are geared to the wheels through twin gears, there being one pinion on each end of the armature shafts. The C.G.E.-229 motor is especially designed for locomotive service and is provided with forced ventilation by a blower located in the apparatus compartment. The locomotives are geared for a free running speed on tangent, level track of approximately 45 miles per hour and will be operated as two-speed machines with ten points in series and nine points series-parallel.

The air brake equipment will be the straight air and automatic type so as to combine the desirable features for train operation through an equalizing reservoir and the independent operation of the brakes upon the locomotive. Provision is made for the multiple operation of the compressors upon all locomotives when operating in multiple

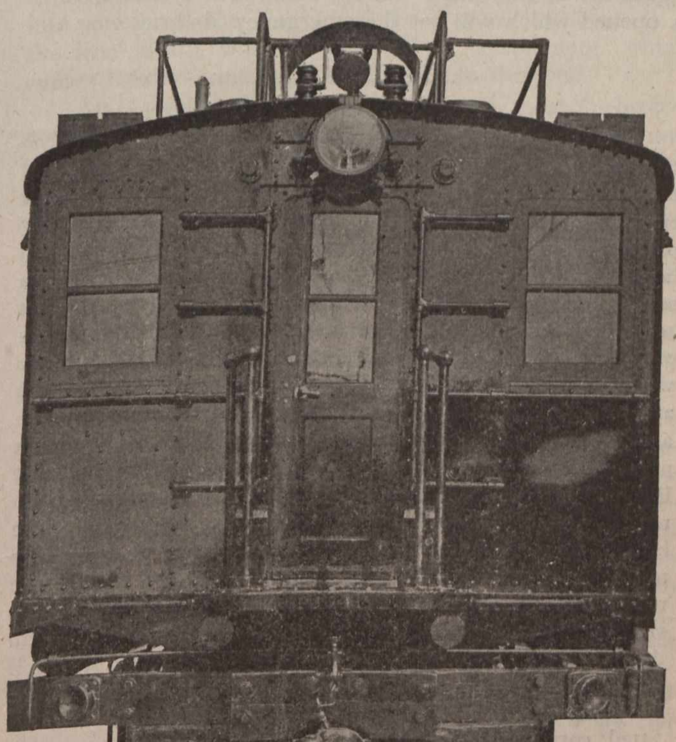

Fig. 2.

reduction in tractive effort during the change. A smooth transition between all points, both rheostatic and transitional, insures motor operation close to the slipping point of the wheels and a steady, gradual acceleration at all times.

The motors have sufficient capacity to slip the wheels, the slipping point serving as a current limit to prevent overloading. Either pair of motors may be cut out, in case of emergency, by means of a special handle on the change-over switch.

**Controllers.**—The master controllers receive their energizing current at a potential of 125 volts from the motor generator set and provide for operating the contactors so that they close the motor circuits under different combinations and regulate the external motor resistances to give 10 points series and 9 points parallel. The controller is of the non-automatic type and has two handles: one regulating the applied voltage at the motors and the other for controlling the direction of rotation of the motors. Each of the above handles control a single cylinder.

**Pantograph Trolleys.**—The overhead trolleys are of the pantograph type, mounted on insulated bases and pneumatically operated. A hand pump is provided for raising the trolley in case a locomotive has been standing some time and has no air supply.

**Automatic Stops.**—Provision is made for automatically opening the control circuit and cutting off all power from the locomotive, in case the engineer over-runs a signal set against him. At the same time a special valve is opened which will set the emergency air brake.

The huge scheme, undertaken at a cost of £3,500,000 sterling, of the provision of a water supply for the gold fields of Western Australia, is a wonderful piece of hydraulic engineering work, and is now well advanced. The primary purpose of the work was not to insure the subsistence of a large community of people, but to maintain and develop a staple industry established in a practically waterless district 400 miles from the western coast of the state. A daily supply of 5,600,000 gallons was to be provided, of which 5,000,000 were for use in the gold fields. The source of supply is an artificial reservoir, from which the water is pumped through a steel conduit 80 inches in diameter by means of eight pumping installations to the main distributing reservoir at Bulla Bulling. This reservoir is 308 miles from the main reservoir and is 1,200 feet above the lowest outlet level of the latter. The water then gravitates a distance of 44½ miles to the Coolgardie service reservoir and the Kalgoorlie service reservoir. The details of all the ironwork used in the construction of the weir were drawn out in the state and all the ironwork used was obtained from Great Britain, and it says much for the accuracy displayed in the drawings that on being grouped together as the work progressed all parts fitted correctly into their proper places. An interesting feature of the work at Kalgoorlie was the use of camels for excavation purposes. According to figures supplied for the use of the Christian Science Monitor by Neil McQueen, the district engineer, 86 camels were used for the excavation work, which was in stiff clay, in connection with the Kalgoorlie reservoir. This reservoir will be lined with a bitumen asphalt compound invented by P. V. O'Brien, the chief engineer in charge, and will be roofed with corrugated iron to keep dust out of the water and prevent evaporation. The reservoir, which is circular, has a diameter of 378 feet and a depth of 22 feet at the deepest part. Its capacity is 10,000,000 gallons.

## THE CORROSION OF PIPES BY RAW AND TREATED WATERS.

The lengthy series of investigations based upon the corrosion of iron pipes by water supply was carried on during 1912 by the Department of Water Supply, Gas and Electricity of New York City. The results of these experiments are contained in a paper read recently before the American Public Health Association by Mr. Frank E. Hale, from whose paper the following information is deduced:—

The presence of carbonic acid is the most potent factor in connection with the presence of dissolved oxygen. The action of these two agents is modified by the presence of other salts, increased by nitrates which furnish oxygen by reduction, and decreased by carbonates which help to form protective coatings upon the pipe. The chemical action takes place in the following order:

The first reaction is the solution of iron as bicarbonate by carbonic acid with the formation of hydrogen. The dissolved oxygen in the water which is near the iron surface oxidizes some of the hydrogen back to water. After the oxygen near the iron is used up the hydrogen remains as a gas. In the cold reaction of the experiments the amount of hydrogen oxidized was found to be about 20 per cent. The dissolved oxygen at the same time oxidizes the soluble iron bicarbonate to insoluble red iron, setting free again the carbonic acid. The carbonic acid set free again dissolves more iron, and is again set free, until all of the dissolved oxygen is exhausted. The red iron oxide then acts as oxidizer until it is completely reduced to black magnetic iron oxide, setting free carbonic acid again. Reduction does not take place beyond this stage. After all dissolved oxygen has been used up nitrates are completely reduced to ammonia, serving to supply oxygen. After all possible sources of oxygen are exhausted the carbonic acid disolves more iron, which is probably thrown out of solution finally as insoluble basic carbonate of iron, since after complete reaction there is only about 0.2 to 0.7 p.p.m. iron in solution, no free carbonic acid, no dissolved oxygen, no nitrate, sometimes no bicarbonic acid, and under some conditions caustic lime is present. The alkalinity of hard waters is reduced to about 25 p.p.m.

The carbonic acid for the solvent action may be derived from three sources—the free carbonic acid, the bicarbonic acid, and the neutral carbonate. In the latter case the carbonate hydrolyzes so that there are in solution neutral carbonate, lime hydrate and carbonic acid. This takes place when the water reaches the stage that only neutral carbonate is present. The carbonic acid set free dissolves the iron. The presence of lime hydrate was proven by titration with phenolphtalein and methyl orange.

The rapidity of corrosive action is affected by the source of carbonic acid in order as given above, and the amount of soluble iron present during the active stages of corrosion varies with the above order of source of carbonic acid.

Another source of carbonic acid is that set free in alum-treated waters. This is really mostly bicarbonic acid set free. The amount set free per grain of alum per gallon is not, as sometimes stated, 6.8 p.p.m., but about 3.5 p.p.m. (determined by analysis).

It must be understood that the facts as given above apply to new pipe with a clean iron surface and to complete reaction.

Attempts to remove dissolved oxygen from water appear to me to be hopeless as well as expensive, because a consideration of the above reaction brings out a fact that seems to me to have escaped general attention, and that is that 15 per cent. of the oxygen in the iron oxides formed by complete reaction, if all the hydrogen were set free, comes from the water and not from the dissolved oxygen, and the greater part of the hydrogen is set free.

A very large amount of iron is corroded for each part per million of dissolved oxygen through the catalytic action of carbonic acid and water. For example, 10 p.p.m. of dissolved oxygen produces 126 p.p.m. $Fe_3$-$O_4$ expressed as Fe, whereas if the hydrogen were oxidized and not set free the amount which 10 p.p.m. oxygen could produce would be only 31 p.p.m. iron. In our experiments 75 to 80 per cent. of this theoretical amount of iron was produced, the difference from theory being due to oxidation of hydrogen. This is a variable quantity, but about 85 per cent. of the hydrogen oxidized was oxidized during the first 15 minutes, which substantiates the idea expressed previously that oxidation of hydrogen takes place only at the surface of the iron while dissolved oxygen is present near the iron. The presence of hydrogen gas is easily shown and has been proven by many investigators. Any hydrogen set free means an equivalent amount of oxygen obtained from the water to oxidize the iron.

**Experiments Conducted With Three Kinds of Pipe.**—The experiments were carried out with Byers wrought iron pipe (protected with an inside coat), Reading wrought iron pipe, lack mild steel, and galvanized wrought iron. The first three showed no difference in the corrosive action when carried to completion, but the steel appeared to corrode most rapidly. The galvanized iron showed great resistance at first, but gradually—especially with alkaline water—the action increased somewhat, though in the time of our experiments the highest amount was only about one-third that of the other pipes.

Experiments with regard to speed of reaction brought out some surprising facts.

About 50 per cent. of the iron produced by corrosion in the cold is produced in two to three hours.

With Croton water (5 p.p.m. free carbonic acid) the action is practically complete in 15 hours. This explains the greater tendency in house service—especially in new services—to show rusty water when first drawn in the morning, since the action is complete over night.

The rate of corrosion is increased proportionately to the increase in free carbonic acid. The action cold was complete in seven to eight hours with Croton water containing 25 to 50 p.p.m. free carbonic acid. The total iron was also somewhat increased with the higher free carbonic acid. The carbonic acid hastens the action by dissolving the iron more rapidly. There being more iron in solution, oxidation is hastened. Analyses for soluble iron and dissolved oxygen proved this to be true. The carbonic acid increases the total iron by forming basic carbonate of iron which is left unoxidized after available oxygen is exhausted.

Alum-treated water showed no appreciably greater corrosive action either in speed or total amount of iron than untreated water. This is due to the comparatively slight increase in free carbonic acid (3.5 p.p.m. per grain of alum per gallon).

Neutralization of the free carbonic acid retards the corrosive action. Neutralization of the free carbonic acid by lime hydrate or by sodium carbonate retards the corrosive action. Neutralization of the free and half-bound carbonic acid by lime hydrate, provided there is no excess caustic, still further retards the corrosive action, and also reduces the total iron produced by cold action 33 per cent., and by hot action 50 per cent. Neutralization of carbonic acid retards corrosion by reducing the amount of dissolving agent, hence the amount of soluble iron present at any moment, and thus slows up the oxidation.

The slightest excess caustic (a few p.p.m.) up to considerable excess hastens corrosion to almost indentically the same degree as does increasing the free carbonic acid to 25 to 50 p.p.m. A large excess of soda-ash acts likewise. The action of alkalis has been noted by Cushman and others.

Excess alkali hastens the corrosion by hastening the absorption of oxygen by the iron in solution, though this is smaller in amount at any time. Until the excess of alkali is sufficient to prevent hydrolysis of carbonates the corrosion takes place. Analyses proved that the oxygen is absorbed faster and that only traces of iron are in solution at any time. Compare in this connection the Levy method of determining dissolved oxygen in water—i.e., oxidation of ferrous salts in alkaline condition.

**Red Water Trouble Caused by an Excess of Iron Dissolved or Suspended.**—The excess of alkali necessary to stop corrosion completely is 100 to 125 p.p.m. excess lime hydrate over that needed to neutralize the free and half-bound carbonic acid. Only slightly more is needed to stop corrosion hot than cold. This amount of excess alkali acts by completely preventing solution of iron, for the oxygen still oxidizes the surface of the iron and is completely gone in twenty-four hours, although no iron over the original amount appears in the water.

The above facts show that whatever helps to put iron into solution is the real cause of red water trouble. It is the iron in the water, dissolved or suspended, which causes trouble—not the iron clinging to the pipe.

All corrosive action was hastened by heat (120-150° F.), so that complete reaction was accomplished in one and a half to three hours on the clean iron surface. Heat hastens corrosion in at least four ways—by hastening the chemical action of solution of iron, by increasing the amount of free carbonic acid since heat sets free the half-bound carbonic acid of the alkalinity, by creating convection currents that cause the dissolved iron to diffuse more rapidly and hence come in contact with the dissolved oxygen faster, and by hastening the oxidation and precipitation chemically of the dissolved iron.

The water of the Flatbush Water Company, which has a hardness of about 140 p.p.m., contains only two-thirds as much oxygen as Croton water and 10 p.p.m. free carbonic acid, produced corrosion as rapidly as Croton water on the clean iron surface and a total amount proportional to the oxygen and carbonic acid content as required by theory. Yet in service this water causes no complaint and is generally free from iron and turbidity. This is undoubtedly due to protective scale formed on the pipe, probably consisting of both iron oxide and carbonate of lime. As previously stated, the alkalinity of hard waters is reduced to about 25 p.p.m., when the action goes to completion.

Dissolved oxygen disappears rapidly in all cases. In the first fifteen minutes 23 to 37 per cent. were used up due to oxidation of both hydrogen and dissoved iron.

The relative speed of oxidation is best seen in comparing percentages of oxygen used up to one and a half hours.

So long as there is oxygen in solution the reaction takes place rapidly and almost proportional to time and the iron precipitate is red ($Fe_2O_3$). After exhaustion of the oxygen the reaction becomes slower, the red oxide being reduced to the lower black oxide, turning green to brown to black. The color of the precipitate gives a good indication of the progress of the action.

While there is dissolved oxygen present there is iron in solution, depending upon the amount of active carbonic acid. Soon after the oxygen disappeared it was but rarely that more than 0.5 to 1.0 p.p.m. iron was in solution. It is obvious that the amount of dissolved iron is greater with increase in the active carbonic acid.

The amount of oxygen within wide limits does not seem to affect the rate of corrosion materially, but the total amount of iron removed from the pipes in complete reaction, other factors remaining the same, is directly proportional to the dissolved oxygen in the water.

When iron pipe is exposed to the continuous action of water, as in service, a protective coating forms according to the nature of the water. Its action is to delay corrosion rather than to stop it, and to reduce the amount of iron appearing in the water. The corrosion goes on slowly, but the oxides cling to the iron, increasing the amount of scale. In cold action the greatest protection was acquired experimentally in ten days, and then remained constant. Flatbush and Brooklyn waters caused a better protective coating than Croton water. The iron produced in 24 hours dropped from 114 and 84 p.p.m. respectively for the two former to 21 p.p.m., Fe, for the Croton, and its modifications from 56-102 to 29-35 p.p.m., Fe. Croton was tried in four modifications—untreated; with free carbonic acid neutralized by sodium carbonic acid; neutralized by lime hydrate to bicarbonate, and treated with one grain of alum per gallon.

In hot action the protective coating formed in two days. Flatbush water reached the lowest level of 3 p.p.m. iron with an average of 8. Brooklyn water reached 4 p.p.m. iron with an average of 9. Untreated Croton fluctuated high and low with an average of 41 p.p.m. iron. The alum-treated Croton averaged 26. The soda-neutralized Croton averaged 23 p.p.m., Fe. All the averages, cold and hot, include results from the tenth to the twenty-first day.

The pipes which had acquired a protective coating from these different waters were subjected for 24 hours to the action of untreated Croton water and to Croton water containing 20-27 p.p.m. free carbonic acid. The water with increased carbonic acid produced an average of 38 p.p.m. iron from the pipes with scale formed in cold action, against 24 p.p.m. produced by untreated Croton (5 p.p.m. $CO_2$). On the pipes with scale produced in hot action about the same relative quantities were produced, 34 against 22 p.p.m., Fe, showing that water containing the greater amount of carbonic acid causes more corrosion upon pipes protected by scale.

The scale produced by Flatbush, Brooklyn and soda-neutralized Croton water proved the more protective.

**General Summary.**—Extensive corrosion takes place rapidly in new pipe while the iron is fairly clean from incrustation. This explains the abundance of complaints of iron rust in new service installation.

Concerning the kind of pipe, there is little doubt that steel pipe is most readily attached, wrought iron next, and galvanized iron the least. The latter is far preferable for use. Lead pipe should never be used any more than absolutely necessary because of the danger of accumulative poisoning with minute amounts of lead (less than 0.5 p.p.m.).

The chief agent in dissolving the iron is carbonic acid, as it is also the chief agent in holding iron in solution.

The chief agent in carrying the rusting to the greatest extent is oxygen.

Through the catalytic action of active carbonic acid about 70 per cent. of the oxygen in the iron rust comes from the water by chemical decomposition, hydrogen gas being set free. The remainder only, about 30 per cent., is furnished by the dissolved oxygen in the water.

**Soft Water Containing Much Free Carbonic Acid Causes the Most Trouble.**—Waters which give the most trouble are very soft and contain considerable free carbonic acid.

Hard waters rarely cause complaint, as they form an excellent protective coating on the pipes.

The action in distribution services probably never reaches completion on account of protecting scale of oxide, etc., which retards corrosive action. The scale varies with different waters in protective properties. Tap samples in New York City have shown no appreciable diminution in dissolved oxygen or in free carbonic acid, so that only slight corrosion can have taken place in proportion to volume of water and possible reaction. Even hot services have shown the usual amount of carbonic acid and more oxygen than would saturate the water at the temperature when drawn.

Since in distribution services there is no exhaustion of oxygen, any increase in free carbonic acid may mean a possible increase of soluble iron in the water, which would be precipitated in the hot water supply.

Neutralization of free and half-bound carbonic acid is impracticable as it tends to hasten corrosion if there be the slightest excess of hydrate, removes zinc when hot from galvanized pipe, interferes with alum precipitation and color removal, and produces considerable precipitation of calcium carbonate in the water, which would deposit in the pipe system, meters, etc., unless previously removed by filtration or sedimentation.

Neutralization of only free carbonic acid is feasible, since it retards corrosion and reduces the amount of soluble iron.

Either soda-ash or lime oxide may be used. Both reduce the corrosive action, cold or hot. Only sufficient lime should be used to form bicarbonate. This reagent increases the hardness 1.1 p.p.m. for every 1 p.p.m. free carbonic acid neutralized to bicarbonate. About 5.3 lbs. CaO per 1,000,000 gals. of water are required for each 1 p.p.m. carbonic acid. It is best handled dry. It costs about 2 cents per 1,000,000 gals. per 1 p.p.m. carbonic acid.

Soda-ash is more soluble, can be handled in concentrated solution and consequently in small-sized tanks, and probably with better regulation of dosage would not increase the hardness, but, on the contrary, would decrease the lime sulphate in the water, changing it to sodium sulphate, thus improving the water for boiler use and for other industrial purposes. It also apparently helps to form a better protective coating on the pipe. About 20.2 lbs. soda-ash per 1,000,000 gals. of water are required for each 1 p.p.m. carbonic acid. This would cost about 20 cents per 1,000,000 gals. for each 1 p.p.m. carbonic acid. Soda-ash has been used successfully on a small scale to obviate red water trouble. The great difference in cost is due to the greater molecular weight, less combining power and greater cost per pound. The cost must be considered in connection with the degree and advantage of the change of sulphates to carbonates, etc.

Aeration of water by splashing followed by neutralization of residual free carbonic acid (about 5 p.p.m.) is probably the best practice.

# FIXED CARBON DEPENDS ON CRUDE

## CHICAGO EXPERT SAYS THAT HIGH FIXED CARBON IN REFINED ASPHALT IS NOT AN INDICATION OF CRACKED OIL IF CRUDE ALSO HAS HIGH FIXED CARBON

By LESTER KIRSCHBRAUN, B. S.,
Director Chicago Paving Laboratory.

(NOTE.—*Mr. Law, in our issue of November 20th, and Col. Howard, issue November 27th, favored the elimination of the Fixed Carbon Test. Mr. Pullar advanced an original suggestion in our issue of November 13th—that the Fixed Carbon Test be retained in specifications but that all asphalts be classified according to their sources and a different maximum limit be imposed for each class. In the following article Mr. Kirschbraun agrees with Mr. Pullar that the test has certain usefulness, and urges consideration of the liquid crude when imposing a maximum limit for fixed carbon in the refined product. He gives a formula establishing the permissible fixed carbon in any asphalt refined from crude of known fixed carbon, but it is of the empirical class of formulae against which Mr. Law presented strong arguments in his article. This shows the difference of opinion among engineers and chemists on this test.* THE CANADIAN ENGINEER *would like to hear from municipal highway or consulting engineers or road contractors who may have definite opinions regarding the Fixed Carbon Test.*—EDITOR.)

SINCE Mexican asphalt has come upon the market, there has arisen considerable comment upon the value of fixed carbon tests. Mexican asphalt has generally shown a high fixed carbon figure, and in many cases it fails to meet specification requirements where the usual maximum is given. On this account, rather than upon the merits of the matter, various producers have advised the elimination of this requirement in specifications. While the arguments presented in this direction are rather of a commercial origin, there is no question but that there should at least be a revision of this clause if retained in asphalt specifications.

In the following discussion the writer shows that the fixed carbon figure in asphalts produced from liquid crude is dependent, among other conditions, upon the nature of the crude from which such asphalt is obtained. It will be observed that the hydrocarbons yielding fixed carbon are, in the course of distillation, retained in the asphaltic product. This product will then have a normal fixed carbon figure represented by the quotient of the fixed carbon in the crude, divided by the percentage yield of asphalt. This applies under theoretically ideal refining conditions.

For example, if we have a crude showing 8% of fixed carbon and the yield of asphalt obtained therefrom is 50%, we should normally have a product giving 16% of fixed carbon. On the other hand, if we have a crude showing 4% of fixed carbon, the product should normally give 8%, on the basis of 50% yield.

If, however, refining conditions are not perfect, there will be formed decomposition products, the hydrocarbons of which yield fixed carbons, and thereby give to the resulting product an increased fixed carbon figure over and above that derived from the normal content of the crude. This is a matter of fact observation. The fixed carbon figure, thereby becomes an index of this decomposition, and herein lies the significance of the test as also the danger of its application.

It is evident that the results must be properly interpreted in the light of the above conditions, and this is only possible when the character of the crude is known, and also the yield of asphalt obtained therefrom. This is a simple matter when applied to refinery control or to inspection work at refineries, but presents some difficulties when applied in specifications generally. It is thought, however, that to those having a sufficiently wide knowledge of crude materials and methods employed in production, this would prove no special difficulty, even though it should be necessary to make tests of crudes and laboratory products in order to determine proper standards.

In the light of the present knowledge of the subject, the writer has arrived at the following tentative conclusions regarding the value of the fixed carbon test:—

(1) As a matter of refinery control it is extremely valuable in gauging the efficiency of the distilling operation.

(2) To the asphalt chemist familiar with crudes and methods of obtaining asphalt therefrom, it is a valuable indication of the care used in refining.

(3) If the fixed carbon requirement is embodied in specifications no fixed maximum should be stated unless such limit takes into consideration the effect of the character of the crude material. In order, therefore, to properly incorporate a fixed carbon requirement in specifications, the writer would suggest a clause (this referring to material of approximately 50 penetration) somewhat as follows:—

"The yield of fixed carbon obtained upon ignition of the asphalt cement must not exceed 14%, unless the amount is smaller than 3% in excess of the quotient of the fixed carbon from the crude, divided by percentage yield of asphalt."

To state this mathematically and to better advantage, the fixed carbon in the asphalt cement should not exceed

$$\frac{\text{Fixed carbon from crude}}{\text{Per cent. yield asphalt}} + 3\%$$

In other words, where the test shows in excess of 14% of fixed carbon, the above formula will apply if such excess is due to the character of the crude from which the asphalt is produced.

So far as known to the writer, the fixed carbon test was first generally applied to the bitumens of the paving industry by Mr. Clifford Richardson. Following, fixed carbon requirements have been largely introduced in specifications for paving asphalts and road binders. The value of this test has been subjected to considerable question, and in many instances much confusion has arisen through improper and empirical interpretation of results. Fixed carbon determinations must be properly considered in connection with other analytical data and further, in connection with the character of the bitumens under examination. When so considered, the writer is of the opinion that the fixed carbon test has a decided value in specifications and is capable of yielding much information to the experienced asphalt analyst.

The writer explained in detail his understanding of the significance of fixed carbon determination in a paper before the American Society for the Advancement of Science, and presented the following laboratory data and explanations thereof, upon which his conclusions have been based.

Fortunately, the method of determining fixed carbon is fairly well standardized, and unlike many other methods employed in the examination of asphalts, the procedure at least is uniform. The method used is that recommended by the committee on coal analysis of the American Chemical Society, published in Vol. 21 (1899) page 1116. Briefly, it may be described as follows: A sample of one gram of the bitumen to be examined is weighed into a previously tarred platinum crucible of about 30 c.c. capacity, provided with a close-fitting cover. This is ignited for exactly seven minutes on a platinum triangle over a bunsen burner carefully regulated so as to give a flame 6-8 cm. high to the top of inner cone and fully 20 cm. high to the tip. The platinum crucible is placed ½ cm. above the tip of the inner cone. The ignition should be carried out in a place free from draft and permitting a steady flame. At the end of 7 minutes the crucible is removed from the flame, cooled in a desiccator and weighed. It is then returned to the flame, uncovered, turned on its side to give access to air, and ignited until all carbonaceous matter is removed. The cover is ignited to remove deposited carbon upon the under side. The crucible and cover are again cooled and weighed, the weight subtracted from that previously obtained, representing the fixed carbon.

When the bitumen carries mineral matter containing carbonates, the ash in the crucible is treated with a few c.cs. of a saturated solution of ammonium carbonate, dried, and ignited at a low heat to remove excess of carbonate and the corrected weight of ash obtained. The percentage of fixed carbon is calculated to the weight of the original sample, less the mineral matter obtained in the ashing. When notable amounts of "free carbon" are present in the bitumen, the results may be reported as fixed carbon less free carbon. The author, however, prefers to report the fixed carbon as obtained for the reason that the organic non-bituminous residues reported by the usual methods of extraction are probably seldom actual elemental carbon, but more often highly dehydrogenized hydrocarbon or hydrocarbon derivatives.

In cases where it is desired to obtain a fixed carbon figure apart from such non-bituminous matter, a portion of the soluble bitumen may be recovered from extraction for this purpose. In the hands of a single operator, uniform and consistent results may be obtained by this standard method, but skilled analysts are known to vary considerably upon check determinations. The heating value of the gas available in different localities is probably a large factor in this variation. Where certain natural gas is available for making this test, variations of 2 to 3% are known to result on this account. The quality of gas used is, of course, beyond the control of the analyst, although in the larger cities the heating value of artificial gas is fairly well regulated.

Aside from this, however, other considerations enter into the accuracy of the determinations—the exact size of the crucible, the tightness of the cover, freedom from draft, the position of the crucible in the flame and the exact size of the flame are all important factors. Considerable stress should be laid upon this latter. The standard method permits of variation of 2 cm. in the height of the inner cone and the exact length of the flame is limited only to a minimum. In the author's laboratory a bunsen burner of the Chaddock type is used for these determinations. This affords a protected and steady flame. The same burner is used for all determinations. The flame is adjusted to a scale laid off on a wood rod, graduated at a point level with 8 cm. and 20 cm. above the top of the burner. Before making the ignition, the rod is placed on the hip of the burner and the flame adjusted exactly in accordance with the graduations. A further advantage results from the use of a Chaddock burner in that the distance of the triangle (on the crown) above the top of the burner is necessarily always constant.

The importance of a more exact regulation of the flame may be illustrated by the following experiment wherein determinations were made upon the same sample under varying conditions of the flame, all other factors being the same, the crucible adjusted in each case ½ cm. above the tip of the inner cone:—

| | |
|---|---|
| 8 cm. cone, 20 cm. flame....... | 13.59 |
| 6 cm. cone, full flame 25 cm. ... | 12.64 |
| 8 cm. cone, 20 cm. flame ...... | 13.55 |
| 6 cm. cone, full flame 25 cm. ... | 12.52 |

The determinations were made in the order given so that the effect of the manipulation in changing the flame, might be observed on the duplication of results. It is evident that very exact conditions of manipulation are necessary to obtain consistent results in these determinations. The discrepancies resulting from careless manipulation or even from variation of the flame with the limits given as standard may be sufficiently great to invalidate the correctness of deductions or proper interpretation of the results. It is believed that these factors are accountable for much of the lack of confidence in fixed carbon tests, and that with closer attention, a high degree of accuracy may be attained. Where conditions of gaseous fuel give comparatively high results, there should at least be no difficulty in making relatively correct and consistent determinations and specifications in such case can be modified and interpreted accordingly.

Some discussion of the derivation of the fixed carbon yielded by bitumens upon ignition is pertinent in considering the significance of fixed carbon and its consequent value in specifications. The character of the hydrocarbons present in the bitumen is a determining factor in their yield of fixed carbon. According to Richardson, this data shows the "relative proportions of carbon and hydrogen in the bitumen under examination. In the cases of paraffine hydrocarbons of the formula $C_n H_{2n} + 2$ no fixed carbon is left on ignition, while the amount increases with each diminution of the proportion of hydrogen to carbon, until in Grahamite as much as 50% is found, where the relation of carbon to hydrogen is as 8 to 1".

In other words, the yield of fixed carbon in bitumen is commensurate with the degree of condensation of the particular classes of hydrocarbons present in such bitumens. This condensation is brought about by natural agencies in the native bitumens. The manufacture of solid bitumen from native liquid bitumens involves the production of more of condensed aggregations of hydrocarbons as the resultant product. This is a function of the process used, and may be effected by means of dehydrogenization by air or sulphur, by oxygenation, by the splitting off of hydrocarbon, or merely by the concentration of more condensed hydrocarbon through the removal of lighter ones by distillation. Several means of condensation may be employed in the same process.

Remembering that fixed carbon is a measure of condensation of any given aggregation of asphalt hydrocarbons; and that such hydrocarbons may vary in degree of condensation to the extent that they become insoluble in certain fluxes, in carbon tetrachloride, and even in the usual solvents for bitumen, the value of this test will be further and more specifically discussed. It is the belief of the writer that the fixed carbon characteristics of various paving bitumens are significant in three particulars:—

First, as a means of identifying and classifying native bitumens; second, as a check upon the suitability of flux combinations with hard bitumens; and third, in the production of oil asphalts, as an important means of determining and controlling the quality and uniformity of the product. With reference to the value of fixed carbon as a means of identification of native bitumens, little need be said. In connection with other data, this feature affords an important item of identification.

As is well known, the Grahamites yield very high fixed carbon, ranging from 30% to 55%. The solid native asphalts used in the paving industry yield approximately 9% to 26% of fixed carbon. Gilsonites show 12% to 17%, the harder varieties giving the higher yield. Distinction between Gilsonite firsts and seconds and their quality is indicated by fixed carbon. The fixed carbon characteristics of the individual paving asphalts are fairly well defined for each kind and this feature affords a means of check of uniformity of such natural products and sometimes of the uniformity of their refinement. This function of the fixed carbon test is not directly pertinent to specifications so far as identification is concerned, but is of much value to the analyst in affording knowledge as to the material dealt with, and correlating with such knowledge a proper treatment in fluxing and handling.

Fixed carbon, as applied to native asphalts or partially fluxed refined products, has no place in specifications. The preparation of asphaltic cements or binders from hard, highly condensed bitumens is a matter of great importance. As previously indicated, such highly condensed products vary in solubility in the different kinds of fluxes available for softening purposes, some fluxes being totally unable to dissolve these products. The life and cementing powers of asphaltic binders are directly dependent upon the permanency and extent of solution of the harder in the liquid hydrocarbons present. The reference to solution is made here, not in the strict sense of the word, but by considering combinations of this character as colloidal systems of widely varying degrees of dispersion.

Certain of these highly condensed bitumens, such as pitch produced by cracking paraffine oils, are entirely insoluble in paraffine flux, so that only a mechanical mixture of oil and solid results from attempts to flux them. They are likewise insoluble in semi-asphaltic fluxes, but are dissolved by strictly asphaltic fluxes. With other highly condensed bitumens a granular or non-homogeneous compound results with paraffine fluxes, representing a minor degree of solubility, increasing generally as the flux or refined asphalts contain more of the heavy asphaltic malthenes which are of high solvent character. The effect of the presence of the heavy asphaltic malthenes is to "dilute" the highly condensed hydrocarbons, which yield high fixed carbon, thus producing bituminous cement of proportionately lower fixed carbon yield.

Some illustration of the variation of fixed carbon in cements in accordance with the character of the flux may be tabulated below (all cements between 50 and 60 penetration).

Fixed Carbon in Bituminous Cements with the following Fluxes:—

| | Paraffine. | Illinois. | Texas. | Calif. | Character of Cement. |
|---|---|---|---|---|---|
| Grahamite | 14.5% | ... | ... | ... | Punky, non-homogeneous |
| " | ... | 13.3% | ... | ... | Dull, greasy, short. |
| " | ... | ... | 12.4% | ... | Bright. |
| " | ... | ... | ... | 12.4% | Bright, ductile. |
| Calif. "B" | 16.3% | ... | ... | ... | Dull, short granular. |
| " | ... | 15.2% | ... | ... | Dull, granular. |
| " | ... | ... | 13.6% | ... | Slightly granular. |
| " | ... | ... | ... | 12.6% | Homogeneous, ductile. |
| Cuban | 13.9% | ... | ... | ... | Dull, short |
| " | ... | 13.6% | ... | ... | Bright. |
| " | ... | ... | 11.9% | ... | Bright, ductile. |
| " | ... | ... | ... | 11 9% | Bright, ductile. |

There is no mechanical method of measuring the condition of solution of these combinations, but the physical appearance, together with the ductility, gives a general index of this feature. The reference to "punky" indicates a putty-like condition, similar to shoe polish, and will be recognized by those familiar with bituminous products thus described. In the preceding illustration the same lot of flux was used throughout, so that this factor remained the same. In the use of California flux, the higher fixed carbon yield of this offsets, in some instances, the dilution of the hard bitumen.

In fluxing combinations, there is a generally improved condition of solution as the more asphaltic fluxes are used in combinations with the hard bitumens. The higher fixed carbon figures are associated with an imperfect state of solution, and the lower ones with more satisfactory combinations or greater degree of dispersion or, if the term might be used, with a better "grading" of hydrocarbons from heavy to light. The foregoing tabulation is not directed to any particular type of bituminous cement, but is given rather as illustrating the principles involved in this feature of the discussion.

It must not be assumed that a comparatively low fixed carbon yield without reference to other tests necessarily signifies in all cases a proper flux combination, but in dealing with hard bitumens fluxed back to paving consistency, the writer believes the reverse may be correctly stated, that a high yield of fixed carbon invariably signifies an improper fluxing, producing a cement of lower or impermanent binding value.

This may be often recognized by the physical appearance, homogeneity or ductility of the cement. If these latter characteristics remained permanent through ageing, it might be safe to place complete reliance upon them for determining these features, but as a matter of fact, combinations of the kind referred to are particularly liable to change and their appearance when fresh and especially their ductility is subject to great loss upon standing, so that the significance of a high fixed carbon content is of evident importance in such connection.

Fixed carbon, of course, varies with the consistency, naturally decreasing in a given combination as the amount of flux used and the consistency increases. It is evident that an apparently low fixed carbon yield obtained at a high consistency may be in reality excessive. For example, a fixed carbon yield of 12% in a fluxed cement may not appear excessive when considered alone, but if associated with consistency of 200 penetration would be of undoubted significance. Therefore, this must be interpreted in accordance with consistency, and the correct significance may be conveniently arrived at by preparing a curve for the given combination covering a sufficiently wide range of consistency to give the relationship desired. Such a curve is given hereinafter for an oil asphalt cement.

Where specifications are so drawn as to cover the character of fluxes used in the cement and carefully prescribe the kinds and amount which may be employed under various conditions, a fixed carbon requirement is hardly necessary. However, very large quantities of prepared cements and binders for bituminous roads and pavements are now purchased and used under such conditions as to make it impracticable to govern the fluxing operations directly. Under such conditions, particularly when a number of bitumens, rather than a single combination may be compounded into the marketed product, the value of a fixed carbon requirement in the specification as applied to the cement, becomes apparent.

The foregoing discussion has referred only to conditions in which hard, highly condensed bitumens are fluxed to paving consistency. In dealing with asphaltic products brought to grade by distillation from liquid native bitumens, a somewhat different and more important significance may be attached to fixed carbon. As has

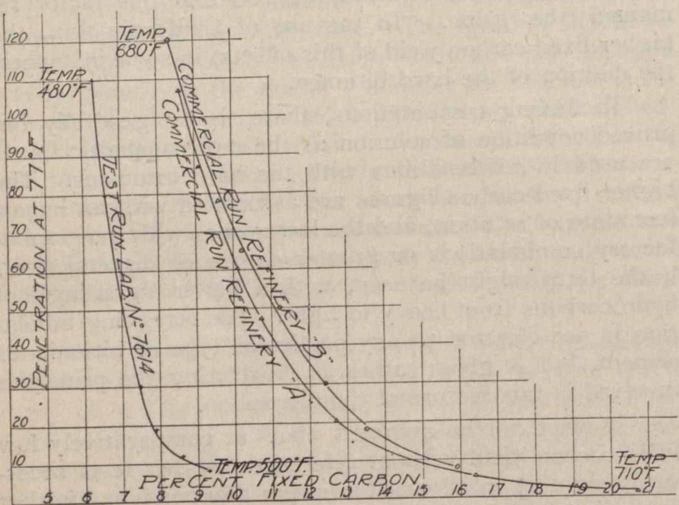


**Fig. 1.**

been previously stated, the formation of this class of materials involves the production of more condensed products than the liquid bitumen from which they are made. In the distillation of liquid bitumens for asphalt, it is recognized that it is desirable to avoid cracking or the splitting off of hydrocarbon so far as possible, in order that the residual may retain its binding strength and permanency to the greatest possible useful extent.

The splitting off of hydrocarbon may take place to a comparatively slight degree, or it may go so far as to evidence itself in the production of "carbenes" or even of insoluble hydrocarbon and free carbon. For a bitumen of a given character, the splitting off of hydrocarbon with subsequent condensation evidences itself by greater fixed carbon yield. It follows, therefore, that the yield of fixed carbon in solid bitumens produced by distillation, becomes an index of the extent to which the splitting off reaction takes place as compared with a simple concentrating of condensed hydrocarbons already present in the crude bitumen. Fixed carbon thereby affords an index of the severity of heat treatment, ranging from evidences of lesser degree to the accompaniment by carbenes or insoluble hydrocarbon or free carbon.

Where solid bitumens are produced by condensation of residum with air, without distillation taking place, a normal fixed carbon content will result from such condensation, greater, of course, than that of the residuum. If, however, the residuum be cracked or partially decomposed in preparation, and abnormally higher fixed carbon will result; likewise if the air treatment be so conducted as to result in distillation by splitting up of hydrocarbon, the product will show higher yield of fixed carbon.

In order to illustrate the effect of heat treatment in the distillation of native liquid bitumen, the writer has prepared data giving the range of fixed carbon figures upon samples taken at various intervals from a still during a commercial run of residual asphalt under known temperature conditions. A lot of the same crude as used in this run was subjected to careful distillation in a laboratory still under conditions, including lower temperature, which minimized, if not entirely avoided, all splitting up or cracking action.

The results are given here in graphical form in Fig. 1, wherein the commercial run referred to is designated refinery "A." The results obtained upon a series of commercial samples from refinery "B" are likewise given, although no data was obtainable in connection with these samples as to temperature conditions during their preparation.

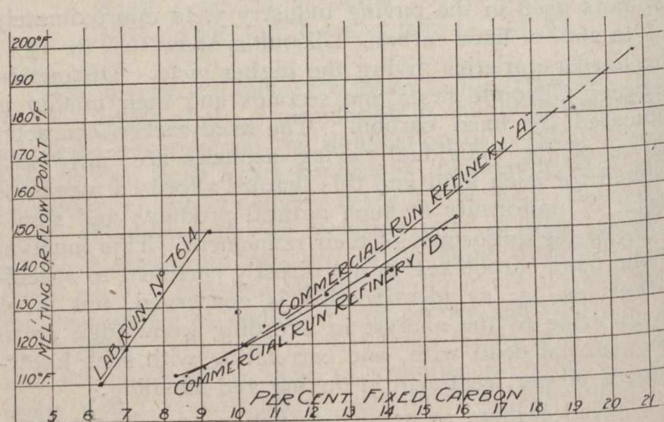


**Fig. 2.**

Fig. 1 gives the relationship between consistency and fixed carbon. A sharp turn in the curves is noted at the harder consistencies, which might be construed as representing conditions of greater severity. This, however, is not strictly the case but is due rather to the imperfection of the penetration test which does not accurately measure relative hardness, particularly at the low penetrations.

In Fig. 2, the flow or melting point relationship with fixed carbon is given, the former representing relative hardness to a more accurate extent. It is noted that these latter curves approach a straight line, indicating nearly direct variation between these elements. It is apparent that a difference of some 200° F. in heat treatment of the bitumen results in a showing of materially different fixed carbon characteristics in the resulting products.

At the low temperatures the distillation follows closely to a true concentration of condensed hydrocarbons originally present in the crude. The difference between this and the commercial run is evidently represented by additional condensation due to the higher heat treatment in splitting off hydrocarbon.

The writer considers the fixed carbon characteristics of the commercial runs given as representing the better grades of this kind of product now available commercially upon the market. As an illustration of the effect of this action to an undesirable degree, are given a few analyses of the residual products of like asphaltic base crude, the first two of which were produced from the same crude as in the preparation of samples of series "A."

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Pen. | 42 | 46 | 80 | 41 | 26 | 22 | 46 | 32 |
| Fxd. C | 14.7% | 14.3% | 16.8% | 16.9% | 16.6% | 20.0% | 17.0% | 18.6% |
| Sol $CS_2$ | 99.8% | 99.3% | 99.7% | 99.7% | 99.7% | 97.2% | 99.0% | 98.0% |
| Sol $CCl_4$ | 98.8% | 96.5% | 96.0% | 97.9% | 96.9% | 86.6% | 94.4% | 90.9% |
| Ductility | 115+cm | 110+cm | 110+cm | 60.0cm | 55.0cm | 18.0cm | 7.0cm | 4.5cm |

Of the above cements, the third has a history of service test. It was laid in a sheet pavement in 1910 on a residence street. The pavement marked well in 1910 and passed through the winter with one crack. The following summer it was harder but still marked. It cracked usually severely in the winter of 1911. In the summer of 1912 it was very hard in the hottest weather but showed freely the calk marks of previous traffic, the pavement being too stiff to iron out. The general appearance indicated very rapid hardening of the cement.

Inspection of these results shows the effect of condensation in various degrees to the final stages where the material has retained but little binding value and is characterized by little ductility, by the presence of considerable amounts of carbenes and by insoluble carbonaceous matter. It will be of interest to locate the fixed carbon points of these samples in comparison with the curves given for the acceptable grades of the commercial article.

Attention may be called at this point to the fact that some crude oils normally give rise to asphaltic residues of much higher fixed carbon yield than the materials used in the foregoing illustration. This is possibly due to an originally large content of highly condensed hydrocarbons, and to the nature of the particular hydrocarbons present. In such cases a relatively high fixed carbon content in the residual product is not necessarily related to the severity of heat treatment and in dealing with such residuals, specifications and proper interpretation of fixed carbon characteristics must be based upon data obtained by careful run of the crude under known conditions.

The effect of the character of crude upon the fixed carbon yield of product prepared therefrom, is illustrated upon two samples treated by test runs as previously illustrated.

| | Gravity. | Crude Fixed Carbon. | Fixed Carbon in Distillation. | Fixed Carbon in Product | Yield Product. |
|---|---|---|---|---|---|
| Crude A | 12.5°Be | 3.7% | .02% | 6.3% | 60% |
| Crude M | 18.0°Be | 7.5% | ... | 15.8% | 50% |

It will be noted that by careful distillation the formation of condensation products is small and that the value of 15.8% of fixed carbon obtained in the residual of crude "M" is quite normal for this, although it would not be so for crude "A."

It will be seen that the determination of fixed carbon in asphalts produced by distillation, affords an important means of control of the quality, uniformity and care used in preparation of the product. The excess of fixed carbon yield above that normally resulting by concentration from the condensed hydrocarbons present in the crude, is a measure of condensation produced by the effects of the heat treatment in splitting off of hydrocarbon.

It is apparent that the best practice should limit this action to the minimum and that specifications should control this by a fixed carbon limit within which the product will retain to a useful and permanent extent, the qualities necessary for pavement and road construction.

It must be understood that the fixed carbon test, like others employed in the examination of bitumens, must be interpreted and applied in specifications upon the basis of a broad understanding of the relationship between the various chemical and physical characteristics of paving bitumens and their origin and methods of preparation for the market.

## OIL AND GAS IN WESTERN ALBERTA.

The Geological Survey has received a sample of the oil recently struck by the Calgary Petroleum Products Company at a well situated at Black Diamond, sixteen miles west of Okotoks, Alta. This oil was struck at a depth of about 1,560 feet. It is what is technically known as a "white oil," being transparent and of an amber color. It is phenomenally light for a natural mineral oil, having a specific gravity of about 62 Baume. Evidently it consists largely of gasoline. In fact it has been successfully used in its raw state in place of gasoline in an automobile.

White oils are rarely found in quantity. They would appear to be the result of filtration through clay strata, under pressure, of the lighter portions of ordinary petroleum. That this has occurred in the present instance is made probable by the fact that at a higher horizon in this well a flow of gas of 2,000,000 feet a day, was struck. This gas is also peculiar in the large amount of gasoline it contains. It probably represents a further stage in the process of filtration.

The amount of oil present has not yet been determined, so that the commercial value of the strike is still unproved. If the amount of gas encountered in the higher level is any criterion, this may prove to be the exceptional case and a considerable quantity of oil, for a white oil, be obtained.

Whether oil is present in large quantities or not, the strike is of importance, as the white oils are usually found only in the vicinity of large bodies of the ordinary petroleum. Thus it is an excellent indicator.

Mr. D. B. Dowling, of the Geological Survey, who visited the well shortly before the strike was made, reports that the well is located on an anticline, in shales of the Pierre formation, and that the oil was encountered in underlying Belly River beds. On either side of the anticline overlying Edmonton beds are exposed. Going eastward, therefore, the covering will rapidly thicken. Westward toward Moose Mountain, according to the work of D. D. Cairnes, of the Survey, the formations are folded into a number of anticlines, bringing lower formations to the surface, and in Moose Mountain faults are encountered. Between this faulted ground and the well are several anticlines where prospecting for oil might be undertaken. These anticlines probably run in the direction of the main structural lines, that is, roughly parallel to the mountain ranges. Mr. D. B. Dowling, of the Geological Survey, is now in the field, having been commissioned by the Director to examine the well and make a study of the geology of the district.

It is not often that a complete electric light station sails away after having done good service to a town. Such an unusual happening is reported from the Township of Ocos, in Guatemala, which, having enjoyed the benefits of electric lighting, has unwillingly reverted to oil lamps, its powerhouse having gone to sea. Four years ago a liner was imprisoned in the lagoon without suffering any damage. An enterprising engineer thereupon used the ship's dynamos for supplying the whole township with current for lighting. The scheme was a great success until a salvage company appeared. The connecting cables were severed, the vessel went back to sea, and Ocos was temporarily left in darkness.

## OVER-OXIDATION OF STEEL.

Messrs. W. R. Shimer and F. O. Kichline, in a paper read before the New York meeting of the American Institute of Mining Engineers, describe some investigations carried out for the purpose of studying, both by chemical and metallographical means, the extent of over-oxidation of steel that can be accomplished by excessive over-blowing in a Bessemer converter. In addition they give some results of basic open-hearth and crucible steels.

The experiments were carried on in a Bessemer converter blowing steel for the duplex process. The hot metal used, with one exception, had the following composition:—*C*, 3.50 per cent.; *Mn*, 0.70 per cent.; *P*, 0.450 per cent.; *S*, 0.050 per cent.; *Si*, 1.20 per cent.

In the basic open-hearth heat a test sample was taken just before adding ferro-manganese. The bath had been boiled down "flat" and held for some time. The following is the analysis:—*C*, 0.05 per cent.; *Mn*, 0.05 per cent.; *P*, 0.023 per cent.; *S*, 0.055 per cent.; *O*, 0.024 per cent. It will be noted that the oxygen content of this heat is low, in spite of the fact that the heat was boiled down flat and held some time at a high temperature, thereby affording the best conditions for over-oxidation. Results on finished open-hearth steel are of interest; the drillings for these determinations were not taken from test blocks, but from the finished product.

**Rail Steel.**

| Heat No. | Oxygen. Per cent. |
|---|---|
| E—21,276 | 0.018 |
| | 0.015 |
| E—17,244 | 0.016 |
| | 0.018 |
| E—22,377 | 0.017 |
| E—17,441 | 0.019 |
| E—21,428 | 0.019 |
| E—24,202 | 0.017 |
| E—26,065 | |

**Structural Steel (about 0.19 per cent. C.)**

| Heat No. | Oxygen. Per cent. |
|---|---|
| E—14,096 | 0.024 |
| E—17,104 | 0.022 |
| E—22,068 | 0.019 |
| E—22,277 | 0.015 |
| E—24,063 | 0.014 |

Oxygen determinations were run on a few 0.60 per cent. carbon crucible steels, and showed the following oxygen contents:—

Sample No. 1.—Test dipped out of a 90-lb. crucible and cast into a small test block; oxygen, 0.014 per cent.

Sample No. 2.—Test dipped out of a 1-ton ladle; same heat as sample No. 1; oxygen, 0.014 per cent.

Sample No. 3.—Finished rolled bar; oxygen, 0.010 per cent.

Sample No. 4.—Rolled bar picked out at random from the stock rack; oxygen, 0.010 per cent.

Samples 1 and 2 were dipped out of the bath and cast into small moulds, and were, therefore, somewhat porous, which no doubt accounts for their showing slightly higher oxygen than the finished bars, which were solid.

The results obtained from converter metal may be summarized as follows. Every effort at over-oxidation was made, both by over-blowing and by ore addition:—

The highest oxygen contents obtained by over-blowing, were 0.074 (in Test 2); 0.064 per cent. (in Test 8) and 0.049 (in Test 11), notwithstanding that the samples were taken immediately, in order to get the highest oxygen possible. Also the samples were cooled quickly so that no gas could escape during casting.

While oxidizing with ore, we obtained 0.029, 0.028 and 0.033 per cent. oxygen, by taking test samples immediately after the ore began working through the metal. When time was allowed for the oxygen to escape after the ore addition, a content of 0.017 per cent. oxygen was found.

A basic open-hearth heat, under oxidizing conditions, gave only 0.024 per cent. oxygen.

It appears that either an unfinished heat or an over-ored heat will produce slag inclusions, such as manganese silicate, instead of iron oxide.

From these results, considering the manner in which they were taken, we may conclude that excessive oxygen leaves a bath of molten steel in a very short time. Also that deoxidation is readily effected by the addition of hot metal.

Under the same conditions, the higher the carbon the lower the oxygen.

Finally, it seems highly improbable that, under the usual conditions of Bessemer and open-hearth practice, with the addition of recarburizers, that a steel of over 0.030 per cent. oxygen can be obtained, and that the highest obtainable under any conditions, without recarburizing, can hardly be over 0.075 per cent. Results higher than this must be from drillings improperly taken, or from oxidation that occurred during pouring.

## NEW YORK'S NEW CANAL.

Progress on New York State Barge Canal furnished the subject for a lecture given on October 30th by State Engineer John A. Bensel before the New York State Waterways Association Convention. Mr. Bensel stated that at present more than 250 miles of the canal are completed to the dimension size, and all of the more important structures are more than 80 per cent. finished. The construction work of the past year has called for an expenditure of $13,000,000; and the total work up to date, for about $64,000,000; while the remaining contracts will have need of an additional disbursement of $82,000,000. Mr. Bensel urged particularly in his lecture that the utmost care be taken to obtain the best possible management for the terminals in New York, Brooklyn, Utica, Buffalo, Albany and all other cities. Work on these is progressing very rapidly. About 35 contracts have been let, and the Albany terminal is already in use in a commercial way.

## GERMAN IRON AND STEEL PRODUCTION.

According to the returns of the Association of German Iron and Steel Manufacturers, the total production of raw iron in Germany and Luxemburg during the first six months of 1913 amounted to 9,567,666 metric tons, as compared with 8,564,988 during the first six months of 1912. The production of foundry pig increased from 1,581,754 tons in 1912 to 1,812,434 in 1913; of Thomas iron from 5,482,432 to 6,049,330; and of steel and spiegel iron from 1,037,902 to 1,269,563. The production of Bessemer and puddle decreased as compared with 1912, the former from 193,763 to 174.483 tons and the latter from 269,137 to 261,856 tons.

# The Canadian Engineer

ESTABLISHED 1893.

ISSUED WEEKLY in the interests of
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The Canadian Engineer absorbed The Canadian Cement and Concrete Review in 1910

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**Published by the Monetary Times Printing Company of Canada, Limited, Toronto, Ontario.**

Vol. 25. TORONTO, CANADA, DEC. 4, 1913. No. 23

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## ENGINEERS AS CITIZENS.

It has frequently been suggested that more of the meetings of the various branches of different engineering societies be devoted to the discussion of civic engineering problems, not necessarily those only that are immediately concerned with an engineer's particular technical work, but problems of a more or less general engineering nature. This suggestion was recalled and strongly upheld by Mr. R. D. Mershon at a joint meeting of the Western Society of Engineers and the American Institute of Electrical Engineers in Chicago, his opinion being that individuals taking part in such discussions would be almost likely to bring to bear in public affairs the conclusions there arrived at, and the ideas that would crystallize in their own minds as a result of such discussions.

One feature of the engineer's life that should be more strongly emphasized and urged by engineering societies is this desirability of his taking a greater part than he has done heretofore, in public affairs, especially in the civic affairs of the immediate community. Practically all economical problems are engineering problems, and the engineer cannot avoid taking his own responsible share in their solution.

The engineer's excuse is that he is an exceedingly busy man, and the result is that unless he has the opportunities made fairly easy for him, he is not likely to get out and interest himself in matters respecting the city's welfare. Those who read the address of Dr. Swain, presented at the Ottawa meeting of the American Society of Civil Engineers last June, and reproduced in our issues of June 26th and July 3rd, doubtless profited a good deal by his illustrations of the personal responsibility which the engineer owes to the community. As to the engineer's capabilities in this direction, the speaker stated:

"If there is anything in training and experience, may we not believe that engineers, as a class, have the training, temper and experience, which will best enable men to judge sanely and solve wisely the social problems that confront us?" When one realizes that the problem of administering the affairs of a city involves the preservation of the health, safety, property, and order of the community, and are, therefore, dominantly of an engineering character, it appears strange that we do not find more of our engineers occupying positions of greater responsibility in the administration of civic affairs.

In some European countries the method of handling civic affairs is quite different from the method in this country. In Germany, the position of mayor is not elective. The work is regarded as a profession, and the individual is not elected, but employed. Recently there was an advertisement for a mayor in one of the German technical papers, and it specified that he should be an engineer.

The findings would be interesting if one were to study the relations between engineering interests and social conditions in general. It is stated, for example, that Illinois, one of the great agricultural states, has progressed to a point where 49 per cent. of its people get their livelihood from something connected with engineering interests. It would be interesting, therefore, to parallel with this, some measure of the attention which engineers pay to legislative and constructive action, public welfare, and social problems of that nature; and it is certain that there has not been enough of co-operation on his part in the past. Although there are no men better qualified, one is safe in stating that there are none that fall farther behind in such obligations than do the engineers.

## THE FIXED CARBON TEST.

Specifications have been issued this week by the city of Toronto for the supply of asphalt for 1914. Practically the same specifications are retained which were used for this year's supply, the clause limiting the maximum amount of fixed carbon to fifteen per cent. remaining the same as in the 1913 specifications.

In view of the differences of opinion regarding the value of the fixed carbon test, as indicated by the series of articles by various prominent chemists now appearing in *The Canadian Engineer*, thorough experiments will be made and much research work done during the coming year by the chemical and engineering staffs of Toronto, in order to determine whether the test should be retained in, or excluded from, the specifications, or retained in a modified form. It was felt by the Department of Works, however, that so little time remained for such an investigation this year, that the 1913 specifications would have to be used again for the 1914 supply, but that the experiments made during 1914 might result in considerable change in the 1915 specifications.

The objections to Mr. Kirschbraun's suggestion that were made by a prominent municipal engineer who was shown an advance proof of Mr. Kirschbraun's article, which appears in this week's issue, were that it would be impracticable to carry out the suggestions made in the article, as no city could be sure that it was securing the refinement from a certain lot of crude, even if it were able to secure a dependable analysis of that crude, nor would they know the percentage of refinement. That, of course, bears out the very argument urged by many chemists against the inclusion of the fixed carbon test in specifications, namely, that this test cannot be included in such a way that it will be both fair to the contractors tendering and also enforcible in a practicable way.

## EDITORIAL COMMENT.

The transformation wrought in the geography of the world by the construction of the Panama Canal, and the consequent changes to be expected in the world's commerce, involve preparations in the form of new harbors, new docks, and additional railways, remarkable alike in extent and in rapidity of construction. Contemplated as a whole, and when the element of time is taken into account, these undertakings constitute an engineering project of variety and magnitude unprecedented in the history of transport development.

* * * *

The Dominion Government has under consideration some new regulations to govern the development of the oil resources of Western Canada. It is reported that Mr. Cunningham Craig, of Birmingham, and Prof. Chadwick, of London, Eng., have investigated conditions as they exist, and that a draft of new regulations has been prepared and at present their applicability is being considered by the Department of the Interior. It is also stated that western men have forwarded a suggestion that the old regulations be revised so that for purposes of development claims may be grouped instead of requiring each claim to be singly developed.

A discussion on the causes of the deterioration of fire-bricks during use was recently presented by Mr. Geo. Rigg, in which the conclusion is reached that, other things being equal, the resistance to the action of corrosive slags and gases is greater the more compact and close-textured the brick is found to be. Spalling of close-textured brick is due to the use of unsuitable clay, or poor workmanship, or both. It is possible to prepare close-textured fire-brick containing considerable amounts of coarse material, provided that sufficient care be taken in sizing the grog, so that the interstices between the larger fragments shall be filled as completely as possible by smaller fragments.

## LETTERS TO THE EDITOR.

### Features of the Springfield (O.) Sewage Disposal Plant.

Sir,—Referring to the article "A Departure from Common Practice in Sewage Disposal" in your issue of October 23, 1913, we beg to call attention to the fact that the so-called "vertical circulation" is neither new nor original with Mr. Potter, as it is an essential feature of the process set forth in our Travis and Ault (Hampton Tank) patent, application for which was filed September 13, 1910. The "Adjustable weir" which he uses for the regulation of this "vertical circulation" is also embodied in another of our applications for patents and follows the lines of explanations and information given by our engineer to Mr. Potter while he was designing the Springfield plant.

We notified the mayor of Springfield on October 25, 1913, and Mr. Potter on October 27, 1913, that the tanks at Springfield were an infringement on the Cameron septic process patent and of the Travis and Ault (Hampton Tank) patent, both of which are controlled by this company, and that we should take all necessary steps to protect our rights.

We call attention to these points that engineers and municipalities may know the facts and avoid any unintentional infringement of our patent rights.

STERILIZATION COMPANY.

Newark, N.J., Nov. 8th, 1913.

* * * *

[Upon receipt of the above the attention of Mr. Potter, who submitted the article referred to, was called to it, and his reply is as follows:—Ed.]

Sir,—Answering the letter of November 8th from the Sterilization Company, of Newark, N.J., I regret that I am compelled to say that there are statements in that letter and in letters to which they refer which are at variance with the facts.

The writer first saw a representative of this company a month after the designs for Springfield were completed. These designs were completed before the middle of February, 1912. The plans were then taken to Springfield by the writer in person for submission to the city authorities. The completion of the drafting of the finished plans took two weeks longer and were forwarded to the writer (then in the southwest) on March 1, 1912. These plans were finally approved by the municipal authorities at Springfield on March 15th, and the work ordered advertised for April 4th.

On March 1st the writer received a letter under date of February 23rd from the Sterilization Company, admitting that they were informed by his office that the plans were based upon other designs than theirs, and requesting consideration of their method.

The writer returned to New York on March 19th, after an absence of a month, and the following day a representative of the Sterilization Company called. For the first time the writer conferred with this company in reference to their system and its application at Springfield. They were advised that the Springfield designs would not be altered, but in response to their request were informed that if they desired to submit an alternate bid based upon their own plans at the public letting on April 4th, such bid would be given consideration if accompanied by guarantees of efficiency.

On the 26th of March a sketch plan was submitted by the Sterilization Company, showing what they proposed to offer, and on the 29th of March a letter was received from them giving a bill of material required for their plan. They found that it was impossible for them to submit a proposition on the sewage disposal plant as a whole, but requested the submission of their tank plans to general contractors.

Discussing the merits of the contention of the Sterilization Company that the Springfield tank is an infringement upon their patents, the writer desires to point out that there is a distinct difference between the Hampton tank and the Springfield tanks. In the former, from ten to twenty per cent. of the entire sewage flow travels horizontally through the digestion chamber towards the outlet setting up a substantial disturbance throughout the digestion chamber where quiescence is more desirable. The debouchment of over ten per cent. of the flow from the digestion chamber very seriously interferes with the ultimate reduction of the sludge. In the Springfield tanks openings are placed along the pipe provided to draw off the relatively small quantity of liquid (less than two per cent.) from the digestion chamber needed to set up a downward circulation in the settling tank.

Furthermore, the discharge of from ten per cent. to twenty per cent. of the liquid from the digestion chamber in the Hampton tank will require separate treatment of the two effluents, otherwise the efficiency of subsequent treatment, if both flows re-unite, is impaired. In the Springfield tank, on the other hand, the small flow from the digestion chamber cannot seriously affect the effluent from the settling tank. In the Springfield tank there is absolutely no horizontal flow towards the outlet end of the tank.

From a structural standpoint, the Springfield tank as built is more effective than other types, in that while the time of retention in the settling tank is the same as in other tanks, the velocity of flow in the tanks is from half to two-thirds less, a condition tending to produce a greater deposition of solids.

It is to be hoped that this discussion will eventually lead to some definite conclusion as to this much-mooted question of sewage disposal patent infringement. It should be noted that this company alleges infringement of the Cameron septic tank patents controlled by them. According to the Winchester, Ky., case, the admission of the use of a two-story tank is considered by the Sterilization Company as *prima facie* evidence of an infringement of patents now controlled by them. The payment to Dr. Imhoff of his license fee where his tank is used, does not give immunity from suit by the Sterilization Company as owners of the Cameron process.

In view of the charge of the Sterilization Company that the Springfield tanks are an infringement of the Cameron patent, the following editorial comment from the "Engineering News," Feb. 6th, 1913, is of interest:—

"In its decision of Jan. 20, 1913, the U.S. Supreme Court declared in unmistakable terms that the United States patent on the Cameron septic tank expired on Nov. 8, 1909, 'with the British patent for the same invention.' To sustain any claim to the contrary, it would therefore seem to be necessary to get the Supreme Court to reverse its decision, either on a re-hearing of this case or by carrying some other case to the U.S. Supreme Court."

Yours truly,

ALEXANDER POTTER.

New York, Nov. 18th, 1913.

## THE EFFECT OF DRILLED HOLES ON STRENGTH OF STRUCTURAL STEEL.*

A series of experiments to determine the effect on the elastic limit and tensile strength of structural steel of drilling and punching holes is described by C. Birault, chief of the department of testing materials of l'Ecole Centrale, Paris. In the first series of experiments, three bars were cut from one piece of steel. One was ruptured in its original condition; the second after perforation with two holes by drilling, and the third, after perforation with two holes by punching. The holes in each case were 15 mm. diameter, spaced three diameters centre to centre. The plain bar elongated much further than the other two, while the bar with drilled holes elongated more than that with punched holes. The fracture of the punched bar did not take place along the diameter of the holes, due probably to fissures caused by the action of the punch. The drilled holes broke at their central diameters.

The following is an average of the results of three sets of tests:—

Plain bar, elastic limit, 24.5 kg.; tensile strength, 40.06 kg.; drilled bar, elastic limit, 30.03 kg.; tensile strength, 45.4 gk.; punched bar, elastic limit, 33.3 kg.; tensile strength, 37.3 kg.

In each case, the elastic limit was higher in the perforated bars than in the plain bars, with the increase in favor of the punched holes over drilled holes, while the reverse is true as regards tensile strength. The bars with drilled holes have 12.3 per cent. greater average elastic limit and 9.2 per cent. greater average strength than plain bars of the same steel. In the case of punched bars, the elastic limit increased 13.5 per cent. and the tensile strength 8 per cent. compared with plain bars of the same steel.

In the second series of tests, bars were perforated with driled holes of various diameters to determine the effect on the physical properties of the steel compared with plain bars of the same steel. Holes 11, 8 and 6 mm. diameter, were drilled and tested as a comparison against the plain steel. The following elastic limits were shown:

Plain bar, 28.9 kg.; 11 mm. holes, 32.3 kg.; 8 mm. holes, 32.0 kg.; 6 mm. holes, 33.7 kg.

The tensile strength of the various bars tested was as follows: Plain bar, 45.2 kg.; 11 mm. holes, 50.4 kg.; 8 mm. holes, 48.7 kg.; 6 mm. holes, 53.0 kg.

As to why there are such increases in the physical properties of bars with drilled holes over plain bars, the

*Abstracted from Le Genie Civil, July 19, 1913.

author states that in bringing into contact the fractured ends of the plain bars, it is found that there is a hollow space near the centre where the metal has evidently drawn away first, the break then proceeding gradually to the two sides. If, however, the metal is perforated with holes that are smooth, as in drilled holes, and not having fissures as in punched ones, this tendency of the metal to separate is removed, and the mean resistance to rupture is more uniform.

The author claims to have established the fact that the resistance to rupture of solid bars and perforated bars of the same metal is not proportional to the sections of the bars, proper allowance being made for the perforations. Section for section the advantage is in favor of the perforated bars, if the holes have been drilled and not punched. The holes weaken the steel much less than would be expected, provided care is taken to drill the holes, or to ream them after they have been punched.

## THE TIMISKAMING DAM OF THE OTTAWA RIVER STORAGE SYSTEM.

By J. A. MacDonald, Ottawa, Ont.

In the Aug. 7th, 1913, issue of *The Canadian Engineer* an article entitled "The Ottawa River Storage System" outlined the objects of the extensive conservation works which are being built by the Department of Public Works, Canada, in the Upper Ottawa Basin. The reader's attention is directed to that article for general information respecting this development, and for the illustrations, several of which refer to the following description of the design and construction of one of the units of the system, viz., the dam at the outlet of Timiskaming Lake.

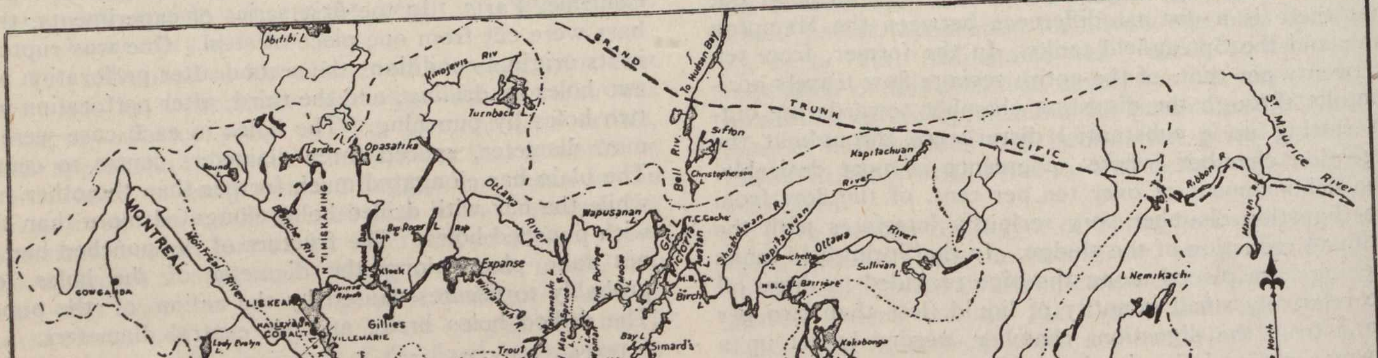



Fig. 1.

At Mattawa, 300 miles above Montreal, which is the discharge point of the Timiskaming basin, including part of Timagami and Kipawa Lake basins (see Fig. 1), the yearly mean flow is 25,000 cubic feet per second from an area of 30,300 square mile feet. The Timiskaming basin, including everything from the source of the Quinze down to Mattawa, has an area of 20,000 square miles.

The Timiskaming storage dam, which is situated at the foot of Timiskaming Lake, was designed for the purpose of emptying the lake to its lowest level before floods and then filling it to the highest attainable stage for winter consumption. The lake itself stretches from Timiskaming Station to New Liskeard, Ont., and Murray, Que., a distance of 60 miles. It is navigable by steamboat and, in fact, until the Timiskaming and Northern Ontario Railway was built, afforded the only transport up to Ville-Marie and to the clay belt of Northern Ontario.

The immediate drainage is very limited as the shores are high and steep, but this lake receives all the drainage of the Kipawa, Quinze, Expanse, Blanche, and Montreal systems, a total area of 18,000 square miles down to Timiskaming Station. The lake is narrow, practically a river for 12 miles up to Opimaka Narrows, then about a mile in width for 30 miles further up to Silver Centre, where it becomes wider until a maximum width is attained at the head of the lake between Haileybury and Murray.

**Outlet of Timiskaming.**—While there are many inlets to this lake, the only outlet is at its south end, where, through the Long Sault Rapids, the waters fall 59 feet in six miles into Seven League Lake, and thence by three other rapids, descends 30 feet more to Mattawa. The discharge averages 110,000 c.f.s. during May, but it shrinks to about 10,000 at low stages during winter time.

18-in. and 15 by 15-in. stop-logs. These sluiceways are illustrated in Figs. 2, 3 and 4. The still platform is at elevation 570 or 19 feet below standard level of reservoir. It would have been preferable to have had the sill 5 feet lower, but the excavation necessary to cut down the approach channel would have doubled the cost.

Between the island and Ontario shore, the width was about 400 feet, so the design was made for 16 sluiceways each 20 feet wide with a pier 5 feet wide between. These are illustrated in Fig. 3, of the article to which reference has already been made. The piers have recesses to hold a movable curtain wall formed by horizontal timbers, 18 inches square, that can be hoisted out one by one. This is a removable dam and during spring floods all the timbers will be lifted out, leaving a larger exit than under natural conditions, because the Ontario channel has been

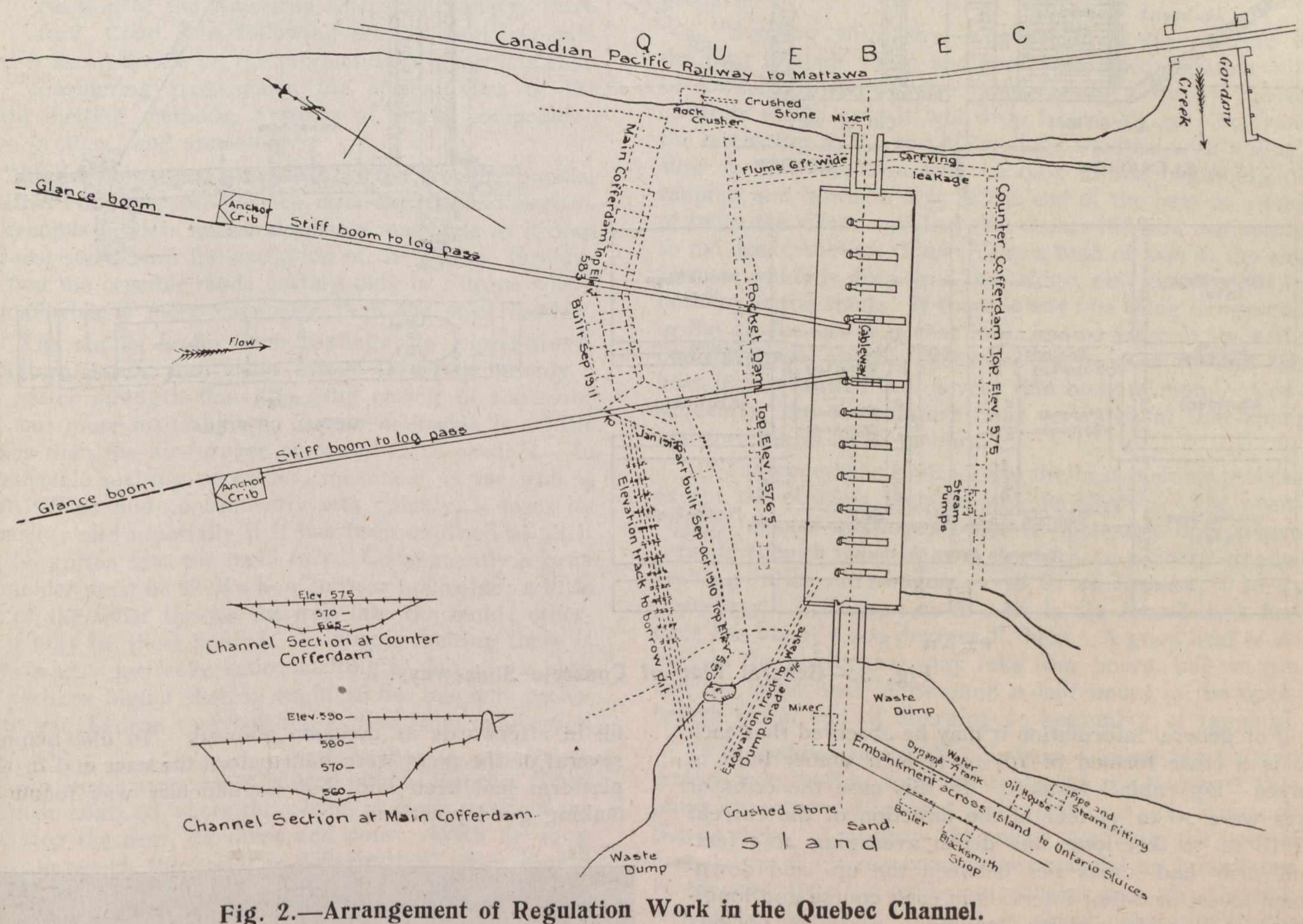



**Fig. 2.—Arrangement of Regulation Work in the Quebec Channel.**

The holding of Lake Timiskaming at a maintained surface level of 588, which was considered to be the best level to prevent damage by flooding, gives a storage depth of 20 feet. The sluiceways will thus drain down the lake to that amount between and augment the low water flow, for at least 150 days, by about 4,000 c.f.s.

**Design of Sluiceways.**—For the Quebec channel the design for a boulder foundation consisted of a monolithic slab of concrete 3 feet thick, extending from 22 to 26 feet up-stream to 12 feet down-stream, to be built across the river with a cut-off wall of varying depth along the up-stream and down-stream edges. The upper cut-off has been built 10 feet and that down-stream 5 feet in depth.

Upon this platform rest 11 piers 20 feet apart and two U-shaped abutments 48½ by 25½ feet with 5 foot walls. The sluiceways are arranged to be closed by 18 by

deepened. To draw off the lower layer of storage during March, however, deeper sluice openings are required, and so advantage of the depth in the Quebec Channel was taken to place those sills at elevation 565, or 5 feet lower.

The minimum discharge through the Timiskaming sluices should be about 20,000 c.f.s. and lake surface must be at 573.95 elevation to discharge the total amount.

As designed, the lake surface can only be drawn down to elevation 573.95, instead of elevation 573.05, so a layer 0.9 feet thick is rendered unavoidable. However, lowering the Ontario Channel would double the cost, and such an outlay was not warranted.

**The Foundation.**—The foundation of the sluices is shown in the accompanying Fig. 3. It consists of a concrete platform 3 feet thick, strong enough to support a pier. To prevent a scour, a cut-off was made 10 feet deep across the upper face, and another 10 feet deep along the lower side. In addition a concrete apron, 25 ft. wide protects the bottom from scouring under the driving water at entry, and a 50-foot apron below prevents wearing away of material by the rapidly flowing water.

For the cofferdam, soundings were taken to determine the shape of the river bottom upon which the cribs were to rest and the bottom of each crib was built to fit its particular place. This was a difficult matter, as over the whole area there were nests of large glacial boulders 8 and 10 feet in diameter, and closely packed in a layer of gravel averaging 3 feet in depth above river sand.

The foundation generally was a mass of boulders, as stated, embedded in compact sand, but 25% of the area toward the island side was sand with only occasional boulders. This was saturated with water which seeped through over practically its entire surface and the sand readily drifted off in the current when disturbed. To cover this with a concrete slab was difficult as scouring constantly took place along the edges. It was found after trial that it was impracticable to drive sheet piling owing to the stones that were encountered.

Owing to the slow rate of excavation it proved best to first lay the foundation slab in unconnected pieces and

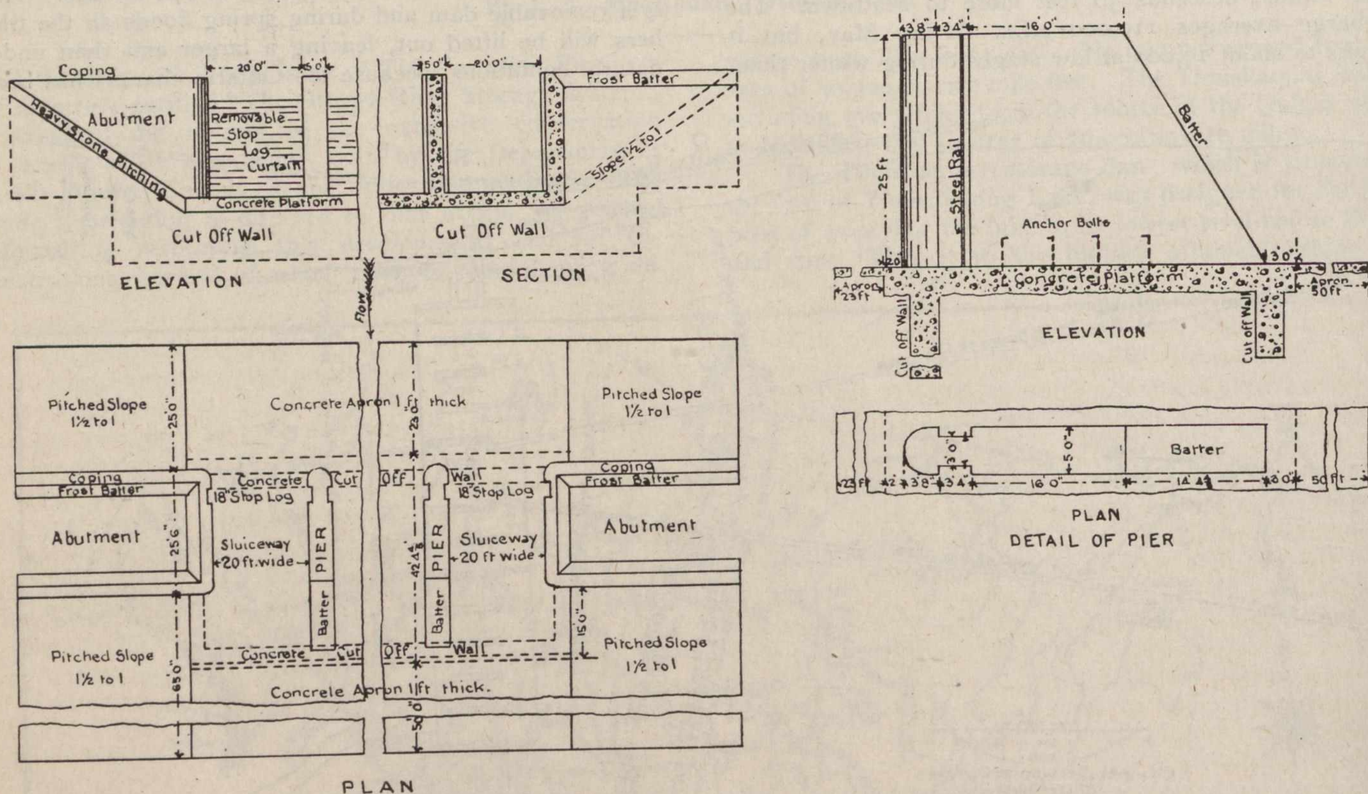



**Fig. 3.—General Plan of Concrete Sluiceways.**

For general information it may be observed that each crib is a crate formed of 10- to 12-inch timber built in courses "log cabin" fashion. In this case the cribs or boxes were 20 to 35 feet in the direction of the current and 18 to 30 feet long, the depth averaging 20.5 feet. Each crib had cross ties between the up- and downstream faces, at 6-foot intervals in each course and longitudinal to provide rigidity, leaving a series of pockets into which the stone filling was loaded.

To set the individual cribs in place, in a rushing current 20 feet deep, was a difficult matter, and for this purpose an anchor crib was built and sunk above the line of cofferdam. Each crib was built on shore to a height of about 12 feet, then launched, attached to the anchor crib with a 1¼-inch wire cable, and gradually lowered downstream to the line of cofferdam. By side lines of wire cable leading to the island and the Quebec shore, the crib was brought to its place. As the channel was narrowed by placing cribs in this fashion, the velocity of the current increased. This condition was provided for by a heavy wire rope tackle attached to the end of the 1¼-inch cable and passed around the drum of the alligator's winding engine. The power thus secured was ample, the alligator being well anchored, and cribs could be set within an inch of their proper line.

fill in afterwards as occasion allowed. In like manner several of the piers were built before the east end of the platform had been laid, but no difficulty was found in making good junctions.

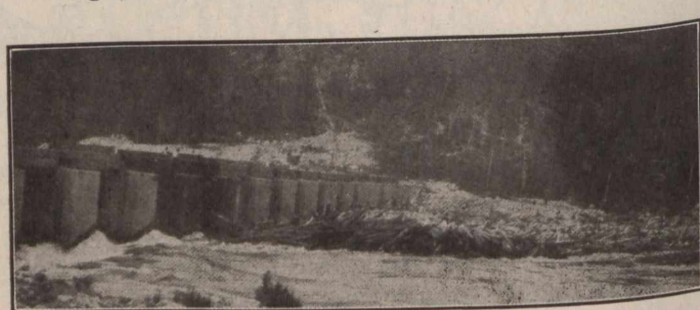


**Fig. 4.—Ontario Sluiceways, Timiskaming Dam, Showing Swiftly Flowing Approach Current.**

At first the whole structure, abutments and piers were built only to elevation 583, or 10 ft. below final height. This was high enough to withstand flood water and in case of an early rise it was thought best to bring everything to a safe height. Time, however, allowed the finishing of the whole structure to full height by the end of April. Since then the bridge across the sluices has been completed and the work is now being put into a neat and finished condition.

Work on this dam began in the spring of 1909, and was continued by the Canadian Government until its completion this year. The construction of the dam was under the direction of Mr. C. R. Coutlee, engineer-in-charge, and he directly under Mr. A. St. Laurent, Assistant Deputy Minister of Public Works. The above information is largely from a recently issued report to the Minister of Public Works.

## PRODUCTION OF MALLEABLE CASTINGS.

MR. RICHARD MOLDENKE has extracted from an address given before the Connecticut Valley Section of the American Chemical Society, Hartford, Conn., the following section, and has published it as an article on the production of malleable castings, considering particularly the special uses of the several melting methods, systems of work, composition of the product, and annealing.

"Malleable making processes are the crucible, cupola, Bessemer converter, air-furnace, open-hearth, and electric. The crucible process makes the finest malleable as it does the finest steel, with the exception of the electric furnace. You find the crucible made casting only in Europe where the malleable is more expensive than the steel casting.

"The cupola is for such castings as pipe-fittings, agricultural work, and those things that require only a little better strength than the gray casing of the same kind, but more malleability. Cupola malleable is a little cheaper than the air-furnace or open-hearth product. In all malleable melting processes, inasmuch as the iron is low in silicon and consequently sets quickly, it loses its life easily; and especially if it has been oxidized at all it must be gotten into the mold fast. Consequently a gray iron molder must be shown how to pour malleable; a little twist of the wrist throws the iron into the mold; otherwise it may be short poured. In cupola melting there is always a very low coke ratio; melting is done on a high bed; perhaps higher than it ought to be, but it is necessary to get the iron very hot and as free from oxidization as possible.

"The Bessemer process is used only in Europe. They blow their heats to where the silicon is down to the right point, stop the heat, dioxidize and pour. With the long anneal, in which the metal is decarbonized, they should make serviceable castings.

"The air-furnace is principally used for "malleable" in this country. Malleable air-furnaces are constructed differently than are air-furnaces for gray iron work. For gray iron they have large cross-sections and are comparatively short. For malleable very long furnaces are used, a long flame being desired. The heat to melt, whether in air-furnace or open-hearth, does not come from the direct action of the flame so much as it does from the radiation of the interior brickwork. The idea in the air-furnace and in the open-hearth furnace is to get the brickwork lining so hot that the radiation downward upon the charge does the actual melting, and does it fast. I have seen a pound of coal used for melting every pound of iron, whereas it ought to be about four pounds of iron to the pound of coal when you run three heats in one day and average them all up. The first heat with the colder furnace is a little harder on the coal supply than the others.

"Not unusually you will find that you can look through the brickwork into the interior, there being plenty of spaces where cold air is drawn in. The radiation of the lining does the business and every square inch of the interior of the furnace should do its work.

"I have seen men throw coal all over the bed of fire and then take the slicebar and poke it up, whereas the right way to do is to pile the coal at the door, shut the door, allow this coal to coke slightly, and then carefully push it over the entire area. Then repeat the operation, and repeat periodically instead of having the fireman using his shovel and bar all the time.

"If we get more than 25 per cent. excess free air in the malleable furnace we begin to get trouble. If that 25 per cent. in excess can be allowed uniformly, we get that magnificent incandescence which does the melting properly.

"Starting with, say, 0.95 silicon in the mixture if the heat is made sharp and short this silicon content will be lowered to the 0.65 required for the ordinary run of castings nicely, and it will drop from 0.65 to 0.60 from the beginning to the end of tapping, whereas with a long, slow melting the iron may be 0.65 at the beginning of tapping and down to 0.55 at the end of the heat or a loss of twice the silicon. When this occurs the iron has begun to oxidize. Another thing: Take a bath of iron in the air-furnace which is deep near the bridge, and feathers out to nothing at the stack. If there is any one thing dangerous in the air-furnace it is that thin, feather edge at the end; because there all the gases are swept over it, and the heat is transmitted into a very thin body of metal. Consequently, the temperature rises very fast at that spot; and the iron is liable to burn.

"The open-hearth furnace is the best melting process except the obsolete crucible and the electric. The open-hearth furnace melting process is applicable only where there is enough work to keep the furnace running steady. Melting ratios are: cupola, 1 to 8; air-furnace, 1 to 4; open-hearth furnace, 1 to 6. Air in the open-hearth furnace has about 1,000 degrees F. heat. A good heat of 10 tons in the air-furnace may take four hours, but we can run the same heat in two and a half hours in the open-hearth (from end of charging to beginning of tapping).

"In making malleable you have a great big bath of molten iron, hot on top, and cooler on the bottom. Test plugs show crystalline and white fractures; the composition is right. You draw the colder iron from the bottom first. Top of charge comes down maybe an hour later. In the meantime the oxidizing reaction goes on; the slag has been taken off; there is a direct contact with the gases, the metal is damaged. It should really be taken from the top first. The ideal method of getting iron out of an air-furnace is to take it from the top. The tilting furnace gives this result. I patented a three-spout arrangement for my furnaces, thus taking off six or seven tons from the top; then the next six or seven tons below; then break the breast out and get the rest of it from the bottom. In my open-hearth practice I never skim, but let the slag cover the iron.

"The composition of a malleable casting, so far as the silicon is concerned, depends on its thickness entirely. In ordinary work the silicon should be about 0.65. For very heavy work I used to turn my silicon down to 0.45. In the old days of charcoal iron my regular silicon was 0.35 (charcoal iron could be used as low in silicon as 0.10). With coke irons it is not wise to have pig iron with less than 0.75 silicon in stock. In making cold-blast charcoal iron you have a very small furnace to begin with; charcoal which eagerly absorbs oxygen as a fuel and hence the iron sponge formed melts with the least chance of oxidation. With the hot and more powerful blast, there is a little further penetration of free oxygen; with the consequent greater oxidation of the iron sponge as it melts, and hence a weaker iron. With coke fuel there is a very serious entrance of free oxygen. Coke does not unite with the oxygen in burning as fast as in the case with the charcoal. The difference between charcoal and coke irons lies only in this oxidation question.

"In annealing, the idea is to get the castings up to the annealing heat quick, hold them at annealing heat for a given time—60 hours is best—then to let them cool gradually. Pack the castings in oxide of iron. We use puddle scale, a silicate and oxide of iron, the flakes from the pots. They are almost pure iron oxide. In some railroad work, as tie-plates, these can be put loose in the oven, practically make a retort of it and use no packing whatever. The castings look rough but are good enough for the purpose.

"As to temperature of the anneal—the old-fashioned way of looking at the cracks in the brickwork to see the white line is very good if the eye of a man does not change. I prefer the LeChatelier pyrometer. Temperature at the coldest point of the coldest pot should be 1,350 degrees F.; it may go as low as 1,250 or it may be as high as 1,400. For cupola iron, the temperature must be about 200 degrees higher, because the iron was melted in contact with the fuel, and has a higher sulphur content, which obstructs the annealing changes at lower temperatures."

## NEW POWER STATION AT KAMLOOPS.

The opening of the Kamloops, B.C., power station took place on October 28th. This station will be a component part of the extensive hydro-electric system, the total cost of which will amount to about half a million dollars, and which will give Kamloops all the additional power needed for many years. Work is now well under way at the Barriere River, 40 miles north of the city, where if necessary some 10,000 h.p. is capable of development. Some 2,000 h.p. is now being arranged for. This, along with present power, will run all the municipal industries and many more which may be established here in the future. The new power station is a reinforced concrete building, 80 by 90 feet in size.

The largest railway station in Europe, estimated to cost $35,000,000, is now under construction at Leipzig.

The Chino-French Bank has signed a contract for a loan to the Chinese Government of $30.000,000. Of this sum $12,000,000 is intended for the construction of the port of Pu-Kow, in the Province of Kiang-Su, and $12,000,000 for the building of a bridge between Hankow and Wu-Chang, over the Yank Tse River. The remainder, $6,000,000, goes to the Chinese Minister of Finance.

The new Gladstone Dock at Liverpool is 1,020 feet long, 120 feet wide, at the entrance, and carries a depth of water over the sills of 46 feet at high water of ordinary spring tides. This dock is the first instalment of a scheme involving the expenditure of $16,000,000. The proposed work includes also an entrance lock over 870 feet in length and 130 feet in width, and in the inside dock area there is to be a half-tide dock of 14¾ acres, two branch docks, each 400 feet wide, with a pier between them over 1,300 feet in length.

## AUTOMATIC RAILWAYS.

**By Reginald Trautschold, M.E.,**
Consulting Engineer. New York City.

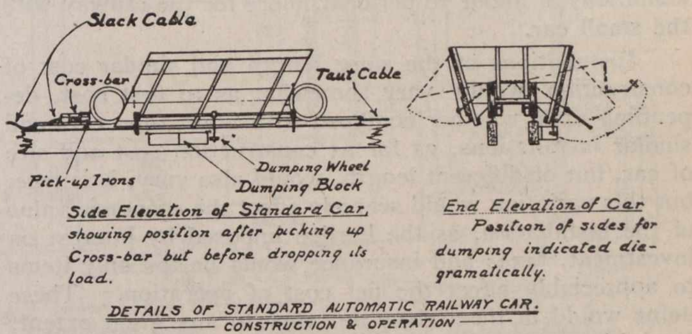
THE material-handling apparatus so far considered in these articles have all called for a supply of power from some outside source for performing their operations of conveying or elevating, or both, and their respective true economic value is largely a question of economy in consumption of power. In fact, their economic value might almost be said to depend upon their mechanical efficiency, the proportion of the total amount of power supplied converted into useful work—work actually performed; total energy supplied. There is one variety of equipment of the intermittent type for conveying, however, that performs such operation without necessitating the supply of any power and would thus appear to have an incalculable economic value. This is not quite true, for this peculiarly efficient system requires the performing of considerable preliminary work, the net mechanical efficiency of the material-handling system then necessitating the consideration of all work done, the preliminary work as well as the work that required no supply of power. However, the "automatic railway," the system referred to, is of particular interest and of very high economic value in many undertakings.

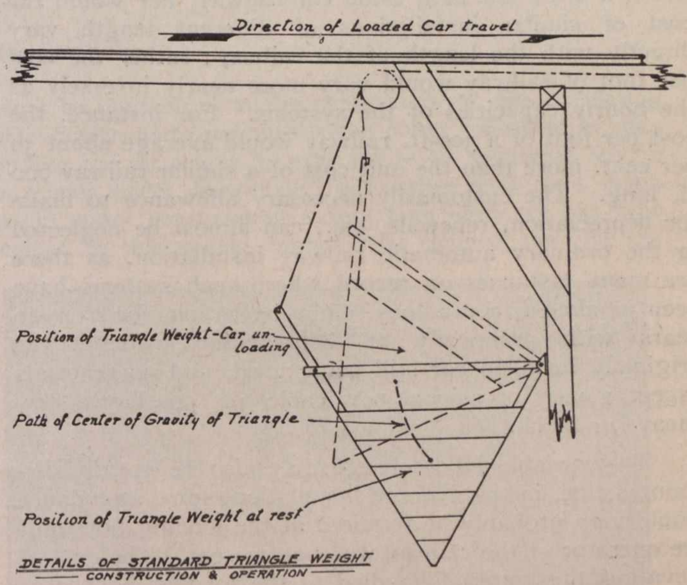
The automatic railway is based on the principle that the momentum of a body descending an inclined plane, like a falling body, is dependent upon the velocity at which it travels and the weight of the descending body and that if the energy required for bringing such a moving body to rest should be applied to another lighter body, or the same body after it has been lightened, it would cause the second body to rise until the energy consumed by such operation equalled that required to bring the first heavier body to a state of rest. Theoretically, the horizontal distance over which such automatic operation could be performed would be unlimited but the necessity of limiting the maximum speed of the descending body, the practical limit to the momentum that can be overcome and partially returned to the lightened body, etc., places a limitation of 600 feet for the operation of an automatic railway. Practical application of the principle calls for a car of special design for the conveyence of the load; a weight, attached to a cable, for operating the system; and a cross-bar, also attached to the cable, which is picked up by the descending car, as it approaches its discharging point, gradually raising the weight until the car stops—the car automatically dropping its load between the time that the loaded car picks up the cable and the time when the raised weight overcomes the momentum of the moving car. The weight, falling from its elevated position, then pushes the lightened car back along the track towards the loading point with sufficient force to return it to the starting point, there to be reloaded and the cycle repeated.

Ordinarily the inclination of the track for such operation is that which causes the car to attain a mean speed of 600 or 750 ft. per minute between loading and discharge points. Such speed is, of course, subject to considerable variation, as on a short railway the inclination of the track necessary for attaining such a mean speed would be excessive and in runs approaching 600 ft. in length, the mean speed attained by the car is frequently greater than 750 ft. per minute. The weight for arresting the travel of the car and to give the requisite shove to the returning car should advisably perform the first operation gradually—that is, the resistance to the further forward travel of the car should advisably commence at a minimum and increase gradually to a maximum as the travel of the car grows slower—otherwise the shock of the car at its maximum speed with the cross-bar, which transmits the shock to the operating weight through the medium of the cable, would be too great for most satisfactory operation. The second operation, that of giving the emptied car sufficient shove to send it back to the loading point, requires application of power in somewhat different order. First, sufficient force should be applied to start the car quickly on its return journey and to enable the car to pick up its maximum return speed as rapidly as possible, after which sufficient force to overcome the resistance to the return travel of the car is all that is required, though it is advantageous to have force acting against the car—in the direction of its return travel—for as long as is feasible. The requirements for both these operations are closely attained by a weight so attached to a rigid support on one side and the operating cable on the other that, when not in use, the weight lies between and is balanced by the tension in the idle operating cable on one side and the rigid support on the other. The cable, picked up by a descending car, raises the weight which, on account of its pivoted attachment to the rigid support, swings about the arc of a circle, causing the pull on the weight to become gradually less effective as far as lifting power is concerned and thus gradually increasing the effective pull of the weight on the cable while, at the same time, the momentum of the descending car is greatly reduced by the discharge of the car load. On the descent of the weight to its position of rest, the pull of the weight on the cable is at a maximum at once and maintains powerful until the car picks up its speed, the speed of both car and cable increasing during this time from zero to that of top speed of returning car. Further descent of the weight tends to cause its fall to grow more rapid and the pull-in of the cable to become more rapid still, the effective pull of the weight on the cable meanwhile becoming less. The empty car having attained its maximum speed, then retards the acceleration of the pull-in of the cable thereby reducing somewhat the shock of impact of the weight on coming to rest—the shock in the cable caused by the completion of the fall of the weight. Any stretch in the operating cable is likewise neutralized, the only rigid connection of the cable being at the far end of the track so that a lengthened cable simply means a little further fall of the weight.

The car generally used on an automatic railway is of the double side dump type, of either one or two-ton capacity, and the automatic tripping device for actuating the release of the car sides is located at the side of the track between the point where the car picks up the "cross-bar" and the end of its travel. The "pick-up irons" for engaging and carrying forward the "cross-bar" are attached to the front of the car and the "cross-bar" is rigidly attached to the operating cable so that the forward travel of the "cross-bar" raises the operating weight until the momentum of the moving car is overcome. The "cross-bar" also gives the empty car the necessary shove for its return trip. The standard type of automatic railway car is built with a gable bottom, with sufficient pitch for rapid drop of load, so proportioned as to throw the load clear of the rails—the standard track gauge being 21 in., o to o.,—and with the car wheels clear of the body proper. This arrangement permits the construction of a low car, presenting comparatively small surface to air resistance, with a wheel base that is not unduly long—in fact, the standard automatic railway car has a wheel base sufficiently short to enable it to take a curve of 30 ft. radius. Such curved sections of track must be confined to sections near the loading end of the railway, however, discharge of load requiring straight track, the operating cable having to be straight and free beyond the cross-bar.

The capacity of an automatic railway, though necessarily rather low when compared to that of a system for continuance conveyance or of one that permits the use of the car on its return trip, compares quite favorably with car-hauls and similar systems that also usually carry their load but one way—the mean speed of car travel being high and little time wasted in loading if the car is filled directly from an overhead hopper of adequate capacity. The car is usually comparatively small so that an expert operator is required to obtain a carrying capacity of 50 tons per hour on a railway 300 ft. long with a 1-ton car or of 90 tons per hour with a 2-ton car. Under the same conditions of service, doubling the length of the railway




**Automatic Railway Details.**

would not cut the carrying capacity in two nor would the difference in capacity between similar railways with 1- and 2-ton cars be so marked, about 38 tons per hour being obtainable with the smaller car and 65 tons per hour on the long railway with a 2-ton car. Such capacities require the handling of material weighing from 50 to 60 pounds per cubic foot and efficient loading of the car from an overhead hopper of adequate capacity and free discharge.

To arrive at the net cost of operation of an automatic railway requires consideration of each individual installation as so many conditions must be known that no law can be advanced for even approximate calculations. For instance, in the case of four similar railways; two of 300 ft. and two of 600 ft. length, one 300-ft. railway equipped with a 1-ton and the other with a 2-ton car, the 600-ft. systems similarly equipped; all handling material of such weight as to carry their rated capacity on each trip and all so efficiently loaded as to be able to realize about the highest hourly capacity of each installation, the cost of labor chargeable to each ton carried would vary considerably, for but one good operator would be necessary in any case. The cost of operation per ton handled on the longer of the two systems with 1-ton cars would be but 30 per cent. more, as far as labor or attendance is concerned, than on the shorter railway, while similar comparison between the two 2-ton car systems would show a labor burden of 36 per cent. more for the longer than for the shorter system. A comparison of the two 300-ft. systems and the two 600-ft. would show an increased burden for labor per ton for the shorter installations of about 80 per cent. for the 1-ton car railway, and for the longer installations of about 70 per cent. more for the railway with the small car.

Installations of the same length and similar cost of construction would vary somewhat as to first cost, depending upon whether equipped with 1- or 2-ton cars and similar installations, as far as construction cost and size of car, but of different length, would also vary, it is true, but this variation would scarcely effect the economic value of the installation, as the burden imposed by interest on investment, taxes and insurance would be the only items to appreciably affect the net cost of operation. These items would in themselves not vary to any great extent, for initial cost of installation would not differ much between a 1-ton car or a 2-ton car railway, nor would the cost of similar installations of different length vary directly with the length of the railway; rather the cost per foot of railway would vary more nearly inversely as the hourly capacities of the systems. For instance, the cost per foot of a 300-ft. railway would average about 30 per cent. more than the unit cost of a similar railway 600 ft. long. The customarily necessary allowance to make for depreciation, renewals, etc., can almost be neglected in the ordinary automatic railway installation, as there are many instances on record where such systems have been in almost continuous daily operation for over 40 years with practically no depreciation evident, the originally installed car still being used, and no renewals except a very occasional new cable or possibly a new sheave or block.

The variable labor charge may also be greatly discounted, for, in the average installation, some attendance would very probably be required at the loading hopper if the operator of the railway was not present. The cost of elevating the material handled to the loading hopper or to the automatic railway car itself—installations occasionally being made where the car is loaded directly from the apparatus performing the preliminary work of elevating the material to be carried—is rarely more than would be required for similar operation by any other system that could be employed to handle the load to the point where the automatic railway car drops its load to bin or storage, not more than a few additional feet of elevating being required for the material to be discharged to a loading hopper of even the largest size ordinarily employed.

In operations requiring the knowledge of the exact weight of material handled, the automatic railway enables such records to be kept easily and economically, without the necessity of any delicate or complicated automatic weighing devices, etc. A platform car scale with double beam is the only accessory necessary. The operator simply records the weight of the empty car on one beam, then loads the car and balances the weight of the loaded car on the second beam, the reading on the second beam then gives directly the net weight of the load, which may be entered in a "tally book" while the car is traveling from the loading hopper to the discharge point and back. This semi-automatic weighing system accurately measures the exact amount of material that is discharged from the car, any material remaining in the car being accounted for in the next empty car reading and subtracted from the load dropped by the car on its next trip.

Possibly the greatest advantage of the automatic railway, however, is the reliance that may be placed on its continual operation. Once properly installed and adjusted, no attention at all is required other than an occasional inspection of cable, etc.—the car always automatically returns to the loading point after discharge of load, so is always ready for operation. High-grade ball or roller bearings are used for all rotating parts so lubrication is reduced to a minimum and the general high-grade of equipment that the system required for satisfactory operation minimizes the expense for incidental supplies of all kinds.

The disadvantages of the system are exceedingly few, one being its somewhat limited capacity. This, however, is no great detraction, for, requiring no supply of power for its operation, it costs practically nothing to have the system in operation for sufficient time to enable it to carry all the material that a power-consuming conveying system of greater hourly capacity could handle in considerably less time but with a charge for power, increased burden of depreciation, etc., and probably a heavier attendence charge for the shorter operative hours than that entailed in caring for the slower system. Another drawback to the automatic railway is its comparatively short operating range. This is limited to 600 ft. as the maximum, and it is doubtful whether railways shorter than 50 ft. in length would operate entirely satisfactorily owing to the comparatively short distance that the descending car would have in which to store up momentum sufficient for the operation of the system. However, this limitation does not affect many installations where the mechanical handling of materials is advisable if not necessary.

Although the automatic railway is primarily designed and adopted for the handling of material in bulk, which can be automatically dumped from a gable-bottomed car, modifications of this standard have been installed for handling materials in bags, etc. For such service, a special type of flat car is used equipped with a mechanism by which the car is held stationary on completing its forward travel, at the unloading point, the operating weight of the system being held in an elevated position at the same time. On unloading the flat car, the holding attachment is released and the operating weight of the system drops and pushes the unloaded car back to the loading point.

[Note—This article is the seventh of a series on "The Mechanical Handling of Materials," written for *The Canadian Engineer* by Mr. Trautschold.—Ed.]

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**Boston proposes to have a forty-foot channel in its harbor because there is now in commission and in prospect ships requiring that depth of water. Boston now has in its service mammoth liners drawing from 32 to 33½ feet. In July this port handled twice as many ocean passengers as Philadelphia, and four and one-half times as many as Baltimore.**

## THE ROTARY TYPE AIR PUMP.

During the past few years, there has been an increasing demand for rotary air pumps for use in connection with surface condensers in steam turbine plants. Such a system seems to have several advantages, chief among which is the factor of space efficiency, as well as general simplicity and absence of reciprocating parts.

The illustrations shown herewith relate to the Willans rotary air pump system, a product of Willans and Robinson, Limited, Rugby, England. This system is brought out under license for the Müller-Josse Patent, controlling a system extensively used on the continent in condensing plant construction in sizes ranging as high as 10,000 K.W. Fig. 1 shows a diagrammatic sketch of the two most common applications of this system, viz., the shunt and the series system. In either case, the air is extracted from the condenser by means of the air-ejector, and the condensed steam is withdrawn by a separate centrifugal pump drawing the water from the bottom of the condenser. The piping for this operation for both systems is well illustrated in Fig. 1. The two systems differ in the manner of supplying the water to the air-ejector. The shunt system is used where the head across the circulating pump, as given by the local conditions and the pipe and condenser friction, suffices for the purpose of extracting air. In such case, the main circulating pump is designed to deliver a greater quantity of water than is required as cooling water in the condenser, the surplus water being used as air-ejector water, and returned to the source of supply or to the suction side of the circulating pump.

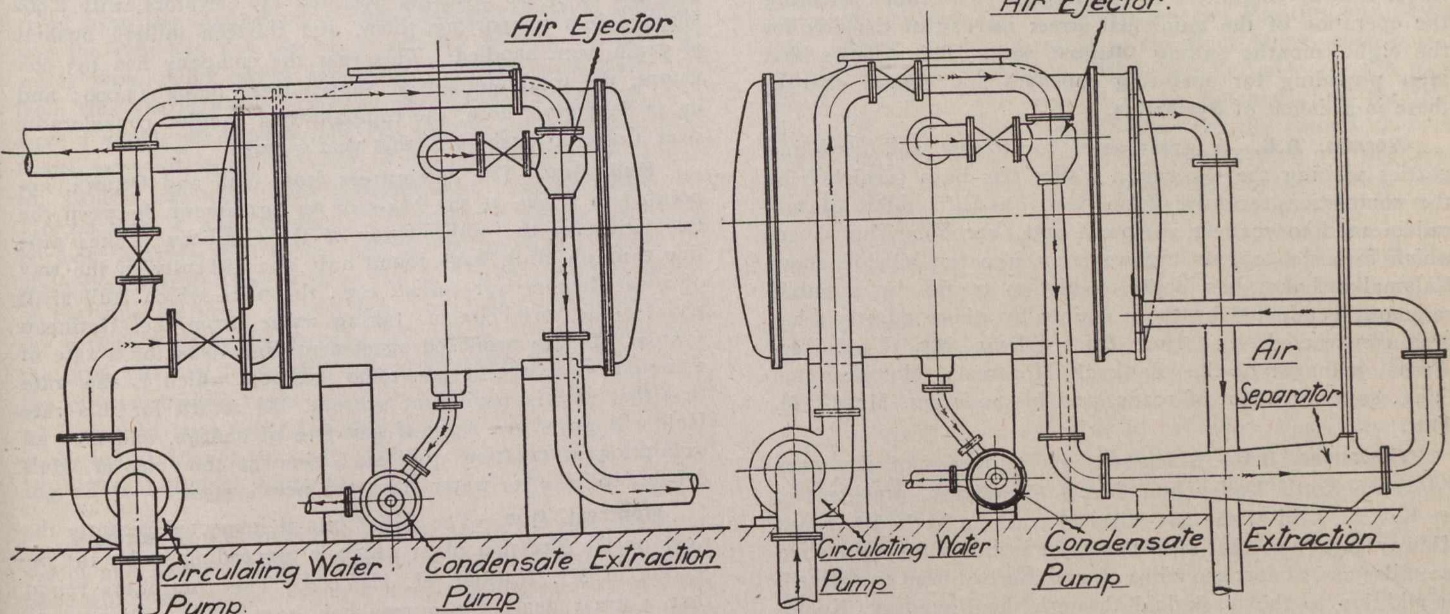


**Fig. 1.—Shunt and Series Systems.**

Where the series system is used, the whole body of the condenser cooling water is passed through the air-ejector before entering the condenser. Thus, in the shunt system, the power required for extracting the air is determined by the surplus quantity of water at the given head, and in the series system by the given quantity of water at a surplus head. In neither case is a greater quantity of cooling water consumed than where a reciprocating air pump or any other rotary air pump is used. Only one simple centrifugal pump is needed for supplying the condenser cooling water and the air extraction water.

The power required in extracting the air is dependent on the design of the ejector and the power actually consumed in compressing the air. The ejector used is the outcome of exhaustive experiments, and is said to be equal at least to any other form of ejector, either stationary or rotary. To reduce to a minimum the power required in air compression, the line of compression should approach the isothermal as closely as possible and compression should be carried out at the lowest possible temperature, namely, the temperature of the cooling water. Generally speaking, other rotary air pump systems call for special water tanks for holding the water required for air extraction; moreover, this water heats up rapidly owing to the small quantity of water in the closed circuit, and provision requires to be made to change the water frequently. Even so, the temperature of the water cannot be maintained at the temperature of the circulating water supply, and consequently the power consumed in compressing the air might be expected to be somewhat less in the system under description. Exhaustive tests have shown that in power consumption a very high efficiency has been obtained by this system, higher, it is claimed, than for any other air extraction system dispensing with reciprocating pumps.

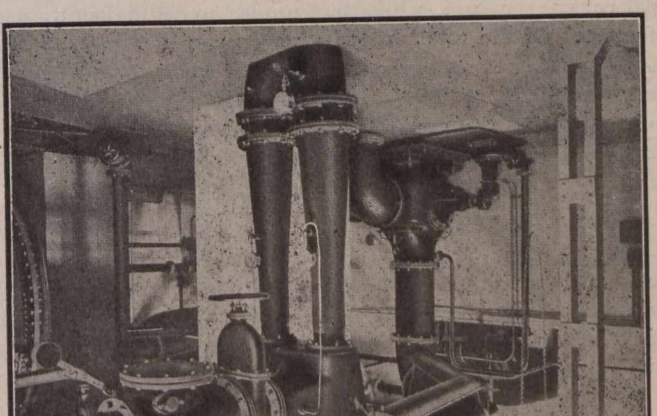

**Fig. 2.—A 4,000-kw. Installation.**

Fig. 2 shows a 4,000-K.W. surface condensing pump in operation. It might be stated that a total of 150,000 K.W. output measures the capacity of turbines for which condensing plants of this type have been built or are building.

## COAST TO COAST.

**Winnipeg, Man.**—The first 25-mile stretch of the Winnipeg-Winnipeg Beach highway has been formally opened. The ceremony took the form of a luncheon, tendered by the municipalities interested, to Premier Roblin, Sir Rodmond and the Hon. Dr. Montague, minister of public works, and others taking a prominent interest in the construction.

**Regina, Sask.**—A report has been submitted to the street railway committee of the Regina city council covering the operation of the municipal street railway of the city for the eight months ending August 30th. This shows that after providing for operating expenses and capital charges there is a deficit of $31,872.34.

**Vernon, B.C.**—A great asset for tourist and travelling parties visiting the Okanagan Valley has been furnished by the completion recently of one and one-half miles of macadam road to connect Kelowna and Vernon. This road, which forms a contour highway, cut into the hillside above Kalamalka Lake, has been opened to traffic by a public ceremony conducted by those mainly by whose efforts it has been constructed, e.g., Hon. Price Ellison, Mr. G. A. Henderson, manager of the Bank of Montreal; Mr. Hamilton Lang, superintendent of roads, and his assistant, Mr. G. M. Watt.

**Vancouver, B.C.**—Discussing the progress of the work along the Kettle Valley line, Mr. J. J. Warren, president of the K.V.R., said of the 295 miles of track to be laid between Midway and Hope that steel had been installed for more than 100 miles and almost 200 miles of grading had been completed. In addition to the track laid through the Boundary, Kootenay, Kettle Valley and Okanagan districts, 25 miles of line have been finished from Merritt to Coldwater Junction. Machine shops and roundhouses have been established at Penticton and good progress is being made all along the route.

**London, Ont.**—During the year 1913, London's engineering department has expended $214,705.08 on local improvements; and up to date this is a record amount. This year is also on record as showing the inauguration of the municipal contract system, which has proven to be eminently satisfactory. Of the total expenditure, $5,500, or approximately 2½ per cent., covers the salaries for the engineering department and office expenses for the eight months of outside work. This is an entirely significant feature, since a 5 per cent. basis is considered low for engineering supervision and plans.

**Owen Sound, Ont.**—The great loss of life and wreckage of vessels on the Great Lakes has been attributed largely to the fact that national elevators are erected at harbors of the most difficult approach and of the least adequate protection. It is therefore being agitated among leading citizens of Owen Sound, that the Government be approached with a request to construct at Owen Sound, where the harbor offers the easiest and safest ingress of any on the Great Lakes, a national elevator or elevators; and already representations have been made in connection with the matter to the proper departments at Ottawa.

**Victoria, B.C.**—It is expected that the steel bridge which has been in course of construction over the Little Qualicom River will be completed in a few days. This is on the Courtenay extension of the line, and, when finished, the laying of the steel will be proceeded with as far as Big Qualicom. While this work is under way the bridge gang will be transferred to Cowichan Lake to erect a steel bridge for which the foundations have been finished. This done the outfit will be removed again to Big Qualicom, which project will be carried forward as rapidly as circumstances permit. It is believed that the East Coast extension will be opened for passenger traffic by July 1 of next year.

**Regina, Sask.**—The development of the Saskatchewan Co-Operative Elevator Company during its short lifetime was reviewed at the recent annual meeting held at Regina. The first year the company operated 46 elevators, with 2,590 subscribers, and handled three and a quarter million bushels of grain. During the second season's business, which ended July 31, 1913, the company operated 137 elevators, with 8,962 shareholders supporting them, and thirteen million bushels of grain were handled. This year the company has 193 elevators, the total number of shareholders being 13,000; and up to September 20th, the company has handled considerably over 1,000,000 bushels of this year's crop.

**Hull, Que.**—The committees from Hull and Ottawa, appointed to arrive at the basis of an agreement between the two cities for the right-of-way of the Gatineau Lakes pipe line through Hull, have found only one difficulty in the way of a satisfactory agreement, e.g., the price which Hull shall pay for the privilege of taking water from the Gatineau system. In the proposed agreement Hull asks for a rate of one-quarter of a cent per 1,000 gallons, which is the rate that that city is paying at present. In return for this rate Hull will grant the right-of-way free of charge, and also an exemption of taxation until such time as the city of Hull decides to take its water from the new system.

**Montreal, Que.**—The City Council inspected recently the work on the filtration plant which is proceeding under the direction of Mr. Norman M. McLeod. The controllers found that a great deal of progress has been made. To obviate the damage by frost, which wrought such havoc with the plant last winter, the filtration plant is being put under four or five feet of water for the winter. The contractor has been helped forward on the work by the particularly favorable nature of the weather this autumn. The council was particularly satisfied with the enlargement of the aqueduct and the laying out of the twin boulevards on either side of the waterworks canal, the work on which is being done by the Cook Construction Company.

**Montreal, Que.**—Improvements upon the city's original sewage farm have been completed at a cost of about $120,000. These improvements were necessary before the farm could be used for the purification of the matter flowing from the sewers to the river. The new farm, purchased a year ago, is to be improved next year at a cost in excess of that of the work on the first farm. It is estimated that the total cost of the enire sewage farm when completed will be between $395,000 and $400,000. The work carried out during the past year on the old farm has been the adding of stone to the property so as to produce an effective filter for the sewage, the land having proven itself not sufficiently porous. The same method of treatment is to be given the new farm, and the final result will be that, in the course of twelve months, all the city sewage will pass through this farm and be purified before emptying into the river. Thus, contamination of the water supply will be obviated.

**Toronto, Ont.**—At the last meeting of York County Council, Mr. E. A. James presented an interim report on behalf of the Highways Commission of York county; and a complete report is to be forwarded to the council before the end of the year. Mr. James' report shows a total expenditure on construction of roads and bridges during the year of about $60,000; and on maintenance, of $14,000. Owing to the request of the Government that no extensive work be undertaken pending the report of the Provincial Highways Commission, construction work was restricted to completing gaps between sections already built. Some of the most important work was one mile of macadam construction on Yonge Street at Thornhill; 1,500 feet of brick pavement on Weston Road west of Black Creek; and three-quarters of a mile of macadam roadway in Vaughan township. Other road construction was 8,470 feet on Kingston Road, 8,500 feet on Vaughan Road, and 6,700 feet on Markham Road. On bridges and culverts the total expenditure, including construction and maintenance, for the year was $16,342.

**Vancouver, B.C.**—The final consignment of steel pipe contracted for by the city at the beginning of the year has arrived from the Mannesmann Tube Company of Great Britain; and the city has now on hand between 80 and 90 miles of water pipe. Only about 5½ miles of mains have been laid from this year's pipe; and it is estimated that the city will have a supply on hand to last for several years. When contracts were let to the National Tube Company of Pittsburg for 320,000 feet and to the Mannesmann Tube Company for 110,000 feet, it was intended that the pipe should arrive at periods, considerably apart; and it was thought to thus obviate the difficulty met with in the past owing to non-arrival of the pipe in time. As the case now stands, and owing to the serious drop in the demand for mains, it is asserted that the pipe will rust long before the city can use it. Last year, the city engineer's report showed that 47.8 miles of pipe of all sizes had been laid; but this year only about 17 miles of water mains have been laid. This is due largely to the falling off in building operations this year in Vancouver.

**Victoria, B.C.**—According to Mr. D'Arcy Tate, vice-president and general manager of the P.G.E. railway, the company will complete its contracts within scheduled time in spite of unforeseen engineering difficulties encountered on the northern section of the line. The section between Point Atkinson and Newport promises to be one of the most costly pieces of construction on the entire line, and will involve an outlay of about $100,000 a mile. This will mean practically the laying of the road on a bed of solid rock. In the Upper Fraser country there will be big rock fills; but the nature of the sub-structure is such that this part of the line will be built for less than one-half the cost of the Newport section. A short section of the line between Newport and Cheakamus, about seventeen miles in length, will be completed this week, and it is probable that Sir Richard McBride will open this small length and at the same time take the opportunity of making a personal inspection of the progress made in construction. The North Shore section will be ready for traffic by January 1 of next year, and the next section by the end of the following July, in accordance with the terms of the contract.

**Niagara Falls, Ont.**—Mr. Frederick Walker of New York, has devised a plan to build a suspended raceway at a cost of about $2,500,000, to tap one-half of the waterfall from the Canadian Falls and one-half from the American Falls at Niagara, and to carry the water through the Niagara River to a point where a great power plant will be erected for the creation and distribution of electricity. The power plant, which is not included in the estimate of cost, would furnish unlimited power to factories in Eastern Canada, just as the Niagara Falls Power Company's plant furnishes power to factories in Western New York and Pennsylvania. The plans provide for the raceway to be suspended with one end upon the rocky ledges of the Niagara River and the other planted on the river bank, and to be arranged so that if the river rises or falls, the raceway will rise or fall automatically. The raceway will follow the Canadian shore for several hundred rods before reaching the place where the power will be harnessed; and its carrying capacity will be about 1,200 pounds to the foot. It will be constructed of steel and concrete. Already surveys for the work are being made, under Mr. Walker's supervision; and options on land on the Canadian side are being received by other men interested.

**Montreal, Que.**—Col. Greenwood, assistant chief engineer of construction on the C.N.R. east of Port Arthur, has inspected the bridges under construction for the company at Back River, and reports that Mr. J. P. Mullarky, the contractor, is rushing the laying of track on the section from the western portal of the tunnel to the crossing of the Back River so that the steel superstructure may be brought for the series of bridges across the Riviere des Prairies and Mille Isle. There are two channels at the Back River, each being crossed by 4-pier bridges. The middle pier of the first channel bridge alone remains to be finished; and for this the coffer dam is now being sunk. On the second channel bridge all the substructure has been placed in position. Where the C.N.R. crosses the Mille Isle, there is being built a bridge of 14 piers, all of which are completed. This is one of the most imposing structures on the main line of the railway; and the superstructure for it will be placed during the coming winter. All other bridges along the road as far as Carillon have been completed, while the sub-structure of the big bridge over the Ottawa River at Portage du Fort, a structure of 12 piers, has also been finished. The C.N.R. main line runs up on the Ontario side of the Ottawa River for a distance of 30 miles as far as Shaw Falls, and then crosses into Quebec. After continuing for 30 miles in Quebec territory, the line crosses the river into Ontario again by the Portage du Fort bridge.

**Montreal, Que.**—Much is planned to be effected at the Montreal harbor before it is opened again in the spring. Before that time the slope of mud and clay at the river edge of Victoria, the dingy old dredge, and the clamshell derrick will all have disappeared; and a smooth concrete wall, of a height uniform with the other high level wharves of the upper harbor, and another of the huge freight sheds which line the wharves all the way to Windmill Point, will have appeared. Half a mile down the shore, from sections 24 to 27, where new concrete piers lying parallel with the river have been constructed during the summer, two more big freight sheds will have appeared. The piles for these have already been driven—long, concrete stilts, thrust down to the rock to take the strain off the heavy structures with the thousands of tons of freight, which they contain when in use. New berths at Victoria pier will be ready to give every opportunity for loading grain. Above the roof of the new freight shed the conveyor gallery will be extended to the very edge of the river. This will be the last link in Montreal's wonderful elevator chain. It will make one continuous system from Victoria pier to the western end of the Allan Line shed at the foot of McGill street, which in all will then have close to 16 miles of belt conveyors to carry the grain from unloading tower to elevator, or from one elevator to another; or, finally from either elevator to any ship lying anywhere between those two extremes. Four miles lower still, a like transformation will have taken place at the site of the Canadian Vickers Company's shipbuilding and repair plant. Acres of mud and construction materials will have vanished and a concrete retaining wall, which will make the whole water frontage of this tract one big wharf, and a heretofore much-needed machine shop of immense proportions, will have been completed. Further improvements that will add materially to the rejuvenation of the harbor, will be the Armstrong steel plant directly across the river; and the river bed itself, which will have a newly dredged channel for the use of light craft in general, which will wind along on the north side of the deep channel, the passageway for large vessels.

## PERSONAL.

A. K. GRIMMER, City Engineer of Medicine Hat, is at present on an extended trip through eastern Canada.

GEORGE T. CLARK, City Engineer of Saskatoon, Sask., has, it is announced, placed his resignation, to take effect February 1st, in the hands of the city council.

M. R. SHAW, B.A.Sc., is assistant superintendent for the Muskogee Refining Company, refiners of illuminating and lubricating oils and paraffine, Muskogee, Okla.

W. E. SKINNER, of Winnipeg, has been retained as consulting engineer for the town of Kenora, and will make a report upon the cost of producing power at the municipality's hydro-electric plant.

P. P. VON WEYMORN, civil engineer of the water power department of the Russian Government, is at present in Canada, to investigate the regulations of water power now in force in this country and the system of administration. For the past month Mr. Von Weymorn has been carrying on an investigation in the various cities of the United States, and is now visiting Canadian cities. He is very much impressed with the results of his investigations so far, and thinks that the regulations of water power of the Dominion Government are the best he has seen so far.

## OBITUARY.

The death was recently announced in London, Eng., ot Sir William H. Bailey, a prominent British engineer. Among his many accomplishments was the design and promotion of the Manchester Ship Canal.

The death occurred in Kingston last week of Mr. John Hazlett, well known in marine engineering, having been for years chief engineer of the Calvin and Hepburn Companies.

Mr. Oswald Gurney Carscallen, the Toronto representative of the Asphalt and Supply Company, Limited, died last Sunday at his home in Toronto after two months' illness. Mr. Carscallen was born in Hamilton and educated at the University School, Port Hope, and at Upper Canada College. Until three years ago he was vice-president and secretary-treasurer of the Gurney-Tilden Foundry Company at Hamilton. Mr. Carscallen had become very popular among the municipal and highway engineers and road contractors in Ontario during the three years that he was interested in paving work, and his death at the age of only forty-five years will be greatly regretted.

## REVISION OF UNITED STATES ROAD LAWS.

A committee of the American Highway Association has been appointed to assist in the revision of the road laws ot the various states in an endeavor to codify and simplify them and render them more uniform. The comprehensive plan which has been evolved will eventually result in a more uniform system of laws dealing with road matters. It is well recognized that most of the road legislation in various states is antiquated, and in many instances, obsolete. Many of the road laws are one hundred years old. There is little uniformity in the laws among the states. These facts appear as serious obstacles in the way of those who are seeking to give the entire country a network of improved highways.

It is probable that as a result of this movement the Governors of the various states will co-operate to urge upon the legislatures the appointment of commissioners, who will revise and simplify the laws.

## THE FIFTH ANNUAL GOOD ROADS EXHIBITION.

The Public Roads and Highway Commission of Ontario will have an exhibit at the Good Roads Exhibition of the American Road Builders' Association, which is being held in Philadelphia, December 9th to 12th. In addition to some eighty-five commercial exhibits, which had been assigned before the end of November, and which figure will likely assume a materially larger dimension before opening day, there will also be extremely interesting and instructive exhibits from a large number of the state highway departments, leading cities, engineering schools and colleges. The United States Department of Agriculture will show the road models prepared by the Office of Public Roads.

The Ontario Highways Commissioners, Messrs. McGrath, McLean and Rankin, and Mr. Wagner, Secretary of the Commission, will be in attendance. Mr. A. T. Laing, Department of Highway Engineering, University of Toronto, and numerous road engineers throughout Ontario, Quebec as well as representatives from Western Provinces, have signified their intention of being present.

The officials in charge of the convention arrangements state that from present indications the forthcoming exhibition will be by all odds the largest and most complete that has ever been held. Every effort has been made, so far as possible, to inclule in this exhibition all the newest labor-saving machinery, methods and appliances, so that altogether, the exhibition will be an accurate and striking record of progress. Several important departures are promised by manufacturers in their respective lines, and the exhibition will afford those interested in the purchase and use of road machinery and materials an excellent opportunity for inspection and comparison.

A detailed programme of the technical features of the Convention appeared in *The Canadian Engineer* for November 20th.

## COMING MEETINGS.

AMERICAN INSTITUTE OF ARCHITECTS.—Forty-seventh Annual Convention, to be held in New Orleans; La., December 2nd, 3rd and 4th. Secretary, Glenn Brown.

AMERICAN SOCIETY OF REFRIGERATING ENGINEERS.—Annual Meeting will be held in New York, December 2nd to 5th. Secretary, W. H. Reed, 154 Nassau Street, New York City.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—The Annual Meeting will be held in New York, December 2nd to 5th, 1913.

AMERICAN ROAD BUILDERS' ASSOCIATION.—Tenth Annual Convention to be held in First Regiment Armory Building, Philadelphia, Pa., December 9th to 12th. Secretary, E. L. Powers, 150 Nassau Street, New York, N.Y.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.—Annual Meeting to be held in New York, December 10th to 13th. Secretary, C. D. Odsen, Polytechnic Institute, Brooklyn, N.Y.

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS.—Seventh Annual Convention will be held at Great Northern Hotel, Chicago, December 29th to 31st. Secretary, I. W. Dickerson, Urbana, Ill.

AMERICAN CONCRETE INSTITUTE.—Tenth Annual Convention to be held in Chicago, February 16th to 20th, 1914. Secretary, E. E. Krauss, Harrison Building, Philadelphia, Pa.

## SHORT COURSE IN HIGHWAY ENGINEERING.

The last Illinois legislature passed a law regarding roads and bridges which introduced new principles and methods concerning the construction and maintenance of roads and bridges; and the law also created the offices of county superintendent of highways, and provides for the possible appointment of township or district superintendents of highways. In view of the new principles of administration introduced by this law, and also in consideration of the entirely new duties devolving upon the county and township superintendents of highways, and further, on account of the recent radical changes in the methods and materials of hard road construction, due to the increasing use of automobiles, the Civil Engineering Department of the University of Illinois will offer a course in highway engineering from January 19th to January 31st, 1914.

There will be no charges of any kind by the University; and the course will be open to anyone, without examination or other condition, who aspires to be appointed to the position of either county or township superintendent of highways, and to any others interested in the maintenance or construction of roads.

The lectures will cover the various phases of highway engineering; and will be given by members of the staff of the Civil Engineering Department of the University of Illinois, and by Mr. A. N. Johnson, State Highway Engineer, and members of the staff of the Illinois Highway Commission. The laboratory exercises are to show the methods of testing and using the materials employed in ordinary road construction, such as hydraulic cement, concrete, tar, asphalt, road oil, etc. It is expected to have several pieces of road machinery on exhibition with experts in charge to explain the manipulation and method of using each. In the evenings there are to be semi-popular lectures, which will be instructive to highway engineers and others interested in road improvement.

## AMERICAN MANUFACTURE OF DIESEL ENGINES

Most of the important European manufacturers of large steam and gas engines are largely concentrating their energies on building Diesel engines, and have such a large number of orders that to make prompt deliveries is practically impossible. It has for some time been a subject of much comment in view of the highly successful business being done in the Diesel engines by many European concerns, that no attempt has been made to build in America a full line of Diesel engines of a design which has proved to be a commercial success in actual use.

It should be remembered that notwithstanding the increase in the price of fuel oil, the actual cost of fuel oil and its relative cost, as compared with coal, is generally much lower on this side the Atlantic than in Europe. Also, that oil suitable for Diesel engines is a by-product which will always be available in ample quantities as long as the present large consumption of gasolene and kerosene exists. Many large new oil fields are also being developed in this country, in the United States and in Mexico.

Not only are Diesel engines said to offer many advantages for central station units, factory and other isolated power plants, and railway service, but are particularly desirable for marine work, where weight and space saved is of prime importance. The Diesel oil engine eliminates the boilers, with their necessary handling of coal and ashes; also pumps, and many other accessories characteristic of steam equipment. The space so saved, and the coal-bunker space, can be used for cargo, and the liquid fuel, handled by pumps, and requiring less than one-third of the room required for coal, can be stored in the ship's double bottom. In view of these facts, there seems to be no reason why there should not be a broad field for this type of engine.

An announcement has just been made that a corporation has been formed with a New York State charter to engage in the manufacture on an extensive scale of a full line of Diesel engines, both stationary and marine, for the American countries. In addition to American interests, the company has behind it a number of Swedish capitalists, who now control the Swedish Diesel Motor Company (Aktiebolaget Diesels Motorer), which company started building these engines in 1898, and many of their designs of the most important features peculiar to this type of engine, such as fuel pump, atomizer, details of pistons, etc., have been adopted by other European builders.

The new corporation will take over the plant and organization of the McIntosh & Seymour Company, of Auburn, N.Y., builders of steam engines, and the construction of both types will proceed under the one organization, the name of which has been changed to McIntosh & Seymour Corporation. Mr. Edwin S. Church, formerly superintendent of the Akron plant, International Harvester Company, will be president; Mr. J. A. Seymour, formerly president of the McIntosh & Seymour Company, will be vice-president, with charge of engineering.

## AGRICULTURAL ENGINEERS.

The American Society of Agricultural Engineers is holding its Seventh annual convention in Chicago. Dec. 29th to 31st, 1913. From a lengthy program we select the following items as of special interest to municipal officials, irrigation engineers and those more closely connected with rural development:—

(1) Farm Sanitation, with Special Reference to Water Supply and Sewage Disposal.—Paul Hansen, Engineer, Illinois State Water Survey.

(2) The Design of Permanent Farm Buildings.—E. S. Fowler, Universal Portland Cement Co.

(3) Standardization of Wagon Wheels and Tires.—E. Parsonage, John Deere Wagon Co.

(4) Concrete in Drainage and Irrigation.—C. W. Boynton, Universal Portland Cement Co.

(5) Small Motor Applications for Farm Work.—C. J. Rohrer, General Electric Co.

(6) The Five Winnipeg Motor Contests, and Lessons to be Drawn from Them.

(7) Address.—C. R. Richards, University of Illinois.

(8) Extension Work in Agricultural Engineering.—F. M. White, University of Wisconsin.

The secretary, Mr. I. W. Dickerson, Urbana, Ill., states that immediately after the close of the convention a brief summary of the papers and discussions will be prepared and will be sent to any one interested.

The Toronto branch of the Canadian H. W. Johns-Manville Company, Limited, announces its removal to 19 Front Street East. This new store and warehouse has a floor area of approximately 35,000 sq. ft., and is situated in the heart of the wholesale district. In their new quarters this firm will be able to carry a larger stock and have ample space for the display of their complete line of specialties.

The Pedlar People, Limited, of Oshawa, have moved their Toronto branch from Bay Street to a new building at the corner of College and Markham Streets, where they have a greater floor space, and will be able to carry a more complete stock of sheet metal work of all kinds, including culverts, flumes, drains, roofing, fire-doors, metal buildings, etc.

# ORDERS OF THE RAILWAY COMMISSIONERS OF CANADA

Each week on this page may be found summaries of orders passed by the Board of Railway Commissioners, to date. This will facilitate ready reference and easy filing. Copies of these orders may be secured from *The Canadian Engineer* for small fee.

20875—November 21—Authorizing C.N.R. to construct across Winnipeg Electric St. Ry. Co., near Helen Street and near Pembina Street, Winnipeg, Man., subject to certain conditions.

20876—November 22—Rescinding Order No. 19310, dated May 16th, 1913.

20877—November 24—Authorizing C.P.R. to construct siding for Quaker Oats Co. in City of Peterboro, Ont., mileage 24.3.

20878—November 1—Directing C.N.R. to furninsh a daily passenger service west of Alsask, Sask., satisfactory to an Engineer of the Board; said service to be put into effect not later than Nov. 10th, 1913.

20879—November 24—Directing G.T. Ry. to construct spur from its railway on south side of Kaministiquia River to factory and plant of Mount McKay Pressed Brick Co. ot Fort William, Ont., adjacent thereto, crossing two city roads and tracks of St. Ry. Co. in said City of Fort William, subject to and upon certain conditions.

20880—November 24—Authorizing G.T.P. Ry., subject to inspection by Dept. Public Works of B.C., after crossing is constructed, to construct main line across Government Road in S.W. ¼ Sec. 11-11-5, Coast Dist. B.C., at mileage 400 Prince Rupert East.

20881—November 24—Authorizing G.T.P. Branch Lines Co. and C.P.R. to operate their trains over crossing, in East Half of Sec. 23-17-20, W. 2 M., Sask., without their first being brought to a stop.

20882—November 24—Authorizing G.T.P.Ry. to construct Lake Superior Branch, at mileage 17.9 across highway between Cons. 3 and 4, Tp. Oliver, Ont.

20883—November 24—Establishing collection and delivery limits of Express Companies in Town of Leamington, Ont.

20884—Nevember 24—Extending, for a period of one month, from date of this order, time within which C.P.R. complete extension of siding for Quinlan & Robertson in Lot 10, Con. 8, Tp. Huntingdon, Co. Hastings, Ont.

20885—November 24—Authorizing G.T.R. to construct siding into the premises of Pollard Manufacturing Co., Limited, north of Buttery St., Niagara Falls, Ont., subject to terms of consent of said city and certain conditions.

20886—November 25—Extending, for a period of thirty days from date of this Order, time within which C.P.R. complete work of fencing portion of right-of-way from mileage 6.8 to 7.6, on east side of track, and repairing fences on west side of track, on Kingston and Pembroke Branch.

20887—November 21—Approving plan showing two new abutments for replacing piers at C.P.R. bridge, at mileage 35.4 on Chalk River Subdivision.

20888—November 21—Authorizing C.N.C.R. to construct bridge to carry its line over Indian River, Tp. Richards, Co. Renfrew, Ont., at mileage 107.85 from Ottawa.

20889—November 25—Authorizing C.N.R. to construct across public road between Secs. 14 and 15, Tp. 26, R. 26, W. 3 M., Sask., Alsask Southeasterly Line.

20890—November 25—Authorizing G.T.R. to construct siding, from siding serving Queenston Quarry Co., Limited, north of road allowance between Twps. Stamford and Niagara, Co. Lincoln, Ont., into premises of S. W. Marchment on Lot 48, Tp. Niagara (near St. Davids).

20891—November 20—Directing that within 30 days from date of this Order, C.N.R. submit for approval of Engineer of Board detail plans showing proposed half-interlocking plants to be installed, as required under Orders Nos. 5598, 6751 and 7291; work of installing said half-interlocking be completed within three months after approval of plans. 2. Cost of putting in diamonds at said crossings be borne and paid by City of Edmonton; and cost of providing, maintaining and operating half-interlockers be paid half by city and half divided equally between railway companies. 3. Leave reserved to G.T.P. Ry. to appeal to Supreme Court upon question whether in view of agreement between it and city, dated Sept. 29th, 1908, it is competent for Board to apportion cost of such protection as provided in paragraph 2 of Order 4. 4. Order No. 14994, dated Sept. 11th, 1911, is rescinded; recission to take effect upon installation and completion of interlocking plants herein required.

20892—November 25—Authorizing T.H. and B. Ry. to construct spur for the Egg-O Baking Powder Co., Limited, Hamilton, Ont.

20893—November 25—Directing that C.P.R. erect fences along portions of right-of-way near Savona, B.C., work to be completed within three months from date of this Order. And rescinding Order No. 17358, dated Aug. 27th, 1912, in so far as it relieves railway company from erecting fences along said portions of railway between Savona and Pennys.

20894—November 24—Authorizing Rural Municipality ot Hillsburgh, No. 289, Sask., at its own expense, to construct highway across C.N.R. at a point 250 feet west of west switch, D'Arcy, Sask.; railway company plank said crossing, and municipality do necessary grading.

20895—November 25—Approving location and detail plans of Windsor, Essex and Lake Shore Rapid Ry. Co station on the Talbot Road, Town of Maidstone, Tp. Sandwich South, Ontario.

20896—Authorizing C.P.R. to open for traffic that portion of double track from mileage 121 to Broadview, at mileage 131.4, Sask.

20897—November 25—Authorizing C.P.R. to construct, at grade, its Snowflake Westerly Branch across nine (9) highways, mlieage 0 to 9.10, Manitoba.

20898—November 25—Authorizing C.P.R. to construct, at grade, proposed switching lead on Eastern Division, Smith's Falls Sub. Div., at mileage 123.0 from Montreal, across public road between Cons. 3 and 4, Tp. Montague, Co. Lanark, Ont.

20899—November 27—Approving revised location C.N. Montreal Tunnel and Terminal Co., Limited's, tunnel line from St. Antoine St., to junction with its main line, at Montreal, Que.

20900—November 26—Approving C.N.R. plan of freight shed proposed to be erected at St. Albert, Alta., as required under Order No. 20765, dated Oct. 31st, 1913.

20901—November 25—Authorizing G.T.R. to construct siding into premises of Harris Abattoir Co., Limited, in Lot 10, Con. 1, Tp. Barton, now City of Hamilton, Ont.

20902—November 25—Directing that G.N.R. construct an open ditch of adequate width and depth, with bottom of uniform grade, on north side of its railway, from point marked "A," being at Hjorth Road, to point marked "B," about 2,000 feet therefrom; at Tynehead Station, B.C.; drainage of land south of track to be looked after by Municipality in connection with its road construction.

20903—November 25—Authorizing C.P.R. to construct spur for William Rutherford, at Stephen, B.C.

20904—November 25—Authorizing C.P.R. to construct siding for National Builders' Supply and Enamel Concrete Brick Co., Limited, Montreal, Que., from a point on existing siding in Lot Cadastral No. 323, Range St. Pierre, delaCabane Ronde, Parish of St. Henry de Mascouche, Co. L'Assomption, Que., mileage 14.81 from St. Martin Jct.

20905—November 25—Authorizing Government of Sask., at its own expense to construct highway over G.T.P. Ry. near N.E. corner of Sec. 17-38-26, W. 2 M., Sask.

20906—November 27—Authorizing Dept. Public Works, B.C., to construct, at its own expense, an overhead highway crossing over G.T.P. Ry. at a point about 127 miles (G.T.P. mileage) from Prince Rupert and near Fiddler Creek, B.C.