PAGES

MISSING

Volume 25. Toronto, Sept. 18, 1913

Contents of this issue on page 469

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

THE WATER LEVEL OF LAKE ERIE

REPORT OF THE INTERNATIONAL WATERWAYS COMMISSION ON THE VALUE OF COMPENSATING WORKS IN THE NIAGARA RIVER —A SEQUEL TO 1910 REPORT AGAINST ATTEMPT AT REGULATION

THE International Waterways Commission, the duties of which, when instituted in 1902, included an investigation into the advisability of locating a dam at the outlet of Lake Erie with a view to determining whether such a dam would benefit navigation, and, if the structure was deemed advisable, a report to the governments of Canada and the United States containing recommendations relative to the construction of of the same, and an estimate of the probable cost, has recently submitted its report.

Upon undertaking the work, the commission first divided it into two parts. It first investigated the advisability of regulating works to reduce the oscillation of the lake, thereby raising the low-water level but not affecting the high-water level. This part of the problem was reported upon in January, 1910, the commission finding that material improvement in regulation could not be accomplished except at the expense and to the injury of the channel below. In the case of Lake Erie it would be possible to raise the extreme low-water stage about 1 ft., and this in turn would raise the low-water stages of Lake St. Clair about 0.61 ft. and of Lake-Huron-Michigan about 0.27 ft., all without appreciable increase in the extreme high stages. But in doing this the low-water stage of Lake Ontario would be lowered about 4½ in., the available depth in the St. Lawrence Canals would be diminished about 7⅔ in., and the city of Buffalo would suffer by increased damage from floods and by a postponement of the date of opening navigation in the spring. The question of damage to vested rights was thus introduced. While the advantages of regulation might outweigh the disadvantages if the persons who were to benefit from the former were identical with those who were to suffer from the latter, the difference was not great enough to justify the two governments in entering upon the vexatious question of damages. The commission therefore recommended that the regulation of Lake Erie be not undertaken, meaning thereby the most complete practicable regulation such as can be secured by a dam and sluice gates located at or near Buffalo.

The second branch of their work, viz., the advisability of compensating works for raising the level at high as well as at low-water, without complete regulation, is the subject of a report under date of June 20th, 1913.

In July 3rd issue of *The Canadian Engineer* mention was made of the recommendations of the commission in this respect. A copy of the entire report has since been received, and we extract from it herewith.

As was stated in the former report, the Niagara River at its extreme upper end is an important safety valve for the protection of Buffalo from the effect of storms, and should not be obstructed by a dam, but it seemed possible that somewhere in the river, between Lake Erie and the Falls, a submerged dam might be placed which would greatly benefit the navigation of the waters above without injury to those below and with only minor damages, if any, to the adjoining lands. To determine this question it was necessary to make a complete survey of the Niagara River from Lake Erie to the Falls, including the topography of the adjoining lands. The survey was made by the commission. A survey was made also by the Canadian Government of the Welland River, in Canada, which enters the Niagara about a mile above the rapids approaching the Falls. A sketch upon a reduced scale, showing the Niagara River in outline, is shown in Fig. 1.

From a study of the maps it appears that the best site for a submerged dam, or weir, is just above the Welland River, extending from Hog Island, at the mouth of that river, to the mouth of Gill Creek, on the American side. As the Welland is a navigable stream, there would be some advantage in placing the weir below its mouth, but the survey of that river showed that a moderate increase in the height of its surface would submerge a considerable area of valuable land. To provide for the navigation of the Welland it is necessary to construct a lock at the Canadian end of the weir. The object of placing the weir as near as possible to the foot of navigation is to improve all of the navigable portion of the Niagara River above. A study of the topography on both sides of the Niagara River showed that the water surface at mean stage could be raised as much as 3 feet at the site of the weir without inflicting damage upon adjacent lands, except for a distance of about 1½ miles immediately above the weir on the American side. At this place it is proposed to construct a levee of suitable height to protect the land from overflow.

The form to be given the weir has been the subject of careful investigation. In order to disturb as little as practicable the natural distribution of flow through the different parts of the cross-section of the river, the crest of the weir is broken into four sections, as shown in Fig. 2, the height given to each section being such as will raise the surface of the water in that section 3 feet at mean stage.

A cross-section of the weir is shown in "A" of Fig. 3. This form was adopted after experiment with various types of weir made under as nearly as possible true river conditions. The experiments were made at the hydraulic laboratory of the college of civil engineering at Cornell University, which was generously placed at the disposal of the commission for the purpose.

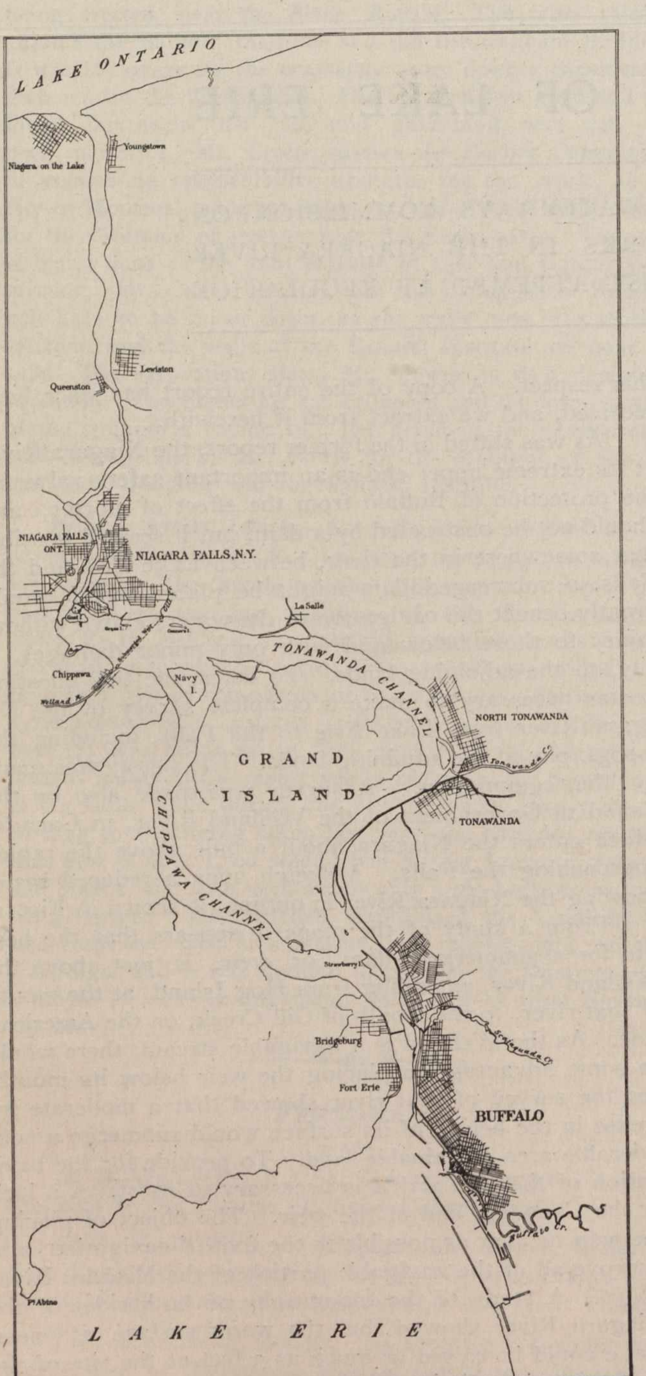

Fig. 1.—Niagara River, Showing Location of Submerged Weir.

The form of weir which was subsequently adopted fills the desired condition of high efficiency at high stages of the river and correspondingly the flow efficiency at low stages. The weir would raise the level of Lake Erie 0.51 ft. at extreme low stage, 0.39 ft. at mean stage, and 0.11 ft. at extreme flood stage. At low-water the surface of the Niagara would be raised 1.08 ft. at the Buffalo waterworks, 1.16 ft. at Strawberry Island, about 5½ miles from the lake, increasing to 3.05 ft. at Schossler's Dock, the foot of navigation. At flood stage these numbers are: For Buffalo waterworks, 0.19 ft.; for Strawberry Island, 0.12 ft.; and for Schossler's Dock, 0.91 ft.

The effect of raising the mean level of Lake Erie 0.39 ft. would be to raise Lake St. Clair's mean level about 0.23 ft., and that of Lake Huron about 0.09 ft.

To change the level of a great inland sea like Lake Erie, upon the shores of which are many populous cities, is a matter to be approached with caution. Any important increase in the height of the high-water level may cause serious damage to the wharves and low-lying lands. Care must be taken to avoid injury to vested rights. In this case, the ordinary high-water level is increased only 0.38 ft., or 4½ inches, and the extreme flood stage at Buffalo is increased only 0.11 ft., or 1⅓ ins.

The construction of the weir recommended in this report will affect to some extent the levels in the first reach of the Barge Canal from Tonawanda to Lockport. The level of the Niagara River at Tonawanda would be raised by 1.71 ft. at mean stage, and by 0.55 ft. at flood stage, so that inasmuch as no provision has been made at the entrance of the canal against the rise which the construction of the weir will cause, it is in our opinion necessary to provide for the construction of a guard lock, the cost of which is included in our general estimate.

The capacity of the lock to enter the Welland River is a domestic question to be decided by the Canadian government. An item of $500,000 in the estimates provides for the construction of that lock, but its dimensions should conform to the capacity which the Canadian government shall determine to give to the connecting waterways, and this estimate can be regarded only as a rough approximation.

The weir is to be constructed of concrete and its cost is estimated as follows:

Rock excavation, 36,300 cubic yards, at $4 per yard	$145,200
Concrete, superstructure, 44,000 cubic yards, at $12 per yard	528,000
Concrete substructure, 48,500 cubic yards, at $10 per yard	485,000
Cofferdam, 105,500 cubic yards, at $3.50 per yard	369,250
Pumping and maintenance, lump sum	210,000
Lock into Welland River	500,000
Guard Lock at Tonawanda	500,000
Excavation for retaining walls along Niagara River, 16,000 cubic yards, at $3 per yard	48,000
Concrete for retaining walls, 12,500 cubic yards, at $10	125,000
	2,910,450
Add for engineering and contingencies about 20 per cent.	589,550
Total	3,500,000

The great value to the navigation interest of an increase of 6 inches in the low-water depth of Lake Erie has already been pointed out. The improvement of Niagara River to be effected by the proposed weir is important. An incidental advantage in its construction is that it would eliminate the possibility of the power companies at the Falls having any injurious effect upon the level of Lake Erie. The Niagara River below the weir and the conditions upon Lake Ontario and the St. Lawrence River would remain without appreciable change. The weir has small regulating effect upon the levels of Lake Erie, the range of the oscillations of the lake being reduced about 4½ per cent. The average natural low stage, 571.3, is raised 0.45 ft., and the average natural high stage is raised 0.38 ft., a difference of 0.07 ft. The storage in Lake Erie is reduced only by that amount, which is not sufficient to affect the level of Lake Ontario seriously.

It is possible that the Canadian government may prefer to assume the damages from overflow in the valley of the Welland River, which would be caused by placing the Canadian end of the proposed weir below the mouth of the Welland, and thus make the lock unnecessary. If so, provision for this should be made in any treaty.

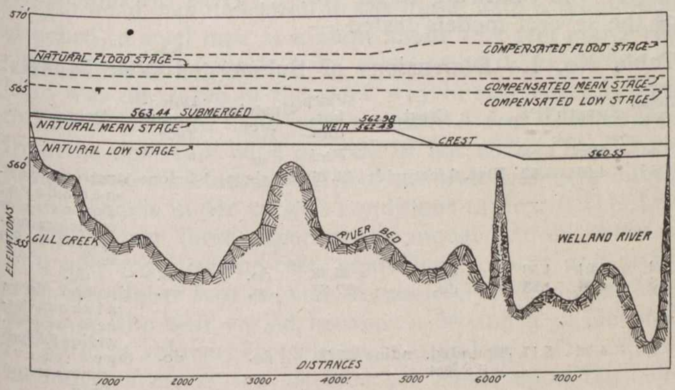

Fig. 2.—Natural and Compensated Stages at Site of Submerged Weir.

The commission believes that the very great advantages to navigation interests will justify and amply repay the necessary expenditure, and recommends that a treaty be entered into between Great Britain and the United States providing for the construction of the weir.

The report has appended to it the findings of Messrs. W. J. Stewart, engineer for the Canadian section, and E. E. Haskell, engineer for the American section, and the following is extracted therefrom:

Niagara River is the outlet of Lake Erie and discharges into Lake Ontario; it is divided into two reaches by the Falls, the "upper" and the "lower." The upper reach is navigable from Lake Erie to Chippewa, Ontario, and to Niagara Falls, N.Y., and is the reach with which we are at present concerned. Strawberry and Grand Islands divide a part of this reach into two channels, known as Tonawanda and Chippewa. The distance from Lake Erie to the head of Strawberry Island is approximately 4 miles and the fall in this distance at mean stage is 5.8 feet. The distance from the head of Strawberry Island to the end of navigation by the Tonowanda Channel is 16½ miles, and between the same points by the Chippewa Channel is 12¾ miles. The fall in these reaches at mean stage is 4.8 feet.

The natural conditions in this upper reach of river are therefore such as to indicate that by placing a submerged weir of proper size at the end of navigation, or below Navy and Connors Islands, it might be possible to create sufficient backwater to restore to Lake Erie a part at least, of what it has lost in stage by diversions, and at the same time greatly improve the navigation of the reach of river under consideration.

It was this project that was in mind when the last report was submitted. Naturally, the question arises: Can the water be raised sufficiently at the location indicated to actually restore to Lake Erie a quantity worth while and at the same time keep within control all flood waters, particularly those that come from heavy southwest windstorms on Lake Erie?

To answer this question it was necessary to have more data than existed at the time of our previous report. A careful topographic survey was required of all lands likely to be affected and a type of weir best suited for the location and conditions had to be determined.

Surveys were started early in 1910 and prosecuted as diligently as the affairs of the commission would permit. The results from these did not become available, however, until about the beginning of the present year. A detailed topographic survey was made of the shores of the Niagara from Lake Erie to within a mile of the Falls; the islands within this reach; and of the Welland River from its mouth to its source, a distance of about 40 miles.

In order to determine the best type of weir, it was deemed necessary to study various types under as nearly as possible true river conditions. These studies were made at the hydraulic laboratory of the college of civil engineering of Cornell University. They covered experiments on seven different types, ranging in height from 3.7 to 6.02 ft. and having in general a 3 to 1 upstream slope and a 1 to 1 downstream, five having a flat crest and the remainder a rounded crest. In two of the flat-top types, the upstream, and in all the downstream corners were rounded on a radius of 9.5 ft. On two of the flat-top and all of the round-top types, the downstream nappe was an ogee curve.

These experiments furnished what was being sought, namely, a type of submerged weir that would be very efficient at high stages and much less so at low stages.

Fortified with these new data, a study was made of the probable effect of submerged weirs placed at right angles to the general direction of the river in the following localities: Willow Island, Port Day, Grass Island, and Gill Island, as well as one on a line between Gill Creek and Hog Island, at the mouth of Welland River. Only the last of these met the conditions desired, and it is not thought necessary to give the results of the studies of the rejected locations because the end to be attained is clearly set forth in the consideration of the site finally chosen.

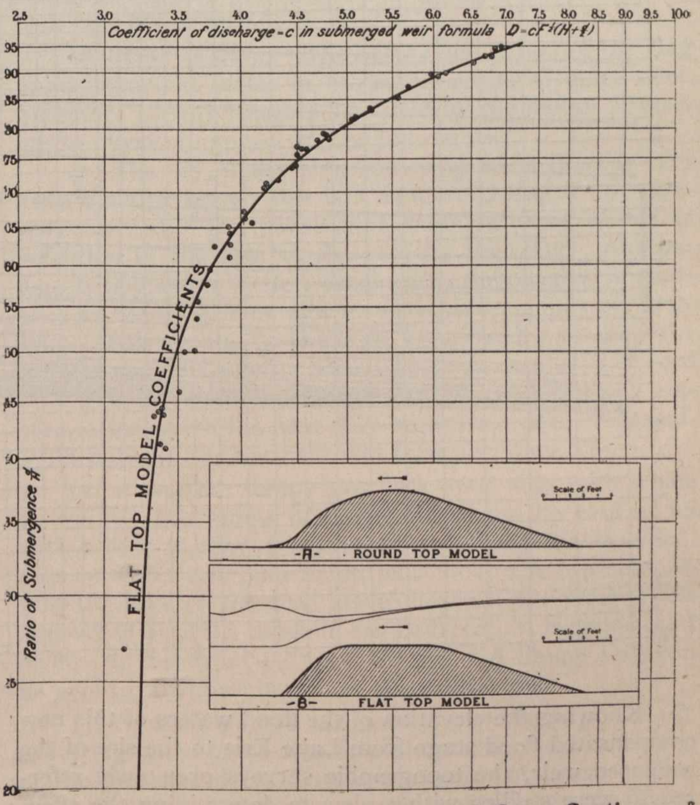

Fig. 3.—Experimental Coefficients and Cross-Sections of Weir Models.

As shown in the previous report, the stage of water in several of the Great Lakes will be materially lowered by artificial diversions of water therefrom. This loss of level on Lake Michigan-Huron, if 10,000 c.f.s. be taken through the Chicago Drainage Canal, will for mean stage amount to 0.53 ft., while the loss of level to Lake Erie due to this diversion and 1,000 c.f.s. through the Erie Canal and 1,100 c.f.s. through the Welland Canal will at mean stage amount to 0.43 ft. and 0.09 ft., respectively, a total of 0.52 ft. The American power companies have also lowered the level of Lake Erie probably by 0.08 ft.

The project here proposed for restoring the loss caused by these diversions is the construction of a submerged weir of suitable type, on a line between Gill Creek and Welland River, as shown in Fig. 1, of such a height of crest as will create sufficient backwater to offset it.

To determine this, backwater curves have been computed, based upon Bernoulli's theorem for steady flow. The backwater on Lake Erie caused by the submerged weir has also been computed by the supply, storage, and discharge method, and the results by the two methods check very satisfactorily, the latter giving 0.07 ft. greater backwater in the high-water year of 1876 and 0.08 ft. greater in the low-water year of 1895.

Owing to the fact that the weir has an increasing efficiency with increase in stage, it was thought that the flow of the river might vary slightly from present natural conditions and therefore might affect injuriously the stage of water in the St. Lawrence Canals. The computed results show that the effect on Lake Ontario of any variation in the flow from Lake Erie caused by the submerged weir would be negligible.

Submerged-Weir Experiments.—As previously stated, submerged-weir experiments were made upon seven different types of weirs, ranging in height from 3.70 to 6.02 feet. All of the models were approximately 4 feet long. The following table, No. I., gives the dimensions of the several models tested:—

Table No. I.—Dimensions of Submerged-Weir Models.

Model No.	Length	H't	Crest	Width bottom	Upstr'm face	Downstream face	Remarks
	Feet	*Feet*		*Feet*			
1	4.005	6.02	Flat, 6 feet wide	31.76	1-3 slope	1-1 slope	Upstream corner sharp, downstream corner rounded, radius 9.5 feet
2	4.01	4.53	do.	25.79	do.	do.	do.
3	4.01	4.53	do.	27.33	do.	do.	Up and down stream corners rounded, radius 9.5 feet
4	4.02	5.17	Rounded, radius 9.5 feet	27.70	do.	do.	Ogee curve downstream face
5	4.005	4.35	do.	23.50	do.	do.	Ogee curve bottom, downstream face
6	4.005	3.70	Flat, 6 feet wide	23.50	do.	do.	Upstream corner sharp, downstream corner rounded, radius, 9.5 feet, Ogee curve bottom, down stream face.
7	4.005	3.70	do.	25.04	do.	do.	Up and down stream corners rounded, radius 9.5 ft. Ogee curve bottom downstream face.

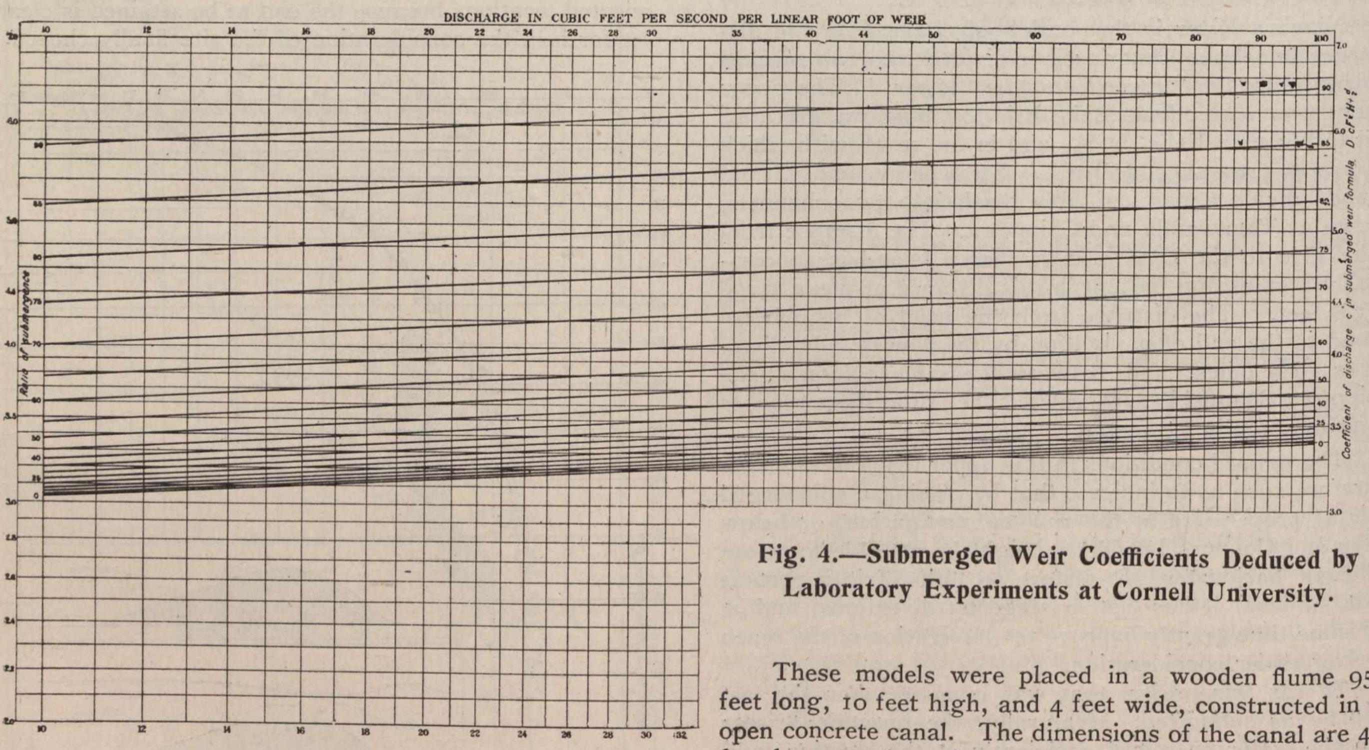

Fig. 4.—Submerged Weir Coefficients Deduced by Laboratory Experiments at Cornell University.

Knowing the elevation of the flood waters of this new compensated flood stage from Lake Erie to the site of the proposed weir, the topographic surveys previously referred to were studied with a view to determining the effect that these new flood waters might have upon adjacent lands. So far as can be seen, but little, if any, damage would result from the proposed weir placed on the Gill Creek-Welland River section. The investigation has also shown that it would not be possible to raise the water at the weir by much more than 3 feet without danger of damage from floods.

These models were placed in a wooden flume 95.5 feet long, 10 feet high, and 4 feet wide, constructed in an open concrete canal. The dimensions of the canal are 418 feet long, 16 feet wide, and 10 feet deep. The grade of bottom of channel is approximately 1 foot in 500. A bulkhead located about 60 feet from upper end of canal divides it into two parts. A standard sharp-crested weir placed on top of this bulkhead measures the quantity of water flowing in canal. The wooden flume mentioned above was built in this canal, the upper end being located about 87 feet below the standard weir. The upper end of flume had a bell-shaped mouth, about 15 feet long, converging from 16 feet, the width of canal, to 4 feet, the width of flume. The crest of weir of tested models was placed about 46 feet below upper entrance to bell mouth. The flow of water over the standard weir, through the canal, and over the experimental models was regulated by gates at the head and foot of canal. By the manipulation of these gates various discharges, submergences, and heads on the experimental weir models were secured. The upstream head was measured in the flume with a plumb-bob attached to steel tape at a point about 25.5 feet above the upstream edge of crest of flat weir, while the downstream head was measured in the same way in still water behind the flume on both sides and about 16.6 feet downstream from the upstream edge of crest of flat weir. The longitudinal water surface curve over the weir was determined for all models under various conditions of flow. The flow of water over these experimental models varied between 27.6 and 203.2 second-feet, equivalent to 6.87 and 50.75 c.f.s. per linear foot of weir, respectively. The upstream heads on the weir varied between 1.66 and 6.35 feet and the ratio of submergences between 0 and 95. The experimental coefficients as derived are based upon the submerged weir formula $D = cF^{\frac{1}{2}} \left(H + \frac{d}{2} \right)$, where D = discharge per linear foot of crest, H = upstream head, d = downstream head, F = fall or upstream head minus downstream head, c = experimental coefficient. The weir coefficients for the flat-crest models are given in Table II. and are shown in Fig. 3.

Table No. II.—Weir Coefficients, Flat-top Model.

Weir condition	Average minimum river flow per linear foot of weir	Co-efficient	Average mean river flow per linear foot of weir	Co-efficient	Average maximum river flow per linear foot of weir	Co-efficient
	C.f.s.		*C.f.s.*		*C.f.s.*	
Free	18.00	3.120	25.00	3.160	45.00	3.260
0.1 submergence	18.00	3.145	25.00	3.190	45.00	3.300
0.2 submergence	18.00	3.195	25.00	3.245	45.00	3.345
0.3 submergence	18.00	3.260	25.00	3.308	45.00	3.419
0.4 submergence	18.00	3.340	25.00	3.397	45.00	3.500
0.5 submergence	18.00	3.480	25.00	3.540	45.00	3.655
0.6 submergence	18.00	3.720	25.00	3.780	45 00	3.900
0.7 submergence	18.00	4.125	25.00	4.190	45.00	4.320
0.8 submergence	18.00	4.850	25.00	4 910	45.00	5.060
0.9 submergence	18.00	5.930	25.00	8.025	45.00	6.210

The weir coefficients of the rounded-crest models were about 5 per cent. greater than those of flat-crest models, but the coefficient increment was about the same for each type within the limits for river conditions. The flat-crest model was therefore adopted on account of the easier construction, inspection, and repair.

The committee does not wish it understood that the type of weir here proposed is the most desirable one for the purpose. The experiments made were by no means sufficient to settle this question. It is very probable that further experiments would reveal a still better type. The one proposed does demonstrate, however, that the project is feasible.

SILICON STEEL FOR ELECTRICAL PURPOSES

The results of extended experiments shows that silicon steel is to be preferred to manganese steel for electrical purposes on account of its superior magnetic properties is the statement made by F. Goltzè in a paper read before the German Foundrymen's Association, Berlin. Annealing improves the structure and the mechanical properties, and has considerable effect on the magnetic properties, at 750° C. reducing them slightly and at 1,000° C. establishing a marked improvement, while at 900° C. it has a decidedly adverse influence. Coarseness of grain and good magnetic properties were found to go hand in hand. The addition of aluminum to cast-iron was also found to increase the magnetic properties of the iron.

BASIC OPEN-HEARTH STEEL CASTINGS.*

By H. F. Miller.

FOR some years the prejudice against basic open-hearth steel for castings has been gradually decreasing. Acid steel has been used for this purpose much longer than basic steel; and the melters in acid practice had it well in hand when basic steel was first tried. Then the necessity of learning a new set of laws for the production of satisfactory basic open-hearth steel for castings became evident. The first of these laws has to do with the furnace construction. The charge should be melted down as speedily as possible to prevent excessive oxidation.

Furnace Hearth.—The hearth of the furnace is a decisive factor in the production of solid castings. The manufacturer should know the size of the heats he intends to make constantly, and should have his furnace built for that size of heat. The hearth should differ in dimensions from that of a furnace making ingot steel. That is, the bath should be deeper and should have less surface area. A shallow bath permits the slag to come out soon after the steel commences to flow, and thus prevents the additions from going into the steel, or from becoming uniformly distributed should they be put in hurriedly.

Under this head comes the very poor practice of making small heats in hearths of a much larger capacity. If into a 25- or 30-ton furnace only 12 or 15 tons of metal is charged per heat, the proportion of heats that will be wild or show signs of wildness at some time during the pouring will be comparatively large; whereas, if the hearth is charged to capacity, a heat showing signs of wildness will be a rare occurrence.

Influence of Slag.—The nature and action of the slag is an important factor in the manufacture of quiet steel. Slags are usually roughly classified by the melter according to physical appearance, as follows:—

(1) The dry, heavy slag occurring when there is very little silica present. This is a dangerous slag if not carefully worked. The burning of many furnaces is due to reflection of the heat to the roof by this slag. Another danger is that the melter, deceived by the physical appearance of the slag, may add an excessive amount of fluorspar. This results in the ladle being badly cut and the stopper rod burned off. These disasters can be prevented by a gradual addition of spar until a "wet" slag is created, after which the heat may be worked down as usual. With natural gas the heat will form for some time.

(2) A wet but lumpy slag is a good slag with which to work. The lumps of limestone should be broken up with a rod, so that a rocky bottom may be avoided. Otherwise an unbroken lump will choke the tap-hole, so that the flow of the slag being stopped, the steel is left uncovered until the tap-hole can be freed. A large amount of heat is lost from the steel thereby. A lumpy slag can be avoided by charging small-sized limestone.

(3) A third slag is the very watery variety, usually occurring when heats melt at high temperature, by reason of the presence of an excessive amount of silica. This slag should have burned dolomite or raw limestone added until a thick slag is made. When the slag is too thin, it will mix with the steel in tapping and a wild steel will be the product. The ladle and stopper rod will be badly

*Abstract of a paper presented before the American Institute of Mining Engineers (Iron and Steel Division).

scorified, and usually some tons of steel will go into the pit by reason of a burned-off stopper rod.

The ideal slag is heavy and wet with no large lumps. This slag makes an easy heat to work and gives a steel low in phosphorus and sulphur. It requires but a small amount of fluorspar to put this slag in shape for the ladle. A heavy slag of this nature will not mix with the steel, and will generally stay in the furnace until the steel is nearly all in the ladle. It also has the good quality of cutting neither the stopper rod nor the ladle brick. The only objection is that it causes a dirty bottom, and unless a washout is made after each heat the bottom will rise to the sill-plate level after a few heats. This result shows very poor practice. No time is ultimately gained by charging up without the usual washout. If a washout from 20 to 30 min. is made after each heat, the furnace will work fast for a much longer time. Moreover, the holes that occur in a high bottom will be largely avoided, if the bottom is kept low and clean.

Tap-Hole.—The tap-hole should be kept large and low. The quicker steel gets into the ladle, the more heat is retained. The shorter a spout the better, for the same reason. Moreover, a large tap-hole will not clog up easily if rabbling has to be done; and few hard taps will occur. For shutting up the tap-hole magnesite is best, because it does not burn together and make a hard tap, nor does magnesite boil out, as may happen when a tap-hole is closed with green dolomite. Burned dolomite, however, may be safely used, the only drawback being an occasional hard tap, due to the burning together of the material.

The foregoing facts are probably known to most smelters; but unless vigilance is constant, one factor is apt to be overlooked. The bottom may be low and the tap-hole all right; but the spout if not smooth at the end may cause the stream to spray over the ladle, thus losing much heat and causing a skull and, perhaps, some misrun castings, all of which could be avoided with a carefully made up spout.

Alloys.—The addition of alloys may be made in the bath or in the ladle. By putting them into the bath, much heat is saved. This is a valuable method where a furnace is working cold or a heat has melted low and there is difficulty in getting it hot. The advantage is that the additions are made while the flame is still on the bath, and the loss of the heat in the bath caused by dissolving the alloys can be regained. The objections are:—(1) That a large amount of each alloy must be added, since in this method from 15 to 30 per cent. goes into the slag; (2) that the silicon, reacting, will throw back the phosphorus into the steel. Putting the additions into the steel as it goes into the ladle is the better method. A uniform distribution of alloys is obtained by shovelling the alloys in gradually. If the alloys are added to the ladle, the steel will be helped greatly by first raising them to red heat, especially in winter.

After the heat has melted down and the limestone has boiled up, the charge will be benefited by allowing it to "soak" from 15 to 30 min. This will allow any contained slag to rise and also much of the gases. Ore may then be fed if necessary or, if the heat has come ready, it remains only to get the steel hot. Sometimes heats will melt low, and if only small ladles are available or there are no heavy castings to pour, it is best to get the heat ready by using manganese. This will not add much metal to the bath, and it is a good substitute for pig-iron.

With large ladles, working the heats with both pig-iron and manganese is recommended. Very little, if any, ferro-silicon should be used instead of manganese, since the silicon mixes with the slag and cuts the stopper rod off while the heat is being poured. Hot metal is preferable to cold additions, as the bath is not then chilled by the additions.

If the slag comes too quickly and all the additions have to be made to the first part of the heat, an even distribution can be obtained by rabbling the heat. If some of the additions are lost in the slag, or if insufficient has been put in, the heat showing signs of wildness, a simple remedy is to take a number of sticks of aluminium, bend a tapping rod around them, thrust them to the bottom of the ladle, stir the bath with them and rabble it afterwards if necessary. There is hardly a heat that cannot be made absolutely quiet by this means. But it is curative treatment, and a good preventive is always better.

The time consumed in pouring is a factor in determining the size of the heat. Good practice demands that a heat of steel should be poured in less than 60 minutes; the faster the better. The high temperature required to pour steel from 1 to 2 hours causes a great increase in occluded gases and necessitates an increase of about 30 per cent. of ferro-silicon to make it as quiet as when poured at a lower temperature.

The use of fluorspar seems also to make the steel less responsive to the quieting action of silicon, since the fluorine appears to be absorbed by the steel. I have noticed when pouring a test that after much spar has been used the steel gives off a smoky gas of the same appearance as when fluorspar is added to the bath. If this is true, the action of fluorspar cannot be beneficial to steel when added in large quantities. Good basic steel is harder to make than good acid steel; but if the practice outlined is followed, the steel produced will be as quiet while molten and as solid afterwards as acid open-hearth steel —and tougher.

FORCE EXERTED BY EXPANSION OF WOOD.

The great pressure exerted by the expansion of wood when soaked with water has been illustrated during the flood at Dayton, Ohio. A quantity of oak dashes veneered with maple was stacked to within one inch of a reinforced concrete girder in the basement of a factory. This girder had a cross-section of 12 by 19 inches and supported a 6-inch reinforced concrete floor. The basement was flooded, and after the water receded it was found that the girder, together with the concrete floor which it supported, had been lifted 3 inches. Ten weeks after the flood the girder still rested on the dashes, but it had settled about ¾ inch. Large cracks developed in this girder, starting at the edge of the pile of dashes and extending upward and outward. These cracks extended from the bottom to the top of the section at an angle of about 30 degrees with the horizontal. It was necessary to replace this girder and a section of the floor.

In these days, when hydro-electric power is becoming so important a factor in industry, it is of interest to note that in the Western Provinces there are vast possibilities in this regard. In Manitoba there is water power which would produce 7,000,000 horse-power, and only 78,000 horse-power is being utilized. This is at Winnipeg, which has a municipally-owned hydro-electric plant, supplying light and power to consumers at cost.

THE EXPRESSION OF PIVOT ERRORS BY A FORMULA.*

By R. Meldrum Stewart,
Dominion Observatory, Ottawa.

EVEN the best measurements of pivot errors of a meridian circle or transit instrument are, of course, affected by accidental errors, and in the case of fairly good pivots these are no doubt larger than the actual deviations of the pivots from a smooth curve. It then becomes a question what pivot corrections should be adopted, both for the zenith distances at which the errors have been observed, and for intermediate zenith distances. The practice ordinarily followed is to plot the observed values and draw a smooth curve representing them as closely as possible. The objection to this proceeding is that it is not a definite one, and, what is perhaps more serious, that the amount of smoothing does not, as it should, depend on the accuracy of the original observations (for it is manifest that accurate observations should be smoothed less than inaccurate ones). It has seemed, therefore, that it would be advantageous, if possible, to obtain from the observations a definite formula which might be used in place of the smoothed curve, and from this formula to construct tables showing the zenith distances at which the pivot corrections change from unit to unit. In a recent series of measurements at the Dominion Observatory it was found that a good representation could be obtained by the use of a few terms of a Fourier series, and it seems probable that the values so adopted are more accurate than the actual observed values.

It is evident that a Fourier series can be made to represent the observed values to any required degree of accuracy; for example, in the case where the pivot errors are observed at intervals of 6°, the use of 72 terms would reproduce the observed values exactly. Since, however, these observed values contain errors of measurement, it is probable that a more exact representation of the actual pivot errors will be obtained by omitting the terms with small co-efficients; it then becomes a question simply of the number of terms to be retained.

It is evident that, the more accurate the original observations, the more closely the adopted curve should be made to represent them. Also, the accuracy of the observations is represented by the probable error of a single observation, computed in the usual way; since several complete sets of observations are always made, this is readily obtained. Hence the deviations of the adopted curve from the observed values should be a function of the observed probable error. But by treating these deviations as residuals they themselves may be utilized to form another probable error, which represents the accuracy with which the adopted curve reproduces the observed values. The most obvious assumption is that these two probable errors should be made equal that is, that sufficient terms should be included in the Fourier series (choosing always the largest terms) to make its representation of the observed values equally accurate with the representation of the true values by the observations themselves.

Freed from technicalities, the above process simply amounts to drawing a smoothed curve in a particular way, with the adoption of a criterion for the amount of smoothing. The tentative adoption of a particular number of terms amounts to drawing a trial curve; if upon examination it is found that it is an even chance that the discrepancies between the curve and the observed values are due to errors of observation, the curve is adopted; if not, another trial curve is formed, and the process repeated until the desired result is attained.

The statement has been made that the criterion adopted (that of equality between the two probable errors) is incorrect, and a different one has been suggested, viz., that sufficient terms of the Fourier series should be included to make the probable error deduced therefrom a minimum. It seems to the writer, however, that a perusal of the preceding paragraph will establish the fact that his criterion is essentially logical and reasonable. The suggested criterion, not to mention the fact that it takes no account of the known accuracy of the observations (which can be measured independently), and that the whole principle involved in its application (that of "minimum probable error") is at least very seriously open to question, is manifestly entirely inapplicable in the present case. For it may be shown that in the attempt to represent any such observed series of quantities by a Fourier expansion, the computed probable error diminishes continually as the number of terms included increases; the proof of this theorem is elementary. Thus the adoption of this criterion would necessarily be synonymous with the use of a curve totally unsmoothed, that is, of the actual observed values.

It has been mentioned above that the use of the Fourier series amounts to drawing a smoothed curve in a particular way. It may be conceivable (though it does not appear in any way certain) that in some special case this particular way might not be suitable, i.e., that a limited Fourier series might not be applicable at all. This could probably occur only in the case of very irregular pivots, where the majority of the co-efficients in the complete Fourier series would be comparatively large. Even in this case the only fact that seems clear is that the number of terms necessary to give a satisfactory representation would be so large that the labor of computation would be prohibitive. In any case an examination of the residuals from the adopted curve will readily show whether any marked runs occur; if not the formula may be safely adopted. In the writer's judgment the occurrence of marked runs in the residuals would simply indicate that the pivots were decidedly irregular, and stood in need of re-grinding.

The actual determination of the pivot errors of the meridian circle at this observatory, referred to at the outset, was made by the microscopic method. Eight complete measurements of pivot errors were made; the probable error of a pair of microscope pointings (treated as a single observation) was found to be .0015 sec.; five cosine terms and five sine terms of the Fourier expansion (which may be combined into five cosine terms) were found to be sufficient to reduce the computed probable error to the same value. When the results are put in the form of a correction to the observed collimation it may be shown that terms involving the sine and cosine of the zenith distance have no effect; consequently these were omitted.

The resulting formula is:

$$\Delta c = {}^{s}.0010 \cos (2\theta - 188^\circ 29') + {}^{s}.0117 \cos (3\theta - 3^\circ 17') + {}^{s}.0021 \cos (4\theta - 59^\circ 45') + {}^{s}.0008 \cos (5\theta - 121^\circ 58')$$

* Appearing in the bi-monthly journal of the Royal Astronomical Society of Canada.

θ being the zenith distance. The residuals from the formula were satisfactorily small (in no case exceeding .002 sec.), and appeared to be purely accidental.

Values of the formula were computed for different zenith distances, and from these a table was prepared giving the zenith distances at which the value of Δc changed from one unit (in terms of .001 sec.) to the next; it is this table which is used in the reduction of transits.

It may be remarked that the strictly logical method of procedure would be to treat the sine and cosine terms independently. Thus, if the complete representation is given by

$$\Delta c = a_0 + a_1 \cos \theta + a_2 \cos 2\theta + a_3 \cos 3\theta + \ldots\ldots\ldots$$
$$+ b_1 \sin \theta + b_2 \sin 2\theta + b_3 \sin 3\theta + \ldots\ldots\ldots$$

the terms with largest coefficients should be chosen without combining the sine and cosine terms in pairs. This mode of procedure would in the actual case considered have changed the adopted formula slightly, in that the term involving sin 2 θ (coefficient – .0002) would have been omitted, and that involving sin 12 θ (coefficient – .0005) would probably have been included. Had the tables not been completed originally with the formula as given above, this change would have been made. As, however, the change in adopted pivot errors would have been extremely minute, it has not, up to the present at least, been thought worth while to make the change.

THE NEW DOCK AT SINGAPORE.

The completion of the King's Dock at Singapore marks an important stage in the scheme of extension and reconstruction works undertaken by the Singapore Harbor Board. The new dock is the largest dry dock in the far east. Its length from the outer stop to the head is 892 ft. 6 in., and from the inner stop to the head 876 ft.; the width at the entrance 100 ft., and inside the dock between the copings 128 ft.; and the depth on the outer sill 34 ft. at high water, and 24 ft. at extreme low water. By means of a central caisson the dock can be divided into an inner and an outer portion, 502 ft. and 346 ft. long, respectively.

With the exception of the entrances, which are of Cornish granite ashlar, the dock is constructed entirely of concrete. The altars consist of moulded concrete blocks, and the remainder of the face is of fine concrete masswork. Three rows of granite keel block courses run the length of the dock under a corresponding number of heavy timber keel blocks, the remainder of the floor being of mass concrete.

For filling the dock two culverts 7 ft. high by 4 ft. 6 in. wide are provided, and for emptying it there are two culverts measuring 10 ft. by 6 ft. The pumping station contains two Gwynnes' 60 in. centrifugal pumps; each has two suctions 36 in. in diameter, and they are together capable of emptying the dock, which contains 22 million gallons of water, in less than two hours against a maximum lift of 39 ft. Each of the pumps is direct coupled to a compound condensing engine of about 1,100 horse-power, having cylinders 24 in. and 46 in. in diameter with a stroke of 24 in. Steam is furnished at 160 lbs. pressure by three boilers, each able to evaporate 12,300 lbs. of water an hour.

Two ship caissons are provided, each weighing 826 tons, including ballast, and as they are identical in size they are interchangeable. Included in the equipment are four ten-ton and eight five-ton capstans, a five-ton crane, a fifteen-ton crane and penstocks, all the appliances being worked electrically by power generated at the Board's own power station. The cost has been over $2,000,000.

SHELLFISH CONSERVATION AND SEWAGE DISPOSAL.

THE American Public Health Association has a committee on sewage collection and disposal which will submit a majority and minority report at the convention in Colorado Springs this week. The question of conservation of the shellfish industry is one reason for the lack of unanimous opinion on the part of the committee. In connection with this question Mr. George A. Johnson, consulting engineer, New York City, and a member of the committee, has favored us with a copy of his comments upon the present situation.

He outlines the reversal of conditions since the day when the aborigines made free use of shellfish as food. Since that time huge sewer outfalls in the neighborhood of shellfish grounds have greatly altered public opinion on the advisability of their use as a fish. The shellfish industry has grown until the value of the total annual output of nearly 40,000,000 bushels amounts to approximately $20,000,000. Where shellfish formerly grew in a naturally pure state the grounds are more or less subjected to currents of contaminated water.

Another point touched upon is the certainty of epidemics of typhoid fever and other disorders as a result of the use of polluted oysters for foods.

It is a problem how shellfish grounds may be protected from contamination from this source. The best grounds are found in the mouths of rivers and bays near the ocean, which is unfortunate, as such waters are usually subjected to pollution by the sewage of cities and towns located directly on or tributary to them. The report goes on to state that although shellfish in constantly changing, unpolluted water will become purified in from one to two weeks, this department of oyster purification has not been receiving adequate attention, although deserving of exhaustive study.

Another point is that shellfish will continue to be used as food, and that, "except in special well adapted cases it is impossible, on financial and other grounds, to conserve absolutely the purity of shellfish by sewage treatment. Complete treatment of the sewage entering waters which flow over shellfish layings will improve existing conditions, and in special cases almost, if indeed not entirely, remove the existing danger; but to be thoroughly effective a condition is required which is seldom, if ever, found at sewage treatment works to-day. There would be required not only extreme conscientiousness in the operation of the sewage treatment works, paralleling the vigilance with which good water filtration works are watched, but also interstate co-operation, the whole order of affairs being supervised by a supreme authority vested by law with power to approve or condemn.

"The conservation of the shellfish industry is a difficult problem, made so by the fact that common law rights of sewage disposal into the sea and its estuaries have been and are being extensively utilized. To set these conditions back a century solely for the sake of conserving the oyster industry, where no other offence is created, is a matter which, if pressed, will engage active sanitary, financial and legal minds for many years to come."

The new Canadian Northern road from Toronto to Ottawa will be opened about October 15th. The line is one of the main connecting links of the Canadian Northern Ontario lines, and will open a straight connection from Northern Ontario and Toronto to Montreal and Quebec.

THE EFFECT OF SATURATION ON THE STRENGTH OF CONCRETE.*

By J. L. Van Ornum, M. Am. Soc. C.E.
Professor of Civil Engineering, University of Washington

THE paucity of recorded information concerning the treatment of concrete specimens, with regard to moisture conditions during their storage while awaiting the test for strength, seems to indicate a general supposition that this feature has no considerable effect on results. Apparently corroborating this attitude is the statement in the recent report of the Special Committee on Concrete and Reinforced Concrete, in which, while specifying the exact dimensions, mixing, consistency, age, etc., of test specimens, the only requirement designed to control moisture treatment during their curing seems to be that they shall be "stored under laboratory conditions." It is the purpose of this paper to invite attention, not only to the great importance of specifying and standardizing the moisture treatment of specimens intended for testing, but also to the further fact that similar conditions, as they act on the finished structures, will affect their strength considerably, and therefore should be considered in specifying the proper unit stresses. It is evident that this factor should not be ignored when great variations in strength, to an amount of perhaps 50% above or below a mean value, result from differences in moisture conditions.

During the last six years this question, at times, has been the subject of investigation in the Washington University Testing Laboratory. Different features have been explored experimentally since 1907. Although these tests leave the greater part of the field still untouched, the results thus far obtained are so definite in their showing of a decided influence of moisture conditions on strength, and so significant in their general indications, as to authorize a summarized statement of experimental results to the engineering profession for its consideration.

The most important part of the investigation is that of the effect, on the compressive strength of concrete, produced by varying systematically the relative length of time of exposure in air and in water.

The test specimens were cylindrical, 8 in. in diameter and 16 in. high. The materials were: a standard brand of Portland cement which fulfilled thoroughly all the requirements of the standard specifications; a clean sand of good quality, weighing about 110 lb. per cu. ft. when dry, and having 36% voids; and a washed river gravel of the same weight, varying in diameter from quite small up to 1½ in., and having 33% voids. The proportions were the usual 1:2:4, by volume; the mixing was done thoroughly by hand; and the quantity of water used was such as to give a moderately wet consistency, which allowed a thorough compacting by stirring with an iron rod and a slight tamping. All details of fabrication, curing, and testing were planned so as to secure such complete uniformity as is practicable to obtain in all regards except the one for which the controlled variation formed the particular purpose of the experimental study.

The cylinders were removed from the moulds when two days old, and were tested at an age of six weeks. The intervening 40 days constituted the period in which the duration of their immersion in water was varied systematically from nothing to the full time. The average results of the 240 tests thus made are plotted on the diagram, Fig. 1, on which the abscissas represent that number of days (after the two days in the moulds and the time of exposure to air) during which each set of specimens was placed in water before crushing them; and the ordinates give the percentage of strength which each set of immersed cylinders (standing in water for the indicated number of days) was found to have, taking the compressive strength of the dry specimens from the same mix as 100 per cent. Thus, at the extreme left is represented the basis of comparison, or those which were not immersed at all; those specimens which were cured in air of ordinary humidity for 32 days and then immersed for 8 days are shown by the black circle to be 86% as strong as the air-cured concrete; those in air for 12 days and therefore finally cured in water for 28 days have gained 9% in strength; and those submerged for the entire 40 days exhibited an average compressive strength fully 50% greater than that of the air-cured specimens.

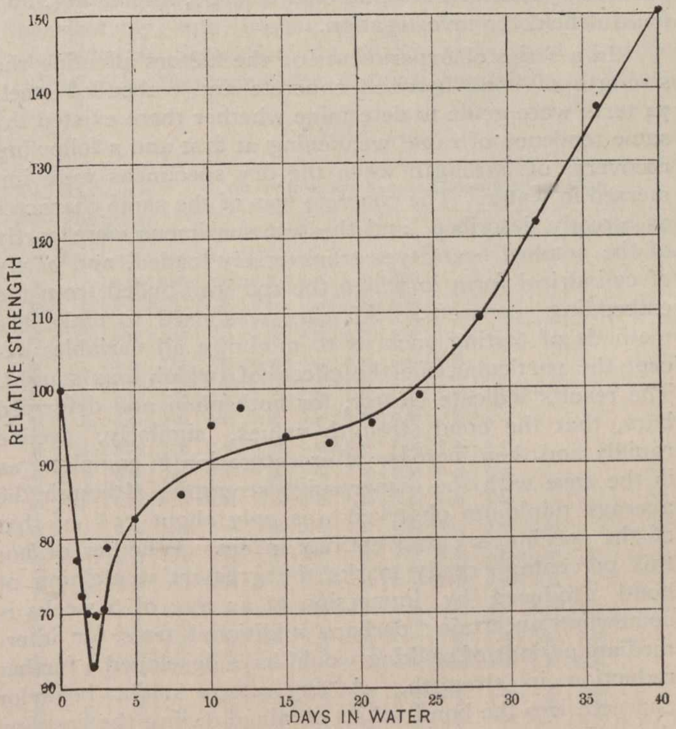

Fig. 1.

An average curve for the plotted points has been drawn as a full line, showing the systematic increase in strength as the time of submergence is lengthened beyond 2 days; but there exists the significant fact that specimens, of the dimensions used, decrease rapidly in strength when stored in air for 38 (or more) days and then placed in water for the remaining 2 days (or less). This particular feature of the rapid loss of strength on first exposure to water, and the active but slower recovery of strength as soaking continued, required a multiplication of tests to determine satisfactorily the locus of the curve in this region; and consequently more than half of the experiments were concentrated in this descending and the adjacent rising portion of the plot.

It thus appears that the compressive strength of concrete exposed only to air may be reduced nearly 40% when saturated with water, but that this loss is actively regained as the treatment is continued. The word saturation is used advisedly, because the minimum strength was found to coincide practically with the length of time required

*To be presented at the November 5th meeting of the American Society of Civil Engineers.

for water to penetrate to the middle of the specimens. Very plainly, this loss of strength has no relation to the percentage of contained moisture, as it is not only regained but much exceeded if the saturation is continued long enough. Perhaps the reduction in strength is purely a temporary physical phenomenon which is gradually counteracted and finally dominated by continued saturation permitting the imperfectly developed chemical processes of hardening to proceed actively. If this be true, concrete would regain something more than its original strength if dried out as soon as completely saturated, but this value would be less than that attainable by a continuance of the water treatment; also a repetition of soaking after such an experience would again temporarily reduce the strength, but less than before. These questions, as well as others, such as the duration of saturation necessary to prevent the temporary relapse of strength described, the corresponding effects of other periods of treatment similar to that discussed, of alternating the exposure to air and water, the result of different dimensions, proportions, materials, etc., all offer a large, interesting, and fruitful field for investigation.

In a series of experiments on the factors affecting the strength of bond between concrete and embedded steel, 74 tests were made to determine whether there existed the same tendency of rapid weakening at first and a following recovery of strength when the dry specimens were immersed in water. The concrete was of the same character as already described, and the test specimens were partly of the notched beam type transversely loaded, and partly of cylindrical form in which the rod was pulled from the embedding concrete. All care was used to make the methods of testing such as to minimize all variables except the particular one the effect of which was sought. The results indicate clearly, for both plain and deformed bars, that the bond strength values, similarly, decline rapidly and then increase after saturation is complete, as is the case with the compressive strength; although the average minimum observed was only about 75% of that of the specimens cured entirely in air. Whether or not this percentage really marks the greatest weakening of bond produced by immersion at an age of 6 weeks is somewhat uncertain; perhaps additional tests for intermediate periods of soaking would have developed a further reduction in strength. At any rate, a similar behavior characterizes the bond values obtained during the first few days of saturation.

Thirty-two beams were made of such dimensions and amount of longitudinal reinforcement (without any web reinforcement whatever) that failure would always occur through the effect of the excessive web tension in the concrete. The materials were of the same quality as those already described, and equal precautions were taken to secure reliable results. These beams were also tested at an age of 6 weeks, but the small number restricted the investigation to lengths of immersion designed to detect only the early loss of web tensile strength and its subsequent increasing value, without tracing it throughout successively lengthening periods of exposure to water to the limit of 40 days. The characteristic effect is again the same, the lowest average found being again practically three-fourths of the strength of the air-cured specimens. It may be that, in this case also, the minimum value was not detected.

A series of experiments on concrete prisms when 7 years old, to determine any change due to age in elastic properties, has been discussed previously by the writer. It may be stated, in reference thereto, that the modulus of elasticity of these old prisms exhibited a practically constant value throughout the repeated loadings equal to the maximum before found, which was about 80% greater than the final constant value as then reported for prisms of ordinary age; or a value of 4,000,000 in compression for that 1:3:5 limestone concrete. In these experiments two specimens were immersed in water until saturated and then carefully tested; the resulting compressive modulus of elasticity for wet concrete was 60% of that observed on the same specimens when dry. This lowering in value refers, again, only to the effect produced as soon as the saturation is complete and has no reference to a continuance of the exposure to water, such as is reported on certain other tests, where the figures given for the compressive modulus of elasticity of concrete specimens cured entirely in water for 26 days are about one-fourth greater than for those cured only in air.

As the various strength values of dry concrete are temporarily reduced from 25 to 40% by saturation, it would seem that this fact should be given definite consideration in fixing the working stresses used in the design of structures which may be thus exposed, or else conditions should be controlled in such a way as to prevent the weakening thus produced. No such effect occurs in concrete constantly under water or in moist earth from the time of its fabrication; but construction above ground, and therefore exposed to dry air for a time and then to a heavy rain or other source of rapid wetting, presents conditions under which this reduction in strength exists temporarily. Fortunately, the remedy is simple and inexpensive. It is to keep the exposed material thoroughly wet until its enclosure by exterior walls and roof renders its saturation by rain impossible. The case of parts not thus protected, or those for which enclosure is delayed, is not so simple; because the length of time of saturation which will make the concrete safe against serious reduction of strength is uncertain. The systematic wetting of concrete is a well-known principle of good construction; but the writer's observation and experience suggest a very considerable tendency to regard that procedure as abstractly correct, but practically rather specious or trivial. One purpose of this paper is to present the facts in such a way that the frequent, thorough, and faithful wetting of all parts of such concrete structures shall henceforth be no more ignored than is now the protection from freezing or disturbance while setting. Probably this treatment should be continued for a length of time substantially greater than that heretofore indicated—perhaps for a period expressed in weeks instead of days.

Undoubtedly, carelessness in a thorough control of this kind is a frequent contributing cause of weakness which is sometimes sufficient to result in failure. Very evidently, this temporary weakening of concrete by saturation is amply covered by the factor of safety required by good practice, if it be the only fault; but the materials may be considerably below standard, or the workmanship may be defective, or the design may encroach on the reserve of safety, or the occasional overload may be imposed; and if the material man, the construction superintendent, the designer, and the user of the structure should each rely on the others to meet fully the requirements, in the expectation that his own delinquency will be safely covered by the factor of safety, it would not require an impossible coincidence of such conditions to cause disaster; especially in view of the fact that considerable variations from the average strength values, which form the basis of design, necessarily exist in different parts of the structure. In fact, the failures which have occurred are generally a result of several such contributing causes. The writer believes that the considerable weakening produced by the saturation of dry concrete has invariably been a contributing factor in all those instances in which there was an active wetting of dry or partly dry concrete when subjected to essential stresses.

This general proposition furnishes one more evidence of the remarkable responsiveness of concrete to variations in its treatment. The fact that differences in control (which to the average artisan are seemingly unimportant) actually do exert a positive influence on its essential characteristics, constitute a definite warning against entrusting it to the uncertainties of irresponsible or skeptical supervision, and assures ample reward for a competent control which is correctly adapted to develop its capabilities. The susceptibility of steel to the influence of phosphorus and sulphur, of details of its heat treatment, and of other conditions occurring in the process of its manufacture, have resulted in restricting its production to the scrutiny of expert superintendence. Equal reason exists for, and commensurate advantages will follow, a thoroughly discriminating control of both the initial fabrication of concrete, and the details of treatment during its hardening, in order to realize the great possibilities inherent in this newer material.

The treatment of steel is not always complete as it comes from the rolls, as is shown by such effects as the changes in strength produced by the cold-twisting of steel rods; much more important in relation to the resulting quality of concrete is the nature of its treatment after fabrication, both because its attainment of strength is a relatively slow process and for the reason that the nature of the prevailing conditions provided during this period affects so greatly the development of its essential properties.

The notable responsiveness of concrete to the character of its treatment is a direct appeal for thoroughly trustworthy and expert control.

WATERPROOF CONCRETE.

In connection with preparations for the construction of a new lighthouse in Germany, some interesting experiments were carried out in the direction of waterproofing concrete. Various mixtures of cement and fine sand, in ratios of from 1 to 1 to 1 to 6, and mixtures of 1 to 3, with the addition of various materials, as soft soap, were moulded into pot-shaped vessels about 15 in. high with 2½ in. walls. When these pots had set, some of them were filled with water and others, empty, were placed in water, and the density of the walls was judged by noting the time required to empty or fill, the water acting under a maximum head of about 10 in. It is curious to note that a satisfactory degree of imperviousness was not reached, since in every test the vessels emptied or filled within one hour. The relative success of the richest mixtures then induced tests of rich-rubbed surfacing. To this end the surfaces were first wetted, then thickly coated with cement paste, and with a soft brush the cement was rubbed well into the surface of the concrete. This procedure was repeated a number of times, until the pores were closed, and a satisfactory degree of imperviousness was then reached, as the pressure tests, continued for three days, showed that no water penetrated through the walls of the pot. It was the success of this method that decided the authorities upon building the lighthouse of concrete made impervious in the manner outlined above.

A RATIONAL FORMULA FOR ASPHALT STREET SURFACES.*

By J. Alden Griffin, Assoc. M. Am. Soc. C.E.

EVERY now and then the question is raised: "What is the proper crown to give an asphalt street?" and there is a discussion as to which of the many formulas of to-day gives the best results.

Having been asked this question many times in the past few years, and especially while connected with municipal improvements in Los Angeles, Cal., the writer has given the matter careful investigation, and, by a comparison of the surfaces proposed by the various formulas, has arrived at the conclusion that the crown rise should vary with the cross-fall as well as the grade of the roadway, and that a crown considerably lower than that proposed by the well-known formula of the late Andrew Rosewater, M.Am.Soc.C.E., should be used on streets having a cross-fall between the gutter grades. The writer even favors one which is slightly lower, where there is no cross-fall in the roadway; and, having reached these conclusions, he proceeded to determine the proper amount of reduction to make in the crown for varying cross-falls. After a great many experiments he adopted the following modification of Mr. Rosewater's formula. This gives the best results, using one-eighth of the cross-fall plus ¾ in. as the reduction factor, but some may wish to change $0.12H$ in the formula to $0.10H$, or even $0.08H$, in order not to reduce the crown quite so much; however, the following is recommended:

TABLE 1.

Width of roadway, in feet.	Percentage of grade on street.	Crown, with no cross-fall.	Crown Rise, for Variable Cross-Falls, in Feet.											
			0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00
28	1	0.48	0.45	0.42	0.39	0.36	0.33	0.30	....	....	....	....	....	....
28	2	0.45	0.42	0.39	0.36	0.33	0.30	0.27	....	....	....	....	....	....
28	3	0.43	0.40	0.37	0.34	0.31	0.28	0.25	....	....	....	....	....	....
28	4	0.41	0.38	0.35	0.32	0.29	0.26	0.23	....	....	....	....	....	....
28	5	0.39	0.36	0.33	0.30	0.27	0.24	0.21	....	....	....	....	....	....
34	1	0.59	0.56	0.53	0.50	0.47	0.44	0.41	0.38	....	....	....	....	....
34	2	0.57	0.54	0.51	0.48	0.45	0.42	0.39	0.36	....	....	....	....	....
34	3	0.54	0.51	0.48	0.45	0.42	0.39	0.36	0.33	....	....	....	....	....
34	4	0.51	0.48	0.45	0.42	0.39	0.36	0.33	0.30	....	....	....	....	....
34	5	0.48	0.45	0.42	0.39	0.36	0.33	0.30	0.27	....	....	....	....	....
40	1	0.71	0.68	0.65	0.62	0.59	0.56	0.53	0.50	0.47	....	....	....	....
40	2	0.68	0.65	0.62	0.59	0.56	0.53	0.50	0.47	0.44	....	....	....	....
40	3	0.64	0.61	0.58	0.55	0.52	0.49	0.46	0.43	0.40	....	....	....	....
40	4	0.61	0.58	0.55	0.52	0.49	0.46	0.43	0.40	0.37	....	....	....	....
40	5	0.58	0.55	0.52	0.49	0.46	0.43	0.40	0.37	0.34	....	....	....	....
46	1	0.82	0.79	0.76	0.73	0.70	0.67	0.64	0.61	0.58	0.55	....	....	....
46	2	0.79	0.76	0.73	0.70	0.67	0.64	0.61	0.58	0.55	0.52	....	....	....
46	3	0.75	0.72	0.69	0.66	0.63	0.60	0.57	0.54	0.51	0.48	....	....	....
46	4	0.71	0.68	0.65	0.62	0.59	0.56	0.53	0.50	0.47	0.44	....	....	....
46	5	0.68	0.65	0.62	0.59	0.56	0.53	0.50	0.47	0.44	0.41	....	....	....
56	1	1.01	0.98	0.95	0.92	0.89	0.86	0.83	0.80	0.77	0.74	0.71	....	....
56	2	0.97	0.94	0.91	0.88	0.85	0.82	0.79	0.76	0.73	0.70	0.67	....	....
56	3	0.93	0.90	0.87	0.84	0.81	0.78	0.75	0.72	0.69	0.66	0.63	....	....
56	4	0.88	0.85	0.82	0.79	0.76	0.73	0.70	0.67	0.64	0.61	0.58	....	....
56	5	0.84	0.81	0.78	0.75	0.72	0.69	0.66	0.63	0.60	0.57	0.54	....	....
62	1	1.13	1.10	1.07	1.04	1.01	0.98	0.95	0.92	0.89	0.86	0.83	0.80	....
62	2	1.08	1.05	1.02	0.99	0.96	0.93	0.90	0.87	0.84	0.81	0.78	0.75	....
62	3	1.03	1.00	0.97	0.94	0.91	0.88	0.85	0.82	0.79	0.76	0.73	0.70	....
62	4	0.98	0.95	0.92	0.89	0.86	0.83	0.80	0.77	0.74	0.71	0.68	0.65	....
62	5	0.93	0.90	0.87	0.84	0.81	0.78	0.75	0.72	0.69	0.66	0.63	0.60	....
72	1	1.32	1.29	1.26	1.23	1.20	1.17	1.14	1.11	1.08	1.05	1.02	0.99	0.96
72	2	1.27	1.24	1.21	1.18	1.15	1.12	1.09	1.06	1.03	1.00	0.97	0.94	0.91
72	3	1.21	1.18	1.15	1.12	1.09	1.06	1.03	1.00	0.97	0.94	0.91	0.88	0.85
72	4	1.15	1.12	1.09	1.06	1.03	1.00	0.97	0.94	0.91	0.88	0.85	0.82	0.79
72	5	1.09	1.06	1.03	1.00	0.97	0.94	0.91	0.88	0.85	0.82	0.79	0.76	0.73

$$C = \frac{W\,(100 - 4\,p)}{5{,}000} - (0.12H + 0.06)$$

in which W = the width of the roadway between curbs, in feet; p = the percentage of grade longitudinally on the street; H = the cross-fall of the street, or the difference of elevation between the high and low gutters, in feet,

*From Proceedings Am. Soc. C.E., for August, 1913.

and C = the height of the crown above the mean gutter grade, in feet.

It will be noticed that on a roadway having a very steep cross-fall the upper gutter will not hold water, which, in the majority of such extreme cases, will do no harm, and will very often save a cross-gutter at the intersection; however, it may be desired at some time to hold the water in the upper gutter, and this may be accomplished, without increasing the side slope of the surface, by shifting the crown to the upper side of the centre of the roadway as shown in Fig. 4, which indicates a special cross-section at that point.

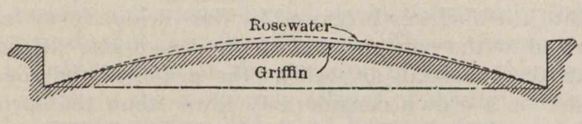

FIG. 1

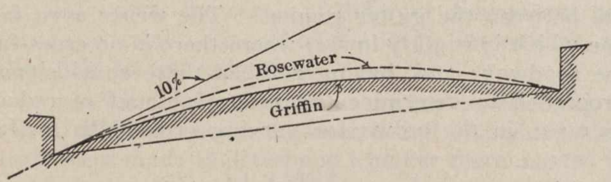

FIG. 2.

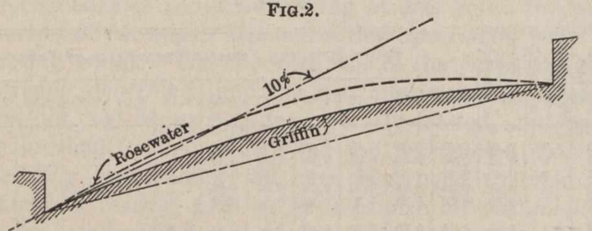

FIG. 3.

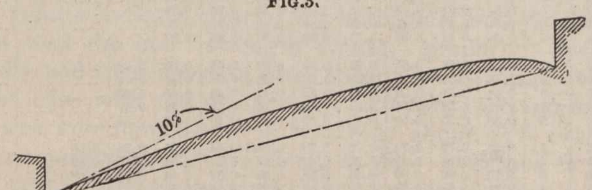

FIG. 4.

Table 1 is compiled from the formula for the more common roadway widths in Los Angeles.

Figs. 1 to 4 illustrate the comparison between Mr. Rosewater's formula and the modification herein proposed on a 40-ft. roadway having a 1% grade. Fig. 1 is for no cross-fall; Fig. 2 for a cross-fall of 1 ft. between the mean gutters, and Fig. 3 is an extreme case with a cross-fall of 2 ft. between the mean gutters. Fig. 4 illustrates a section in which the lower half meets the formula and the upper half is modified to hold the water in the upper gutter.

A new building material, known as "Tekton," which is being introduced in Glasgow, is stated to be of the nature of artificial wood and to possess the strength and durability of concrete. The ingredients of which the material is formed are magnesite, granulated slag, chloride of magnesium, and "wood flour," and its principal properties are that it is porous, has a low heat conductivity, and is sound-proof, fire-resisting, odorless, and not liable to develop dry-rot. It is made in boards and planks, or it may be modelled in any required shape. It is claimed to be particularly suitable for use in the construction of portable buildings which have to be erected rapidly and cheaply.

RAILWAY EFFICIENCY.*

By Mr. A. Crumpton,
Assistant Engineer, Grand Trunk Railway, Montreal.

THE product of a railway is transportation, and the measure of its efficiency is the quality and cost of producing the same. In transportation upon land the railway has proven itself pre-eminently superior to any other way. It is a far cry from a rate of $1 per ton per mile for "packing" upon men's backs, or even 25c. per ton mile by team, to ¾c. per ton mile, which is the average cost to the public by railways in America. Passengers in America pay an average charge of a little less than 2c. per mile, and a trip of 500 miles in 12 hours is common. Only the man on the inside realizes what this means, both as regards perfection and economy of construction and operation.

In Europe the average freight charge per ton mile is 1½c.—double what it is in America—while passenger rates run from 1¾c. to 2c. for third-class to 3c. to 4c. for first-class accommodation. This is only of interest as showing where we stand, but does not prove anything as regards relative efficiency, the conditions of construction and operation being different on the two continents.

In 1870, the average freight rate per ton mile was 2c. as against ¾c. in 1909, a reduction in 40 years of 62%.

Mr. W. M. Acworth, an international authority on railway economics, who from time to time inspects American railways in the interests of English investors, says: "It has been my opinion that in actual economy of operation the railways of the United States are first in the world."

A railway to continue and increase its efficiency must not only keep up its lines and equipment for current traffic, but must have means in advance to provide for increasing requirements. This country is rapidly growing in population and wealth, and there is an insistent demand for a better and more improved passenger service, faster freight service, and greater safety. Since these things, speaking generally, do not increase revenue they are a proper charge against operating expenses, and should be met by increased rates for transportation, where necessary. The peculiar fact is that while the public appreciates the situation in ordinary matters and expects to pay more for better pavements or better clothes, yet, in matters of transportation it demands better service but refuses to pay more for it.

When, in 1910, a large section of the railways of the United States made application to the Interstate Commerce Commission for authority to increase rates, they were met by statements alleging lack of scientific management—that a million dollars a day could be saved by increased efficiency—and their request was refused.

Detailed records of cost of building and maintaining railways and of conducting transportation have now to be kept by the railways, at the instance of the commission, and the appraisal of all the railways in the United States has just been ordered, so that, no doubt, any future question of rates will be dealt with in the light of the efficiency shown by the railways.

Briefly, it is claimed that the railways fail in efficiency as follows:

*Read before the Canadian Railway Club, September 9th, 1913.

(1) Maintenance of equipment, which consumes about 20% of total operating expenses.

"Railroad repair shops throughout the country do not show 50% efficiency on an average as regards either materials or labor."—Emerson.

(2) Maintenance of way, consuming about 20% of total operating expenses.

"Standards of maintenance of way vary, but innumerable assays of actual work show a maintenance-of-way labor efficiency of scarcely more than 30%."—Emerson.

(3) Transportation, consuming about 50% of total operating expenses.

"Fuel.—On the Santa Fe average fuel used per 1,000 freight train ton miles was reduced from 261 lbs. to 239 lbs. On the Chicago, Milwaukee & St. Paul, 175 lbs. Dynamometer Car, 80 lbs."—Emerson.

"It has been demonstrated that by proper instruction, fuel consumption could be reduced at least one-half."—Brandeis.

Terminal expense, particularly the handling of less than car load lots, should be improved by the use of mechanical conveyers.

Maintenance of Equipment.—A fair comparison cannot be made between industrial shops with uniform output and railway repair shops with little uniform work, particularly as such repair work is incidental to the main purpose of producing transportation, and while low cost is desired, expedition is primarily which is required.

Maintenance of Way.—The fact that maintenance-of-way forces may be scattered over thousands of miles of line makes adequate supervision difficult, and that the labor requirements vary with the season makes it impossible to always have the force as efficient as could be desired. The force required to man a thousand miles of line could be concentrated on one acre in a textile mill, so that comparisons of efficiency made under such conditions would be unsatisfactory.

Transportation.—Transportation forces are strongly organized and militant, largely increasing the difficulty of reducing labor charges, but by betterment of roadway and the use of heavier power the railways are effecting such economies as are possible. In this connection Mr. Emerson said: "The efficiency of the traffic by my standards is very high; that is, the efficiency of expense in the traffic departments."

As regards economy in fuel and in its use, this has ever been a subject of investigation on the part of the railways, as also that of mechanical conveyance.

It may also be said that railway development has been proceeding along logical lines. First, the period of railway building, then one of traffic organization and consolidation, followed by one of betterments, embracing perfecting of machinery, strengthening roadbed and bridges, cutting down grades and increasing the motive power and weight of trains. Now the human factor is coming in for increased attention and systems of organization are being studied to the end that the machine as a whole may be brought to the highest efficiency.

In this connection it will be interesting to examine the fundamental principles of scientific management as given by Mr. Frederick W. Taylor, its originator:

"1st.—Each man in the establishment, high or low, should daily have a clearly defined task laid out before him. This task should not in the least degree be vague or indefinite, but should be circumscribed carefully and completely, and should not be easy to accomplish.

"2nd.—Each man's task should call for a full day's work, and, at the same time, the workman should be given such conditions and such appliances as will enable him to accomplish his task with certainty.

"3rd.—He should be sure of large pay when he accomplishes his task.

"4th.—When he fails he should be sure that sooner or later he will be the loser by it.

"When an establishment has reached an advanced state of organization, in many cases a fifth element should be added, namely, the task should be made so difficult that it can only be accomplished by a first-class man."

The railway as a proposition is characterized by its great extent requiring unusual specialization in every branch and this has in the earlier days led to undue centralization and the creation of departments whose heads endeavored to perform both "staff" and "line" duties. A departmental organization of this kind, projected over large areas with distant headquarters, has proved cumbersome in operation, a breeder of departmental jealousies, and unsatisfactory to both the public and employees. This type of organization is now being superseded by one in which the "staff" and "line" functions are being separated. "Staff" functions, consisting largely of the theoretical side of the work, studying the underlying principles, whether physical or psychological, which make for efficiency in construction and operation; systematizing and standardizing every operation; providing instruction as to application and formulating means by inspection and otherwise for unerringly recording attainment, is necessarily the work of specialists.

Line functions, consisting of the more practical side of the active conducting and directing of the work is none the less the work of specialists and experts, but of execution rather than design.

Line officers are in charge of stated districts, representing the railway in general and not any particular department. Under this arrangement the different departmental activities are co-ordinated and all the advantages of the public and employees being brought into close touch with a responsible representative of the railway gained.

In line with this, the accounting for each district is done on that district, to the end that greater accuracy may be attained by first-hand knowledge and the officer in charge of the district be in possession of all the figures pertaining to the work for which he is responsible, thus enabling him to supervise more intelligently.

A further development follows—that is a common office and file. While merely a detail, this has proved of great value in reducing the volume of correspondence and locating upon one file everything that pertains to any given subject. The use of this system on the railways recently known as the Harriman lines saved half a million letters a year.

Since material as well as labor enters into the work of a district, it is logical that this, both as regards purchase and supply, should be as far as possible in the hands of the local man, in order that he may be informed on every point. In the larger matters, blanket contracts would be let and districts would simply order under these, while in minor matters, standard prices would be fixed and when goods could be purchased locally as cheaply, preference would be given to the district, thus decreasing handling and increasing the good-will of the local public.

The distribution of the prime functions of railway building and operation would be:

Headquarters.—Building of railway; construction of equipment; creating standards for conducting transportation, and for maintenance of roadway and equipment, as well as for the necessary instruction and inspection.

District.—Conducting transportation; maintenance of roadway; maintenance of equipment.

A superintendent with a staff expert in the above-mentioned lines, and first-hand knowledge through his accountant of actual costs to compare with standard costs, both of labor and material, would at all times know the relative efficiency of his district.

The strong feature of this type of organization is that with reasonable standards of work to be performed, everybody concerned from start to finish has something by which to measure his work. A New York contractor, as an experiment, arranged for each man to have a bucket to shovel into. Result—almost at once the number of buckets that came out of the hole was doubled.

The creation of standard practice, both as regards methods and cost, is merely an elaboration and extension to every operation of practice now in vogue on all railways. For example: it is decided to bring a line up to a certain standard. Careful account is taken of what exists, then the method of producing the desired result is determined, written instructions are given and the cost calculated. Or a new train service is to be put on. Its requirements are determined, time tables prepared and its cost calculated.

Working to standards throws into prominence any over-running of standard costs, and this acts automatically, and those in immediate charge of work look into the cause and remove it if possible, and if unavoidable keep proper records of its nature, for the creation of a new standard, if necessary.

Increasing Efficiency.—Efficiency experts have placed railway efficiency at 70% as against 60% in industrial concerns generally. While the total elimination of waste is impossible, certain classes of work have on many roads reached a much greater efficiency than the above average.

The first step should be to ascertain, tabulate and analyze present practice with particular reference to unit cost of performance. In most cases this could be done with little or no additional expense, simply the introduction of forms designed to this end in place of those now in use. The knowledge so obtained would be a basis from which to work, in fact, could be used as a standard of measurement pending the introduction of proper efficiency standards. Concurrently, present standard practice, as ascertained on one road should be compared with standard practice on other roads or elsewhere, and when a superior method is found it should be adopted. Plans should be made, written instructions prepared of every step of the operation, not only what is to be done but how, and a standard of cost provided.

The following is an example from shop practice: Mr. Emerson went to the Santa Fe and found the annual cost of maintaining belting was 100% of its first cost. From previous experience he knew that this figure should be about 14%. Having this to work on, the best belting obtainable was purchased, 5% above the market price being paid for the privilege of rejecting unsatisfactory belting. A man was put in charge of the belting with instructions that belts were to be kept in condition and replaced before and not after failure. Results—failures reduced from 300 a month to 50 and cost dropped from 100% to 14%. Incidentally machines were not delayed.

In the creation of standards details down to the tool or machine to be used for a given service are specified. For example, in section work the relative economy of hand cars and motor cars is ascertained. Cars are then studied, improved and standardized, and under given conditions, which is to be used is specified.

The following are a number of instances of increased efficiency given before the Interstate Commission:

1. When applied to the simple operation of loading by hand a railroad car with pig iron, the performance of the individual worker increased from 12½ to 47 tons per day.

2. When applied to shovelling coal, it doubled or trebled the performance of the shoveller.

3. When applied to machine work, it developed in certain operations, increases in production, ranging from 400 to 1,800 per cent.

4. When applied to bricklaying, the day's accomplishment rose from 1,000 to 2,700 bricks.

It should be borne in mind that in dealing with this side of the question that a representative of railway labor appeared before the commission and stated that the methods referred to could not and should not be introduced into railway work. In like manner the introduction of the Mallet Compound locomotive was strongly resisted by the Brotherhood of Locomotive Engineers, and organized efforts were made by conductors and trainmen to have double-heading prohibited. The fact is that labor organizations, notwithstanding the good which they have accomplished, are, as at present constituted, by their very nature, detrimental to efficiency. Employees in their respective classes are allied with like classes on other railways, for the furtherance of their particular class interest, and where this interest demands it, the interests and rights of fellow-employees, the public and the owners are made subordinate to their own. With the railway the tendency is to make the standard the pace of the fastest while with the union it is towards that of the slowest. The reasonable standard is somewhere between these extremes and should be scientifically determined, both as regards performance and remuneration, and the present system of highly organized labor holding a pistol at the head of the railways, to the detriment of classes less highly organized should be abolished. It would not be easy and would take much time, but it is conceivable that with a scientifically arranged and, therefore, equitable schedule of wages covering every branch of railway service, the settlement of schedules would become a matter peculiar to each railway and not determined by conditions on other railways having no bearing on the case. Such an arrangement would at least be an effort to give a "square deal" to all classes of employees.

As showing the way how not to create standards I quote the following from "Scientific Management of Railways," by W. J. Cunningham:

"The year 1910 saw the successful culmination of an ambitious plan to 'standardize' the wages of conductors, trainmen, and yardmen in the Eastern States; that is, to set a uniform rate per day, per hour, or per mile for each class of service, regardless of local conditions. The road with the highest wage scale (the Baltimore & Ohio) was selected as the battle ground, and the entire forces of the train-service brotherhoods focused upon it in a demand for new and unreasonably high rates. To prevent a strike the railroad invoked the aid of the Board of Mediation under the Erdman Act, and the award, while not granting the rates demanded, carried with it substantial increases over rates already considerably higher than those of other roads in the East with distinctly different operating characteristics. The new basis was then in turn forced upon practically every road in eastern territory. The increases in New England averaged between 20 and 30 per cent., and in some cases exceeded 50 per cent. At the same time long standing differentials between different grades of employees were seriously disturbed. Throughout, the new wage basis and working rules (prescribed partly by governmental mediation) are far from scientific or equitable."

Cost keeping must be systematized with the same care as other operations and be beyond criticism to be effective. The old saying that there are "lies, d—— lies and statistics" had its origin, no doubt, in poor cost-keeping. There is a story told of a locomotive standing in the shop waiting for small repairs where costs were carefully (?) kept and everything had to be charged. The old locomotive came in for all doubtful and odd charges until, at the end of three months, it had $5,000 charged against it.

If time is wasted it should be known as surely as if material is wasted and should be considered a reflection upon the system rather than upon the individual. The trouble is that where standards are lax there is an uncertainty as to where such waste is taking place, and advantage is taken of this to let the matter go.

Cost-keeping as above is becoming necessary to comply with the requirements of the Interstate Commission.

The phase of the situation which is the peculiar problem of to-day—that is, the bringing of the human factor in the machine up to standard—is first and last a matter of men, the production of highly trained men, for however efficient in design an organization may be, its real efficiency is measured largely by the human element. Unfortunately, under present conditions, a man enters railway life at the point of least resistance and gets where he can by force of circumstances and native wit. The result is that thousands of men are struggling to hold positions for which by nature they are largely unfitttd. For certain railway positions men are specially selected, the unfitted being rejected. Why should this not be the case for all? For practically every class of material used specifications have to be complied with, and a certain standard attained to be accepted. Why should this not be the case with men? Psychology has made such strides that it is conceivable that a bureau for the purpose could, after some experience, pass upon all applicants, and after deciding upon their general fitness or unfitness for railway work, guide as to the particular class of work for which they are best adapted. Inefficiency under present conditions is often as much a matter of circumstances as any fault of the individual.

When once accepted for railway service a boy or man should have definitely placed before him the necessity for qualifying for the position ahead, and failure to respond should be taken as an indication of unfitness for his particular work or lack of ambition, and the case should be dealt with accordingly. Vocational training has many enthusiastic advocates among railway officers, and is more or less the practice on some of our large systems, so that the material is not wanting for the elaboration of this idea.

The intelligent application of the principles briefly outlined above was the means by which the German army became well nigh invincible, and the nation has in a generation by scientific administration and rational educational training of its people, notwithstanding the poverty of its natural resources, passed from inefficiency to the front rank among the nations of the world.

The nucleus of the foregoing exists on the railways as operated to-day and all that is needed is that present practice should be brought up to date to meet expanding needs, and more thoroughly understood by all concerned. Speaking generally, what we need is a better understanding between head and hand, the proper blending of theory and practice; the creation of a feeling down to the last man that the railway interests are his and that in furthering its interests he is furthering his own.

THE WATER SUPPLY OF PARIS.

THE city of Paris is supplied with water from many different sources, and the distribution of the supply is under the control of several separate companies, and in part only by a committee of the municipality. Samples of the water from each of the supplies are taken each week and examined chemically and bacteriologically at the municipal laboratory at Montsouris, by Mr. F. Diénert, the official chemist and bacteriologist to the city of Paris. The results are published from time to time in the official municipal bulletin of the city. The bacteriological results, for a period of six months, from September, 1912, to March, 1913, as recently published in Engineering, London, are set forth in Table I. from which a comparison of the results obtained by the various systems of water purification may be made.

In the case of the four large service reservoirs at Paris, supplied respectively by aqueducts from the rivers Marne, Loing, Dhuis, and Avre, it will be noted that the bacteriological results are extremely variable, depending to a large extent on the rainfall and consequent state of each river. With regard to the filtered water supplies, the following is a brief summary of the systems employed at the various works.

At Choisy-le-Roi the raw water of the Seine is first passed through Anderson revolving purifiers, by means of which a certain quantity of ferrous oxide of iron is taken out by the water as it flows through. This iron is precipitated as ferric oxide in labyrinth settling-tanks—that is to say, decanting basins—through which the water is made to flow in a continuous stream by means of baffle-walls from inlet to outlet. Recently, however, this system has been partly abandoned, and one-half of the labyrinth settling-tanks have been transformed into roughing-filters, after which the water passes to ordinary sand filters. The roughing filters are scraped by means of the Boistel automatic machine.

At Neuilly the water of the Marne is treated by the ordinary system of decanting-basins and sand filters. At Nogent-sur-Marne decanting-basins, roughing-filters, and slow sand filters are employed. At Ivry Puech "degrossisseurs" were installed some 14 years ago, but the water passes direct from these on to slow filters, instead of being passed through coarse-sand pre-filters in series between the degrossisseurs and sand filters, as in the case of more modern installations on the Puech-Chabal system. At St. Maur, roughing-filters of the ordinary type are employed previous to slow sand filtration, after which the water of the Marne is passed through ozone sterilizers.

Week Ended	UNFILTERED WATER SUPPLIES. Montsouris Reservoir. River Vanne Water.	Montsouris Reservoir. River Loing Water.	Menilmontant Reservoir. River Dhuis Water.	Montretout Reservoir. River Avre Water.	FILTERED WATER SUPPLIES. Choisy le-Roi. Raw Water (Seine).	Choisy le-Roi. Filtered Water.	Neuilly. Raw Water (Marne).	Neuilly. Filtered Water.	Nogent-sur-Marne. Raw Water (Marne).	Nogent-sur-Marne. Filtered Water.	Ivry. Raw Water (Seine).	Ivry. Filtered Water.	St. Maur. Raw Water (Marne).	St. Maur. Filtered Water.	St. Maur. Water after Sterilisation by Ozone.	St. Maur. Water from delivery Mains.	Suresnes. Raw Water (Seine).	Suresnes. Filtered Water
1912.																		
Sept. 29	60	150	300	40	4,400	80	900	50	1,600	10	6,200	28	8,100	420	1	—	116,000	29
Oct. 6	286	132	310	242	—	—	400	308	300	36	148.350	41	2,400	36	2	—	144,300	13
Oct. 13	90	90	310	400	12,770	145	2,000	50	—	—	11,760	42	700	14	0	—	56,000	63
Oct. 20	135	120	110	250	54,785	271	34,390	70	—	—	41,730	91	5,500	14	0	—	81,320	66
Oct. 27	250	230	260	870	40,985	659	5.500	214	—	—	61,270	64	19,450	40	249	—	88,200	32
Nov. 2	787	733	4012	305	5,670	27	15,360	130	—	—	10,920	50	12,720	10	113	—	58,500	35
Nov. 9	610	260	453	874	52,115	535	50,180	576	—	—	25.270	42	18,120	24	—	—	40,000	28
Nov. 16	523	329	370	245	12,600	237	21,200	220	—	—	14,200	51	29,200	230	—	80	21,700	41
Nov. 23	129	172	473	868	34,800	260	3,600	28	—	—	580	44	7,900	60	—	199	32,300	71
Nov. 30	87	122	2446	562	14,600	112	34.060	160	—	—	12,400	220	20,800	160	—	219	22,000	20
Dec. 7	740	210	2496	350	44,710	375	45,000	361	—	—	64,370	270	14,900	20	—	152	42,000	32
Dec. 14	210	205	540	689	37,740	880	19,700	470	—	—	30,400	215	13,000	110	—	278	117,120	18
Dec. 21	510	420	911	1662	32,400	120	15,100	170	—	—	84,200	181	12,500	165	—	1170	55,620	17
Dec. 28	462	420	911	1408	69,440	840	24,200	218	—	—	82,080	104	15,600	235	—	158	21,450	19
1913.																		
Jan. 4	260	363	291	803	33,400	660	—	—	—	—	22,600	60	34,000	510	—	156	30,800	16
Jan. 11	297	143	253	286	21,350	665	30,250	88	—	—	35,480	26	28,800	215	—	190	20,900	6
Jan. 18	200	195	1254	310	21,400	540	120.250	412	—	—	29,200	63	46,600	115	—	133	4,500	19
Jan. 25	440	722	816	570	126,600	1930	96,200	547	—	—	102,370	58	44,800	390	—	203	43,450	33
Feb. 1	968	401	816	1331	97,300	2015	120,250	412	—	—	44,770	70	25,600	455	—	410	85,250	14
Feb. 8	975	358	606	406	51,000	570	30,450	445	—	—	23,520	59	47,200	650	—	920	74,400	19
Feb. 15	92	82	312	356	10,200	330	11,570	33	24,360	375	24,000	54	34,000	1620	—	690	24,680	14
Feb. 22	126	154	341	210	9,600	490	5,500	25	6,000	427	21,200	116	13,600	559	—	190	12,100	15
Mar. 1	749	209	962	713	12,000	530	20,600	1084	36,720	4115	21,400	—	14,600	295	—	806	75,820	59
Mar. 8	125	195	962	442	12,400	580	17,080	840	1,059	30	35.420	187	15,400	155	1	144	46,360	59
Mar. 15	89	52	203	160	20,800	304	2,250	17	6,250	90	22,200	67	25,200	175	1	420	10,550	24
Mar. 21	125	81	748	934	—	—	—	—	—	—	39,933	158	46,600	560	4	168	56,500	29

TABLE II.—SUMMARY OF RESULTS AT FILTERING STATIONS.

Total Bacteria per Cubic Centimetre after an Incubation of Fifteen Days.

—	Average.	Highest.	Lowest.
Choisy-le-Roi, (Seine)—			
Raw water	34,711	126,600	5,670
Filtered water	544	2,015	27
Neuilly, (Marne)—			
Raw water	30,249	120,250	400
Filtered water	288	1,084	17
Nogent-sur-Marne, (Marne)—			
Raw water	11,041	36,720	300
Filtered water	726	4,115	10
Ivry, (Seine)—			
Raw water	39,070	148,350	580
Filtered water	96	270	28
St. Maur, (Maine)—			
Raw water	21,434	47,200	700
Filtered water	278	1,620	10
Ozone sterilizers	42	249	0
Supply mains	352	1,190	80
Suresnes, (Seine)—			
Raw water	53,533	144,300	4,500
Filtered water, (mains)	33	82	6

All of the above filtering stations draw their supplies from the Marne or Seine above Paris. At Suresnes the raw water of the Seine is drawn from the river after it has received the refuse from the city. It is pumped to the filtering station on Mont Valerien, where it is treated by a complete modern plant of multiple filters on the Puech-Chabal system., consisting of four series of degrossisseurs, coarse-sand pre-filters, and final slow sand filters. The pre-filters and sand filters are all fitted with automatic regulators.

The summary of the results, given in Table II., clearly shows that the more elaborate the filtration plant the more regular are the bacteriological results; and although at Suresnes the raw water contains a far higher number of bacteria per cubic centimetre than at any other filtration station, the results are extremely regular, the highest figure recorded in the final filtrate being 82 per C.C.; the average 33 per C.C., and the lowest 6 per C.C.

The samples at Suresnes are drawn from the supply mains after the water has been stored for about two days in the service reservoirs. At St. Maur it is curious to note that while the sterilizers occasionally eliminate all the bacteria, these appear again in the supply mains, after the operation of sterilizing, in apparently higher numbers than those found in the filtered water before sterilizing.

At Ivry a sterilizing installation on the ultra-violet-ray system has recently been installed; and it will be interesting to note in a future summary of the bacteriological results, whether the bacteria are augmented in this case also after sterilization. Unless filtration is carried out with a due regard to the time necessary for nitrification, the effluent is frequently too highly charged with organic matters in solution, and a possible explanation is that the bacteria afterwards found in this water are nitrifying bacteria, which would naturally multiply rapidly until they had fulfilled their function of mineralizing the organic matters in solution. It should be stated that the whole of the figures in the table are obtained by the French system of counting the colonies after an interval of 15 days.

The Canadian Engineer

ESTABLISHED 1893.

ISSUED WEEKLY in the interests of
CIVIL, MECHANICAL, STRUCTURAL, ELECTRICAL, RAILROAD, MINING, MUNICIPAL, HYDRAULIC, HIGHWAY AND CONSULTING ENGINEERS, SURVEYORS, WATERWORKS SUPERINTENDENTS AND ENGINEERING-CONTRACTORS.

Present Terms of Subscription, payable in advance
Postpaid to any address in the Postal Union:

One Year	Six Months	Three Months
$3.00 (12s.)	**$1.75** (7s.)	**$1.00** (4s.)

Copies Antedating This Issue by More Than One Month, **25** Cents Each.
Copies Antedating This Issue by More Than Six Months, **50** Cents Each.
ADVERTISING RATES ON APPLICATION.

JAMES J. SALMOND—MANAGING DIRECTOR.
H. IRWIN, B.A.Sc., EDITOR.
A. E. JENNINGS, ADVERTISING MANAGER.

HEAD OFFICE: 62 Church Street, and Court Street, Toronto, Ont. Telephone Main **7404, 7405** or **7406**, branch exchange connecting all departments. Cable Address: "ENGINEER, Toronto."

Montreal Office: Rooms 617 and 628 Transportation Building, T. C. Allum, Editorial Representative, Phone Main 8436.

Winnipeg Office: Room 820, Union Bank Building. Phone M. 2914. G. W. Goodall, Western Manager.

Address all communications to the Company and not to individuals.

Everything affecting the editorial department should be directed to the Editor

The Canadian Engineer absorbed The Canadian Cement and Concrete Review in 1910.

NOTICE TO ADVERTISERS

Changes of advertisement copy should reach the Head Office two weeks before the date of publication, except in cases where proofs are to be submitted, for which the necessary extra time should be allowed.

NOTICE TO SUBSCRIBERS

When changing your mailing instructions be sure and give your old address in full as well as your new address.

Printed at the Office of The Monetary Times Printing Company, Limited, Toronto, Canada.

Vol. 25. TORONTO, CANADA, SEPT. 18, 1913. No. 12

CONTENTS OF THIS ISSUE.

THE ROAD CONGRESS IN DETROIT.

Now that Canada has fully entered upon a new era of road development whereby the introduction of heavier, faster and more numerous traffic will be met by the adoption of more scientific methods in road engineering, Canadian municipal and highway engineers should come forward with keener desires for closer relations with those in the van of highway engineering throughout the world. It was not the good fortune of many to have been able to attend the London Congress in June. Doubtless the substantial gain therefrom in acquiring a fund of information of utmost practical value to them in their work would have vindicated the sacrifice of time and duties, had not such factors so strongly asserted themselves at that stage of the summer. From those who did attend Canada hopes to acquire many improved ideas, of practical value.

The Canadian Engineer has several times, of late, called the attention of its readers to the Third American Road Congress, Sept. 29th to Oct. 4th, in Detroit. The official programme appeared in Sept. 4th issue. No phase of highway work seems to have escaped the designs of the committee responsible for the programme, and the coterie of speakers is a substantial inducement in itself.

The educational advantages of the Congress should be grasped by Canadian municipal authorities. Many municipalities are not content with traffic conditions, and, while on the lookout for the essentials of better construction, their officials should not overlook the Detroit meeting, where papers and discussions will provide them with the brand of information which they find to be indispensible. Considering the enthusiasm which is being put into the movement for better Canadian roads, and the value that the Third American Road Congress will prove itself to be in this respect, a good representation of Canadian highway and municipal engineers should be in evidence.

EDMONTON'S WATERWORKS PROBLEM.

Like many another city, Edmonton has before it an acute problem in the acquiring of a better and a greater water supply. The question has been under heavy fire during the past year. Like many a western city, also, geographical and other conditions forbid placing material reliance, toward a solution, upon the designs carried out in the older and slower-growing cities of the East. The application of engineering skill must be direct. A thorough conception of principles underlying water service, blended by an exhaustive knowledge of all contingent conditions of the past and present, and a judicious forecast for the future, makes it a problem that only highly qualified engineers may be relied upon to handle. A water problem for a city differs from city planning, street paving, transportation, and others prominent in the category of municipal affairs, in that it has such a direct bearing upon life and health. It thereby maintains a degree of importance calling for the best, whether or not the attached expenditure is away and beyond comparison with that for other municipal works. Water supply is the chief contender for the most expert attention and advice in any municipality.

Edmonton is certainly not exempt from difficulties in the way of a pure supply, and the civic authorities are fully awake to the acuteness of the situation. The Saskatchewan River, the only feasible source, flows directly through the city, and its water is subject to dangers of pollution from various causes. Again, the growth of the city has been phenomenal. From a town of about 2,600 in 1901, it has grown into a city with a population approximating 67,000, practically doubling its number of citizens every four years. Indications point to continued development, wherein lies a weighty and perplexing problem for the engineer who sets about to design systems for the requirements of future years. The average life-time which considerable portions of such a system may attain is 30 or 40 years. It need hardly be wondered at, that there are radical differences, at times, in the opinions of highly competent engineers, in their endeavors to find the best solution to problems such as Edmonton's. One point is clear: an adequate and consistently pure supply of water in the service mains commands superiority over antagonistic factors of speedy installation, low first cost, low operating costs, etc. In the consideration of the reports now in its possession, the city of Edmonton should keep constantly in the foreground the desirability of establishing a system that will provide such a supply; that may be extended as the city grows without unnecessary scrapping of plant before its day of usefulness has expired; and that will not be lacking in efficiency throughout its life-time, as a result of curtailment of initial expenditure with an aim at economy. For it must be acknowledged that, owing to the indefiniteness of the city's needs twenty or even ten years hence, the most careful aim at true economy in the construction and operation of the system may fall very widely off the mark. It remains, therefore, to make now the safest selection of source; then choice of the best site, and economic factors may enter the problem. Indefiniteness of future requirements makes the latter subsidiary to the former.

A NEW TRAIN CONTROL.

Mr. F. W. Prentiss, of Toronto, recently conducted a very successful demonstration of the Prentiss system of automatic "wireless" train control, of which he is the inventor, at the Hampton Court Station of the London and South Western Railway (England). In this system the track is divided into a number of insulated sections, in each of which a low-voltage track circuit is arranged, with, in addition, a high-tension wave wire running between the rails. At the end of each section is a box containing the high-frequency plant for the supply of current at 20,000 volts to the wave wire. This plant is controlled by a relay in connection with the track circuit of the section ahead, with the result that if that track circuit be short circuited the controlling relay is de-energized, and the supply of high-tension current to the wave wire ceases. The locomotive is fitted underneath with an arrangement of wires equivalent to the antennæ of the ordinary wireless apparatus. These receive the energy transmitted from the wave wire, and by means of a system of coherers and relays in the cab a green "line-clear" signal is provided for the driver if the section ahead is unoccupied. If, however, the section ahead be short circuited the wave discharge ceases, and a red light is shown and a buzzer simultaneously sounded, while the brake is at the same time applied, these operations being effected by power obtained from a battery in the cab. Provision is made to enable the driver to release his brake, but the red light and the buzzer continue until the section ahead is cleared, when the high frequency supply is re-established and normal working is resumed. The system, therefore, provides for a continuous danger signal on the locomotive so long as the line is not clear, the automatic application of the brake and a prompt intimation of the restoration of line clear conditions. In the event of failure of the high-tension, or the track circuit danger indications would be given. The operation of the cab apparatus naturally depends on uninterrupted battery supply. The demonstration was quite successful, the train being brought up on every trial by the automatically applied brake, although the regulator was untouched. The system requires electrical supply to all the section-boxes, and transformer plant in each section-box, in addition to the boxed-in high-tension wire between the rails and the apparatus on the engine. The expense question is therefore one which will have to be seriously considered before the system is likely to be largely adopted. In addition to initial cost the working cost must also be taken into account, the power taken by a half-mile section being about 1 horse-power.

COST OF WOOD BLOCK PAVEMENT.

In an article on street and pavement construction, which was published in our issue of September 4th, 1913, the following paragraph appeared on page 410:—

"In Hamilton this pavement (creosoted wood block) has become so popular that some residential streets have petitioned for it on account of its quietness; although it is a costly pavement, running from \$2.25 to \$2.65 per square yard, according to the kind of block, whether plain or grooved for heavy grades. All of these pavements have assumed a concrete base 6 in. thick at least on business streets, with a mixture not less than 1:3:6, which will cost from 50 cents to 60 cents per square yard."

Some readers are evidently under the impression that the city engineer of Hamilton, who was the author of the above article, meant that the cost of the foundation was included in the "\$2.25 to \$2.65." This is not the intended meaning. The cost of the foundation is extra, and the wood block is estimated by Mr. Macallum to cost from \$2.25 to \$2.65 per square yard, assuming that it is to be laid on a good concrete foundation.

In this article also the second paragraph of the second column of page 409 refers to "a temperature not less than 28%," where "28° F." was intended.

For the equipment of the two new battleships now being built at the Government dockyards of Lorient a crane of the Goliath type has been put in service, able to deal with a load of 150 tons, divided between two parallel travelling crabs of 75 tons, which can work separately or simultaneously. The crane consists of an inner framework or tower, surmounted by a platform which supports a cast-steel roller path, and of an outer slewing framework carried on the supporting tower. The lower part of the outer framework is fitted with rollers running on the roller path, which is of 14m. outside diameter. The jib has a total length of 70m., and is composed of lattice girders spaced 6.40m. from centre to centre. The crane has a maximum radius of 23m. with 150 tons and 39m. with 75 tons; a lifting speed of 1.50m. a minute with 150 tons, or unloaded of 4m. a minute; and a speed of horizontal motion of 8m. a minute with 150 tons. The upper part of the jib is fitted with a runway on which travels an auxiliary crane of 20 tons, designed with a lifting height of 60m. and a lifting speed of 10m. per minute (loaded). The crane has been successfully tested with a load of 180 tons at 23m. radius and with 90 tons at 39m. radius.

THE WATER SUPPLY OF EDMONTON, ALTA.

A DESCRIPTION OF THE PRESENT SYSTEM—SOURCE OF SUPPLY UNDER DISCUSSION — IMMEDIATE EXTENSIONS NECESSARY—RECOMMENDATIONS AND ESTIMATED COSTS*

THE water supply for the north side of Edmonton is drawn from the Saskatchewan River through intake pipes, and pumped by low-lift pumps to a sedimentation basin, in which the bulk of the solids are deposited. Hypochlorite of lime is applied to raw water before its entry into the basin. The water then flows by gravity to a battery of filters, thence to a clear water basin. By high-lift pumps the purified water is forced directly into the distributing mains, the normal pressure of 100 pounds being raised to 120 pounds, or thereabouts, for fire service.

The south side is supplied with water by an independent pumping station, without sedimentation or filtration. A submerged force main was partially laid during last winter. When the low stage of the river arrives this main will be completed and the south side will be supplied by filtered water from the main system. The mains and service pipes on the south side are now being filled with liquid mud that flushing cannot completely remove. Treatment by hypochlorite of lime is relied upon solely to reduce the bacteria.

Three intake pipes have been laid to date, not including the original intake of 1902, which was abandoned some years ago. One of these three is available during the winter months only; a second was blocked during the high water in 1912 and has not yet been cleared; the third, completed in 1913, is now furnishing the supply. This last is a 36-inch steel pipe provided with an intake crib located about 200 feet from the shore.

The low-lift machinery comprises three units, all steam-driven turbine pumps, and with a daily capacity of 12 million gallons. There is also an electrically operated turbine pump of three million gallons capacity which is used during winter months only. The high-lift machinery comprises two pumps of two and a half million gallons total capacity, steam-driven, now held in reserve in the original pumping station, a vertical Inglis plunger pump with a normal capacity of six million gallons, seldom operated, and two turbine pumps of the same capacity that are now relied upon for the normal supply. Two electrically operated turbine pumps, each with a capacity of 10 million gallons, are in the course of erection, and an additional low-lift, steam-driven unit of 18 million gallons capacity is on order.

In the original system an open sedimentation basin of less than one million gallons capacity was constructed, which gave satisfactory results. This basin is not now in use as part of the waterworks system. Another open basin has been constructed, with a capacity of about one and a half million gallons, into which the low-lift pumps discharge. By a central longitudinal baffle partition, the water entering at one corner is forced to flow from end to end, returning through the other half of the basin, the greater part of the silt being deposited near the inlet. This basin effects the removal of about 95 per cent. of the solids in suspension during the periods of maximum turbidity.

In 1910 the Roberts Filtration Company installed a temporary filtration plant comprising eight units, which, for various reasons, was not entirely satisfactory. In 1911 the company added four additional units of steel, the former units being of wood. Last season the results were more satisfactory, but not entirely so. This filtration plant is in the open, unhoused, and cannot be operated during the winter. In the autumn the filters are emptied, the filtering materials being replaced in the spring. The drying out of the wooden tubs caused them to leak and the cost of emptying and refilling them was no small item. This year the plant was overhauled, different sand used, and the results during July have been most satisfactory. The plant can now easily filter six million gallons daily, the effluent being perfectly clear, and the turbidity zero. Filtration alone materially reduces the bacteria present, but sufficient examinations and analyses have not as yet been made to warrant a statement being presented of the actual reduction made.

The city has under consideration an additional filtration plant of five million gallons daily capacity, comprising coagulating basins, filters, clear water reservoir, laboratory and chemical room, the entire plant to be enclosed in a suitable building.

The distribution system includes the following lengths of mains and sizes, laid to June 30th, 1913:

20-in.,	8,112 feet	14-in.,	5,923 feet	8-in.,	88,696 feet
18-in.,	2,889 feet	12-in.,	20,969 feet	6-in.,	343,419 feet
16-in.,	2,145 feet	10-in.,	40,517 feet	4-in.,	69,306 feet

This makes a total of 110.22 miles of pipe. Of the total distribution system over 70 per cent. is 6 in. and 4 in. in diameter, which is claimed to be too high a proportion for a waterworks system.

Necessity of Extension and Investigation of Supply.—The present unsatisfactory condition of the existing waterworks system in Edmonton is largely due to the unsettled question: Shall the supply continue to be drawn from the river at the present pumping station site, or shall the supply be taken from a source less liable to future pollution?

The demand for water is rapidly increasing, and additions to the present pumping plant are urgently needed. Further, improvements are required in the filtration plant and larger force mains are necessary to give proper fire protection.

Source of Supply.—There is no doubt that the city of Edmonton must rely upon the Saskatchewan River for its present and future water supply. The distance from the Rocky Mountains precludes mountain streams, and the elevations of the streams to the northwest, west and southwest of the city are insufficient to give a great supply. Pigeon Lake, distant about 42 miles southwest of the city, has been suggested as a source, but the conditions, when carefully studied, lead to the conclusion that it would not yield the requisite supply, neither would the quality of the water at all times be satisfactory, even after

*From a report dated August 9th, 1913, by Willis Chipman, C.E., to the City of Edmonton.

filtration. The capital cost of the project would be excessive. Further, it would only be a waste of time and money to investigate the possibility of securing a water supply from small streams and lakes or from deep wells. The city requires an unlimited supply of water, suitable for domestic and industrial purposes, delivered at a reasonable cost. This can only be supplied by the Saskatchewan River which flows through the city.

Quality.—Above the city the river water is free from sewage pollution, and there is no immediate prospect of cities or towns springing up upon the main stream or any of its tributaries between the city and the Rockies. The most serious objection to the river water is its turbidity, in which respect it resembles the Missouri at St. Louis, the Ohio at Cincinnati, and the Red River at Winnipeg.

During the months of May, June and July, 1911, the turbidity ranged from 5 to 850, and the solids in suspension from 167 to 2,260. During the same months in 1913, the turbidity ranged from 40 to 950, the average being 215.

The melting snow in the mountains during hot days or heavy rains produces great fluctuation in the river, from ten to twenty feet being the difference between low-water and high-water. In 1899 a level of 35 feet above low-water was attained, the highest observed since a traditional flood about sixty years ago.

High water is invariably accompanied by high turbidity, due to the caving in of cut banks. But during the late autumn and winter months, when the river is ice-bound, the water is clear, and for a month or more after the ice leaves the turbidity is low.

By the simple process of sedimentation, 95% of the solids may be removed, and the remaining 5% by filtration, the effluent being clear and sparkling. With a turbidity approaching 1,000 in July, 1913, the effluent from the filters was perfectly clear.

The hardness varies from 50 to 100 in the summer months, and the alkalinity from 100 to 200.

Recently bacteriological examinations of the river water have been made at the Provincial Laboratory, and show a high bacterial count. Sedimentation and filtration remove a large percentage of these bacteria, but treatment by hypochlorite of lime is relied upon to destroy those remaining.

The typhoid outbreak which occurred in September, 1912, was not attributed to the public water supply by the health authorities. The cause, however, has not been determined, and there is a likelihood that the water supply may have been contaminated, as the filtration plant was not working satisfactorily at all times. This season, however, the treatment of the supply is receiving more careful attention and the typhoid rate is below the normal.

Quantity.—The average quantity of water required for all purposes in cities of 100,000 population is about one hundred gallons per capita, where the services are unmetered. In metered cities the consumption varies from fifty to seventy-five gallons, the average being about sixty-six gallons; that is, by metering the capacity of the entire plant is increased by fifty per cent. As Edmonton is now an unmetered city, the consumption may be taken at one hundred gallons per capita.

At the present time about 40,000 people are supplied from the waterworks system, which is approximately sixty per cent. of the population. The maximum daily consumption frequently exceeds the average by fifty per cent., and the maximum rate of consumption may be double that of the average for the year.

The approximate quantities of water necessary for a city supply is presented below in tabular form, for different populations, where the supply is by the direct pumping:

Population	70,000	100,000	150,000	200,000
Gallons, daily average ...	4,000,000	6,000,000	9,000,000	12,000,000
Gallons, maximum average.	8,500,000	12,000,000	18,000,000	24,000,000
Fire streams required	21	25	31	35
Rate for fire supply	6,000,000	7,000,000	9,000,000	10,000,000
Total rate ...	14,000,000	10,000,000	27,000,000	34,000,000
Underwriters' requirements ..	14,000,000	17,500,000	24,500,000	30,000,000

River Pollution.—The Saskatchewan, like all rivers in an agricultural country, is polluted to a certain degree by surface drainage, and in the growing district surrounding Edmonton, this pollution will increase until the country is fully settled. This surface pollution cannot be prevented. Further, the April break-up of ice in the river, which has served as a highway during the winter months, produces a serious pollution for some weeks. This cannot be prevented, either. Both of these sources of pollution are more intense at the present waterworks intake than at points farther up the river, outside the city limits.

The greatest danger from pollution, however, is from storm water discharging directly into the river, conveying into it street washings, catch basin contents, etc. Likewise, domestic sewage may find its way into the river. Such dangers will increase annually. Disease germs therefrom cannot be entirely eliminated by sedimentation and filtration, although those remaining after such process may be destroyed by hypochlorite treatment. Not being in accord with the theory advanced recently that because it is possible to sterilize an impure water, it is therefore perfectly safe to adopt a cheap polluted water supply and trust to filtration and chemical treatment to insure safety, Mr. Chipman recommends that the future water supply for Edmonton be taken from the river at some point above the city limits. This conclusion is based upon a preference to secure the purest water obtainable, whereby less trust need be placed upon the efficiency of purifying apparatus, and chemicals, and the skill of employees.

New Works.—If new works be decided upon they will be of such magnitude that it may require three years for their completion after construction has commenced, while fully one year may be necessary in making surveys, in locating on and securing the land and right-of-way. Preliminary engineering work of this character is frequently so hurried that the best results are not obtained. It will also take time to provide transportation for building materials, plant, machinery, supplies, etc., and the fuel problem must also be satisfactorily solved before proceeding with construction.

To meet the demand for water during the period the new works are under construction, and until they are completed the existing pumping plant must be maintained and extended. The report deals fully with these extensions, a cost summary of which appears in a later paragraph.

Criticism of the Rabbit Hill Project.—Considerable space is given to the consideration of the Rabbit Hill scheme, as described in the previous report of a board of engineers. This hill is situated on Sec. 36, Twp. 52, R. 25, distant about six and one-fourth miles in a straight line from the Parliament Buildings and two and one-half miles east of the river. The elevation of the extreme top of the hill is 152 feet above the general elevation of the city. This pinnacle, however, is limited in area, and slopes rapidly in every direction. The hill is of sand, and reservoirs and other works erected upon it would demand careful construction.

In this project it was proposed to locate the pumping station on the Prison Farm (Sec. 33) or in that vicinity, pump the raw water to Rabbit Hill, where sedimentation basins and filtration works were to be constructed, also a clear water reservoir, the clear water to flow by gravity to the city. In his criticism, Mr. Chipman refers to several weak points in this proposition. In the first place, turbid water should not be pumped through a long pipe line. The sedimentation basins and filtration plant should be located as near the pumping station as possible, and such works will occupy a considerable area of ground, when the city attains 200,000 population. The elevation of the ground at the Prison Farm does not furnish an ideal pumping site, the flats below the escarpment being below flood level. The pumping station might be constructed near the river at a point above flood level, the water pumped to basins on the plateau above, treated there and returned to the pump-house below.

From the pump-house the water would then be pumped to a clear water basin on Rabbit Hill, with not less than five millions of gallons capacity. The topography of the hill is such that it would be practically impossible to construct a reservoir of more than ten millions of gallons capacity. From the reservoir, the water would flow to the city by gravity. The static pressure on the north side of the city from the reservoir would be 130 feet or 56 pounds, but with ten million gallons flowing through one 36-inch main, the friction loss would be 16 pounds at the centre of the city. In the outlying sections the loss would be from 20 pounds upwards, depending upon the consumption and the size of the mains. With twenty millions discharging through one pipe, the friction loss would exceed the head from gravity. Three conduits would be then required—two for constant service, one for reserve—in order that 30 pounds to 40 pounds might be available for average domestic supply, as pointed out previously. The maximum rate may double the average and the fire supply must also be provided; that is, with a population of slightly over 100,000 the capacity of the conduits should approximate twenty million gallons.

The elevation of Rabbit Hill would not be sufficient to give a proper pressure or supply when the population exceeds 100,000, without additional conduits to the city, each of which would cost about half a million dollars. Better service can be given with much less expenditure by direct pumping, the pressure on the pumps being increased or decreased in proportion to the demands for water.

In the Rabbit Hill scheme, also, about two and one-half miles of conduits would be required between the pumping station and the river, the friction loss in which would increase the operating expenses. Assuming this system in operation, with three conduits leading from the reservoir, the pressure might be increased by one or more booster pumping stations located within the city, but this would be an expensive and complicated arrangement.

Criticism of the Beaver Hills Project.—The Beaver Hills are situated to the southeast of the city, distant approximately eight miles from the Parliament Buildings. These hills extend for some miles from northeast to southwest and on Section 16, Twp. 52, R. 23, the elevation of ponds near the summit of the enclosing ridges is about 200 feet above the city. A previous report suggested this location as a suitable reservoir site.

In this proposition raw water was to be pumped to large open reservoirs to be constructed among the hills, the natural ponds to be excavated, cleaned out and embanked where necessary. The first reservoir would act as a sedimentation basin from which the water would flow by gravity to filters thence to large open clear water reservoirs. Hundreds of millions of gallons of pure water stored at an elevation of 200 feet above the city appeals to the average citizen as an admirable waterworks scheme, eliminating for the present the matter of cost. There are, however, many points to be taken cognizance of that are not apparent to the layman. First, as stated under the Rabbit Hill scheme, turbid water cannot be pumped through long mains without causing trouble, sooner or later. Secondly, in open storage reservoirs, vegetable growths will cause offensive odors and tastes at certain seasons. Thirdly, the static pressure of 86 pounds would be reduced materially by friction loss, and the head required for filtration; and fourthly, the cost would exceed that of the Rabbit Hill scheme.

If this project were carried out, the raw water should be sedimented and filtered at the pumping station, then pumped to clear water reservoirs in the hills. The distance from a suitable pumping station site above the city to the proposed reservoir would not be less than eleven miles, and in addition conduits would be required leading from this conduit line or from the reservoirs to the city. The cost of the pumping station, filtration work, etc., would be practically the same as in the Rabbit Hill scheme, also the cost of the reservoirs, but the conduit lines would be about double the length and, therefore, double the cost.

Cost of Extensions to Existing System.—An estimate of the cost of the improvement proposed in the report is as follows:

First outlay at pumping station (new works necessary to guarantee a continuous service for a population of 100,000 people)	$ 330,000
Large distributing mains (also necessary for present requirements)	550,000
Second outlay at pumping station (additional works to provide for a population of 150,000)	460,000
Third outlay at pumping station (further additions to provide for 200,000 population)..	390,000
Total	$1,730,000

Cost of New Works.—On the assumption that the city decide to locate a new pumping station at some point southwest of the city limits, the capital expenditure is estimated to be as follows:

Outlay at existing station (immediately required, as in alternate case)	$ 330,000
Large distributing mains (also required forthwith)	550,000
Outlay at new station, and one conduit pipe to city	980,000
Second outlay for 150,000 population	800,000
Third outlay for 200,000 population	250,000
Total	$2,910,000

The proposed new station, with its equipment, and the additions necessary to the present system, would therefore exceed, by $1,180,000, the expenditure required if the present site be retained.

The following is a summary of the definite conclusions arrived at:

(1) That the existing pump house site in the central part of the city is an ideal one from an operative standpoint, as there is ample space for extensions to serve a population of half a million people or more.

(2) That the water supply at this point is not now seriously polluted, but the degree of pollution will undoubtedly increase with the population and may become positively dangerous when the population approaches 150,000.

(3) That a less contaminated supply may be obtained at some point above the city limits at a cost that cannot be considered as prohibitive.

(4) That the distribution system requires immediately many large feeder mains.

(5) That the Roberts filters now installed may be depended upon to filter six millions of gallons daily, the year round, if properly housed and additional clear water reservoirs and sedimentation basin be constructed this year.

(6) That the present station be enlarged to meet the city's demand for water until the new system is operative.

(7) That fire service by direct pressure be abandoned and portable fire engines adopted.

(8) That the waterworks department be consolidated and placed under one executive head.

(9) That about $880,000 should be appropriated for expenditures on the existing plant, including the feeder mains, whether the old pumping station site be retained or not.

(10) That neither the Beaver Hills project nor the Rabbit Hill scheme should be adopted.

THE HARRISBURG FILTER PATENT DECISION.

A COPY has just been received of the decision in the negative head patent case between the New York Continental Jewell Filtration Company, and the City of Harrisburg, Pa., as handed down a few weeks ago in the Middle District of Pennsylvania U.S. Circuit Court.

The case, which has been in the course of trial since the middle of 1908, has attracted wide attention, and the outcome is of extreme importance to the water filtration world, made so by the fact that the down-draft feature is now being used in most rapid sand gravity filtration plants.

Infringement of patents, commonly known as the negative head patents, was claimed by the Company on account of the building and use of the filter plant of the City of Harrisburg, which was erected in 1905, the engineer being Mr. James H. Fuertes, of New York City. It was claimed in this case that the Harrisburg plant was copied in design from the Little Falls plant of the East Jersey Water Company, which plant, according to the evidence, was designed by the complainant Company.

A few points which led up to the decision are as follows:—

The effective filtering agency in slow sand filters of the positive head gravity type is the sediment layer which gradually gathers on top of the sand in the form of an unbroken scum. This layer, a vital factor in filtration, is known as the "Schmutz-Decke." In more rapid, or mechanical, filtration plants, coagulants are used which rapidly form a film that corresponds in function to the "Schmutz-Decke."

As this surface sediment thickens it is so compacted by the head of water pressing upon it that there is little percolation, and further, its compact shell tends to create a vacuum beneath, which, by liberating the air in the passing water, also impedes percolation. In plants of the positive head gravity type of slow sand filtration this "Schmutz-Decke" is substantially the sole place where filtration occurs.

It is in this state of the art of filtration—with the slow formation of the surface sediment layer; with that layer constituting virtually the sole potent factor of filtration; with the sand bed being practically confined to forming the surface sediment shell; with vacuum regarded as a retarder of filtration, and tending to lessen plant output—that the involved patents entered. Mr. Ira Jewell in his process disclosed the radical suggestion that this vacuum, if of such relative completeness as to utilize its efficiency, could be made not only to avoid all troubles incident to air-releasing, but to utilize the whole sand bed as an active filtering agency. In other words, he claimed, by the proper use of vacuum, to convert virtually the whole sand bed into a "Schmutz-Decke."

The practical outcome of his process has been to create in sand filtration a differential type of plant known as the down-draft or negative head filter. It is bottomed on a vacuum, created by design, which results from an off-carrying pipe, vertically arranged and of such length that as the filtered water is carried off by it, a partial vacuum is created within the filter bed. The pipe extends downward a sufficient distance to provide the necessary down-draft, usually several feet. Its action is such that the entire body of filtering material is utilized instead of the upper surface only.

This mere insertion of a water-sealed vertical off-take pipe has added to filtration an important improvement, and the continued use thereof by the defending City of Harrisburg occasioned the charge laid by the Company.

From the evidence and discussion brought to bear upon the case, it was shown that the process really does, by the use of the down-draft sealed vertical outlet pipe, create and maintain an operative vacuum which effects a deeper utilization of the sand body for filtration than is found in positive head filters; that the presence of released air incident to the use of this vacuum is helpful and not harmful by reason of the velocity imparted to the passing water by such a vacuum; that the process makes the runs longer, and that both structural and maintenance costs are lessened by its use.

The court dwelt upon the question as to whether this disclosure involved invention. It was conceded to be an original conception. Further, it was not the mere suggestion of the use of the down-draft tube to create a vacuum. The originality and substance of the disclosure was pronounced to be in the utilization of the vacuum and the apparatus was the concrete means suggested to utilize the process. The disclosure was a marked departure from the previous ideas and practice; it gave to the whole of the large sand body a compacted functional working capacity that it did not previously have; it created a new type of filter in the art, and the process has gone into widespread and extensive use.

On these grounds the disclosure involved invention, according to the decision, and the claim of patent infringement was sustained.

APPROXIMATE CALCULATIONS OF TRANSMISSION LINES WITH DISTRIBUTED CAPACITY.

By Bradley T. McCormick, M.E.

THE recent adoption of voltages of 110,000 and higher for power transmission, somewhat complicates the computations of transmission lines, due to the effect of capacity which can no longer be neglected at such high voltages. During recent years several articles have been published, giving the exact mathematical treatment of transmission lines with distributed capacity, but these usually involve the use of hyperbolic functions, and the formulas are too complex to be of any practical value.

Dr. Steinmetz, in his discussion of Percy H. Thomas' paper on "Output and Regulation of Long Distance Transmission Lines," (A.I.E.E., 1909, Volume 1, page 712), gives the exact formulas on transmission lines with distributed capacity, in a very much simplified form; while in the June issue of the General Electrical Review is an article by Mr. F. W. Peek, Jr., in which the exact formulas of Steinmetz are still further simplified. However, in using Peek's method it is necessary to perform several multiplications of complex variables. Anyone who does not use complex variables frequently is liable to be out of practice and make mistakes in signs.

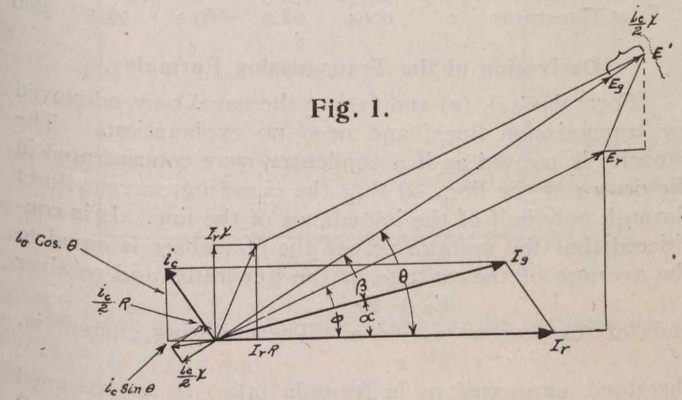

Fig. 1.

Mr. Peek, in his article, works out some examples on a 120,000-volt transmission line 130 miles long, and in his calculations he adds the resistance and reactance of the step-up and stepdown transformers to the resistance and reactance of the line. Since in the transmission line the resistance and reactance are distributed while in the transformers they are concentrated, the formulas, when used in this manner, are therefore not exact, after all. It is also worthy of note that the charging current does not flow through the impedance of the step-down transformers, as assumed by Mr. Peek. In view of the above, there is nothing gained by the use of the exact formulas, if approximate formulas can be found that will give fairly close results. Approximate formulas based on the assumption that the capacity of the transmission line is concentrated at the centre will give results agreeing very closely with Peek's, more exact formulas, though it may sometimes be necessary to calculate some of the values twice, the first calculation being approximate, and the second more accurate.

Below are given some formulas which the writer has found to agree very closely with the exact formulas. Several calculations have been made on Mr. Peek's transmission line so that the values obtained can be compared with those obtained in his article.

Symbols.

Let E_r = receiver voltage between lines,
Let E_g = generator voltage between lines,
Let I_r = current at receiver end of line,
Let I_g = current at generator end of line,
Let i_0 = charging current at generator end of line,
x and R = three phase reactance and resistance = $\sqrt{3}$ times the value per log,
Let ϕ = power factor angle of receiver circuit,
Let β = power factor angle at generator,
Let θ = angle between generator voltage, E_g, and receiver current I_r,
Let α = angle between generator current, I_g, and receiver current I_r,
Let c = capacity of line to neutral,
Let l = distance in miles that power is transmitted,
Let d = distance apart of wires, centre to centre in inches,
Let r = radius of wire, in inches,
Let cm = area of conductor in circular miles,
Let $\sim$ = frequency in cycles per second.

Formulas.

(1.) $R = 56{,}000 \frac{l}{cm}$ for copper and $89{,}000 \frac{z}{cm}$ for 63% conductivity aluminium.

(2.) $X = \sqrt{3}\, 2\pi \sim l\,(.00074 \log_{10} \frac{d}{r} + .00008)$.

(3.) $C = \frac{.0194}{\log_{10} d}\, l.$

(4.) $i_0 = \frac{2\pi \sim C}{\sqrt{3}\, 10^6} \times \frac{E_g+E_r}{2}.$

(5.) $E_g^1 = \sqrt{(E_r \cos\phi + I_r R)^2 + (E_r \sin\phi + I_r x)^2}.$

(6.) $E_g = \sqrt{(E_r \cos\phi + I_r R)^2 + (E_r \sin\phi + I_r x)^2} - \frac{i_0}{2} x$

$= E_g^1 - \frac{i_0}{2} x.$

(7.) $\sin\theta = \frac{E_r \sin\phi + I_r x}{E_g^1}.$

(8.) $\cos\theta = \frac{E_r \cos\phi + I_r R}{E_g^1}.$

(9.) $I_g = \sqrt{(I_r - i_0 \sin\theta)^2 + (i_0 \cos\theta)^2}.$

(10.) $\sin\alpha = \frac{i_0 \cos\theta}{I_g}.$

(11.) $\beta = \theta - \alpha$

(12a.) Loss in line $= [I_r^2 + I_r (I_g - I_r) + \frac{1}{3} (I_g - I_r)^2] \sqrt{3} R$, when I_g is greater than I_r;

(12b.) or $[I_g^2 + I_g (I_r - I_g) + \frac{1}{3} (I_r - I_g)^2] \sqrt{3} R$ when I_g is less than I_r.

Line Constants of Mr. Peek's Line.

$R = \sqrt{3} \times 39.5 = 68.2$ ohms.
$X = \sqrt{3} \times 182.4 = 316.$ ohms.
$\cos\phi = .85$, $\sin\phi = .53$.
$E_r = 120{,}000$ volts.
$C = 1.735$ M.F.

Check on 5,500 kw. Load at Receiver at 85% Power Factor, I_r = 31.1 Amperes.

From (5) $E_g^1 = \sqrt{(120000 \times .85 + 31.1 \times 68.2)^2 + (120000 \times .53 + 31.1 \times 316)^2}$, $= \sqrt{104125^2 + 73300^2} = 127000$ volts,

As a first approximation assume $E_g = E_r$, and from (4)

$i_0 = \frac{2\pi 60 \times 1.735}{\sqrt{3}\, 10^6} \times 120000 = 45.3$ amperes,

From (6) $E_g = 127000 - \frac{45.3}{2} 316 = 127000 - 7150 = 119{,}850$ volts, The voltage at the generator is, therefore, approximately the same as at the receiver when operating at 55,000 kw. load at 85% power factor. Our assumption that $E_g = E_r$ is therefore very close and it will be unnecessary to recalculate the charging current i_c.

From (7) and (8) $.577 \ \text{Cos}\ \theta = \frac{104125}{127000} = .82 \quad \theta = 35^\circ \quad \text{Sin}\ \theta = \frac{73300}{127000}$.

From (9) $I_g = \sqrt{(31.1 - 45.3 \times .577)^2 + (45.3 \times .82)^2} = \sqrt{4.9^2 + 37.1^2} = 37.5$ amperes.

From (10) $\text{Sin}\ \alpha = \frac{45.3 \times .82}{37.5} = .99, \ \alpha = 82^\circ$.

From (11) $\beta = \theta - \alpha = 35^\circ - 82^\circ = -47^\circ$, Cos $\beta = .682$.

The minus sign denotes a negative angle of lag or an angle of load, indicating that with a load of 5,500 kw. at 85% power factor lagging at the receiver end, the charging current is sufficient to give a leading current of 68.2% power factor at the generator.

From (12) Loss in line $= [31.1^2 + 31.1\ (37.5 - 31.1) + \frac{1}{3}(37.5 - 31.1)^2]\ \sqrt{3}\ 68.2 = 138.5$ KW.

Check on 44,000 kw. Load at Receiver at 85% Power Factor. $I_r = 249$ Amperes.

From (5) $E_g{}^1 = \sqrt{(120{,}000 \times .85 + 249 \times 68.2)^2 + (120{,}000 \times .53 + 249 \times 316)^2} = \sqrt{(119{,}000)^2 + (142{,}300)^2} = 185{,}500$ volts.

As a first approximation assume that $E_g = E_r$ and as before, see (4) then, $I_c = \frac{2\pi \times 60 \times 1.735}{\sqrt{3} \times 10^6} \times 120000 = 45.3$ amperes.

From (6) $E_g = 185{,}500 - \frac{45.3}{2}\ 316 = 185{,}500 - 7{,}150 = 178{,}350$ volts.

Our assumption that $E_g = E_r$ is therefore incorrect, so we must recalculate i_c from (4) and substitute again in (6) to get E_g.

$i_c = \frac{2\pi \times 60 \times 1.735}{\sqrt{3} \times 10^6}\ \frac{178{,}350 + 120{,}000}{2} = 56.2$ amperes.

Substituting again in (6) $E_g = 185{,}500 - \frac{56.2}{2}\ 316 = 185{,}500 - 8{,}900 = 176{,}600$.

This compares very closely with $E_g = 177{,}300$ as obtained by Peek from his more accurate formulas.

From (7) and (8) $\text{Sin}\ \theta = \frac{142{,}300}{185{,}500} = .766 \quad \text{Cos}\ \theta = \frac{119{,}000}{185{,}500} = .641 \quad \theta = 50^\circ$.

From (9) $I_g = \sqrt{(249 - 56.2 \times .766)^2 + (56.2 \times .641)^2} = \sqrt{208.7^2 + 36.1^2} = 212$ amperes.

From (10) $\text{Sin}\ \alpha = \frac{56.2 \times .641}{212} = .17 \quad \alpha = 9.78^\circ$.

From (11) $\beta = \theta - \alpha = 50 - 9.78 = 40.22^\circ$ Cos $\beta = 7.65$ = power factor at generator.

The plus sign for β indicates a lagging current at the generator.

From (12) Loss in line $= [212^2 + 212\ (249 - 212) + \frac{1}{3}(249 - 212)^2]\ \sqrt{3}\ 682 = 6{,}300$ KW.

Check on no Load.

Assume as a first approximation that the voltage at the generator and receiver ends of the line are equal. As a first approximation we have as charging current from (4)

$$i_c = \frac{2\pi\ 60 \times 1{,}735}{\sqrt{3} \times 10^6}\ 120{,}000 = 45.4.$$

Since there is no load on the receiver, $I_r = 0$ and (6) becomes,

$$E_g = E_r - \frac{i_c}{2}\ x = 120{,}000 - \frac{45.4}{2} \times 316 = 120{,}000 - 7{,}180 = 112{,}820 \text{ volts.}$$

Now recalculates i_c from (4),

$$i_c = \frac{2\pi\ 60 \times 1{,}735}{\sqrt{3} \times 10^6} \times \frac{112{,}820 + 120{,}000}{2} = 44.1 \text{ amperes.}$$

Recalculating the generator voltage from (6),

$$E_g = 120{,}000 - \frac{4.41}{2}\ 316 = 120{,}000 - 7{,}000 = 113{,}000.$$

$$\text{Line loss} = \frac{1}{3}\ (44.1^2\ \sqrt{3}\ 68.2) = 76.5 \text{ KW.}$$

The following table gives the comparison of the results obtained by Mr. Peek's formulas and the approximate formulas as worked out on the transmission line treated above. It will be noted that the difference between the results obtained by the two methods is in most cases very small, and in other cases close enough for practical purposes.

	No Load.		5,500 K.W., P. F. .85.		44,000 K.W., P.F. .85.	
	Approx.	Peek.	Approx.	Peek.	Approx.	Peek.
Gen. Kilovolts ..	113	112.9	119.85	120.1	176.6	177.3
Gen. Amperes ..	44.1	44.42	37.5	38.45	212	214.1
Line Loss KW...	76.5	81.36	138.5	?	6,300	6,448
P. F. at Generator	0	0094	68.2	69.9	76.5	76.6

Derivation of the Transmission Formulas.

Formulas (1), (2) and (3) are the usual ones employed for transmission lines, and need no explanation. The capacity is treated as if a condenser were concentrated in the centre of the line, so that the charging current flows through only half of the impedance of the line. It is considered that the voltage across the condenser is equal to the average of the voltage at the generator and receiver ends of the line or $\frac{E_g + E_r}{2}$. The charging current is, therefore, expressed as in formula (4). It is assumed that the phase position of the charging current is 90° ahead of the generator voltage E_g. This is not strictly correct, since for that portion of the line nearest the generator the charging current is 90° ahead of E_g, while for that portion nearest the receiver the charging current is 90° ahead of E_r. The voltages E_g and E_r are not in phase but differ by the angle $\phi - \theta$.

If there were no capacity in the transmission line the voltage at the generator end would be expressed in the usual way by formula (5). However, if capacity cannot be neglected there must be added to E_g the voltage consumed by the charging current flowing through the impedance of the line. This voltage may be split into two components $\frac{i_c}{2}\ x$ in phase with $E_g{}^1$ and the component $\frac{i_c}{2} R$ in quadrature with $E_g{}^1$. We should therefore write

$$E_g = \left\{ [\sqrt{(E_r \cos + I_r R)^2 + (E_r \sin + I_r x)^2} - \frac{i_c}{2} x]^2 + [\frac{i_c}{2} R]^2 \right\}^{1/2}$$

The second term $\frac{i_c}{2}$ R can be neglected so that the equation will take the form shown in formula (6). Neglecting this last term bring E_g and $E_g{}'$ in phase, as shown in the figure. This is not strictly correct, but the error resulting from this assumption is small. The sine and cosine of the angle between the receiver current and the generator voltage can be expressed by formulas (7) and (8).

The current at the generator is the vectorial sum of the receiver current and the charging current. The charging current may be split into two components $i_o \sin \theta$ in phase with I_r, and $i_o \cos \theta$ in quadrature with I_r. We may, therefore, express the generator current by formula (9).

For the purpose of calculating the energy loss of the line, we will assume that the difference between the current at the receiver and generator ends follows a straight line law. This is not strictly true, but is close enough for present purposes. In Fig. 2 it is assumed that the receiver current is greater than the current at the generator. The current I at any point distant l from the generator end will be $I = I_g + a$ where a is a constant.

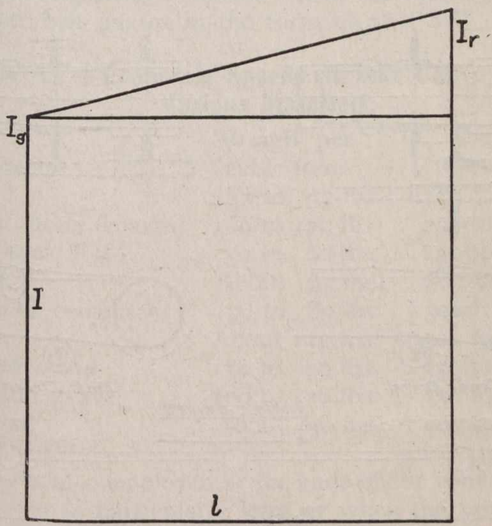

Fig. 2.

The mean square value of current can be obtained as follows:—

$$\frac{1}{l}\int_0^l I_g^2\, dl = \frac{1}{l}\int_0^l (I_g^2 + 2I_g\, al + a^2 l^2)\, dl$$

$$= \frac{I_g^2 l + I_g\, al^2 + \frac{1}{3} a^2 l^3}{l}$$

$$= I_g^2 + I_g\, al + \tfrac{1}{3} a^2 l^2$$

But $a = I_r - I_g$ so we have

$$I_g^2 + I_g (I_r - I_g) + \tfrac{1}{3} (I_r - I_g)^2$$

This is the mean square value of the current and when multiplied by $R\sqrt{3}$ is the line loss as in formula 12b. If the current at the generator end is larger than that at the receiver end of the line the expression for energy loss takes the form given in formula 12a.

Twenty-four railway lines radiate from Winnipeg. The Canadian Pacific Railway, Canadian Northern Railway and Grand Trunk Pacific shops are all located there, employing over 5,000 hands; with 130 miles switch siding facilities for manufacturers. Water transportation on Red and Assiniboine Rivers; vessels drawing nine feet of water ply between Winnipeg and Lake Winnipeg, a body of fresh water, in area, 9,414 square miles. The Winnipeg electric railway carried three million people in 1900 and 35 million in 1912, operating over 300 cars on over 72 miles of city tracks and 45 miles of suburban lines.

BELT CONVEYERS.

By Reginald Trautschold, M.E.

OBVIOUSLY, the easiest way—so far as consumption of power is concerned—of transporting material from one place to another is to carry or convey it on a moving body rather than to attempt to drag it along a trough, as in the case of flight conveyers; or to push it, as in the case of screw conveyers. Obviously, also, the simplest kind of conveyer carrying its load on moving parts consists of an endless belt running over end pulleys and supported throughout its length by occasional supporting idlers, or carriers, on the carrying stretch of the belt and by less frequent supporting idlers on the return or lower run of belt. Such apparatus, belt conveyers, have now been brought to such a high state of perfection that they are almost indispensible in the handling of materials in bulk and are also used to great extent in carrying packages, boxes, bales, etc. This latter application of belt conveyers usually requires a flat carrying surface (belt) running between guides to prevent the load from leaving the belt. Material in bulk, such as ores, coal, cement, paper pulp, wood chips, etc., etc., on the other hand, are most frequently carried on troughed belts, belts having their edges turned up and inclined to the plane of the conveyer so as to form a trough in which the material is carried, thus materially increasing the carrying capacity. Troughed belt conveyers being more generally and widely used, they will be chiefly considered in this discussion.

The original troughing idler, or belt carrier, consisted of a spool-shaped pulley or series of individual pulleys mounted so as to form a spool. Following this form came the "dish pan" idler, consisting of one or more centre pulleys of the same diameter between concentrating end pulleys of "dish pan" shape which turned up the edges of the carrying belt. These simple types of carrying idlers had the desired effect of troughing the belt, but they possess one very undesirable feature, the circumferential speed of the pulley or pulleys varying with their diameter while the speed of the belt passing over them is constant from edge to edge; the result being that either the belt was travelling faster than the circumference of a particular pulley, or else the belt lagged behind certain circumferential of the troughing idler, causing much unnecessary wear on the belt due to the scouring action between the contact surfaces of belt and troughing idler. Relatively, the belt is the most expensive part of a belt conveyer and the main improvements have necessarily been in the troughing idler to obviate slippage between it and the belt. Troughing idlers are now almost invariably constructed of several individual pulleys of the same diameter mounted so that the end pulleys are inclined to the horizontal and cause the carrying belt to form a trough conforming more or less to an arc of a circle. These individual pulleys constituting a troughing idler may be mounted all in one plane, the end pulleys in a plane in advance or behind that of the centre pulley, may be mounted on hollow shafts in which grease for lubrication is stored and which is supplied to the bearings through small holes in the hollow shafts, mounted on solid shafts with either grease or oil lubrication, or on ball bearings that require only occasional lubrication, depending upon the construction and patent rights of the manufacturer. The latest construction consists of complete individual units of one pulley each which may be mounted on a board so that the pulleys all lie in one plane and may be so inclined as to form any desired form of trough. Any of these various types of troughing idlers will give satisfactory results if properly proportioned and, which is even of greater importance, if properly cared for. Particularly, must care be taken not to allow the lubricant to come in contact with the belt, oil or grease having a harmful action on rubber—the material that enters the construction of most belts.

The angle with the horizontal made by the inclined pulleys of the troughing idler varies considerably, being but 10 to 20 degrees in some cases and in others as much as 35 or 40 degrees. Deep troughed conveyers, those in which idlers with steeply inclined end pulleys are employed, have slightly greater carrying capacity than conveyers with more shallow trough, it is true, but such gain is counteracted somewhat by increased power requirements and by increased wear on the belt by the material handled. One of the most successful manufacturers of belt conveyers builds all troughing idlers with end pulleys inclined at about 25 degrees (slightly less in most cases). This angularity would seem to be about the most satisfactory, for with such it is possible to attain within 10 or 15 per cent. of the theoretical capacity of the conveyer, while even with the deepest practical trough the theoretical capacity cannot actually be reached and both depreciation, through abrasive wear of material slipping on the belt, and power requirements are unduly enhanced. A deeper trough may be advisable at loading points, however, as such construction would have the tendency to facilitate the proper arrangement of load on the belt for subsequent conveying. Theoretically, the capacity of a belt conveyer is limited by the amount of material that can be piled on a flat belt of the same width and is, therefore, dependent upon the angle of repose of the material handled. This arbitrary limitation is due to the fact that at some section of every belt conveyer the belt must be flattened. This may be either over the flat pulleys constituting discharging devices, or over the flat bend pulleys where the direction of the conveyer makes a sudden change, or, for conveyers in which there is no interruption to the trough from loading point to point of discharge, over the head pulley of the conveyer. A well proportioned belt conveyer carrying suitable material—i.e., material that is not too bulky for the size of conveyer, that possesses no disadvantages of undue heat or other quality productive of disastrous chemical action on the belt, etc.—has a pretty rigidly fixed carrying capacity at a given speed, however, and Table V. contains such data for conveyers handling material weighing 100 pounds per cubic foot at a conveyer (belt) speed of 100 feet per minute. Conveyers carrying material of other weight have capacities proportionally greater or less according to the weight of the material and, of course, the capacity of any belt conveyer varies directly with the speed at which it is run. Similar data, expressed in the form of a convenient equation, is given as Formula XIII.

Capacity:—

$$W = \frac{1.43\, w^2 V W'}{100{,}000} \qquad \text{Formula XIII.}$$

Where W = Weight of load (capacity) conveyed in tons per hour.

w = Width of conveyer (belt) in inches.

V = Velocity (speed) of conveyer in feet per minute.

W′ = Weight of material handled in pounds per cubic foot.

Table V.—Capacity of Belt Conveyers, Continuously and Uniformly Loaded.

Material weighing 100 pounds per cubic foot.
Conveyer speed, 100 feet per minute.

Width of belt.	Tons per hour.	Width of belt.	Tons per hour.
12″	20.0	26″	96.0
14″	27.0	28″	108.6
16″	35.7	30″	126.8
18″	45.0	32″	143.5
20″	55.6	34″	160.0
22″	67.7	36″	183.0
24″	80.0		

All materials suitable for handling by belt conveyers are not necessarily possible of conveyance at the same speed, however, and this question of advisable speed is one over which there has been considerable controversy

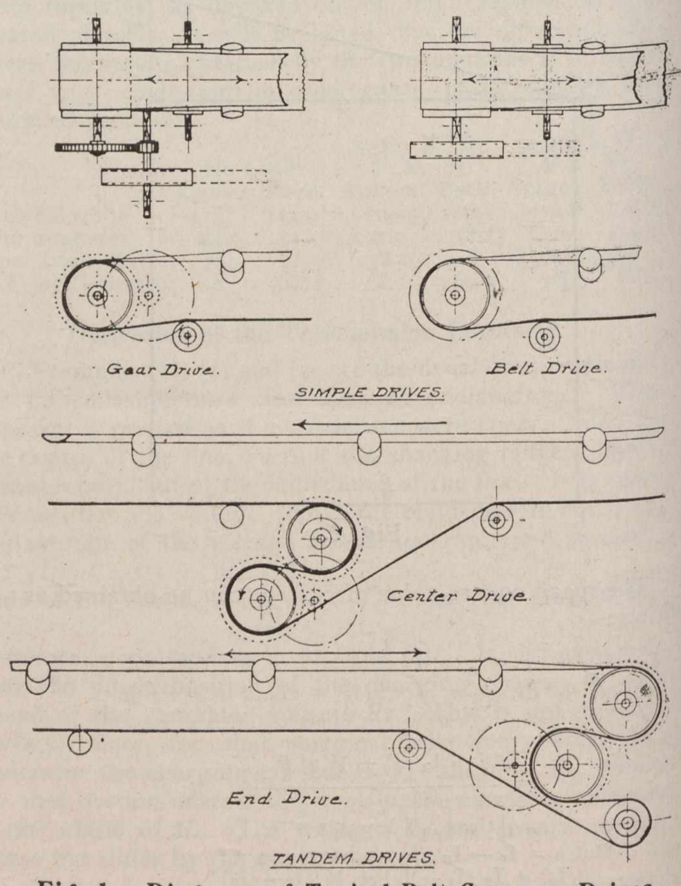

Fig. 1.—Diagrams of Typical Belt Conveyer Drives.

and no fixed rule can be advanced to cover all cases. Ordinarily, heavy materials can be carried at a higher speed than lighter ones, but practice has brought out many exceptions to such a rule. Table VI., compiled from records of a number of successful and efficient installations of belt conveyers, gives suitable speeds for handling a variety of the commoner materials usually conveyed by this class of apparatus, together with the average weight of such materials. The speeds given in the table allow for considerable lee-way, for a variation of as much as 20 to 30 per cent. is allowable and frequently advisable.

Before taking up a consideration of the power requirements and economic value of the belt conveyer, it is advisable to study in some detail the construction of the apparatus, general design of systems, etc. The troughing idlers that have already been considered are usually spaced from 3 to 6 feet apart, depending upon the width of the belt and to some extent upon the character of the material handled. The return idlers, those carrying the lower run of belt, are invariably of pulleys in the same horizontal plane; that is, a return idler has all its individual pulleys in the same plane; and are spaced about twice as far apart as the troughing idlers. Guide idlers, in a plane tangent to the edges of the conveyer belt, are required for long conveyers to prevent the belt from leaving the troughing idlers and these are usually spaced 40 or 50 feet apart. The driving pulley of the conveyer may be one of the end conveyer pulleys driven through suitable gear-reducing mechanism or simply by a driving pulley fast to the shaft of the conveyer driving pulley if the speed of rotation can be satisfactorily controlled without gears. In installations where such simple drive is not feasible, a centre drive may be installed, consisting of tandem conveyer driving pulleys around which the return run of the conveyer belt passes in the form of an "S." This type

Table VI.—Economic Speeds of Belt Conveyers for Various Materials.

Material.	Weight per cubic foot.	Advisable speed.
Coke	32 to 35 lbs.	250 ft. per min.
Broken stone (coarse)	160 to 170 lbs.	250 to 300 feet
Lump coal, R/M	50 to 60 lbs.	250 to 300 feet
Ashes	About 45 lbs.	300 ft. per min.
Lime and cement	50 to 80 lbs.	300 ft. per min.
Ore	About 125 lbs.	300 to 400 feet
Crushed stone	150 to 170 lbs.	350 to 400 feet
Sand and gravel	100 to 120 lbs.	350 to 400 feet
Fine coal	About 50 lbs.	400 ft. per min.

of drive is also employed at the ends of the conveyer when a conveyer is particularly long or when the service is so severe that the simple end conveyer pulleys do not have sufficient belt grip to drive the conveyer. Excessively severe conditions of drive are also met by covering the conveyer driving pulley or pulleys with a "lagging"—material that increases the grip of the pulley on the belt. Means must also be provided for adjusting the tension in the conveyer belt, and this is usually accomplished by providing take-up bearings for the conveyer pulley at the opposite end of the conveyer from the driving end, though the take-up may be located at any convenient point on the return run of the belt. The driving pulleys should be of the heavy crown type and should be slightly greater in diameter than the width of the conveyer belt; their face should also be about two inches greater than the width of the conveyer belt. The end conveyer pulleys, if not used as conveyer driving pulleys, may be somewhat smaller in diameter and the upper and lower runs of conveyer belt should be about parallel except at the point where the driving conveyer pulley is installed—the greater diameter of such pulley increasing its grip on the belt.

Not only is the belt the most important part of a belt conveyer, as upon it the load is carried, but it is also relatively the most costly. All the abrasive wear caused by material slipping on the belt at time of loading and during a certain unavoidable slippage while in transit is naturally concentrated on the belt itself and the depreciation from such causes constitutes by far the greatest expense of maintenance. Belts of many materials have been experimented with and that found the most generally satisfactory is the rubber belt, a belt that is composed of the necessary plies of heavy duck for strength bound together with a rubber "friction" and protected by a rubber covering that is considerably thicker on the carrying side (top of belt on the upper run). Such a belt is comparatively expensive—a conveyer so equipped costing nearly twice as much as one in which the conveyer belt is of stitched canvas construction without rubber covering—but is by far the most economical and satisfactory in the majority of installations, owing to its excellent properties of resisting abrasive wear. The rubber covering of a conveyer belt should not be highly vulcanized, but should be quite resilient, as the tendency of the material to slip on the hard belt is much greater than when the adhesion of the particles of material in contact with the belt is more tenaceous—the case with the relatively soft resilient belt. Refinements of the standard rubber belt of uniform thickness, with the same thickness of rubber wearing cover from side to side of belt, have been made in attempts to lengthen its life for conveying purposes and, for installations presenting exceptionally trying conditions of service, two of these patented types deserve particular consideration and criticism. One of these belts has sections of the duck plies omitted on its carrying side, the gaps increasing in width as the plies approach the surface of the belt, and replaced with rubber, making a belt with a rubber cover that is thickest at the centre of the belt and becomes thinner towards the edges. This construction, augmented by stiff reinforcement of the edges, makes a very pliable belt that readily conforms to the trough of the conveyer. Another claim that is advanced by the manufacturers of this belt is that it possesses greater wearing qualities, owing to the fact that the rubber cover is thickest at the centre where the wear is claimed to be the greatest. In installations of conveyers in which the load is carried up so steep an incline as to cause a slippage of material (load) on the belt or where the belt is run at such speed that a vibratory oscillation of the belt as it passes over the troughing idlers is great enough to cause readjustment of load on the belt. This claim is substantiated, and even in installations where neither the inclination of the conveyer nor the speed at which it is run is excessive the agitation of load in passing over the troughing idlers may be sufficient to create a slight and continual readjustment of load, causing a certain scouring action on the surface of the belt. In such cases, the wear is naturally greatest at the centre of the belt where the load is the thickest and consequently the heaviest. Whenever the carrying belt passes over a flat pulley, however, rearrangement of load on the belt is necessary and the portion of load that changes position is not at the centre, but toward the edges of the belt. Another change of location or position of load on the belt takes place on retroughing the flattened belt and, as in the case when flattening the belt, the abrasive wear takes place along the edges of the loaded section of belt. In a properly installed system, in which the tension on the conveyer belt is maintained correctly, the main wear of the load, other than that which may be caused at the loading point when charging the conveyer, *is* toward the two edges of the belt. However, as the section of the conveyer belt covered by the load never extends to the edges of the belt, the abrasive wear due to the shifting of load on passing over a flat pulley comes at a point on this patented belt where the rubber is still comparatively thick, so that this construction produces an excellent belt. The second noteworthy special rubber conveying belt is one that has some of the plies of duck omitted at the point where the belt would turn upward if it followed closely the pulley surfaces of a three-pulley troughing idler and the gap thus formed filled with rubber, which construction also makes a pliable belt that clings to the troughing idler pulleys. This belt has no extra cover at its centre, so possesses no particular wear-resisting qualities where the load is the thickest, but does possess increased resisting properties against abrasive wear at the hinged points just outside the limits of the centre pulley. The peculiar shape to the trough when using the "hinged belt" also increases the carrying capacity of the belt to some extent, but the re-adjustment of load on passing over a flat pulley is correspondingly greater and necessarily the abrasive action of the load in shifting its position on the belt is augmented. Both these patented belts are of necessity more expensive than belts in which the refinements of varying the thickness of rubber cover are not attempted—straight ply belts —and, without disparagement of the patented belts, it is a question whether greater benefit might not be gained by putting the extra money into a straight ply belt with an extra heavy rubber cover of uniform thickness.

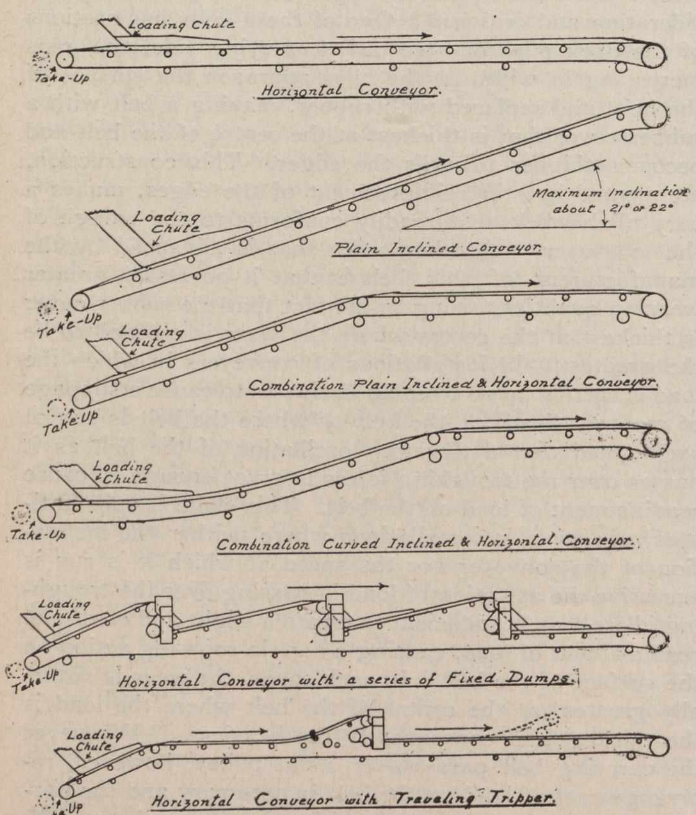

Fig. 2.—Typical Arrangements of Belt Conveyers.

Note.—Installations of Belt Conveyers may consist of any combination of the above arrangements and conveyers can frequently be made reversible—*i.e.*, arranged so they be operated in either direction. They also may be loaded at more than one point, can be driven at any point and the Take-Up can be loaded wherever convenient.

Fixed Dumps may be installed on any horizontal stretch of conveyer or inclined stretches may be interrupted for their accommodation.

Traveling Trippers may be installed on any horizontal or slightly inclined stretches of conveyer, may be propelled by hand or be of the automatically traveling and reversing type.

Provision for discharging the load from belt conveyers, other than over the end pulley of the conveyer, necessitates the forming of an "S" in the carrying belt, similar to that required in the return belt for a tandem drive, the load leaving the conveyer as the belt passes over the upper of the two straight pulleys employed to so guide the belt. This discharging arrangement may be mounted on a movable carriage that can be moved from position to position by a hand crank (hand-propelled tripper) or else the motion of the moving conveyer belt may be employed automatically to cause the tripper to travel back and forth over a fixed length of track on which the tripper is supported (automatic tripper). When it is required to discharge load at only a specified point or at several fixed points in the length of the conveyer, the discharging device is usually made permanent, part of the supporting structure of the conveyer system, and is known as a "fixed dump." By arrangements of chutes and gates, either trippers or fixed dumps may be made to discharge the conveyed load on either side of the conveyer in any desired proportion, and may also be arranged to discharge any proportion of the load to the conveyer belt beyond the particular discharging point for subsequent discharge at some further advanced point.

Belt conveyers carrying wet or sticky materials also require brushes for cleaning the belt at each discharge point. These brushes are usually of the rotary type, constructed of stiff bristles, and are gear- or belt-driven from the conveyer pulley over which discharge of load takes place—rotation of brush being in the opposite direction to that of the conveyer pulley.

(To be continued.)

COAST TO COAST.

Ottawa, Ont.—"Until the report of Sir Alexander Binnie, founded on his own investigation and those of his engineers, is submitted, I do not propose to give out any information whatever, and anything which may be published in the meantime must be regarded as only conjecture." This was the statement made by Mayor Ellis recently in regard to the water scheme. "I expect to have complete reports upon every phase of the water question ready to submit to council in October," added Mayor Ellis.

Ottawa, Ont.—The appointment of a commission to consider the practicability of the Georgian Bay Canal project will be taken up shortly by the Minister of Public Works. Heretofore the investigations have had reference wholly to the engineering features of the work and the estimate of its cost. What is now proposed is an inquiry into the economic aspect of the project and its probabilities as a profitable proposition.

Windsor, Ont.—Seeking protection from disease or possible contamination of the city's water supply, the members of the Windsor Water Board and Medical Health Officer Ashbaugh have gathered several samples of Detroit River water near the mouth of the intake pipe and in the current flowing directly into the pipes. The samples will be packed and shipped at once to the Ontario Health Board at Toronto for analysis. The water was obtained from near the bottom of the river by means of an especially devised apparatus, consisting of a metal box containing a sterilized bottle. The equipment was lowered to the required depth and the bottle uncorked. While Windsor's water supply is taken from the channel in the river and not from the lake, former tests have shown it to be as pure as any water in the Dominion. Only two samples out of nearly a dozen taken last summer were found to contain the least trace of contamination.

St. John, N.B.—Mr. H. A. Powell, K.C., member of the International Waterways Commission, has left for Grand Falls and vicinity to conduct an investigation into the boundary waters, which, it is understood, have given rise to much serious consideration through their pollution. The idea of the visit of Mr. Powell, who is acting in the interests of both the United States and Dominion Governments, is to investigate the waters with the intention of reporting as to the extent of the pollution, the interest of each country in the matter, and the remedial measures which are deemed necessary with a view to the protection of the health of the dwellers in the vicinity. The Board of Health officials will be conferred with and a thorough examination of the waters from a bacteriological standpoint will be undertaken. After the scientific examination has been completed, Mr. Powell will report as to the nature and extent of the contamination and the precautionary measures necessary to protect the residents. The responsibility which rests upon each country in connection with the waters under examination will also be considered. The problem of investigating and inquiring into the condition of waters in different countries believed to be contaminated is now occupying the serious attention of every country where the danger is found, and it is most necessary that remedial measures be considered at the inception of the pollution. In such a connection a commission has for the past ten years been conducting scientific examinations on the waters of the Thames River in England.

Toronto, Ont.—Mr. E. A. James, Highways Engineer, is back in his office again after a tour of inspection of the work being done by the Commission in York County. At Unionville the abutments for the new bridge are finished, and the bridge at Markham Village has been started. In the western part of the county a new concrete bridge is under way at Kleinburg, and a 40-foot concrete retaining wall near Woodbridge to protect the roadway from the spring freshets of the Humber River is being built. The repair gangs are all out and busy at their work of keeping the good roads in proper shape. Spoken to regarding the road on Yonge Street, Mr. James explained that within the city limits, near Hogg's Hollow, it is badly rutted in places. Near the foot of the hill the oil put on by the Commission had not penetrated the earth, but had formed a crust on top. This was now breaking up, but the repair gang would soon have that in first-class shape. "If they are prepared to give us the money," said Mr. James, "we can easily lay asphalt roads in York County. But they would cost $25,000 per mile as against the $5,000 the Yonge Street roadway has cost. There is also the cost of repairing an asphalt roadway to be taken into account, and this would prove almost prohibitive in the county. The plant required is too cumbersome to be easily moved long distances over the county roads, and it would pay to move it only to districts where extensive repairs were necessary. Then a well-built macadam roadway is better fitted to carry the class of traffic that uses the country roads. Commissioner Harris compelled the owners to remove the cleats from the wheels of motor trucks in Toronto, because of the damage they did to the asphalt. What a heavy traction engine, with its cleated wheels, drawing a tank, would do to a country road built of asphalt can be better imagined than described."

Toronto, Ont.—One of the things which it is understood the Ontario Government may lay hold upon when the Legislature convenes early in the new year, is the problem of water purification and sewage disposal. The numerous instances of difficulty which municipalities have encountered during the past year and the general desire for reliable methods of solution were instrumental in the sending of Dr. J. W. S. McCullough, chairman of the Provincial Board of Health, to the Continent this summer to gather information on the subject in general. He returned recently from a nine weeks' tour of investigation and will present an authoritative report within a short time to the Cabinet. In the same manner a report will be made up for the consideration of the Federal House by Dr. C. A. Hodgetts, chairman of the Commission on Conservation, who travelled in company with the Ontario representatives. Dr. McCullough, in company with Dr. Hodgetts, made an especially exhaustive study of sewage and water conditions in Great Britain, and brought home voluminous notes on the different systems in use in the different cities. The aim in every case was to find the extent to which the civic authorities were succeeding in producing water for domestic and public uses of a necessarily high quality and uncontaminated by the sewage, which perforce was disposed of in proximity. Twenty large sewage plants of different natures were visited in Great Britain. The water systems, while varying in smaller details, nearly all came under two general divisions of filtration, viz., mechanical and slow sand. Another feature, however, was observed in the ozone process utilized in Paris.

Windsor, Ont.—Governor Ferris, of Michigan, is personally urging the Governors of each State to name delegates to the Third American Road Congress, which will be in session at Detroit during the week of September 29th. Thirty Governors have named their delegates, and it is expected that a number of the governors will be present in person at the Congress. Governor McCreary, of Kentucky, which State has recently established a State Highway Department, expects to attend the meeting. It now seems assured that the heads of every State Highway Department from Maine to California will personally take part in the big meeting, and as a result of this unusual interest the demand for exhibit space by manufacturers has been unprecedented. All available space has been reserved by nearly one hundred manufacturers, who will display their products, including every kind of road-making machinery, engineering instruments, concrete machinery, bridges, culverts, concrete, wood block, asphalt, tar and oil preparations. Important progress is expected to be made in three great questions affecting the road movement. The Congress will endeavor to agree upon a policy of national aid, which, with the united support of the good roads workers throughout the country, will be submitted to the Congress of the United States. Steps will be taken at the session on State Road legislation, to be held under the auspices of the American Bar Association, to the formation through official action by the several states, of an interstate commission to codify and simplify existing State road laws. At present, most of the States are laboring under a weight of antiquated and contradictory road laws, and it is plain that the Commission will recommend simple, clear-cut and uniform road laws as a substitute for the mass of useless existing road legislation. Maintenance of roads will be discussed from every standpoint during the sessions held by the American Highway Association, the parent organization in the Congress, and the engineers will endeavor to determine among themselves upon the steps which should be taken in the several States to insure adequate maintenance.

Winnipeg, Man.—Considerable discussion has taken place in regard to what can be done by municipalities in the construction of good roads under the Good Roads Act, chapter 73, of the Statutes of Manitoba, 1912. Under this Act a municipality can issue debentures at a rate of interest not exceeding 5 per cent., spread over a period of forty years or less, which have to receive the approval and consent of the electors of the municipality in the usual way of all by-laws, and the interest on which is guaranteed by the Government, in order to insure the better sale of the debentures. The Government provides the municipality with an engineer, upon receiving a proper request by resolution of the council to do the engineering work for the municipality, lays out the roads, makes recommendations as to same, gives estimate of the cost, likewise of all bridges to be made, and generally furnishes the municipality with plans for the development of roads coming under the Act. The Government also co-operates with the municipalities in every way in order to assist them to bring their municipality under the Act, furnishing them free all engineering services, making plans, estimates, and carrying out the work of construction. By taking advantage of this Act taxpayers will find that the actual cost of construction may possibly be lessened, and by the issue of debentures payable in a long term of years the present taxpayer does not have to pay for all work done, but any additional settlers coming to the district have to bear their fair proportion of the taxes. Thus, the taxpayers only pay a small amount of the principal and a small rate of interest, and have the satisfaction of obtaining good roads through the district almost immediately. The present system of patchwork will be found, upon investigation, to be much more costly than to go right ahead and construct a road system on thoroughly up-to-date and modern lines.

Ottawa, Ont.—The following recommendation of the board of control was passed at a recent meeting: "On the advice of the city engineer the board recommends that in future, to avoid the sinking of permanent roadways over excavations, no permanent pavements be laid until six months after sewers and other underground works have been completed; and, further, that the city clerk notify all public service companies that should they neglect to take advantage of the city engineer's notice from time to time of contemplated pavement works, and proceed with any repairs or new work which may require trenching the streets, permission thereafter will be refused." It was explained by the mayor that the city engineer was of the opinion that much of the faulty pavement of the past was due to not giving the roadway sufficient time to settle after it had been dug up when installing underground services. Some objection was raised to the recommendation, because it will mean a great deal of delay, as, for example, O'Connor Street has been dug up in a number of places recently, and if six months is allowed for the ground to settle again, it will mean that the paving can hardly go on this fall. Ald. McNeill thought that it should not apply to O'Connor Street. Practicaly all the members of the council were agreed, however, that it is better to wait than put down pavements that soon get out of repair because of the ground underneath settling.

Regina, Sask.—The civic construction works are proceeding very rapidly, an effort being made to complete the entire programme mapped out during the early part of the year. The sewer work is now well on toward completion, with the exception that about half a mile or so of trunk sewer still remains to be laid. Practically all of the street car line extensions to be completed this year are completed, while large gangs are employed on paving and laying concrete sidewalks. During the past week or two good progress has also been made on the construction of the federal armories at Regina. The steelwork has practically all been erected with the exception of that required to support the roof, and a large force of bricklayers are working at building the walls.

PERSONAL

J. E. RITCHIE, B.A.Sc., has been appointed permanent secretary of the University of Toronto Engineering Society.

C. W. LEAVITT, of New York, has been engaged by the city of Berlin, Ont., as civic expert to prepare a plan of the city.

F. W. SEIBERT, B.A.Sc., D.L.S., is now connected with the Department of the Interior, topographical survey's branch, at Edmonton, Alta.

RAYMOND UNWIN, a town planning expert of England, has completed preliminary work in connection with a housing scheme for Halifax, N.S., and has returned to London.

J. E. PENNYBACKER, chief statistician of the United States Joint Congressional Committee on Federal Aid, and secretary of the American Highways Association, has received an appointment to organize a Canadian statistical road bureau.

A. T. LAING, B.A.Sc., lecturer in highway engineering, and secretary, Faculty of Applied Science and Engineering, University of Toronto, has returned from a trip to Italy, France, Switzerland and Great Britain, where he has made a study of road conditions.

K. L. AITKEN, formerly general manager of the Toronto Hydro-Electric system, and under whose direction the system was designed, constructed and placed in operation, has returned from Europe and is re-establishing in Toronto his practice as consulting engineer.

R. G. BLACK, consulting engineer, has been appointed a member of the Toronto Hydro-Electric Commission to fill the vacancy caused by the resignation of H. L. Drayton, K.C., who accepted the chairmanship of the Dominion Railway Board last spring. Mr. Black is a University of Toronto man, with a broad, general experience in electrical engineering. The Commission, as now constituted, is P. W. Ellis, chairman, H. C. Hocken and R. G. Black.

OBITUARY.

H. BODE and E. R. ROBERTS, of the Canadian Boundary Survey staff, were killed in a landslide which occurred on September 6th, destroying their camp at Cape Musson, Dale Island, Alaska. The party had been working on the boundary survey up Portland Channel and Dixon Entrance.

GEORGE STREET, of the Dominion Government Survey staff, and his companion, H. V. RADFORD, of Washington, met death last year at the hands of an Eskimo band at Bathurst Inlet. The two men were engaged in coastal survey work, and had been away several years, eventually intending to follow the coast of Canada across the Arctic to the Yukon and thence south to Vancouver. The news of their sad fate did not reach headquarters for fully a year after the occurrence.

COMING MEETINGS.

ILLUMINATING ENGINEERING SOCIETY.—Annual Convention to be held at Pittsburg, Pa., September 22nd to the 26th. Secretary, I. D. Israel, 29 West 39th Street, New York City.

AMERICAN ROAD CONGRESS.—Annual Session will be held in Detroit, Michigan, from September 29th to October 4th. Secretary, J. E. Pennybacker, Colorado Building, Washington, D.C.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—Twentieth Annual Meeting to be held in Wilmington, Del., October 7th to 10th. Secretary, A. Prescott Folwell, 15 Union Square, New York.

UNITED STATES GOOD ROADS ASSOCIATION.—Convention will be held at St. Louis, Mo., November 10th to 15th. Secretary, J. A. Rountree, L021 Brown-Marx Building, Birmingham, Ala.

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

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.

20151—August 25—Authorizing the C.P.R. to construct a diversion of the surveyed trail in Secs. 23 and 14, Tp. 22, Rge. 3, W. 4 M,. and between Secs. 14 and 11, Tp. 22, Rge. 3, W. 4 M.; and to construct its tracks, by means of a grade crossing, across the said diversion in Sec. 14, mileage 102.2 on C.P.R. Bassano Easterly Branch.

20152—August 22—Authorizing the Essex Terminal Railway Company to construct its railway, at rail level, across the Langlois Road, and existing highway, being the boundary line between Twp. of Sandwich West and town of Ojibway.

20153—August 22—Ordering the C.L.O. & W. Railway to provide a cattle pass on the property of J. R. Irwin near Cobourg, Ont., of the same dimensions as that furnished by the C.N.R.

20154—August 22—Authorizing the Montreal Tramways Company to construct its proposed new track across the tracks of the G.T.R. on Notre Dame St., at the intersection of St. Ferdinand St., Montreal, Que.

20155—August 21—Authorizing the Winnipeg North Eastern Railway, to construct its line and tracks across the lines and tracks of the C.P.R. Co.'s Emerson Branch, in Roman Catholic Mission Lot 312, St. Boniface, Man.

20156—August 25—Authorizing the C.N.R. to construct its line of railway across the trail in the S.W. ¼ of Sec. 9, Tp. 7, Rge. 25, W. 4 M., Calgary South Branch, Alta.

20157—August 25—Authorizing the G. T. P. to construct bridge across Cottonwood Creek, at mileage 211.6 Wolf Creek West, District of Fort George, B.C.

20158—August 23—Approving revised location of Dominion Atlantic Railway, North Mountain Branch, between Grafton and Tory Lane, Tp. of Cornwallis, N.S.

20159—August 23—Approving plans showing location and details of D.A. Ry.'s proposed new station at Annapolis Royal, in Annapolis Co., N.S.

20160—August 22—Authorizing the Midland Ry. Co., C.P.R., C.N.R. and G.T.P. to operate their trains over the crossings within the scope of interlocking plant installed at said crossings.

20161—August 22—Authorizing the C.P.R. to construct a road diversion in Lot 10540, Kootenay Dist., B.C.

20162—August 22—Authorizing the C.P.R. to construct, maintain and operate a branch line of railway, or spur, for the British Columbia Sugar Refining Company, Limited, Regina, from a point on the existing spur in lane in Block 137, thence across said lane and across Lots 16 to 20 inclusive, Block 137, Regina, Sask.

20163—August 18—Approving location of C.N.R. Co.'s railway through Tp. 26, Rges. 23-26, west 3 M., Sask., mileage 105.42 to mileage 125.45, Alsask Branch.

20164—August 18—Approving revised location of G.T.P. Ry.'s main line of railway, mileage 138.19 to mileage 149.41, Prince Rupert East, through Squin-Lix-Stat Indian Reserve, Cassiar Dist., B.C.

20165—August 25—Granting leave to the C.P.R. to cancel siding agreement between the C.P.R. and the Nelson-Ford Lumber Company, dated July 17, 1909.

20166—August 23—Amending Order No. 19236 and providing that the Campbellford, Lake Ontario and Western Ry. and the C.N.R. build the bridge and approaches over its own line on the farm of John Pearse, in the S. ½ of Lot 4, Con. 4, Tp. Scarborough, Ont.

20167—August 19—Ordering that paragraph 1 of the operative part of Order No. 19500 be struck out; and that the plan dated Winnipeg, July, 1913, marked "A," showing the proposed layout at Herbert, Sask., be approved.

20168—August 25—Authorizing the G.T.P. to construct proposed bridge across Dome Creek, mileage 273, Wolf Creek West, Cariboo District, B.C.

General Order No. 109—Suspending, until further Order, the mileage rates on less than carload shipments of grain and grain products.

General Order No. 110—Requiring Railway Companies subject to the jurisdiction of the Board to accept and carry by freight, trunks containing wearing apparel and personal effects when securely corded.

20169—August 26—Approving revised location of G.T.P. Co.s main line from the west boundary of Lot 4900, into Fort George Indian Reserve, mileage 459.61 to mileage 466.11, east of Prince Rupert, Dist. of Cariboo, B.C.

20170—August 19—Authorizing G.T.P. Branch Lines Co. to construct, maintain, and operate a spur for the Lyall-Mitchell Company, turning out from its Melville-Regina Branch into Sixteenth Ave., thence easterly across Albert Street and the two tracks of the Regina Municipal Railway, and turning southerly into Wascana Park to the G.T.P. Hotel site in Regina.

20171—August 26—Authorizing the G.T.R. to construct, maintain, and operate branch line of railway, or siding, commencing at a point on the 13th Dist. of its railway on Lot No. 3, Con. 1, Tp. Caledon, Co. Peel, Ont., about one mile north of Inglewood Station, thence extending in a northerly direction to and into the premises of Charles Mould, Lot 3.

20172—August 19—Authorizing the G.T.R. to construct, maintain and operate, branch line of railway or siding and spur therefrom, commencing at a point on the G.T.R. west of Muskoka Wharf, Ont., thence extending in a northwesterly and northerly direction to the premises of the Ontario Granite Crushed Stone Company, Lot 8, Con. 4.

20173—August 26—Authorizing the G.T.R. to construct, maintain and operate branch line of railway or siding, commencing at a point on its railway south of Milton Station, Ont., thence extending in a westerly and northerly direction across Lot 14, 1st con., Tp. of Trafalgar, to and into the premises of Brandon's Pressed Brick and Tile Company, of Milton, Limited, on said Lot 14.

20174—August 26—Authorizing the G.T.R. to construct, maintain and operate branch line of railway, or siding, commencing at a point on its railway on Lot 13, 5th Con. of Tp. of Somerville, Co. Victoria, Ont., thence extending in a northerly direction to and into the premises of S. Suddaby on Lot 13, occupied by Messrs. Britnell and Company.

20175—August 26—Authorizing the Municipal Corporation of the town of Sudbury to construct and maintain, at its own expense, grade crossing over the C.P.R. Co.'s Soo Branch, Sudbury, at the intersection of Regent and Riverside Streets with the Copper Cliff Road.

20176—August 18—Authorizing the Corporation of the County of Richelieu to construct and maintain, at its own expense, a highway under the tracks of the Quebec, Montreal and Southern Railway Company. Parish of St. Joseph, Dist. of Richelieu, Que.

20177—August 26—Authorizing the New Brunswick Coal and Railway Company to construct bridge No. 1.1 on its line of railway.

20178—August 26—Approving location of extension of Niagara, St. Catharines and Toronto Ry. Co.'s line to Lake Front, Lot 12, Con. 1, Tp. of Grantham, Co. Lincoln, Ont., mileage 0 to mileage 0.68.

20179—August 26—Approving location of C.N.R. station grounds at Bratton, Sask.

20180—August 21—Approving location of C.N.O.R. station grounds at Cedar Lake, Tp. of Deacon, Dist. of Nipissing, Ont., at mileage 163.06 from Ottawa.

20181—August 26—Approving revised location of C.N.R. Co.'s de Lourdes spur through Sec. 36, Tp. 6, Rge. 9, W. P M., Man., mileage 0 to mileage 2.627.

20182—August 26—Approving plans showing locations and details of Algoma Central and Hudson Bay Railway Co.'s station proposed to be erected at Frater, Dist. of Algoma, Ontario.

20183—August 23—Ordering the G.T.P. to erect fences and install cattle guards at the east end of its station grounds at Ingelow, in Sec. 4, Tp. 12, Rge. 16, W. P M., Man.

20184—August 19—Extending until the 30th October, 1913, the time within which the C.P.R. move and complete stock pens at Shelburne.

20185—August 25—Ordering the T.H. & B. Railway to employ a day and night watchman at the crossing of Bailey Street, Hamilton, Ontario, at its own expense.

20186—August 20—Relieving, for the present, the G.T.R. from providing further protection of the first highway one hundred and fifty feet west of St. Hilaire Station, Quebec.

20187—August 23—Amending Order No. 19957, dated August 2nd, 1913, by adding thereto the following clause, namely:—

"And it is further ordered that the Applicant Company be, and it is hereby, authorized to re-arrange the remaining tracks of the Grand Trunk Railway Company on the property of the Acton Tanning Company, in the manner shown on the said plan, in green,—using for the purpose the rails, ties, and other track material in the existing spur tracks, and supply, at its own expense, such other material and labor as may be required for the purpose."

20188—August 18—Authorizing the Esquimalt and Nanaimo Railway Company to construct, maintain and operate siding for Scott and Peden from a point on its railway, near Victoria Station, B.C., thence crossing Store Street, Victoria, into the premises of Scott and Peden.

20189—August 26—Authorizing the Government of the Province of Saskatchewan to construct and maintain highway over the C.P. & G.T.P. Rys. in Sec. 28, Tp. 32, Rge. 27, W. 2 M., Sask.

20190—August 26—Approving proposed location of C.P.R. Co.'s station on the S.E. ¼ of Sec. 32, Tp. 6, Rge. 15, W. 4 M., at Conrad, Alta., at mileage 24.7 on its Suffield to Blackie Branch.

20191—August 27—Extending until 1st of November, 1913, the time within which the C.P.R. install gates at the crossing of Montcalm St., St. Boniface, Man.

20192—August 26—Authorizing the C.P.R. to construct additional track of its main line, Lake Superior Division, Cartier Subdivision, across certain highways in the Tp. of Balfour, Sudbury, Ontario.

20193—August 27—Approving location of C.P.R. station on land lying to the north of Wellington Street and westerly of Robinson Street, Port Butwell, Tp. Bayham, Co. Elgin, Ontario.

20194—August 19—Authorizing the C.P.R. to construct, maintain and operate branch line of railway or spur from a point on the existing spur in Lot D.G.S. 45, Parish of St. James, to and into the premises of the Pease Foundry Co., Limited, situate in Lot D.G.S. 45, Parish of St. James.

20195—August 18—Authorizing the C.P.R. to construct, maintain and operate branch line of railway or spur, for Peter Verigin, of the Doukhobor Society of Brilliant, B.C., from a point on the westerly limit of the C.P.R. Co.'s Slocan Lake Branch, mileage 19.75 from Slocan Junction, into Lot 3463 G 1, B.C.

20196—August 26—Authorizing the C.P.R. to construct, maintain and operate branch line of railway or spur for the East Kootenay Lumber Company, Jaffray, B.C., from a point on the easterly limit of the C.P.R. right-of-way at Glenlily, Alberta Division, in Lot 7927 Group 1, B.C.

20197—August 19—Authorizing the C.P.R. subject to the terms of city's consent, excepting paragraph 5, to construct, maintain and operate two branch lines of railway or spurs, from a point on C.P.R.'s line, thence across Lachine Canal Lands and St. Patrick Street, to and into the premises of the Canadian Rolling Mills Company, situate in Lot Cadastral No. 3607, Parish of Montreal, Emard Ward, Montreal, Que.

20198—August 26—Authorizing the C.P.R. to construct, maintain and operate branch line of railway or siding from a point on the existing spur in Lamoriciere Street, thence across said street and Cadastral Lots Nos. 209-100 to 209-105. inclusive, in village of Cote St. Louis, to and into the premises of the Canada Produce Company, situate in said lots in St. Denis Ward, Montreal, Que.

20199—August 22—Authorizing the C.P.R. to construct, maintain and operate branch line of railway or spur for Orr Minnis, Markdale, Ontario, from a point on the northeasterly limit of the C.P.R. right-of-way, at mileage 66.12, Owen Sound Subdivision, Ont. Div. to and into premises of Orr Minnis, Lot 100, village of Markdale, Tp. Glenalg, Co. Grey, Ont.

20200—August 26—Authorizing the C.P.R. to construct, maintain and operate extension of existing siding for Messrs. Quinlan and Robertson, in Lot 10, Con. 8, Tp. Huntingdon, Ont., at mileage 85.86, C.P.R.'s Havelock Subdivision, Ont. Division.

20201—August 19—Authorizing the C.P.R. to construct, maintain and operate branch line of railway or spur from a point on the existing spur in the lane in Block 206, thence across and along said lane in Block 206, Lethbridge, Alta., for the International Harvester Company of Canada, Limited.

20202—August 19—Authorizing C.P.R. to construct a diversion of the road allowance in Sec. 4, Tp. 21, Rge. 9, W. 4 M., and to construct its tracks by means of a grade crossing, across the diversion, at mileage 60.78 of the C.P.R. Co.'s Bassano Easterly Branch.

20203—August 27—Authorizing the Corporation of the city of Edmonton, Alta., to extend Peace Avenue across the Edmonton, Yukon and Pacific Railway, at rail level.

20204—August 27—Ordering the G.T.P. Branch Lines Company to construct its Prince Albert Branch across the highway in the S.E. ¼ of Sec. 4, Tp. 33, Rge.. 27, W. 2 M., at mileage 1.5, Sask., on or before September 15th, 1913.

20205—August 27—Authorizing the C.N.R. and G.T.P. Railways to operate their trains over, upon, or through the connection and junction of the C.N.R. with the National Transcontinental Railway at St. Boniface, Man.

20206—August 28—Authorizing G.T.P. Branch Lines Company to carry traffic over portion of its Biggar-Calgary Branch between Dodsland, mileage 48.0, and Loverna, mileage 104.06.

20207—August 27—Authorizing the Government of the Province of Saskatchewan to construct and maintain, at its own expense, road under the C.N.R. right-of-way in the S.W. ¼ of Sec. 21, Tp. 29, Rge. 17, W. 3 M., Sask.

20208—August 27—Ordering the C.N.R. to construct a standard portable passenger and freight shelter and platform and a two car cattle pen at Mulvihill, Man.

20209—August 28—Relieving, for the present, the C.N.O.R. from providing further protection at the crossing of Ontario Street, Cobourg, Ont.

20210—August 28—Authorizing the C.P.R. to construct, maintain and operate branch lines of railway or spurs for the Moose Jaw Flour Mills Limited, Moose Jaw, Sask., from a point on the N.W. limit of the right-of-way of the C.P.R. main line of railway in Block 102, Moose Jaw, thence across said Block 102 and Second Avenue, to and into the premises of the Moose Jaw Flour Mills, Moose Jaw, Sask.

20211—August 27—Authorizing the C.P.R. to construct, maintain and operate a branch line of railway or spur for the Sherwin-Williams Company, Winnipeg, Man., from a point on existing spur in lane in Blocks 65, 66, 68 and 69 and across 6th St. W, 7th Street W, 8th Street W, and 9th Street W, Calgary; and a branch line of railway or spur from a point on above spur in lane in Block 66, thence across said lane and 7th Street W., to and into the premises of the Sherwin-Williams Company, situate in subdivision Lots 39, and 40, Block 67, Calgary, Alta.

20212—August 28—Rescinding Order No. 17282, in so far as it approves the revision of the location between mileages 15.1 and 31.5; providing that if C.P.R. file with the Board a new plan showing a connection at mileage 19, the Board will approve the revision from mileage 15.1 to mileage 19.

20213—August 27—Authorizing the C.P.R. to construct, by means of grade crossings, additional track across certain highways in the District of Sudbury and Province of Ontario.

20214—August 27—Relieving the C.P.R. of speed limitation of fifteen miles an hour on the Lauder Extension of its railway from Tilson, mileage 28.7 to Alida, mileage 54.72.

20215—August 27—Approving revised location of portion of C.P.R. main line, as constructed, Lake Superior Division, Schreiber Subdivision, from mileage 16.91, thence in a westerly direction to mileage 21.79, Dist. of Thunder Bay, Ont.