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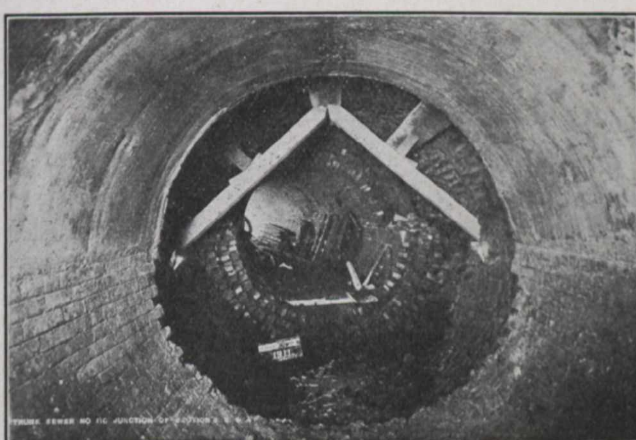
TORONTO MAIN DRAINAGE WORKS.

It is a realization of not so much the present needs of a city as her future requirements that leads to the undertaking of most civic improvements. In thus forecasting the future of the city of Toronto some three years ago it was seen that, at her present rapid rate of growth, it would soon be essential to provide some means of sewage disposal to improve the existing and, what had already become, unsanitary conditions prevailing along the waterfront.



High Level Interceptor, A Junction in Tunnel.

Lake Ontario, into which, under the present conditions, crude sewage is being discharged, is the source from which the city's water supply is being drawn. In spite of the fact that a large body of fresh water forms as efficient a natural sewage purifier as can be found, unmistakable evidence of contamination had been discovered in the water drawn from the city taps, although the intake of the waterworks system is located more than two miles distant from the nearest sewer outlet. Three-quarters of the city's sewage emptying as it does into the restricted area of Toronto Bay, overtaxed the oxidizing power of the water to such an extent that nuisances of a disagreeable character were created. The same objectionable conditions prevailed in a less degree along the shores in the east and west ends of the city, injuring their value as sites for recreation parks and summer residences, for which purpose they are so admirably suited. It was therefore decided to relieve these conditions and doubly safeguard that all-important feature—the public health—by constructing a sewage disposal plant and a water filtration plant. It is with the former that this paper deals, a brief description of its design, and method of construction appearing below.

The system as outlined by the experts consulted on the question, Mr. Rudolph Herring, of New York, and Mr. John D. Watson, of Manchester, England, and as approved and finally adopted by Mr. C. H. Rust, City Engineer, included the construction of two trunk sewers—the high and low level interceptors—a sewage pumping station, sedimentation tanks and submerged outfall sewer.

Toronto is at present drained by the combined system, the sewers carrying off both surface water and sanitary sewage. The direction of the flow is generally from north to south, each principal street carrying its own sewer which empties at its foot into the lake or bay. To convey this sewage to one point for the purpose of disposal, it was necessary to construct intercepting sewers, located so as to cross the line of all important existing sewers, at which point each would be relieved.

In order to secure a gravity flow for the major portion of the sewage, the high level interceptor was located as far south as possible, and still retain a continuous grade from the most westerly existing sewer to the disposal plant in the east end of the city. In order to catch all that was left by the high level interceptor, the line of the low level interceptor was located as near the waterfront as possible. This sewer carries the sewage by gravity to the pumping station, where it is raised by pumps to the level of the high level interceptor. The channels of the two sewers join after passing through the pumping station, and the sewage flows into the settling tanks. In its passage through these the sewage leaves behind a percentage of the solids contained therein, the effluent being drawn off through the outfall sewer and discharged into the lake.

The Method of Interception.

To intercept the sewage in the existing sewers, the plan, as adopted throughout the high level and in some cases on

High Level Interceptor, Open Trench Work.

the low level interceptor, was to construct a bellmouth chamber and weir. When a good fall could be obtained into the interceptor, the chamber was located just north of it, and the weir built across the bottom thereof. The sewage is deflected by the weir and conveyed through a vitrified connection pipe into the interceptor. The flow through this pipe can be regulated by a gate, so that an excess of storm water can be excluded and allowed to continue on down the sewer.

In several instances sewers were encountered that would not permit of the passage of the interceptor beneath them, in which event a sufficient length of the existing sewer was torn out and passed under the interceptor in the form of an inverted syphon. To secure a good grade in the connection pipe under these circumstances, the interception had to be made some distance up the line of the sewer. The most notable instance of this kind was that in connection with the interception of the Garrison Creek sewer. In this case the connection pipe, built of 72-inch reinforced concrete pipe, was 1,200 feet long, and a bellmouth chamber 30 ft. in length was required to accommodate the volume of sewage intercepted.

In several of the small sewers crossing this line of the low level interceptor the leaping weir was employed as a means of interception. The principle upon which it is worked is to leave a gap in the invert of the sewer wide enough to receive the designed amount of flow and over which the excess will leap. Due to the fact that the level of the invert of the low level interceptor is below lake level, it was necessary to place the crests of all intercepting weirs not lower than the elevation of high water. In this way lake water is prevented from backing up the existing sewers and finding its way into the interceptor.

The Design of the Intercepting System.

The system is designed to accommodate the sewage of Toronto in the year 1930. At this time it is assumed the city will have a population of 566,000, and provision was made for carrying sewage at the rate of 200 gallons per capita per day, with the interceptor running a little over one-half full, leaving the remaining area available for storm water. Another item influencing the grade and diameter of the interceptors was the assumption that one-half of the daily average flow would be discharged in eight hours, that is, during the 4 hours on either side of the point of maximum daily flow.

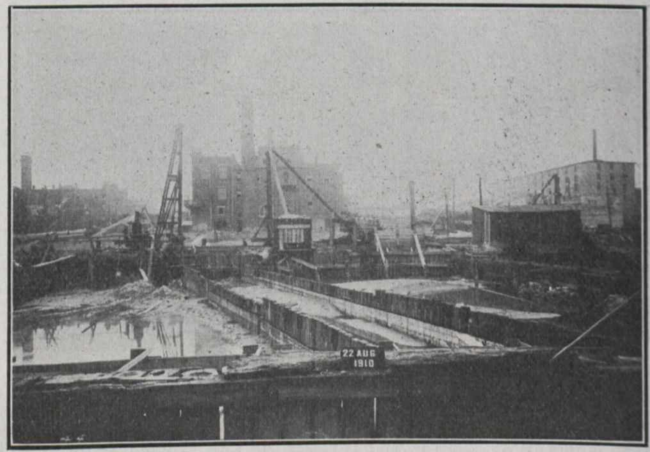
The result of these assumptions is that all the sanitary, or dry weather, flow, together with all surface water up to the capacity of the interceptor will be intercepted and treated at the tanks. During storms of great intensity the weirs in the bellmouth chambers will overflow and allow the storm water to flow by way of the existing sewer outlets into the lake or bay. Meteorological reports show that this will not occur more often than six or seven times a year, on which occasions the sewage will be so diluted with storm water that its presence in the lake will not be noticeable.

The High Level Interceptor.

The high level interceptor will extend from the corner of Roncesvalles avenue, where it intercepts the West Toronto trunk sewer, to the Disposal Works, which are situated at the foot of Morley avenue, its fifteen sections covering a distance of 9 miles. The line was determined roughly by the contour of the city, and is located on King and Liberty streets in the west end; and Defoe and Adelaide streets in the centre as far as Victoria street. From this point it follows a north-easterly direction, and crosses the Don river just below Wilton avenue, and thence to its destination by way of Elliott street, Dagmar, Doel and Morley avenues. Its cross-section and grade will vary from a 4-foot diameter circle at a slope of 1 in 1,800 at its western extremity, to the equivalent of a 9-foot 6-inch diameter circle at a slope of 1 in 3,200 where it enters the tanks. The smaller sections, for a distance of 2 miles, will be built of concrete pipe laid in open trench; where the line lies along important streets, for a distance of 3½ miles, tunnel construction is being employed, in which case an all-brick section is used. The larger sections in the east are being built in open cut, of monolithic concrete lined on the invert with a single ring of vetrified brick.

The Don Syphon.

At one point, however, the continuous grade of the high level interceptor is broken. This is where an inverted syphon had to be employed in order to pass the sewage under the Don river. The length of the syphon, including entry and exit chambers, is 500 feet, and the difference of elevation of the east and west ends is 18 inches, giving an hydraulic gradient of 1 in 330. The lowest point is 21 feet below the grade of the interceptor, this great depth being necessary by the fact that the Don river will at some future date be made navigable. The syphon consists of two parallel lines of bell and spigot cast iron pipes, 3 ft. 6 in. and 5 ft. 6 in. in diameter, supported on pile bents. The former is designed to take the present maximum dry weather flow, while the latter will be used for future increase and at time of storm. At the east and west ends of the syphon there is a concrete chamber, where the flow through the pipes is controlled by means of stop logs. From the latter a 36-inch cast iron overflow (which can be used in case of flood) is run into the river. A concrete blow-off chamber is also built around the pipes at the low point in the syphon for the purpose of unwatering it should the necessity arise.



The Don Syphon, Showing the Cofferdam Unwatered.

For the purpose of construction four lines of sheet piles, 130 feet long, were driven across the full width of the river, the water, which is only 4 feet deep, being carried by two flumes 8 feet wide, one on each side of the river channel. The two rows comprising the outer cofferdam were placed 100 feet apart and composed of 16-foot Wakefield sheeting. The two inner rows, made up of southern pine timbers 6 x 12, 32-ft., tongued and grooved, followed the line of the syphon and were driven 16 feet apart. The area between the two outer dams was unwatered and the space filled with the material as it was removed from the trench. Pile bents were spaced 4 feet apart on centres. The pipes, which were craddled and bevelled blocks, were supported by 8 x 12-inch southern pine sills, bolted to the piles, which were dapped to receive them. A brace was also placed over the top of the pipes, where they ran under the river, to prevent any buoyant tendency in case they had to be unwatered. The pipes, which were 6 feet long, the heaviest weighing 5 tons, were delivered by a derrick on shore to a gantry over the trench, by which they were lowered into place.

Another syphon in connection with the high level interceptor is that to intercept the Rosedale Creek. It will be approximately one mile in length and will be built of 42-inch reinforced concrete pressure pipe. The pipe has been designed to withstand an internal pressure of 14 pounds per square inch, and will have a special collar to protect the joints.

The Low Level Interceptor.

Located near the waterfront, we have a second trunk sewer which is practically a duplication, on a smaller scale, of the one just described. This is called the low level interceptor. Running as it does from the corner of Front and Bathurst streets by way of Front street and Eastern avenue, to the pumping station, it covers a distance of 5 miles. The cross-section of the low level interceptor varies from a 2-ft. x 4 ft. 3 in. brick, egg-shaped, to a 5 ft. 6 in. circular reinforced concrete pipe. As in the case of the high level, to avoid the numerous underground obstructions and any further congestion of traffic on the streets, that portion of the sewer lying between Bathurst and Parliament streets, a distance of 2½ miles, was specified to be built in tunnel, and the remaining 2½ miles, of concrete pipe, laid in open cut. The material encountered in this work, like that on the high level, was a stiff blue clay, of a very uniform character. Driving a heading without sheeting was the practice, and open cut work could be bottomed up accurately to template.

As in the high level we also have a syphon in the line of the low level interceptor. On account of the low elevation of the latter, however, it could be constructed to the bank of the river on both sides, thus requiring a syphon only 150 feet in length over all. The design is therefore a simplification of the one described above, requiring only two concrete drop manholes on either side of the river, connected by two lines of cast iron pipe, supported on pile bents. The lines of pipes in this case were both the same diameter, namely, 42 inches.

The Pumping Station.

On reaching the eastern ends of the two interceptors, we find them both passing through the pumping station, which is situated just west of the settling tanks. Here are located the screens for both sewers, the pumps for raising the sewage in the low level interceptor, the sludge well and the high and low level venturi meters. The channels of both interceptors are widened as they enter the building to accommodate the screens, of which the high level requires four, and the low level two. Across the full width of the channel and immediately in front of the screens runs a trough 10 ft. wide and 6 ft. deep, which is designed to catch grit and heavy foreign matter carried along in the sewage. This sump will be emptied by chain-operated bucket elevators, discharging into a worn conveyer which, in turn, will deposit the material into a hopper from which it will be carted and wasted. The screens will be made up of ½-inch tapered steel bars, spaced ½ inch apart. The frame will measure 6 ft. 8½ in. wide by 9 ft. 6 in. long over all, and will be set at an angle of 60 degrees to the horizontal, slanting in the direction of flow. Each screen will be cleaned by a rake operated by chains. These rakes will engage with revolving combs which will remove whatever material has been collected and allow it to drop into the worm conveyer just mentioned. All the moving parts in connection with the rakes and elevators will be operated by two 10 h.p. motors.

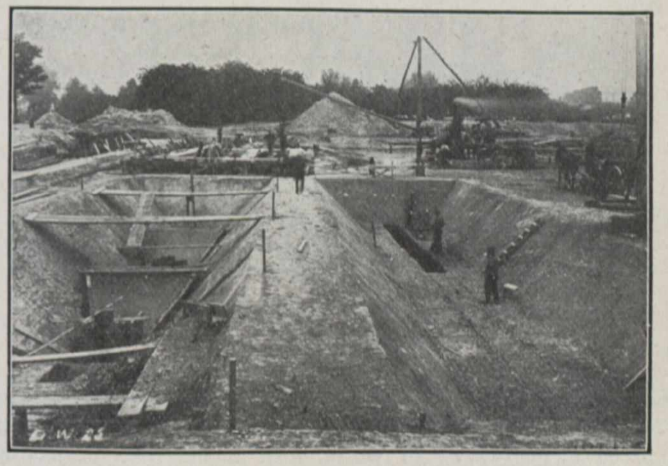
After passing through the screens the low level sewage will run into the suction well from which it will be raised by centrifugal pumps, through a height of 23 feet to the elevation of the sewage in the high level interceptor. The pumps will be operated by electric motors set vertically above them on the main floor of the pumping station. At present three are being installed, two with a capacity of 4,500 gals. per minute, and one with a capacity of 13,500 gals. per minute, requiring for operation respectively 75 and 200 horse-power motors.

Provision has been made for the addition of a fourth pump, should it be necessary, and also for the installation of a gas engine plant to supply power should the electric current fail. The motors will be fitted with automatic control, arranged so that one pump will be continually in use, while during the maximum daily flow a second will be thrown into operation, the third being reserved to assist in handling the flow during a storm.

The sewage of both interceptors is now measured by passing through venturi meters, the high level requiring 4-56 inch diameter and the low level 2-40 inch diameter. The meters are composed of throat and entry castings of iron, set in reinforced concrete tubes. The measuring mechanism is located on the main floor of the pumping station, and is provided with an indicating recorder from which the flow at any moment, and the total flow for the day, can be ascertained.

The Sedimentation Tanks.

After the flow in the two interceptors has been measured separately by the meters their channels unite and the combined flow passes into the sedimentation tanks. They are built of reinforced concrete throughout, and measure 209 x 368 feet over all. There are 24 separate tank units, each measuring in plan 25 x 100 feet, and the whole is roofed with a 5-inch reinforced concrete slab carried on concrete beams. The walls of the tanks are vertical for a distance of 10 feet from the top, at which point they converge to the centre on



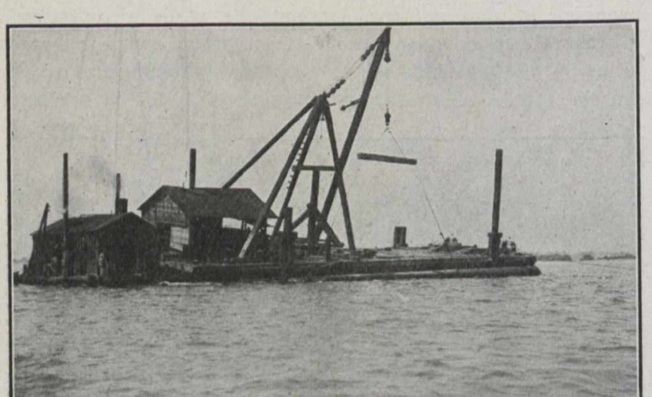
Sedimentation Tanks, Showing Excavation and Bottoms.

a slope of 45 degrees, meeting at a further depth of 12½ feet, the bottom of the tank is in the form of 4 valleys and 3 ridges, the latter being 4 feet high. From the former run 10-inch cast iron sludge drains, connecting with the sludge well, the flow in which is controlled by valves operated from the roof of the tank. Sewage is admitted to each tank along one side through 4-18 inch cast iron pipes, which are controlled by penstocks, and discharge downwards through a 90 degree bend over each of the valleys. Thirteen outlets are provided on the opposite side of the tank in the shape of adjustable weirs 10 inches wide, in front of which are baffle plates to prevent scum or floating matter escaping into the lake. The control of the inflow penstocks and the manipulation of the weirs are both conducted from the roof.

Sewage enters through the main inlet channel, which runs along the entire north side of the tanks, and is directed into the lateral inlet channels, which are located between each alternate row of tanks. The height at which the sewage will stand in each tank will seal the ends of the 18-inch inlet pipes, which in conjunction with the decreased rate of flow now attained by the sewage, will result in a slow, quiet passage across the tank. It is during this retention of the sewage in the tank that the solid matter, or sludge, is separated from the liquid. The sludge is deposited in the four valleys in the bottom of the tank and is drawn off daily, being admitted to the sludge drains by the opening of a valve which is operated from the roof. The sludge is collected in the sludge-well, situated in one corner of the pumping station, from which it is removed by an electrically driven pump, and disposed of. The liquid remaining in the tank is discharged over the weirs into the lateral effluent channel, along which it flows to the main effluent channel, and thence to the entrance of the outfall sewer. Here provision has been made for the installation of a chlorination plant. If it is found that the effluent has not been purified to the required extent it will be subjected to further purification by this process.

The Outfall Sewer.

The outfall sewer is a submerged pipe 5 feet in diameter and 5,300 feet in length. It carries the effluent from the tanks across Ashbridge's Bay and Island, and discharges it into the lake, 3,200 feet from shore, at a depth of 30 feet. For the construction of the first 1,500 feet of its length reinforced concrete pipes were used, each 24 feet in length with a wall 6 inches thick. These were cast vertically and fitted



Outfall Sewer, Lowering a 100-ft. Section of the 60-in Steel Pipe.

with cast iron flanges. The pipes were floated out on scows and laid by a derrick. They were supported on pile bents spaced 12 feet centre to centre, with anchor piles projecting above the pipe every 25 feet. Wooden gaskets were used in making the joint, and were bevelled to take up any slight differences due to error in alignment or grade. On Ashbridge Island the section changes from concrete pipe to riveted steel. The plate used was ½ inch thick and the pipe made in 50-foot lengths. The method of support was the same as for the concrete pipe, the bents, as before, being framed first and dolleyed down by a double hammer driver. In laying the pipe, the contractor jointed two 50-foot lengths on shore and loaded them on a scow, from which he handled them with the derrick. The pipe emerges from cover about 2,500 feet from its outer end, from which point it conforms to level of the lake bottom. Provision has been made to sheet pile this portion in order to reduce the likelihood of the loosening of the joints due to vibration. An expansion joint was located at the point where the cover over the pipe stops, to allow for changes in temperature.

The discharge of the effluent takes place not only at the end of the pipe but also through perforations along the sides. These are 4 inches in diameter, spaced 8 feet 6 inches apart, and extend over a distance of 500 ft. To maintain the velocity in the pipe a tapered section had to be employed, the diameter decreasing from 5 ft. to 2 ft. In this gradual diffusion of the effluent into the lake water the likelihood of the occurrence of nuisances at this point is very remote.

This is the final destination of the waste of the city, which has been diverted from its course and transformed from a foul, germ-carrying stream to a comparatively clear and harmless liquid. Observations show that there is no definite set to the currents in the lake at the point of outfall of the effluent, but should such a condition prevail and the effluent find its way to the vicinity of the mouth of the waterworks intake, some 5½ miles distant, contact with the intervening water would have removed any harmful qualities it might have previously possessed.

The above general description of this work has been furnished to the Canadian Engineer by Mr. A. B. Garrow, B.A.Sc., the assistant engineer in charge of Main Drainage Works, to whom we are also indebted for the accompanying cuts.

TRIALS OF SEWAGE PRECIPITANTS AT WAKEFIELD.

To determine the most economical and efficient precipitant for the sewage received at the Wakefield, England, disposal works, Mr. J. P. Wakeford, city engineer, conducted tests with a number of chemicals. The results, summarized below, are from a paper read by him at the Royal Sanitary Institute Congress in Belfast, Ireland. The sewage is classified as "strong" and contains sundry trade wastes, wool-scouring refuse predominating. Heavy chemical precipitation, followed by filtration on percolating filters, was the method of purification adopted.

The precipitants experimented with were (1) lime, (2) lime and ferric sulphate, produced by oxidizing copperas solution, (3) lime and copperas, (4) lime and ferric sulphate, in slabs, (5) lime and ferric sulphate, produced by dissolving ferric hydrate in vitriol.

The flow of sewage was taken as 1,800,000 imp. gals. per day, and the quantity of precipitant added was regulated according to the average hourly variation of flow. The lime was used in every instance, as had been previously determined by laboratory experiments, giving very much better and more economical results. In order to avoid the expense of purchasing a lime mixer of the usual type the following simple method of applying the lime was adopted:

Lime.—The dry lime was added gradually to water and kept constantly stirred until it "boiled." It was then run through a riddle, to remove any stones or lumps, into shallow pits about 2 ft. deep, where it was allowed to set for a day or two until it reached the required consistency; it was then fed into a barrel resting on planks across the inlet channel.

The barrel had a hole about 2 in. diameter bored in the side near the bottom, and a jet of water playing into this gradually washed the lime out in the form of a thick milk, which dropped into the sewage flowing down the channel and was thoroughly mixed; about 8 gr. of lime per imperial gallon of sewage was used. After continuing for three days the tank effluent certainly showed some improvement, but had a cloudy appearance and a strongly alkaline reaction, which would be injurious to bacterial filters. Furthermore, upon adding other precipitants (ferric sulphate of both varieties) to this tank effluent considerable further precipitation took place, thereby proving that with lime alone the purification was incomplete.

Lime and Ferric Sulphate.—Copperas solution of ferrous sulphate, $Fe\ SO_4$, was caused to absorb oxygen from the air by being churned up with sodium nitrite in a machine called an "oxidizer," when it becomes ferric sulphate, $Fe_2(SO_4)_3$. It was found that to precipitate the sewage efficiently it was necessary to use on an average 28 gr. of ferric sulphate liquor and 4 gr. of lime per imperial gallon, which represents about 3½ tons of the liquor and ½ ton of lime per day.

Lime and Copperas.—The copperas was made up into a solution as in the previous process, but no acid was added, and, of course, it was not oxidized, it being added to the sewage through the gauge as before. In three days 5 tons of copperas were used, 4 gr. of lime per imperial gallon also being added. This was at the rate of about 14 gr. of copperas per imperial gallon. The precipitation appeared fairly good, but the tank effluent was somewhat cloudy and lacked the clear appearance produced by the ferric sulphate.

Lime and Ferric Sulphate in Slabs.—The slabs were placed in cages in the inlet channel and the lime added in the usual manner (6 gr. per imperial gallon). The total weight of the slabs dissolved was 11,937 lb. in 60.5 hours, which works out at 17 1/7 gr. per gallon, or exactly 2 tons per day. The tank effluent was fairly good, but had a slightly cloudy appearance, probably due to the large amount of china clay (22 per cent) that it was necessary to mix with the ferric sulphate in order to obtain slabs firm enough to handle. The cost was found to be prohibitive.

This precipitant gave very satisfactory results in "breaking up the sewage," a heavy precipitate settling down readily. Only a short trial, however, was made, in order to obtain some idea of the action of ferric sulphate upon the sewage, with the intention, if the trial was successful, of experimenting with it in the liquid form, as this latter requires a special plant for its manufacture.

Lime and Ferric Sulphate.—In view of the satisfactory action of the slabs of ferric sulphate, it was decided to give a trial to this precipitant in liquid form. Accordingly two tanks, 8 x 6 x 5 ft. deep, which had been used for dissolving copperas in the former trials, were lined with lead and steam pipes laid down for boiling the liquid. Eighteen carboys of vitriol were put into the tank and heated up by steam; a little water was added until the liquid showed a strength of 90 deg. when tested with a Twaddell hydrometer. When thoroughly boiling the ferric hydrate was added gradually with a shovel, 3,360 lb. being the average quantity required. After all the hydrate had been added the mixture was kept boiling for about half an hour. The amount of liquor thus produced averaged 4 tons at 100 deg. Twaddell. This was usually diluted to 50 deg. Twaddell before being added to the sewage so as to flow more readily through the gauge, and be more accurately measured. The above process of manufacture occupied about four hours per mixing.

Lime was added at the average rate of 6 gr. per gallon as before, and the ferric sulphate run into the sewage through the gauge used in the previous tests. The amount required to give satisfactory precipitation was found to be 2 tons per day, or 17⅓ gr. per imperial gallon. The sewage was broken up very rapidly, and a good, clean tank effluent produced and taking the crude sewage for hours' oxygen absorbed test as 18.55 parts per 100,000, 70 per cent. purification was often obtained.

From the foregoing trials it was demonstrated that the use of lime followed by ferric sulphate in solution provided the most effective means of purification for the Wakefield sewage, and of the two processes, (a) oxidizing copperas solution, (b) dissolving ferric hydrate in vitriol, the second is the cheaper and also entails less labor, a mixing being required only every other day, whereas the oxidizer must be kept running almost continuously.

In view, therefore, of the saving in cost and convenience in working this process has been adopted in the new scheme designed by Mr. Wakeford and at present in progress.

EFFICIENT EARTHWORK ESTIMATES.*

By J. C. Van Zandt.

Preliminary estimates of earthwork quantities have always been a subject of discussion, because of the fact that they do not require any great exactitude, and hence engineers may reasonably differ on the degree of precision that should be attained. It is probably true that one reason why engineers' estimates are frequently spoken of so disparagingly is that in assuming approximate quantities some of the essential items have been disregarded and the results have been accordingly inaccurate.

Among the items which must not be omitted, Wellington says, in the Economic Theory of Railway Location; that the surface slope is "one source of error that must be allowed for," and suggests that "this may be done by either using a coefficient to multiply the quantities when obtained or by working from a diagram." It is certain that in estimating merely from profile center-heights without taking this important matter into full consideration there may be sufficient lack of precision in a single cut or fill to introduce a considerable error in the computation. Even when the equivalent level sections are used there is, according to Wellington, "a constant tendency to deficiency" in the estimate of quantities.

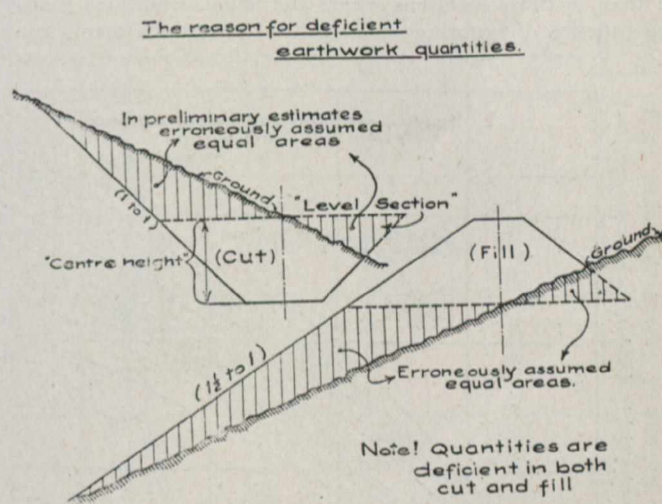


Fig. A—Effect of Changes of Surface Slope on Area of Cross-Section.

This deficiency of quantities in the estimate is contrary to one of the fundamental principles upon which all authorities agree, namely, that all quantities should be estimated liberally. In some cases an arbitrary percentage is added at the end "to be on the safe side," or an arbitrary amount is added to "make an even figure," and insure sufficient quantities. In every case the purpose has been to allow for the deficiency which common experience shows is characteristic of preliminary estimates, computed in the usual manner and known to be mathematically incorrect. One reason for this deficiency is clearly indicated in the diagram illustrating the effect of transverse slope on the area of the cross-section and showing the geometrical principles involved in computations using the level-sections from profile center-heights.

In country where the topography is especially rough and side-slopes are steep this becomes a serious problem. In the comparison of two or more possible routes the earthwork is an important item, and as it may materially increase the cost it should be known to be within an estimated

*From Railway Age Gazette.

amount in order that financial interests may determine whether it would be profitable to make the investment or not. In these mountainous districts the earthwork is often the largest item of cost and the final construction work should show an improvement or a smaller volume of earthwork than the preliminary estimate. As it often occurs that the final yardage is greatly in excess of that originally estimated, and as in some cases financial difficulties have followed which have threatened the continuation of the work, it is proper that special precaution and care be exercised to eliminate constantly recurring errors which invariably produce deficient quantities, and which in special cases may affect the total materially.

Of course, in comparatively level country, the transverse surface slope is generally not of sufficient importance to be given special consideration, but it often happens that at river crossings or along stream bluffs there are surprisingly steep transverse slopes which should certainly justify attention. There is no place where error is more likely to creep in than in those locations where the usual conditions justify the practice of ignoring small errors, but which errors may at unusual places introduce large inaccuracies in the estimates. It is certainly evident that there is inconsistency in the practice of taking into full account small quantities on the level ground and then disregarding the effect of surface slope at some river bank where that effect may produce an error in yardage larger than any item that had previously been considered.

The effect of a slope of 30 deg. upon a 5 ft. cut is given by Raymond in his Elements of Railroad Engineering as amounting to an increase in volume of 60 per cent. He further suggests that "what sections may be considered level across may be determined by remembering that a cross slope of one in ten will be erroneously calculated by the level-section method by about 2 per cent., the truth being in excess, and a slope of one in five will be erroneously calculated by about 8 per cent." Steeper slopes increase this more rapidly, as they become very steep and may give rise to errors of over 60 per cent. as mentioned above. Raymond suggests, however, that "these values are roughly approximate and the more accurate method is to use a diagram for sloping ground."

There has been a number of diagrams for earthwork in which the slope of the ground has been considered, among which those of Wellington and Trautwine are perhaps best known. These diagrams as well as the tables which consider transverse slopes are made on a basis of angle of slope in degrees. This requires that either the angle be measured in the field or calculated from other data. The latter method is most generally employed and frequently involves a considerable amount of computation. It has appeared that the work could be done more efficiently by the use of diagrams based on a contour slope-distance instead of angle in degree. The data may then be taken directly from the contour map and profile and applied to the diagram from which the volume of earthwork may be read. Standard diagrams similar to those shown herewith may be made for any roadbed dimensions and used efficiently in the field or office. In case reference was to be made to tables on the angle basis a curve as shown herewith would save time in changing from one system to the other. In fact all computation work involved in transferring data on the contour-distance basis to the angle-of-slope basis may be eliminated by the use of this diagram.

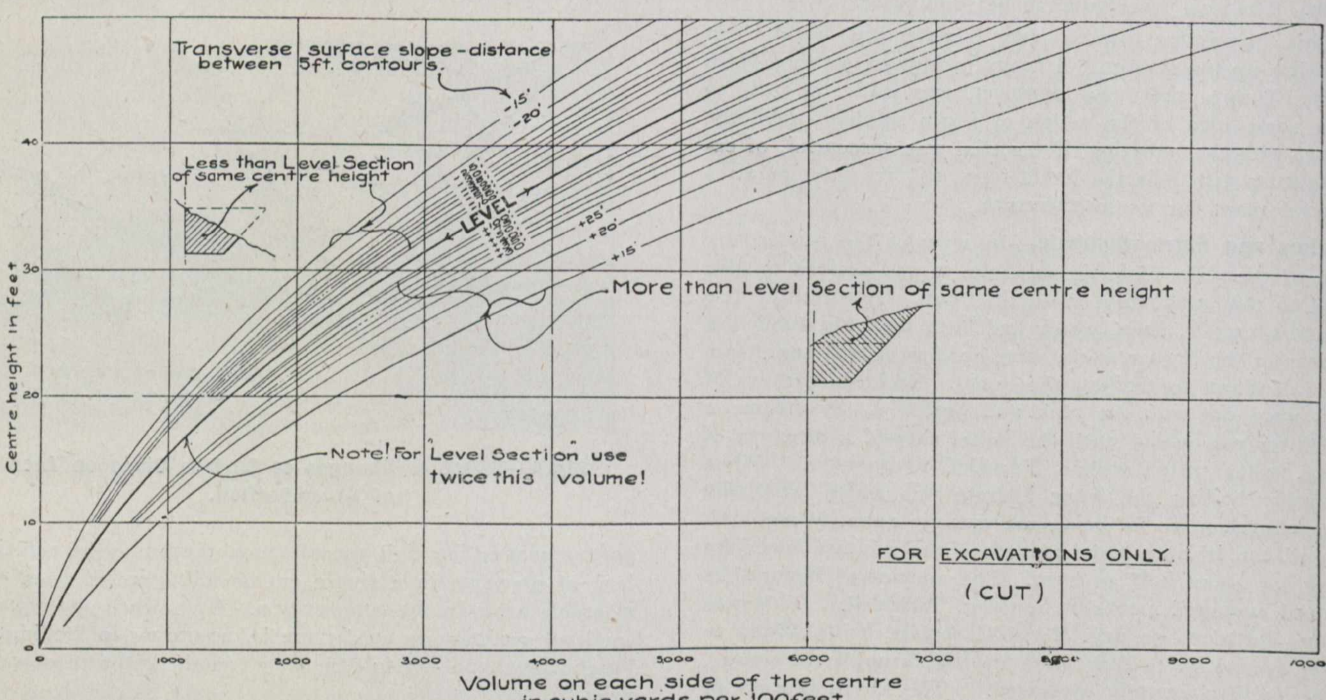


Fig. B—Effect of Changes of Surface Slope on Volume of Earthwork. Base 20 ft.; Slope 1 to 1.

Many of the tables given for surface slope correction give quantities for equal increments to extreme angles of slope, and do not take into account the fact that in these extreme cases a change of 1 deg. may alter the total by a large quantity. It appears that when the surface-slope is very steep the cross-section should be taken approximately at least, if the quantity is to be estimated with a consistent degree of accuracy. On one of the western roads the following rule has been used:

"Where the transverse surface slope is steep and the 5-ft. contours are less than 15 ft. apart, cross-sections must be taken."

This limits the slope to one in three for the application of graphical methods and requires constantly that necessary data be taken for extreme cases. Since it cannot be expected that the contours on a topographical map are located correctly within two or three feet on scales usually employed, it is evident that it would be inconsistent to use this data as the measure of surface slope when contours are very close together, especially since the effect of small changes is greatest when the distance between contours is small. As has well been said by Mr. Lavis in his Railroad-Location Surveys and Estimates, "estimating is, to a certain extent, of course, a matter of guess work and judgment," and "there is plenty of room for the engineer to exercise his judgment even after having obtained the most minute information." It was his practice "as soon as the profile of the projected location has been made" to indicate "where allowance must be made for steep transverse slopes," and to further urge that "every effort be made to collect all available data."

It might be suggested that the expense of making such diagrams as those given would not be justified by the results, but it will be remembered that not only are the corrections above outlined easily made, but the probability of error in the use of tables is reduced as well, and this has often

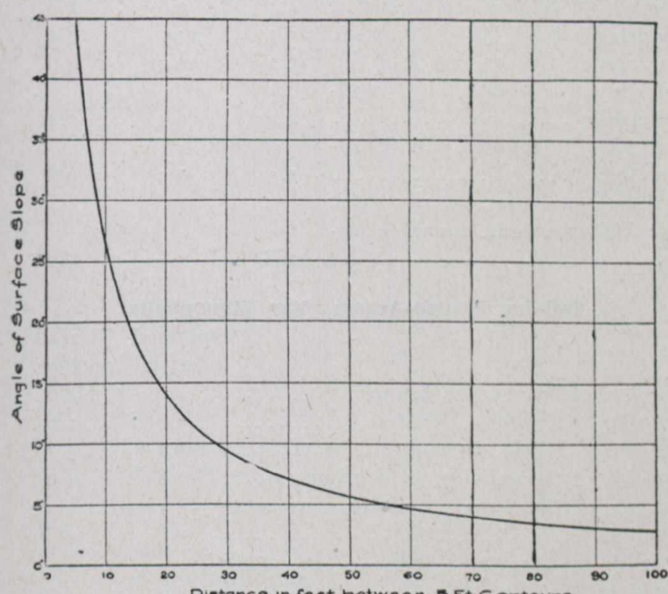


Fig. C—Relation Between Angle of Surface Slope and Horizontal Distance Between 5-ft. Contours.

been shown to be a decided item in efficiency. The time required for making the diagram is relatively small and the method resolves itself into the making of a few short calculations with a table of level section volumes, as follows:

(1) Formulae:

Let s = slopes (as 1½ ÷ 1 for fill, 1 ÷ 1 for cut)

c = center-height (from profile)

b = width of base in feet

x = angle of slope in degrees

cot x = slope distance ÷ contour interval (5 ft.)

then the excess, E, of volume in cubic yards per one hundred feet of track, on one side of the center line would be,

$$E = \frac{(\frac{1}{2}b + sc)^2}{2\cot x + 2s} \times \frac{100}{27}$$

and the deficiency, D, on the other side,

$$D = \frac{2\cot x + 2s}{(\frac{1}{2}b + sc)^2} \times \frac{100}{27}$$

(2) Method. These values of E and D are added to or subtracted from a table of level section values or a single value of E—D may be addel to the tabular values to give the corrected volumes for changes of surface slope, which may then be p'otted to any convenient scale.

Should it be desirable to make provision for changes of slope in the cross-section, which is more often the case than not, the data may be plotted, as shown in the charts already mentioned, and in case of high fills or deep cuts this may prevent introducing a large error from assuming a uniform

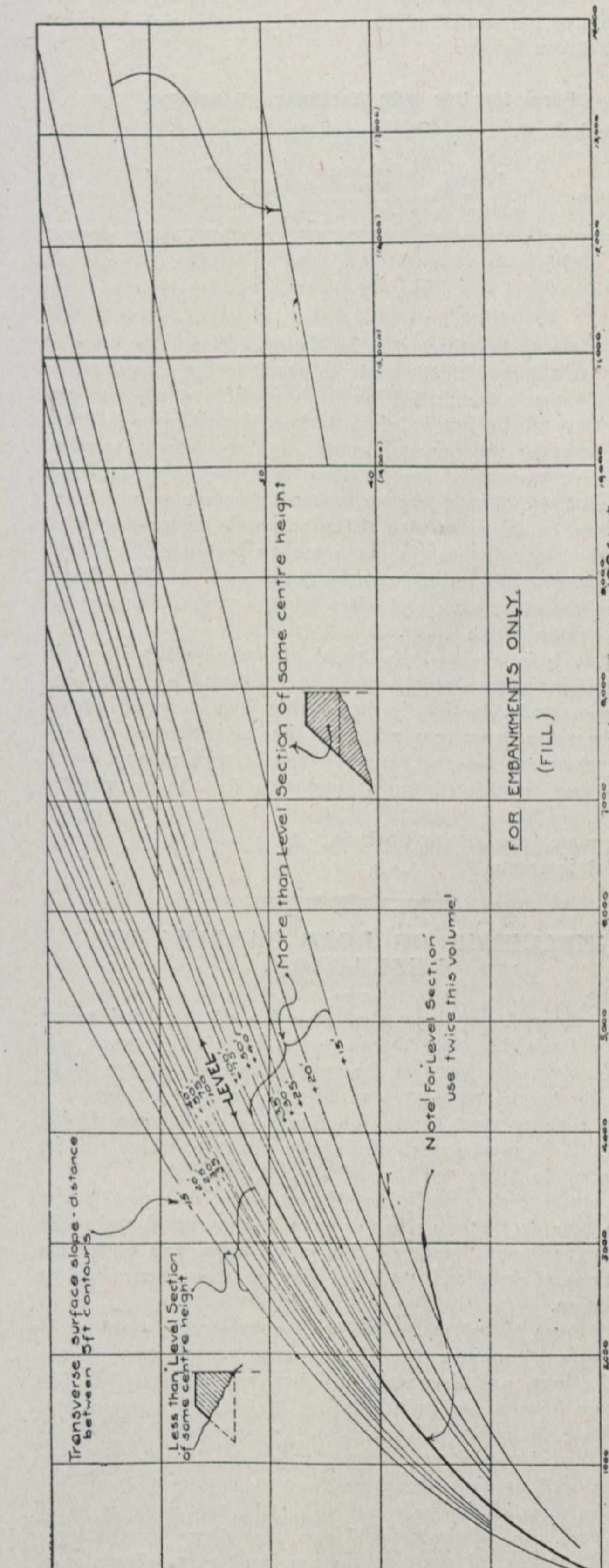


Fig. D Effect of Changes of Surface Slope on Volume of Earthwork. Base 18 ft.; Slope 1½ to 1.

slope. In fact in some cases the ground may slope away from the center or be nearly level on one side and steep on the other, in which cases this form of diagram is convenient. There are other advantages also for this form of diagram, among which may be mentioned the important fact that smaller quantities are plotted, and hence a larger scale may be used which increases the accuracy of reading the diagram.

A method of tabulating the data which has increased the efficiency of the work and further reduced the probability of error is given below:

Form for Use with Earthwork Diagrams.

A. B. & C. R. R. Earthwork Estimate for Mile

Station.	Average Ctr. Height Cut or Fill.	Contour Slope Dist. ±L	Contour Slope Dist. ±R	Volume Cut. L	Volume Cut. R	Volume Fill. L	Volume Fill. R	Remarks.

The station numbers may be placed between the lines of the rest of the data in the table to assist in the identification of the item and the profile center heights, and contour distances may all be put in place before the diagram is used. Under remarks any unusual items, such as tunnels, trestles, bridges, or extremely steep surface requiring cross-sections, may be noted. The reference to book numbers in which the data may be found is also to be recorded under remarks. When the slope-distance is the same on both right and left, it may be given in one column or the other and a line drawn through the other side, and when level section a line may be drawn through both sides.

While it is obvious that there are many other items in the preliminary estimates which affect the total substantially, it appears probable that if these other items are considered with the same consistent accuracy that is suggested for the earthwork quantities the estimate may become a more satisfactory and reliable document, not only for the comparison of lines and fixing of grades, but also as an estimate of the approximate cost of the work for the consideration of the financial interests.

INFLUENCE OF ROAD TARRING ON VEGETATION.

On several occasions the attention of the Academy of Science, Paris, has been drawn to the harmful influence that tarring roads may have on the surrounding vegetation, more especially by the researches of Mirande and of Griffon.

In a paper read before the Academy of Science, Paris, Mr. C. L. Gatin makes the following remarks, which will be of interest to those working with road materials:

A study of the vegetation of the trees of the tarred walks of the Bois de Boulogne has enabled me to record the result or an experiment "made on the large scale, and under the conditions of practice," thus realizing the hope expressed by M. Griffon.

Of these tarred walks we shall consider the Sablons to the Porte Dauphine; the Longchamp (Acasias-walk), the Fortifications, and that from the Acacias to Bagatelle. The first two have a particularly heavy traffic, and are not tarred along their entire length, so that comparisons may be established between vegetation bordering their tarred portion as well as that alongside the untarred portion.

The trees bordering or adjoining the tarred parts, as all may see, are distinguished from the others by the more stunted aspect of their vegetation, by the smaller size of their leaves, which are often shrivelled and spotted, by the premature falling of the foliage, and by the lessened vigor of the growth throughout the year. It is further of interest to remark that the upper part of the trees along the tarred region is less affected than the lower part, which is more exposed.

On the different species I have carried out a large number of biometric measurements, which are capable of showing the influence of the neighborhood of a tarred road much frequented and exposed to the sun:

Catalpha Bignonicides.

	Untarred portion.	Tarred portion.
Number of leaves on one branch........	13.5	11.2
Breadth of the leaves, in centimetres...	10.2	9.3
Length of the leaves, in centimetres...	20.9	14.6
Length of the border, in centimetres....	15.1	10.4
Surface of the leaves, per year's growth, in square centimetres	956.4	495.7

Robina Pseudo-Acacia.

	Untarred portion.	Tarred portion. Upper branches.	Tarred portion. Lower branches.
Number of leaves per branch..	4.4	3.6	2.2
Length of leaves in centimetres	2.5	14.7	14.4
Number of folioles per leaf....	16.2	14.0	9.0
Length of folioles, in centimetres	4.4	2.2	1.5
Breadth of folioles, in centimetres	2.3	1.3	0.8
Surface of the leaves, per year's growth in square centimetres	288	—	180

Robina Pseudo-Acacia, Var Monophylla.

	Untarred portion.	Tarred portion.
Number of leaves per branch..............	4.0	4.0
Number of folioles per leaf.............	1.8	1.6
Length of foliole, in centimetres.........	7.1	3.7
Breadth of the folioles, in centimetres....	2.8	1.9
Length of the small folioles, in centimetres	2.6	1.8
Breadth of the small folioles, in centimetres	1.2	1.0

Analogous measurements made of other species gave similar results. By using the dust taken from the Place d'Iéna, I have, moreover, been able experimentally to effect the phenomenon of browning on the leaves of the rose and sycamore. Nevertheless, it is at present impossible to determine the part played by the vapors and that resulting from the action of the dust in the phenomenon of stunting. This phenomenon, moreover, does not occur in the case of the vegetation bordering all the tarred walks. The trees of the Bagatelle-walk, and of the Fortifications-walk, which are shaded, and subjected to little traffic, do not appear so far to have suffered from tarring. It therefore appears that in certain cases only, particularly when the road is very much exposed to the sun and subject to very heavy traffic, can tarring have any harmful effect on the vegetation of the neighboring plants.

AUTOMOBILE STREET CLEANERS IN BERLIN.

The city of Berlin has this year purchased for cleaning its streets a number of machines which are driven by electric power, these being the "Waschmaschin" manufactured by Hentschel & Company of that city. These are squeegees, similar to those used in this country, except that the latter have all been horse-drawn, we believe. These are the first motor-driven squeegees to be purchased by Berlin, although a number of horse-drawn ones have been used for several years.

THE ORIGIN AND PRODUCTION OF "CORRUGATION" OF TRAMWAY RAILS.*

By W. WORBY BEAUMONT, M. Inst., C.E.

Few of the phenomena of the behavior of materials employed in tramway construction have given rise to so much inquiry, speculation and diversity of opinion in the last few years as the phenomenon known as "corrugation" of tramway rails. The rapid spread of its occurrence, in nearly all towns with heavy tramway service, has directed anxious attention to the discovery of its cause, and much has been written concerning it, and some experimental investigations have been made. Unfortunately, the indoor experiments have seldom been conducted with apparatus or under conditions which simulate those of the tramway itself.

On the other hand, the observations which have been made by many on the rails themselves have led to every possible variety of interpretation of the cause of corrugation, largely because of the apparent contrariety of its occurrence and non-occurrence. The author had commenced the preparation of an index to the papers and articles which have appeared in this and other countries during the past five years, but it was soon found that this would be of intolerable length, and, after all, of but little service. The Proceedings of the Institution of Civil Engineers provide abstracts of papers too numerous to mention; the Institution of Electrical Engineers has dealt with the subject; the Municipal Tramway Association and the Tramway Congress hardly ever met without dealing with the subject; the Tramways and Light Railways Association Official Circular and Journal for some years has been crowded with corrugation inequalities and vagaries, and lately a joint committee of the two associations —the Municipal Tramways Association and the Tramways and Light Railways Association—has been working on the subject. To the proceedings of this committee the author has contributed, and had previously dealt with the subject elsewhere. Foreign authors have contributed largely, and a report by a committee consisting of the managers of nine continental tramway systems, one British professor of engineering, and the secretary, was discussed at the International Tramway Congress held in Brussels in 1910. One of the recent and most useful reports on the subject (although some judicious analysis of the facts presented is required) has been prepared as a provisional report by a Committee of the Technical Department for Railway Construction and Exploitation of Amsterdam, including Messrs. J. Schroeder van der Kolk, M. P. Mass Geesteranne, and T. E. van Putten, and, more recently, a paper by Herr von Borries, of much merit, has been published.

Having given some attention to all this literature of this particular engineering ailment, and being aware of the indecision that still exists in the minds of many upon it, the author now ventures at more length, and with the object of greater precision, the explanation he has on previous occasions attempted to convey. The subject has hitherto been treated mainly from the general point of view suggested by the practical experience of the tramway manager and engineer, and has seldom attracted or received the considered reasoning conjointly of the mechanic and the physicist. It is, however, one which in a marked degree demands the patient application of the attributes of both, and in this paper I may repeat the words of M. H. R. A. Mallock,† and say, "It is often useful to have a simple, even if incomplete, theoretical treatment of a subject, provided that the theory is correct so far as it goes, and is kept within bounds by comparison with actual observations."

In a surface of a homogeneous solid under compressive stress in orthogonal directions in the plane of the surface, every particle tends to cause every particle surrounding it to recede in every direction. If one surface of a free flat bar of steel or iron, as Fig. 1, be rolled or hammered, the material of that surface is subjected to a compressive stress. Of this stress it is relieved in the direction of length of the bar so far as the stress is no greater than that which is necessary to bend the bar, and cause it to keep the bent form of Fig. 2. If of wrought iron, the molecular surface stress will in part be relieved by flow of the material or detrusion along the edges of the hammered surface, and the longitudinal bending be less than if the bar be rail steel, in which the detrusion will be less.

If of cast iron, the surface compressive stress will accumulate, and the bar will be bent by it, but the accumulation of stress reaches an earlier limit, as it sooner exceeds the limit of cohesion between the surface and subjacent films. The result is that with cast iron surface crumbling occurs and limits stress accumulation. It does, however, become, sufficient to permit its use as a means of straightening cast-iron coping-plates and the like if slightly curved when taken out of the sand.

If, when a bar has been bent by surface compression of one side, it be forcibly straightened, the compressive stress will be increased, and a tensile stress impressed on the opposite side sufficient to eliminate the difference of dimensions of the two sides caused by the compression. To remove the difference permanently the stress on the uncompressed side must reach the character of strain equally distributed throughout the whole length of the bar. At the same time an increase is made in the compressive stress on the rolled or hammered surface. This cannot be removed by a single pucker or extrusion of the surface about the center of length of the bar, as the stress is uniformly distributed. Hence at distances apart (or pitch) depending on the elastic and cohesive properties of the material there will result incipient surface crumblings or corrugation, as shown exaggerated in Fig. 3.

The bearing of this fact on the tramway or railway rail will appear hereafter, but here it may be observed that the stresses in a bar which is bent by compression of one side, and caused to retain the bent form by that resident molecular stress, are not in the same condition as to stress throughout its structure as a similar bar bent and maintained in a bent form by mechanically imposed distributed load.

In the bar bent by compression of the material on one side, there is molecular tensile stress immediately below the hammered surface. The compression differentiates in intensity from the surface, to a zone or couche under tensile stress resulting from the molecular cohesion which has prevented the compression and extended surface from separating itself by shear. Beloy this, tensile stress differentiates into a neutral zone, and therefrom into the compressive stress, which remains resident in the bar so long as it is bent by these internal forces.

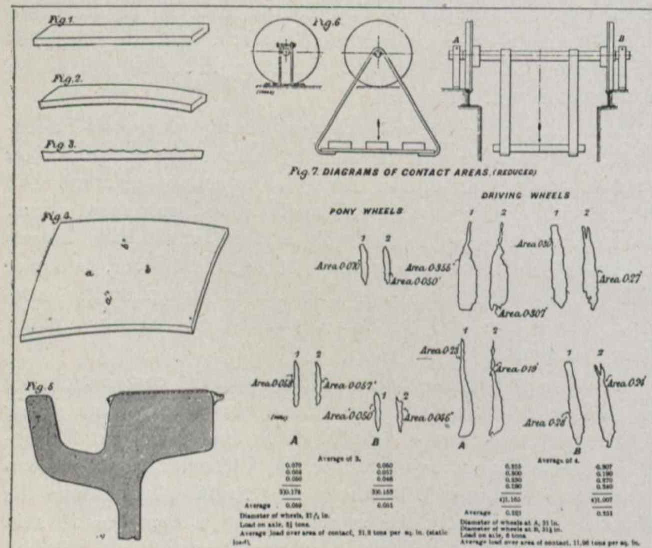
In a surface, such as that of an iron plate which has been rolled or hammered on that surface only, the particles

*Paper read before Section G of the British Association at Portsmouth, August 31.

†Proceedings of the Institution of Civil Engineers, vol. clxxviii., 1909.

of the hammered surface are, as previously mentioned, restrained by cohesion of and with the subjacent particles, which are less and less under compression as they are remote from the compressed surface film.

If any two points a b or a^1 b^1, Fig. 4, be taken in such a surface film, it will be seen that all the particles round each point press towards it with forces proportional to some function of their respective distances from such points. In a line drawn from a to b, or a^1 b^1, there are therefore equal and opposite forces tending to separate those points, and when their amount exceeds the elastic resistance of the material, deformation or crushing or crumbling must occur, if change of form of that of which the surface is a part be restrained. If the surface be that of a deformable plate then the forces are in part relieved by bending the plate in orthogonal directions. It is not necessary here to determine the distance between a and b at which any given material will reach the yielding point or at which the accumulated forces will be sufficient to cause either the bending of a plate, or give rise to destructive stresses in any other form of which the compressed surface is part.



To this a return may be hereafter made, but here it is sufficient to repeat that it will be dependent upon the relation between the elastic resistance of the material to compression and its elastic tensile strength, and its hardness.

In dealing with these stresses as occurring in practice, and in such forms as those of a railway or tramway rail, it will be seen from the foregoing that the values of the stresses in orthogonal directions, soon reach inequality, because, while they become cumulative in the direction of length of the rail, the distance transversely separating the points a and b earlier reaches the limits of dimensions at which the forces can arise, because relief of the stresses is found in lateral deformation or detrusion at the rail edges (Fig. 5).

There is a further view of the physical conditions to be considered which, under the mechanical conditions of the rolling of a wheel on the plane surface of a rail under pressure greater than or approaching its elastic resistance, gives rise to that which results in what is known as corrugation. A loaded circular surface, as of a roller or wheel resting upon a deformable straight plane surface, has but a line contact with that surface until either or both the circular and flat surfaces of contact are so deformed by loading the roller as to increase the area of contact. The deformation will continue until the resistance to deformation equals the force producing it. If the materials of the two surfaces be equally resistant, the circular surface will be flattened and the flat surface will be depressed or indented. If the roller be of the more resistant material, the deformation may be chiefly in the material of the flat surface. If the roller be made to roll along the surface which it can so deform, it presses before it a wave of deformation. The depression giving rise to this wave may (as in the case of the tramcar wheels and rails) approach or exceed the limit of elastic deformation of the material of the rail. When this is the case, continuation of the movement of the roller upon the surface demands the translation of the crest of the wave, and this would involve the destruction of the cohesion between the rolled compressed surface wave crest and the material supporting it, and of which it is a part. The result, therefore, is that tensile stress arises, pari passu, with the wave formation between the wave particle and the subjacent particle of the material supporting it, and the point is reached at which the tensile resistance to the increase of the wave height prevents further increase. The roller then must rise upon the minute crest, and in doing this with its heavy load upon the extremely small area, compresses it to extreme hardness. The roller (wheel) in its continued progress repeats the process and continuously adds to the rearward dimensions of the hardened spot.

The foregoing then shows that the rolling and hammering of the upper surfaces of a rail originate a condition of intense compressive stress, the elimination of which produces or tends to produce modification of form. It also shows that areas of maximum compression are originated at points separated by distances which are determined mainly by the relation between compression resistance and elastic strength of the material rolled, but in part by the relative hardness of the roller and rail, and by the mechanical conditions which affect the area of the roller and rail contact.

The area of contact of hard-tire tramway wheels on steel rails is very small—is less than on ordinary railway wheels. On the latter it has been found to vary, with wheels of 4 ft. 6 ins. to 5 ft. in diameter and carrying a steadily applied static load of from 12,000 lbs. to 14,000 lbs. per wheel, from 66,000 lbs. to 48,000 lbs. per sq. in. of contact area. The minimum and maximum areas of a larger number of observations gave loads of per sq. in. of contact area of from 26,607 lbs. to 85,961 lbs. This, however, was the minimum pressure, as it was taken with engines standing on a level rail, and the wheel gently lowered on to it. With an engine moving at speed, and heeling over as on curves, this pressure would be much greater. It must further be noted that the central part of the area of contact would be much more severely pressed than the borders of the area.

By the courtesy of Mr. A. L. C. Fell, M. I. E. E., the author has been enabled to give measurements, made at his request, on the pressure of the wheels of a standing car on rails of standard type. These measurements were made by loading the axles of the larger and the smaller wheels of the bogie of one of the large standard London County Council double-bogie trucks. For the purpose of the experiments a sling was made as shown on the sketch (Fig. 6). This consisted of flat bars, to which were bolted three pieces of timber, on which the load was placed. The rails were carefully cleaned, and the wheels turned to the correct standard taper, but with a finer cut than that usually adopted in practice. The load used was as follows in each case:—Driving-wheels, 31 ins. in diameter, 6 tons; pony-wheels, 21.56 ins. in diameter, 3.25 tons. These weights approximate closely to the actual weights on a standard bogie car when loaded.

The wheel on the side marked "A" (Fig. 6) was on the rail, where it was continuously supported. On the side marked "B" the wheel rested immediately above the center of a pier 14 ins. wide, where the rail was not quite so rigidly carried. The diagrams obtained, marked 1, were slightly larger on this side. The rails showed very little sign of wear, and the experiments were made at the end of a shop which had not been very much used. At each end of the axle a guide-bracket was fixed to the ground, as shown on the sketch (Fig. 6); between these brackets and the axle journal taper-pieces of wood were fixed to prevent lateral movement. The axle was lifted at the extreme end by means of a jack and lowered carefully on a piece of tissue-paper on thin carbon paper placed on the rail under the wheel. The impressions made are shown by the diagrams (Fig. 7). The rails are of British standard hardness, and the tires were manufactured to the specification, for the following extract from which the author is indebted to Mr. Fell.

Tensile strength not less than 55 tons and not more than 70 tons per sq. in., minimum elongation of 11 per cent. to 8 per cent. in 2 ins. and of the following composition:—

	Per Cent.
Carbon	0.65 to 0.75
Silicon	0.32
Manganese	0.6 to 0.8
Sulphur	0.035
Phosphorus	0.035

The tires are thus of harder material than the rails, which have 0.40 to 0.55 per cent. carbon.

The areas of contact, carefully measured from these diagrams, are given on the drawings accompanying this paper, the areas and pressures given being those obtained from the smaller diagrams marked 2, measured on the inner edge of the black lines made by the carbon paper. The loads given per sq. in. are the average loads over the whole area of the diagram when the tire had pressed into the rail, and the tire itself also microscopically deformed until the area of the support given was obtained. The pressure per unit of area in the center of the area of support would, of course, enormously exceed this average, and I estimate the maximum static pressure to be not less than 35 tons per sq. in. under the driving wheels. When the car is running at ordinary speeds this pressure would rise to not less than double this as impulse pressure, and when the car runs at speed round curves, and the greater part of the load with the heeling over of the car is visited on the wheels on one side, the pressure might easily reach at least 100 tons per sq. in.

On the pony-wheels the average pressure of the whole area of contact under static loads reached 31.8 tons per sq. in. The maximum pressure in the center of area of contact was probably not less than 50 tons. This, with the car running at ordinary speeds, would probably reach 90 tons per sq. in., and when running at speed round curves, and the car heeling over so that the greater part of the load rested on the wheels on one side, the maximum pressure would probably reach 120 tons per sq. in.

It is clear, then, that the pressure per unit of area exceeds the limit of elastic compression of the material of the average rail, and that flow or deformation would occur were it not that the area pressed is supported by the surrounding material and held encastre, so that flow cannot occur. One result of this is the detrusion of one or of both the rail edges, as shown by Fig. 5, by which cumulative disruptive forces are in part dissipated and the extruded material on the groove edge of the tread is removed by the car-wheel flanges. Another result is corrugation, and a third is the minute crumbling and pitting of the rolled surface.

Under some circumstances and conditions corrugation may decrease as the raised hardened surfaces approach by lengthening; and as corrugation and the surface become more uniform by the removal of surface material by crumbling or minute flakings, especially of the harder rails up to 0.66 of carbon which best resist the causes of corrugation. The removal of corrugations, however, by grinding, only prepares the rail surface for quick recommencement of corrugation or for lengthening the hardened part of the corrugations.

If the preceding be accepted as the origin and production of corrugation, then the question remains, what are the remedies? The mechanical originating conditions being the weight on the wheels and the increase of that weight more especially on outside curves by car-heeling at the higher speeds, then:—The first and most effective remedy is the reduction of the great destructive weight of the wheels of the modern car. The second is the use of larger wheels than can be used with the present design of car. The third is the maintenance of moderate speeds; of much lower speeds than are common on curves, even those of large radius, and moderate speeds on lines that may be classed as straight, but which have such departure from straightness, horizontal and vertical, as will encourage boxing or wandering of the cars from side to side. Fourthly, the use of harder rails than the hardest at present employed.

The reduction of weight is possible, the reduction of speed is possible, the use of larger wheels is possible with future cars, and the use of harder or more resistant rail materials may be possible, but they would have to be produced by methods more costly than those now adopted.

The remedies will involve modifications in the views at present prevalent as to the place, purpose and working of tramway services, but even the most ardent advocates of tramway ubiquity will ultimately be constrained to admit that tramways, like all other things that have and offer desirable ends and conveniences, have also their economic and expediency limits.

Addendum.—The occurrence of corrugation of electric tramway rails as recorded by many tramway engineers and managers, and, as found by my own observations extending over some years at home and abroad, is everywhere associated with the following broad generalizations of facts:

1. That it occurs on straight lines and on curves.

2. That it is most prevalent and generally commences on curves of large radius—flat curves.

3. That it never or rarely occurs on curves of small radius—e.g., from 40 ft. to 80 ft.

4. That on hills, and especially on slight gradients, it is most prevalent on the down line.

5. That its occurrence as to date or length of time after laying the rails varies broadly with (a) the position of the rail on straight or flat curve or down gradient; (b) the frequency of the service; (c) the mechanical properties and composition of the rails as shown by more or less outer-edge detrusion.

6. That it occurs with all types of truck.

7. That it is most prevalent where the speeds are highest.

The general appearance of corrugated rails is known to all who are interested in the subject, and photographs showing corrugations in various stages of growth in many towns might be shown. The author is enabled, by the courtesy of Mr. J. B. Hamilton, the general manager of the Leeds Tramway, to show thirty-three photographs of three rails in that city. These photographs show rails which have been in use from four to thirteen years on straight track. Those which have been in use thirteen years are on the level, those of ten years are on a gradient of 1 in 70, and those which have been in use four years are on a gradient of 1 in 50.

A small photograph of a rail in a straight piece of track on the Midland Railway, Sheffield, on a falling gradient of 1 and 100, shows a much worn rail, with the bright hard spots about the center of the tread. It also shows that what is called "corrugation" is not confined as to nature of origin or production to street-tramway rails, although it is necessarily much more general and severe on tramways and other rails where heavy vehicles with small wheels and high speeds are used, as for example, on some of our tube lines and the Metropolitan, of Paris.

OIL IN CONCRETE ROAD CONSTRUCTION.

A progress report of experiments in dust prevention and road preservation, 1910, has been issued in circular form by the U. S. Department of Agriculture, Office of Public Roads, Logan Waller Page, director. The report includes experiments with oil mixed with cement and concrete, a process introduced by Mr. Page.

During the month of June, 1910, the Office of Public Roads, in co-operation with the District of Columbia, conducted a series of experiments on Meridian place to determine the value of oil-cement-concrete as a road surface. Certain laboratory investigations had indicated that a mixture of Portland cement-concrete with residual petroleums might possibly be suitable for this purpose, and the experiments were therefore made for the purpose of trying such mixtures in a thoroughly practical manner.

The part of the street selected for this work runs from Center street east toward Fourteenth street, a distance of 356.1 ft. It is 19.5 ft. between gutters. The soil forming the subgrade is a coarse gravelly red clay, which after a rain becomes sticky on the surface, but remains firm below. The grade here is light and slopes toward the west. The north curb is 6 in. lower than the south curb, because of the fact that the District constructs its cross streets on the same grade as the main street running north and south. Meridian place is subjected to light traffic consisting of delivery wagons and pleasure vehicles. When the Board of Public Roads assumed supervision of the work all grading had been completed and the curbs and gutters were in place. The cost data given in this report, therefore, include the cost only from this point on.

The foundation of the road was constructed in two courses, the first of which consisted of from ½-in. to 1½-in. broken stone placed to a depth of 5 in. loose upon the prepared subgrade. After this course had been rolled until firm with a 12-ton 3-wheel roller, screenings ranging from ½ in. to dust were applied, and surface finished as in ordinary macadam road work. This method of construction was followed in the preparation of the foundation for all of the experiments.

Common labor for this work cost $1.50 per 8-hour day; foreman, $4; double teams, $4; a 5-ton tandem roller, $8; the 3-wheel roller $12; and a "bug" concrete mixer, $4 per day. Stone and sand cost $2.50 per cubic yard delivered on the work. The oils and cement were donated, but their cost, including freight, is given in the cost data.

The bulletin gives methods of construction in detail, embracing seven experiments. It was found that the concrete could be handled best when made sufficiently wet for the mortar to flush to the surface upon tamping, but not so wet that it would not hold its shape after being tamped.

The oil experiments were made with fluid residual petroleum and cut-back petroleum residue. Different methods and aggregates were used. For example, in the first experiment a stiff mortar of 1 part cement to 2 parts sand with oil to the amount of 10 per cent. by weight of the cement was used, while in the second experiment the same oil was used with a concrete composed of 1½:2:4 of cement, sand and broken stone, the stone, a crushed trap, ranging from 1½ to ½ in. in diameter.

The best surface finish was obtained by troweling the wet concrete with the back of a flat No. 2 shovel until smooth and uniform. All sections were closed to traffic for at least seven days after being laid and were sprinkled with water daily during that period. On one section a thin layer of sand was spread over the surface and on another a thin layer of stone screenings ranging from ½ in. to dust. All the sections were in excellent condition when inspected on January 31. The materials and cost data for the experiments are given in the following table:

MATERIALS AND COST DATA OF EXPERIMENTS WITH OIL CEMENT-CONCRETE AT WASHINGTON, D.C.

Description.				Quantity of Material.							Cost Data (cents per square yard).							Total Cost.	
Experiment No.	Section No.	Oil	Length of section (feet)	Area of section (square yards)	Stone (cubic yards per square yard)	Screenings (cubic yds. per sq. yd.)	Sand (cubic yards per square yard)	Cement (cubic yds. per square yard)	Oil (gallons per square yard)	Stone at mixer	Screenings at mixer	Sand at mixer	Cement at mixer	Oil at mixer	Mixing and laying Concrete	Foundation and miscellaneous	Cents (per sq. yd.)	Entire section
1	7	Fluid residual petroleum...	65.8	142.6	0.063	.....	0.027	0.015	0.534	15.75	.....	6.75	14.18	4.01	24.20	52.52	117.41	$167.43
2	6	...........do............	24.3	52.6	.047	.....	.024	.018	.640	11.75	.....	6.00	17.01	4.80	23.05	52.52	115.13	60.56
3	5	...........do............	45.0	97.5	.047	0.036	.....	.018	.640	11.75	9.00	.....	17.01	4.80	23.05	52.52	118.13	115.18
4	4	...........do............	37.0	80.2	.047	.024	.012	.018	.960	11.75	6.00	3.00	17.01	7.20	23.05	52.52	120.53	96.67
5	3	Cut-back petroleum residue	68.0	147.3	.047	.024	.012	.018	.937	11.75	6.00	3.00	17.01	12.18	23.05	52.52	125.51	184.88
6	2	...........do............	72.4	156.9	.047	.024	.012	.018	.625	11.75	6.00	3.00	17.01	8.13	23.05	52.52	121.46	190.57
7	1	None....................	39.4	85.4	.047	.024	.012	.018	.....	11.75	6.00	3.00	17.01	.....	23.05	52.52	113.33	96.78

THE STRENGTH OF FLAT PLATES.

The formulas proposed by Grashof, Bach and Navier may all be reduced to the expression $S = C a^2 p/t^2$, in which S = stress, and p = hydrostatic pressure, both in lb. per sq. in.; t = thickness of plate in in., a = short side of rectangle in in., and C = a constant depending on a and on the long side b (in in.). Eight tests were made by the author, using 18x18-in. and 24x24-in. soft steel boiler plates, the thickness of which ranged from ⅛ to ½ in. The edges of the plates were all fixed. The mean value of C was found to be 0.141, and the deflection at the centre, d, was found to equal $0.0000000516\ p\ a^3/t^{2.1}$. For rectangular plates the author suggests that C be taken as equal to $0.5/(1+2.55\ r)$, in which $r = a/b$ = ratio of short to long side; also that for plates simply supported at the edges the value of C be multiplied by 1.5. The values of C are somewhat lower than those obtained by Bach, and it is believed that the formulas given are substantially correct for thicknesses from 0.1 to 0.6 in. and for values of a/t from 50 to 150.—Condensed from Rensselaer Polytechnic Institute, Engineering and Science Series, No. 2, by T. A. Bryson.

The Canadian Engineer

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

NOTICE TO ADVERTISERS.

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CONTENTS OF THIS ISSUE.

NEED OF SKILLED LABOR.

Canadian industrial progress is hampered by the lack of skilled labor. The efficient artisan, as he is known more especially in European countries, is not plentiful in the Dominion. Elsewhere, we have discussed briefly the prospects of the pulp and paper industry. As an example of Canada's deficiency in skilled labor, we may take the same industry. Canadian paper and pulp mills are equipped, as a rule, with the latest and most improved machines made by American manufacturers in the United States. The general managers and superintendents are, for the most part, Americans of wide experience. Those who are Canadians by birth are men who, like the Americans, have had long years of training in American paper and pulp mills. The skilled men, the machine tenders, and other hands who operate the paper machines are, as a rule, Americans brought from the United States for the purpose. They are paid American rates of wages, although in several instances the rates are for a 12-hour shift, instead of for an 8-hour shift, as in Eastern United States. Excepting for the comparatively small number of skilled men necessary to operate the paper machines and the mechanics employed on repairs, the great majority of the men employed in the paper and pulp mills are classed as unskilled, and receive the pay of unskilled laborers.

These conditions will be remedied in the course of time. In the meantime, the dearth of men properly trained for certain work in particular industries is acting as a drawback upon our industrial growth.

RECORDS OF TYPHOID FEVER.

During August there were ninety cases of typhoid fever reported in Toronto. We have received information from Dr. Nasmith, the City Bacteriologist, that of the ninety cases reported forty-two cases were undoubtedly infected outside of Toronto. Of these, ten came from two summer resorts in Muskoka, and Dr. Nasmith has obtained evidence that fourteen other cases now in various cities in the United States were infected from the same source. Of the other cases, some came from Northern Ontario and various municipalities throughout Ontario and the United States and some from the steamboats. Only in cases where a definite history is obtained does he give credit to outside sources.

It must be said that the above information is decidedly alarming when we understand that during one month alone two summer resorts in Muskoka have scattered twenty-four cases of typhoid which are known, and, no doubt, a number unknown.

Any person who has been at many of the resorts in Northern Ontario will appreciate the unsanitary conditions surrounding the most of them, and from this it appears to be high time that the Provincial Board of Health did something to prevent this wholesale spreading of disease.

With the increase in numbers of people who go to these resorts the danger is constantly augmenting. There is just as much reason, in fact more, for a rigid inspection and control of the water supplies and sanitary arrangements of the hotels there as there is in the cities or towns. This is a matter that the Provincial Board of Health should immediately take steps to ameliorate. It is criminal negligence to allow such a condition of affairs to exist.

THE WATERWORKS DEPARTMENT OF TORONTO.

The City Council appear to have arrived at the conclusion that the Waterworks Department should be separated from the balance of the Works Department and placed under a different head.

They propose to place the revenue end of the Waterworks Department and the engineering together under a business man as manager and Mr. Fellowes as Engineer.

With the present uproar in connection with Toronto water, the Council must, of course, display some activity, particularly as it is now approaching election time again. To us it appears a bad mistake to take this department away from the City Engineer. It is undoubtedly a retrogression. Civic affairs, as also private affairs, to be efficient must be concentrated under one head. Central organization is a dominant factor in industrial and commercial life to-day, and to depart from this is to take a step backward. Why this change is demanded is hard to understand. At present the business end of the Waterworks Department is in good condition in the hands of the City Treasury. Without question the intake question is in a fearful muddle, but it is hard to see how a division of duties will improve it.

Some one must take the responsibility soon for this condition of affairs, and the reckoning, when it comes, will be rather hard to meet. Toronto, this winter, faces a worse condition than ever before in connection with its water supply. With its intake pipe resting on a flimsy structure of piles daily sinking as the sand is scoured from their bases, and the danger imminent of a break at any time, it looks to us as if all those concerned in bringing on such a condition were on the edge of trouble.

It appears as though by this move the Council were endeavoring to throw dust in the eyes of the public. Then when the crash comes, and Toronto finds itself in a situation similar, or even worse, than last winter, as it unquestionably will, they will have deflected blame from themselves.

THE AUSTIN DAM FAILURE.

In this issue of The Engineer a short article appears on the "Failure of the Austin Dam in Pennsylvania." It will be noted in the statement there that at the filling of the reservoir behind the dam, after completion two years ago cracks formed in it and water came through.

It would appear from this that a bad error had been made either in computing stresses for the design of the dam, or in taking care of the foundations. It is understood that the dam was afterwards reinforced, but any engineer experienced on work of this kind will appreciate of how little value work of this kind is after incipient failure. According to matter published shortly after the first signs of trouble had appeared, the engineer who designed the structure ascribed the weakness to either construction in freezing weather, neglect to ascertain the ability of the strata beneath the foundations of the dam, or failure to allow concrete to attain sufficient strength before imposing the maximum condition of full reservoir upon it.

Great responsibility attaches to those who allowed the dam to remain in use in its precarious condition, and this responsibility will, no doubt, be fixed by the official investigation now being carried on by the district attorney.

It is, of course, impossible to say now where the responsibility for the disaster belongs. One strong lesson is, however, to be drawn from the failure: that the design of dams is at all times a dangerous affair, and that there should be a most liberal factor of safety used. The static stresses of dams are among the easiest to figure, but a tremendous element of doubt enters into the question of foundations and joints in the work. For that reason most conservative assumptions must be made, with the utmost attention paid to the foundations and drainage. When one considers the fearful consequences resulting from a failure, as in this particular instance, it behoves the engineer to be exceedingly careful in endeavoring to keep the cost down by too economical use of material and lack of excavating to good foundations.

When all is said, however, there is very little excuse for such a failure. Competent engineering in the first place would have put in a safe dam, and, after the signs of failure, competent engineering should have prevented such a catastrophe.

It is so important that dam construction and design should be of the safest and best type of engineering that it appears to us, since in the usual case so many lives depend on their strength, that the Government should exercise some kind of supervision over their design and construction.

If in our cities we exercise supervision over the strength of buildings erected, how much more ought we to inspect structures of this type, on the safety of which so many lives depend.

EDITORIAL COMMENT.

What is the matter with the Water Commission appointed by the City of Toronto some five months ago? Very little has been heard about them except in an occasional note that they are taking borings near Scarborough.

* * * *

With all this talk going on in the Press concerning the relative advantages of sand filtration and mechanical filtration, the fact is rather lost sight of that the present filtration plant is not finished. It is nearly time that this plant was placed in operation.

* * * *

It is interesting to hear of the City Council discussing the prospect of Toronto obtaining a pure water supply. Some of their statements are rather interesting to the engineer. They seem to be men of widespread qualifications to be able to give expert opinions on the engineering problems in connection with the city water supply. However, the results obtained so far by them rather tend to make one doubtful of their genius along this line.

The Board of Commissioners of Montreal last week called for tenders for the supply and delivery of 500 tons of refined asphalt, allowing only eight days between the issue of the advertisement and the time the tenders would be opened. This certainly gives very little chance for supply houses to bid, and is also liable to rather bad interpretation by those who are debarred from tendering on account of lack of time. In calling for tenders in any quantity, ample time should be allowed between the date of advertisement and the opening of the tenders, and certainly eight days is not sufficient.

* * * *

We have much pleasure in informing our readers that each week an abstract of metallurgical news, of interest to the Civil and Mechanical Engineer, will be published in the columns of The Canadian Engineer. Mr. T. R. Loudon, B.A.Sc., Lecturer in Metallurgy in the Faculty of Applied Science at the University of Toronto, will conduct this department, and it is hoped that our readers who are interested in this subject will forward discussion in the form of letters or articles to him. We felt that this subject was becoming of such importance to the Engineer that it should be covered as thoroughly and adequately as possible.

For that reason each week under the head of "Metallurgical Comment" abstracts and short discussions on this subject will appear.

GENERAL NOTES.

Precipitation was generally deficient in British Columbia, Western Alberta, Southern Saskatchewan, Ontario, except west of Port Arthur, the greater part of the Peninsula, and the Eastern Counties, the Gaspé Peninsula and North-eastern New Brunswick. In other parts of Canada the amount recorded exceeded the average with heavy falls in Manitoba, Southern New Brunswick and Nova Scotia.

The table shows for fifteen stations, included in the report of the Meterological Office, Toronto, the total precipitation of these stations for September, 1911:—

	Depth in inches.	Departure from the average of twenty years.
Calgary, Alta.	0.9	—0.34
Edmonton, Alta.	1.04	—0.46
Swift Current, Sask.	1.00	—0.33
Winnipeg, Man.	1.08	—0.84
Port Stanley, Ont.	2.1	—0.71
Toronto, Ont.	2.57	—0.28
Parry Sound, Ont.	1.5	—2.06
Ottawa, Ont.	3.2	+0.58
Kingston, Ont.	2.8	+0.20
Montreal, Que.	4.3	+0.91
Quebec, Que.	4.5	+0.73
Chatham, N.B.	3.1	—0.03
Halifax, N.S.	6.9	+2.89
Victoria, B.C.	2.25	+0.15
Kamloops, B.C.	0.9	—0.09

LETTER TO THE EDITOR.

Sir,—In your issue of September 28, 1911, I note an article reporting the resolution adopted by the Labor Congress, recently held in Calgary, and your remarks thereon.

I have been interested in the study of Efficiency Engineering or Scientific Organization and Management for a number of years, and as you state, it is evident that the delegates to the Labor Congress did not understand the ideals of the Taylor, Emerson or Gantt systems.

The "proof of the pudding is the eating thereof," and one has only to investigate the organization and management of such shops as the Link Belt Company, and the Tabor Manufacturing Company, of Philadelphia to realize the enormous benefits that accrue to the employees as well as employers, under the new conditions. These new principles give the workman more air, better light, more pleasant surroundings, and on an average 30 per cent. higher rate of pay, and not later than six months ago I heard Mr. Taylor, in a lecture, state that up to that time no strike had occurred in a shop operated under principles of scientific management.

The men are not crowded to a point of exhaustion—it is true their work is speeded up, but it is speeded up by the elimination of useless motions and thought on the part of the workman, and the man is not expected to give any more than a good day's work for his hire, which is all that any man is asked to do under any system of mangement. The drones and shirkers are eliminated, as they will be in any well-conducted plant, but their services are dispensed with sooner under the Taylor system than otherwise—to the benefit of the men themselves.

These principles are spreading, and spreading fast, and it is only a question of time until they will be introduced in all sections of the continent. At the present time the demand for well trained Efficiency Engineers is greater than the supply, and there is no branch of the Mechanical Engineering profession which offers more prospects to a young man than Efficiency Engineering.

Very truly yours,

J. J. MARTINDALE,
Consulting Engineer.

TABLE FOR GRAVEL.

Table showing number of cubic yards of gravel required in the construction of one mile of gravel road, of widths varying from 6 feet to 20 feet. and depths from 6 to 12 inches. The within quantities should be multiplied by 1⅓

Number of feet in width.	Number of cubic yards in road 6 inches deep.	Number of cubic yards in road 7 inches deep.	Number of cubic yards in road 8 inches deep.	Number of cubic yards in road 9 inches deep.	Number of cubic yards in road 10 inches deep.	Number of cubic yards in road 11 inches deep.	Number of cubic yards in road 12 inches deep.
6 feet	586 2/3	684 4/9	782 2/9	880	977 7/9	1,075 5/9	1,173 1/3
7 feet	684 4/9	798 14/27	912 16/27	1,026 2/3	1,140 20/27	1,254 22/27	1,368 8/9
8 feet	782 2/9	912 16/27	1,042 26/27	1,173 1/3	1,303 19/27	1,434 2/27	1,564 4/9
9 feet	880	1,026 2/3	1,173 1/3	1,320	1,466 2/3	1,613 1/3	1,760
10 feet	977 7/9	1,140 20/27	1,303 19/27	1,466 2/3	1,629 17/27	1,792 16/27	1,955 5/9
11 feet	1,075 5/9	1,254 22/27	1,434 2/27	1,613 1/3	1,792 16/27	1,971 23/27	2,151 1/9
12 feet	1,173 1/3	1,368 8/9	1,564 4/9	1,760	1,955 5/9	2,151 1/9	2,346 2/3
13 feet	1,271 1/9	1,482 26/27	1,694 22/27	1,906 2/3	2,118 14/27	2,330 10/27	2,542 2/9
14 feet	1,368 8/9	1,597 1/27	1,825 5/27	2,053 1/3	2,281 13/27	2,509 17/27	2,737 7/9
15 feet	1,466 2/3	1,711 1/9	1,955 5/9	2,200	2,444 4/9	2,688 8/9	2,933 1/3
16 feet	1,564 4/9	1,825 5/27	2,085 25/27	2,346 2/3	2,607 11/27	2,868 4/27	3,128 8/9
17 feet	1,662 2/9	1,919 7/27	2,216 8/27	2,493 1/3	2,770 10/27	3,047 11/27	3,324 4/9
18 feet	1,760	2,053 1/3	2,346 2/3	2,640	2,933 1/3	3,226 2/3	3,520
19 feet	1,857 7/9	2,167 11/27	2,477 1/27	2,786 2/3	3,096 8/27	3,405 25/27	3,715 5/9
20 feet	1,955 5/9	2,281 13/27	2,607 11/27	2,933 1/3	3,259 7/27	3,585 5/27	3,911 1/9

to give the number of cubic yards of loose gravel required to make the within depths of compact gravel. This table is published in the annual report of the Commissioner of Public Roads of the State of New Jersey, for 1910.

Metallurgical Comment

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

It is the intention in these columns to give from week to week an abstract of Metallurgical news. Where the subject matter warrants it, a great deal of the allotted space may have to be devoted to merely one or two articles, but the reader is reminded that as The Canadian Engineer appears weekly, the total matter for the month should give an average sufficiently interesting to all.

A point that is very often lost sight of is the fact that the subsequent working of metals, heat treatment, rolling, etc., constitutes a very large proportion of the field covered by the subject of Metallurgy. Now, although the Civil or the Mechanical or the Electrical engineer may not care to go deeply into Metallurgical Chemistry, a great deal of available material bearing on the manufacture of metal goods, which comes under the field of Metallurgy, should be interesting to engineers in general, and it is to be hoped that the reader bearing this in mind will find in this new department something of value.

In order to add to the interest of this department discussion is invited in the form of letters or articles. All questions will receive due consideration.

AMERICAN ELECTRO-CHEMICAL SOCIETY MEETING.

The recent meeting of the American Electro-Chemical Society, held in Toronto September 21-23, was an event worthy of particular notice. The meetings of this society are noted for the congenial atmosphere that is always in evidence, and this gathering was certainly no departure from the rule.

The first morning and afternoon were devoted to registering and to the reading of papers in the Chemical Amphitheatre of the Chemistry and Mining Building, University of Toronto, the evening of the same day being given up to a meeting of Section Q, one of the most important departments in the society, as far as general meetings are concerned. (The meetings of Section Q are devoted to personal research.)

On Friday, the meeting was held at the Lambton Golf Club, the morning being given up to the reading of papers; and after luncheon many of the visiting guests enjoyed a good game of golf.

On Saturday an excursion was run to Hamilton to give the members an opportunity of going through the Westinghouse Factory and the plant of the Hamilton Iron and Steel Company. The afternoon of the same day many of the guests visited the Hydro-Electric Transforming Station in Dundas.

The growing membership of the society is directly indicative of the wonderful advances being made in electrochemistry and metallurgy, and one could not but be impressed by the optimistic views taken by the various members relative to the future. It was pointed out that 47 per cent. of the power developed at Niagara Falls was used for electrochemical and metallurgical purposes. The opinion was also expressed that, in view of the development of hydro-electric power throughout Ontario. there was no reason why a large number of electro-chemical industries should not spring up throughout this area, and, indeed, throughout any area where cheap hydro-electric power was available.

It is worthy of mention that at this meeting a demonstration of the Evans-Stanfield electric furnace was given in the laboratories of the University of Toronto, one heat of metal being made and tapped in full view of the visiting members.

The papers read were, as usual, of a sufficiently diversified nature as to give something for all present. It is the intention to publish abstracts from the papers in these columns in the near future.

TITANIUM IN IRON AND STEEL.*

Charles V. Slocum.

In electrometallurgy no development of late years has been of greater importance than the manufacture of ferrotitanium in the electric furnace. It was not until 1903 that Auguste J. Rossi was able to produce the remarkable material now widely known as "Titanium Alloy." Some thirty years or more of his life has been devoted to developing the methods of manufacture and the uses of this material, but it was not until he used the electric furnace in 1903 that his life-long efforts were crowned with success. Since that time the manufacture and consumption has grown with leaps and bounds, and now the plant occupies a large tract of land, and railway facilities are necessary for the prompt handling of the large output.

As the uses of this alloy are so many and so varied, it has been suggested by a well-known member of this society that the more important features be discussed in a suitable paper. Metallurgists have practically all agreed that the use of a small percentage of an alloy of titanium is of benefit in both iron and steel, but some question has arisen as to the form which this alloy should take. In a recent publication[1] the statement has been made that carbon-free metals dissolve more easily than metals containing carbon, since the latter contain carbides. The experience of the writer does not bear out this fact, he having found that a carbon-free alloy was not at all adapted to use in the iron and steel industry, and the manufacturers were obliged to make a product containing from 5 to 8 per cent. carbon for such use. Our early experience with an alloy of iron and titanium free from carbon, but containing 5 to 10 per cent. aluminium, resulted in almost complete failure, as the aluminium when present in any appreciable quantity made the steel brittle and its oxide showed great tendency to remain in the steel.

"Titanium Alloy," as stated above, contains 5 to 8 per cent. of carbon, mostly in the form of graphite. Analyses of this material made in the laboratory of Dr. C. F. McKenna show the following proportions of the two forms of carbon:

Sample No.	Graphitic Carbon.	Combined Carbon.
141	9.601	0.147
162	9.179	0.12
291	7.012	0.13
298	6.234	0.118

From these analyses it appears that titanium acts very much like silicon in that it causes a separation of carbon as graphite. Dr. G. B. Waterhouse recently cited an interesting experiment to bear out this fact: A ladle of iron for making malleable castings was treated with 10 per cent. titanium alloy sufficient to equal 0.1 per cent. metallic titanium added to the iron. The original iron gave castings showing a white fracture with a little graphite in the centre. The titanium-treated metal showed a white border between ⅜ and

*Abstracted from a paper read before the Am. Electro-Chem. Soc. at the general meeting held in Toronto, Sept. 21-23, 1911.

[1]Goldschmidt: The Melting Point and its Relation to Alloying Capacity. Met. & Chem., Eng., 9, 348 (1911).

½ inch (1 to 1.25 cm.) deep and a gray centre showing the separation of graphite. Contrary, therefore, to the viewpoint of Dr. Goldschmidt, there need be no fear of the non-solution of the electric furnace titanium alloy, as it does not contain more than the merest fraction of the unreadily soluble carbide.

The density of a ferro-alloy to be used as ferro-titanium is used has an important bearing on its incorporation in the molten bath. Careful determinations made on the electric furnace product containing both 10 and 15 per cent. titanium show a density of 6.20 to 6.40. The metallothermically produced alloy shows a density of between 6.20 and 6.30. The difference between the densities of the two alloys is therefore hardly noticeable.

The alloy is best added to the ladle of steel after tapping from the furnace and before the slag begins to run. For open-hearth steel the supply should be placed convenient to the ladle and shovelled in precisely as so much coal. For soft steel an addition equivalent to 0.03 per cent. titanium is sufficient to make the steel more ductile. Larger quantities are of increased benefit, but cannot always be added because of the carbon content and also because of the density imparted to the steel, which increases as the proportion of alloy is increased, and therefore is not always desirable. In high-carbon steels this increased density is desired and more alloy is used. The addition of the alloy permits the use of a considerably higher carbon content without increasing the brittleness, and several railroads are now using as much as an equivalent of 0.10 per cent. titanium or more in securing tough, durable rails.

In the crucible practice the best results have been obtained by adding the titanium alloy to the pots before they are removed from the furnace, giving more time for washing and deoxidizing before teeming.

Leading authorities seem to agree that titanium achieves its remarkable results through its strong deoxidizing powers together with its effect of giving the slag formed sufficient fluidity to completely separate it from the metal.

"The presence of titanium oxide lowers the melting point of slags occulded in iron and steel and imparts thereto sufficient fluidity to account for their elimination."[2]

"Titanium * * * has a stronger affinity for oxygen than have the well-known deoxidizers; * * * it probably gives the slag such a consistency that it separates more completely from the molten iron."[3]

"The treatment of all steels with ferro-titanium for the purpose of purifying the metal is strongly recommended, the presence of nitrogen to the extent of .02 to .035 or .045 in certain steels being enough to cause the metal to break asunder, destroying all elongation and reduction of area."[4]

"The great affinity of oxygen and titanium is an absolutely sure means of completely deoxidizing the steel, the advantages of which need no further elaboration. It has been proved that an ingot of steel containing a very small quantity of titanium will show practically no segregation."[5]

The cost of treatment with titanium varies from a minimum of 25 cents to a maximum of $2.00 per ton of metal treated. It is the cheapest deoxidizer above the grade of manganese or silicon, and a far greater purifier than any other alloy. The amount to be used is very small, and should be proportioned according to the carbon content of the steel and to the amount of impurities present. To the electrometallurgist it is a triumph worthy of record that Rossi should take an element like titanium, so long considered useless, and make out of it so wonderful a servant in the iron and steel industry.

The above paper brought forth a rather lively discussion. Mr. W. C. Cuntz, general manager of the Goldschmidt Thermit Company, read a discussion forwarded by Dr. Goldschmidt. It is not claimed by Dr. Goldschmidt that ferro-titanium containing carbon is useless; but, he does claim that carbon free from ferro-titanium and containing aluminium brings about results in a more effective manner. It was pointed out that the aluminium in the alloy had a threefold purpose: (1) It caused the alloy to be embedded and dissolved more easily and intimately in the steel; (2) Titanic acid is difficult to fuse. Alumina is also very difficult to fuse, so that if either titanium or aluminium alone are used as deoxidizers the products of the reaction would be liable to remain as suspended particles in the steel, which can be easily seen by metallographic methods. If, however, the aluminium and titanium are used together, the product of the reaction is titanite of aluminium which is much more easily fused and will, therefore, separate out from the steel. (3) The third reason is that when the aluminium serves this purpose of cleaning and deoxidizing, it enables the titanium to exert more effectively its own specific properties. Dr. Goldschmidt also denied that titanium is a stronger deoxidizing agent than aluminium, giving as proof the fact that aluminium reduces titanic acid, but titanium does not reduce aluminium He did agree, however, that titanium is a good purifier; but emphasizes the point in his contention that it is most likely the properties of the added metal that give the good results.

Dr. Waterhouse, of the Lackawanna Steel Company, who has had a large amount of experience with the use of ferro-titanium, recommended that the alloy is best added to the steel during the tapping from the furnace, although Mr. Slocum recommends in his paper that it be added to the ladle of steel after tapping. Dr. Waterhouse brought out very forcibly the fact that time should be allowed for the reactions to go on and for the products formed thereby to completely separate out. It was by observing such fundamental principles that the best results were obtained.

PROGRESS IN THE ELECTRIC STEEL INDUSTRY.

At the meeting of the British Association at Portsmouth, Professor Andrew McWilliam, A.R.S.M., M.Met., of Sheffield University, submitted a report which he had prepared at the request of Section B of the Association, on the present position of the electric steel industry. He pointed out that the output of electric steel in Germany, the United States and Austria-Hungary in 1910 amounted to almost 112,000 tons, which was an increase of 63,000 tons over the figures for 1909. These were the only countries for which the exact output of electric steel was published, but there was no doubt that the figures for Sweden, France, Belgium, and Italy would also show large gains. The increase would probably be more than maintained in 1911, as more than 30 new furnaces of various types should be started during the year, and many which only started towards the end of 1910 would put in a full year's work in 1911. England would also for the first time appear as a regular producer.

Before the beginning of the present year the Héroult furnace at Edgar Allen's in Sheffield was the only arc furnace in steady operation. In January three Héroult furnaces were commenced in England, one each at Vickers, at Thomas Firth & Sons, and at Lake & Elliott's in Braintree, Essex.

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[2] Bradley Stoughton, U. S. Patent Office Proceedings, Ser. No. 463610.

[3] Henry M. Howe, Ibid.

[4] H. le Chatellier, Paper, Congress of Metallurgists, Belgium, 1905.

[5] E. von Maltitz. Stahl und Eisen. No. 41, 1909.

A Gronwall furnace, for demonstration and maufacturing purposes, also started at about the same time in Sheffield. As a result the output of England for 1911 should amount to about 13,000 tons. A 15-ton Héroult furnace was to be erected at Skinningrove shortly, and was expected to turn out 200 tons per day. Kjellin induction furnaces had been working satisfactorily at Vickers and at Jessop's in Sheffield, and an experimental furnace at the University of Sheffield. Great progress would be made in Germany with electric furnaces during next year when Héroult furnaces at 25 and 22 tons capacity are to be constructed. At present the largest size furnaces of this type in operation were the two 15-ton Héroult furnaces at S. Chicago and Worcester, U.S.A., belonging to the United Steel Corporation, who had recently acquired the Héroult patents for America, and would probably erect several more furnaces shortly.

The electric furnace could be used either for melting scrap directly or in combination with some other form of furnace, in which case it simply acted as a refiner. The majority of the recent furnaces had been employed in this way, in conjunction either with Bessemer or open-hearth furnaces. The latter were usually of the basic tilting type, part of the charge being removed to the electric furnace after the pig was melted and the bulk of the phosphorus removed, leaving some phosphorus and the oxygen and sulphur to be eliminated by the electric furnace. In this case the time required for the electric furnace was from one hour to two hours, according to the degree of refining required and the original condition of the steel when removed from the basic furnace. The power used varied from 100 to 300 kw.-hours per ton. When cold scrap was melted the time required was about six hours and the power consumption said to be from 650 to 750 kw.-hours, but more probably 800 to 1,000, per ton. Of the 44 Héroult furnaces in operation or construction, 21 were to melt scrap, 20 to take molten steel from the basic open-hearth, one from a Talbot furnace, and two from converters.

Electric furnaces were being employed in the following cases:—(1) To replace crucibles. The gain was then in cost of production. (2) For foundries. At George Fischer's & Schaffhausen they were the only furnaces employed, and Lake & Elliott, of Braintree, were now making most of their steel electrically. (3) To replace Swedish Bessemer steel, and for steel of axle and tyre quality. (4) For weldless tubes. The Mannesmann Company had Héroult furnaces in Germany and Italy. (5) In combination with Talbot furnaces. Owing to the fact that the heat need not be sufficiently great for teeming on transference to the electric furnace, the output of the Talbot and the life of the lining and roof were said to be largely increased. This would be the procedure at Skinningrove for making rails. (6) For melting turnings, especially high-speed turnings. These made excellent scrap for the electric furnace. Nickel scrap could be melted without any loss of nickel.

THE ECONOMIC DEVELOPMENT OF ALUMINIUM.

A monograph on the economic development of the aluminium industry has been published for Dr. Wilfried Kossmann by the Strassburger Druckerei, which, among other matters throws fresh light on the activity of the former international syndicate in this branch. It is stated in the first instance, that the world's production of the metal only amounted to 175 metrical tons in 1890. In 1900 the output reached 7,300 metrical tons, and the consumption was the same quantity; in 1905, the figures were 11,500 tons and 11,500 tons respectively; in 1909, 24,200 tons and 30,800 tons; and in 1910, 34,000 tons and 33,500 tons respectively. The work sets forth the following companies as the producers of aluminium at the present time together with their individual output in 1910:—

Companies and situation of works.	Production in metrical tons in 1910.
Aluminium Industrie Gesellchaft, Neuhausen (Switzerland, Austria and Germany)	6,000
Société Electro-Metallurgique Francaise, Froges (France)	6,000
Compagnie des Produits Chimiques d'Alais et de la Camarque, Salindres (France)	2,500
British Aluminium Co. (Scotland)	4,000 to 5,000
Aluminium Co. of America (United States), Northern Aluminum Co. (Canada)	12,000
Société des Forces Motrices et Usines de l' Arve (France)	600
Société des Produits Electro-Chimiques et Métallurgiques des Pyrenées (France)	500
Société Electro-Métallurgique du Sud-Est (France)	300
Société d'Electrochemie (France)	300
Gebruder Giulini, Ludwigshaven (Switzerland)	400
Società Italiana per la Fabbricazione dell' Alluminio (Italy)	600
Anglo-Norwegian Aluminium Co. (Norway)	500

The first five companies produce nine-tenths of the world's output, the remaining one-tenth being divided among the other works. As to the amount of the production, it will be seen that France and the United States, including Canada, occupy the leading position. Only one works is located in Germany, namely, that of Rheinfelden, Baden, which belongs to the Neuhausen Co. It is considered that the existence of water power has played a much greater part in the selection of the site of the works than the geographical situation of the bauxite fields which contain the raw material alumina.

NEWS ITEMS.

The Lackawanna Steel Company, of Buffalo, recently placed in operation its new Merchant mill, which will be known as No. 9 Mill. The output of this mill will be in the neighborhood of from 10,000 to 12,000 tons per month, made up mainly of one-quarter to seven-eight inch rounds and the equivalent sections in squares, flats and ovals.

It is reported that A. W. Farnesworth, Consulting Engineer, London, England, is looking about in Canada for a site on which to locate a steel plant to cost in the neighborhood of $5,000,000.

News has just arrived to the effect that an Iron and Steel Trust has been formed in Italy. The method of operation of this corporation will be along the lines of the same trusts already existing on the Continent.

Iron and Steel Institute of Great Britain.

Owing to rather unsettled conditions in Great Britain and Europe, it has been decided to cancel the Italian meeting of the Iron and Steel Institute.

Institute of Metals.

The recent meeting of the Institute of Metals at Newcastle-on-Tyne brought out a series of extremely interesting papers. It is hoped that at a future date abstracts from these papers can be printed in these columns.

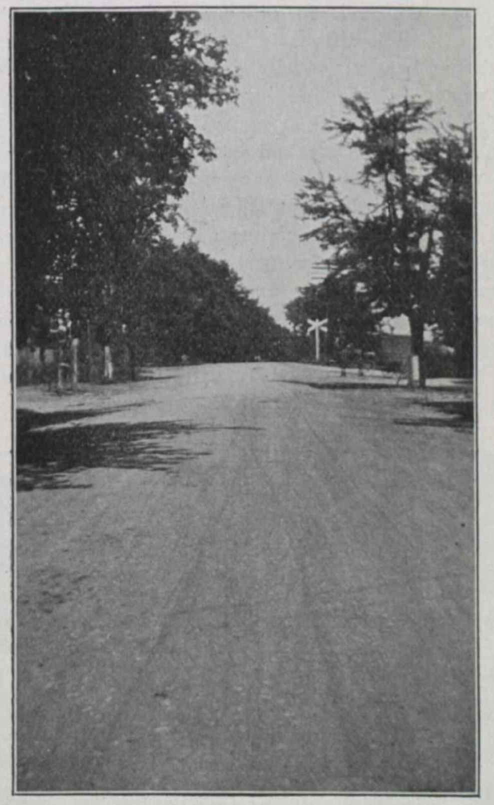
OHIO STATE EXPERIMENTAL ROAD.

Correction.

Section III—"Pioneer" Asphalt Binder.

The material used as a binder in this experiment is refined from rock asphalt mined in Utah. In the construction the foundation course was finished as a water-bound macadam road, thoroughly rolled and bonded. The second layer was composed of stone ranging in size from one and one-half to two and one-half inches. This was rolled to a finished depth of about two inches, no water being used. One-half to three-fourths inch screenings were broomed into the surface in a quantity sufficient to reduce the voids about 50 per cent. The asphaltic cement was then poured at a temperature between 390 deg. and 410 deg. F., until all of the stone was thoroughly coated. When the coating had cooled, a thin dressing of screenings was sprinkled over the surface. These screenings were sprinkled but a short distance ahead of the roller, which followed immediately after the screenings were placed. The screenings were sprinkled at first in a thin layer, and as the rolling proceeded more screenings were added, until the coating had absorbed all the screenings which it was possible to absorb. The quantity of the binder used was one and one-fourth gallons per square yard.

The surface is smooth, dustless and in excellent condition with no excess of binder. Photograph 3 indicates this condition.



Section III. Pioneer Asphalt Binder.
Ohio State Experimental Road.

The paragraph quoted below appeared in our last issue as part of the above report through error. We wish to call the attention of those interested to the fact that the following section of the aforesaid article referred to a description of Section Two, namely "Standard" Asphalt Binder. (Editor)

Asphalt has been forced to the surface to a degree that it has flowed to the side of the road. The temperature at the time of inspection was only about 85 degrees and yet the imprint of the horses hoofs was plainly visible at points on the surface where the asphalt had exuded to a great extent. Excepting for these points the surface is hard and dustless. Photograph 2. shows this section.

SMOKE NUISANCE IN MONTREAL.

If a resolution recently adopted by the Council of the City of Montreal is put in effect, it is likely to have a very considerable influence not only on the cleanliness of the city but on railway and other large companies doing business in the city. The aldermen are evidently desirous of putting an end, as far as may be, to smoke nuisance which of late years has been constantly becoming more objectionable. Alderman Marcil made a motion, which was adopted, asking the Board of Control to see the Railway Commissioners and asked them to pass a rule forcing the companies to adopt one of the following four methods of preventing the smoke nuisance:—

1st. Using electric engines within the limits of the city.

2nd. Burning hard coal to prevent smoke.

3rd. Adopting smoke consumers on engines.

4th. Use of oil for fuel.

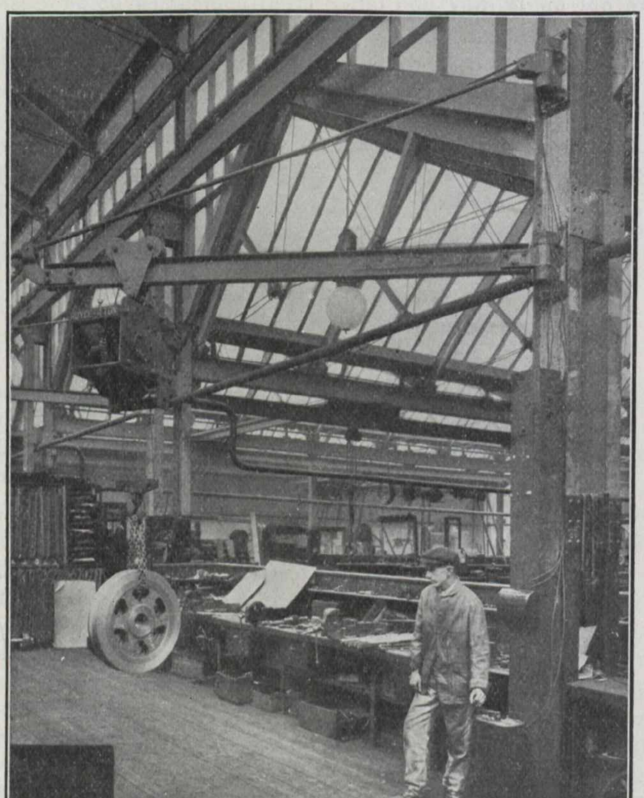
The complaint was also made that there are still plenty of smoky chimneys and that the by-law be enforced against them. One of the Board of Control however, recently seemed to take the attitude that smoke was a necessary nuisance and could not be suppressed without suppressing the industrial activities of the city.

From the wording of the resolution and the schemes offered to abate the smoke nuisance, and from the fact that the matter is to be brought to the attention of the Railway Commissioners, it would seem as though the proposal applies especially to the railways. It may be of interest to add that the railways, within the past year or so, have had their attention drawn to this matter and have given consideration to the plan of electrification of their terminals. The Canadian Pacific Railway, after investigating the matter, decided that so far as it was concerned it would not alter its present system for the time being at least. The Grand Trunk probably came to the same decision. It will be interesting to see what the Railway Commission will do about the matter. The electrification of the terminals would certainly give rise to a demand of a very large quantity of electricity. Fortunately, developments are being carried out in the vicinity of Montreal which will mean that many thousand horse power will be available in the course of a year or two, so that it would seem that the hydraulic power would be available as quickly as the railways could accomplish the necessary alterations to make use of it should the Railway Commission decide to order them so to do.

Up to the present the Canadian Northern has its station located in the East End, a considerable distance from the centre of the city. The company is now considering seriously the question of how it may reach the centre of the city. Sir Donald Mann, Vice-President of the company, when in the city last week, stated that the company expected to build a terminal in Montreal during the next two or three years, and that so far as he could see, the most feasible way of gaining the centre of the city would be by means of a tunnel through the mountain. He spoke of tubes and the operation of the service by electricity. Whether this matter is being seriously entertained by the Canadian Northern Railway or not, it would certainly be in line with the suggestions of the City Council.

A NEW ELECTRIC LIFTING BLOCK.

In many engineering shops and foundries of considerable size when an electric overhead travelling crane cannot be accommodated for the reasons either of lack of overhead room, or the building not otherwise suitably constructed, an electric lifting block will be found of great advantage, for there is always considerable lifting to be done, and the hand chain block erected as a temporary expedient often remains and while some hand blocks operate easier and some quicker than others, there is a very wide margin between the speed of the very best of them and a motor driven block.



Electric Lifting Block.

A new and substantial design of electrically operated lifting block has been brought out by Messrs. Royce, Ltd., of Manchester, England, and 207 Lumsden Building, Toronto. The block contains some excellent features which will no doubt interest some of our readers, many of whom will have looked for something reliably built and capable of withstanding the abuse to which a machine of this kind is so frequently subjected.

There have been motor driven pully blocks upon the market for a few years past, but few of them seem to live long when put into the hands of men who are not accustomed to mechanical devices, or, indeed, if put into the hands of men of average ability, they are given very little attention, and as long as they do their work no further notice is taken until a breakdown occurs.

To endeavor to overcome the many troubles found to exist with the usual lightly built machines with small high speed motor, our attention has been called to the following details; at present four sizes have been standardized, namely, 1,000 lbs., 2,000 lbs., 3,000 lbs., and 4,000 lbs lifting capacity.

The very simplest form of construction has been adopted and every effort made to reduce the number of parts to a minimum.

The side frame plates are of wrought steel securely braced and riveted together, thus giving the greatest strength possible. The motor which is of quite moderate speed (approximately 700 to 800 r.p.m.) is totally enclosed, and is supported between the side frame plates, and is provided with grease retaining ball bearings which will run on continuous service for months without attention.

A self-retaining brake is provided to hold the load in any position and it has also been considered necessary to make the over-loading and over-winding safeguards a mechanical arrangement, and not to rely wholly upon fuses in the electrical circuit to blow out every time either of the excuses referred to are met, as it is always within the power of the thoughtless individual to put in a fuse of too large a size (to prevent fuse blowing).

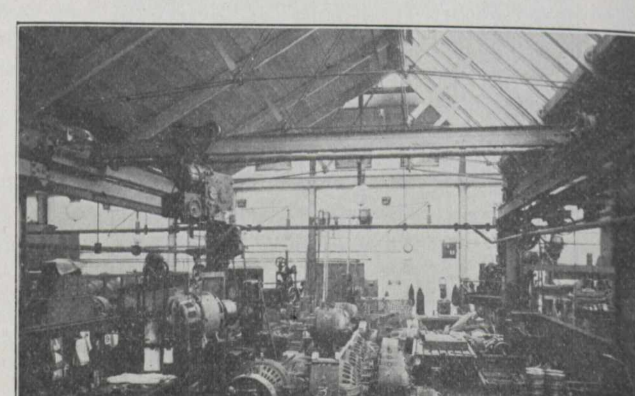
Another detail that has received attention is that the machines are always balanced under all conditions of load, i.e., they do not tip when a load is lifted.

The machines are all fitted with two hoisting ropes and upon which the load is always equalized. A swivelling hook is provided so that, in revolving, the load the falls are not twisted, and provision has also been made to prevent any risk of the ropes coming off their respective barrels, when lifting or lowering is being done at an angle.

Another feature that impressed us as being most desirable is the entire absence of any complication of gearing, and in place of such the simple open spur gearing is employed.

Attached to the motor shaft is a half coupling, and faced up to this and flexibly connected is another half coupling of the usual type which is forged solid upon a shaft together with a worm. The thrust of this shaft is taken against a ball end thrust bearing totally enclosed and grease lubricated. The worm is meshed into a phosphor bronze worm wheel which has cast with it two pinions, one on either side. These two pinions are meshed into gears that are cast solid upon one of the flanges of each hoisting drum. This arrangement, this simple construction, does away with any parts that may require special tools to make, besides overcoming any possibility of loosening parts.

To control the motor a multi-speed controller of the barrel type is provided. The contacts are all "get-at-able" and are renewable. The controller can be supplied, fitted upon the block and operated by pendant chains or supplied separately and fixed in any convenient position.



Lifting Block and Overhead Crane.

Regarding the suspension of the blocks they are made chiefly in two designs; the one with a simple forged yoke, enabling it to be suspended for an existing hook on the arm of a jib crane or the carrier upon an existing runway, the other design is that the two side plates are carried up sufficiently far to enable the four travelling wheels to be fitted to them. If necessary, two of these wheels can be geared together and the machine moved along by use of a pendant chain over a wheel placed upon a shaft carrying the pinions so geared.

Many of these blocks are used with a great measure of success, in some of the largest engineering firms in Great Britain, and do their work with a minimum of trouble and expense.

THE AUSTIN DAM DISASTER.

The town of Austin in Potter County, Pennsylvania, which adjoins the New York State line, was partially destroyed by a wall of water that broke loose a mile and a half above the town when the dam of the Bayless Pulp and Paper Company gave way under pressure of the great body of water impounded as a result of the heavy recent rains. Austin is thirty-five miles south southeast of Olean, N.Y., and about the same distance from Bradford, Pa.

The dam which gave way had forty-five feet of impounded water at the breast. It was built across from hill to hill, catching the entire drainage of a large creek, called Freeman River, the water of the dam backing for a mile and a half over an area of hundreds of acres.

The dam thrown over Freeman's Run at Austin, was designed and its construction in 1909 supervised by T. Chalkley Hatton, a civil engineer and member of the American Society of Civil Engineers.

It was built for the Bayless Pulp and Paper Company of Binghamton, N.Y., which has a pulp mill at Austin. The mill and a large part of the town itself are located close to the banks of the creek, as the valley is narrow, and the surrounding hills steep and rugged, rising in a distance of one and one-half miles to 500 feet or more above the creek.

Freeman's Run has a watershed of about thirty square miles, which is quite mountainous, and much of which is covered with a short growth of timber. In the Summer and Fall the run-off from the stream is not enough to supply the mill with water for its purposes. About eleven years ago, therefore, a small dam was built across the run about a mile above the mill, to impound about 25,000,000 gallons of water as a reservoir.

This was built of rubble stone, with a core wall 5 feet and 6 inches thick at the bottom and 18 inches at the top, with an unpacked earth slope on the down-stream side, built on a slope of 1:1, and an unpacked slope on the upstream face of 1½:1. The core wall is 20 feet high and rises a foot above the water level in the dam when full. It rests on a top layer of sandstone rock, which lies under the entire valley in thin layers. To the eye, this dam when the water is out, looks very weak indeed, but it has successfully withstood the floods of eleven years, during which much of the downstream slope has been washed away, exposing the core wall for a depth of several feet for most of its length, which is about 380 feet.

Toward 1909 the increased business of the paper mill created a necessity of impounding a much greater volume of water to carry on its operation of washing pulp and the like over low runs of the stream. Mr. Hatton was therefore, engaged to design the new dam to contain the greater reservoir and to supervise its construction. He located the new dam about 800 feet below the old, where the width of the valley is about 350 feet. The dam was to impound 200,000,000 gallons of water and to carry water at a depth of 40 feet above the normal level of the valley. This depth was increased in the course of construction to 42 feet to the level of the spillway with a 2 foot 6 inch freeboard.

In the construction of the dam a cut was made to a depth of four feet and a width of four feet in good rock bottom, which runs under the entire valley in horizontal layers to a depth of from 8 inches to 3 feet. Inside the dam itself twisted steel rods 1¼ inches in diameter and 25 feet long were placed vertically five feet inside the up-stream face of the wall. Against that face of the dam, too, an earth embankment was laid at a slope of 3.1, reaching to within 27 feet of the normal water level at that face. The embankment consisted of shale, clay and some loam, compacted tightly by grooved rollers.

The dam itself was built of cyclopean concrete, stones measuring from ½ to 2 cubic yards and surrounded by not less than 6 inches of concrete, generally more. The construction itself, according to The Engineering News of March 17, 1910, was carried on by C. J. Britnall & Co. of Binghamton, N.Y., on a percentage plan.

The dam was begun in May and completed on Dec. 1, 1909. It contained 15,780 cubic yards of concrete, 7,925 cubic yards of excavation in the foundation, and 6,300 cubic yards in the embankments. The total cost, exclusive of the engineering, was $71,821.

The dam had not been completed, when a small vertical crack was discovered 51.3 feet to the right of the spillway running from the top to the ground level, and 1-16 of an inch in width. In December a second crack was discovered 39.5 feet to the right of the spillway. There followed much cold weather, and then, in the week of January 17, 1910, considerable rain and snow, that led to the overflowing of the run. The weather, too, grew considerably warmer, resulting in sudden and violent expansion, followed again by contraction. Great bodies of earth were loosened from the near by hills and slid into the stream, and on Monday, Jan. 23, 1910, a section of the dam itself slid out. At that time, too, the flood engulfed portions of the town of Austin, and the town barely escaped destruction.

Many of the houses in the town were frame buildings built on piles and of a type of building characteristic of lumber towns that had been quickly built. Ruthgeber street was the path of the torrent until it struck the main street of the town, running north and south, and along which the substantial store buildings and hotels were situated. Some of these withstood the flood and formed a blockade against which the smaller buildings lodged. The dam had been erected at an elevation of 300 feet above the town.

Austin is a town of about 2,000 inhabitants. It is a lumber town, the principal industry being the plant of the Bayless Pulp and Paper Company, owners of the dam. One of the things that added to the destruction was the fact that thousands of feet of cord wood, which had been piled below the dam was caught by the water. As this swept down the narrow valley it formed a battering ram, which frame buildings, of which the town was largely made up, were totally unable to resist.

Property loss will be about $5,000,000. The Goodyear Lumber company's and the Emporium Lumber company's mills were partly destroyed. The Bayless Pulp and Paper company's plant, owners of the dam which caused the ruin, is jammed full of pulpwood. Roofs of this mill are raised and walls are bulged by the tremendous pressure of the wedged clumps of wood.

The cause of the breaking of the dam is a matter which the district attorney of Potter county has taken steps to investigate. The Bayless dam was examined by experts over a year ago and certain recommendations were made looking to its safety. The district attorney has secured the names of some of the experts who submitted the report to the Bayless company and will summon them to testify at an inquest.

A NOVEL BRIDGE FOR CHICAGO.

A bridge of novel and interesting design, soon to be built across the north branch of the Chicago river at West Chicago avenue, in Chicago, for the use of the Chicago Railways Company, operating on this street, and for the general public is described in a recent issue of Electric Traction Weekly, and we reproduce the description here.

The bridge will be a temporary structure located a short distance down-stream from the present bridge, which has been condemned and ordered removed by the War Department. The present bridge, under the condemnation act,

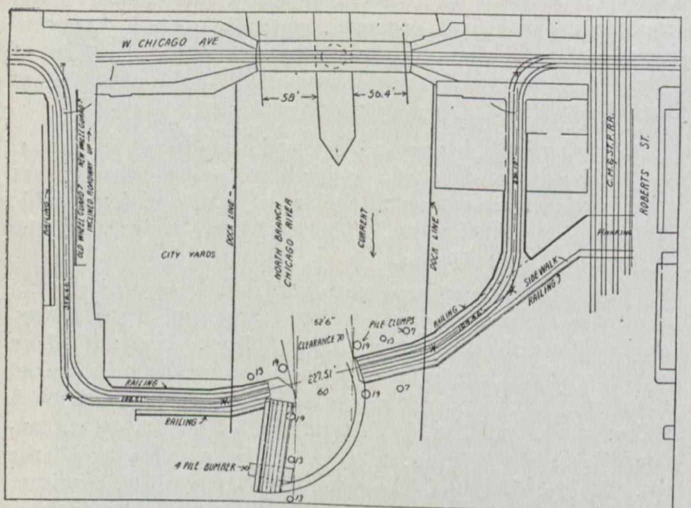


Fig. A—General Plan of Pontoon Bridge and Approaches.

could have remained in place until June 30, 1912, but the city authorities considered that it was becoming unsafe and it will be replaced with a new two-leaf bascule bridge as soon as the temporary bridge is built and in commission.

In general, the temporary work will consist of two land and water approaches, built on piles and trestles, a pivot abutment on which the movable section of the bridge will swing to allow the passage of boats, an abutment pier, a movable span, a scow for supporting one end of the span, and machinery for swinging the span and for raising and lowering it to bring it flush with the abutment pier. In reality the bridge will be a pontoon bridge, inasmuch as one end is supported and swung on a scow. In order for the railway line to cross the bridge it will be necessary for the company to build about 225 ft. of track and trestle work from the present tracks on Chicago avenue to a point intersecting with the east approach of the bridge. At one point this trestle will have to be built 20 ft. high to allow entrance and exit to a warehouse located on the river bank. The east approach, from the point where the street railway tracks run onto it, continues in a northeasterly direction to the C., M. & St. P. tracks, which are crossed at grade. On the other side of the tracks is a street running parallel to the railroad and intersecting with Chicago avenue. The west approach to the bridge commences at Chicago avenue, at a point about 200 ft. west of the river bank, and runs south for about 360 ft., where it turns to the east for 200 ft. to the bridge. The greater portion of this approach will be on a trestle and will involve no expense to the street railway company other than laying the rails. About 100 ft. of the total length of the approaches will be built on piling and about 165 ft. will be built on fills. Both of the approaches will be 27 ft. 10 ins. wide, of which width 21 ft. 6 ins. will be given over to a roadway and the remainder to a foot passage, the floor of which will be raised 4 ins. above the floor of the roadway. The floor of the roadway will be of 4-in. oak planks and the rails laid on 12-in. by 12-in. yellow pine stringers, on top of which will be 3½-in. by 3-in. strips, to which the floor will be nailed, to bring the floor flush with the top of the rails. All of the approach bents, both trestle and pile, except at the warehouse entrance, will be spaced on 11-ft. centres. The top of the rail at the point where the approaches connect with the bridge will be 14 ft. above the normal water line of the river.

The distance between the centre lines of the two last bents of the approaches will be 106 ft., of which distance 29 ft. 2 ins. will be occupied by the pivot pier and 6 ft. 6 ins. by the abutment pier. This will leave a maximum clearance for boats of about 70 ft. when the bridge is swung open. The abutment pier will be built on the last pile bent of the east approach and on a row of seven piles driven 6 ft. 6 ins. distance from the bent. The top of this pier is 9 ft. above the water level of the river and will be covered with a floor of four 12-in. by 12-in. yellow pine timbers, bolted to the 4-in. oak stringers. The pier will be about 26 ft. wide.

The abutment pier will have a width of about 40 ft. and a length of about the same distance. This pier will be built on five rows of piles, with an intermediate row at the limit of the swing of the span to take care of the added load when the span is open. The greater portion of the top of the pier will be floored with 12-in. by 12-in. yellow pine, on top of which will be laid 24-in. by ¾-in. plates laid with a radius of 12 ft. 8 ins. from the pivot bearing to form a track for the wheel under one corner of the span. This wheel will be finished, furnished with roller bearings and accurately fitted and bolted to the span so that it will bear fully on the track and its axis cut the vertical through the centre of the pivot. At the other corner and at the same end of the span will be located the pivot, a half ball and socket joint, upon which the span will revolve.

The bridge proper consists of a movable span, one end of which will be supported on a floating scow and the other end on the pivot ball and socket at one corner and by a 22-in. wheel at the other corner. With this arrangement the span can be revolved and the channel of the river made open for the passage of boats. The bridge will be a Pratt truss of 12 panels, with a length of 96 ft. and a width from inside to inside of struts of 20 ft. 4 ins. Wheel guards, 8 by

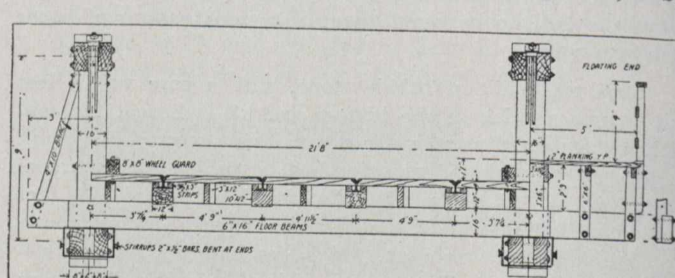


Fig. B—Cross Section at Floating End of Span.

8 ins., will be used, so that the clear roadway width will be 19 ft. On the downstream side of the span, outside of the main struts, will be a foot passage, 4 ft. 4 ins. wide, protected with a railing, 4 ft. high, made of dressed white pine. The floor of this foot passage will be 1 ft. 1 in. above the floor of the roadway. The top and bottom chords of the span will be of two 8-in. by 16-in. yellow pine timbers spliced every alternate panel. These splices will be made with 3½-in. by ½-in. splice bars, two to each splice, bolted through and fastened to the other timber forming the chord. The struts will be 10-in. by 16-in. yellow pine and the diagonal bracing will be iron rods varying in size from 1⅜ ins. to 2 ins. in diameter. The floor beams will be 6-in. by 16-in. timbers, extended far enough on the downstream side of the span for the support of the foot passage.

Perhaps the most interesting feature of the bridge will be the floating scow for the support of the one end and the arrangement of machinery for swinging the span and for raising and lowering the span to bring it flush with the abutment pier. The scow will have an over all length of 45 ft. 8 ins., a width of 15 ft., and will be built of dressed yellow pine and oak timbers especially selected for the purpose. The sides and bottom will be of 3-in. planks, surfaced on both sides and nailed to each cross frame and cross piece with 40d. nails. All of the joints will be made water-tight by calking. The free end of the span will be supported on the scow by means of four screw jacks, two under the centre line of each truss and spaced 8 ft. apart, resting on heavy oak foundations. Between these foundations and extending the width of the scow will be a water-tight compartment 5½ ft. high and covered over with 3-in. pellow pine planking. At one end of this compartment will be a pipe running to a 6-in. quick-opening sea valve at one end of the scow, for admitting water into the compartment. This valve will be so connected that it can be operated from the operating house, located on the span, and will be so arranged that the operator will know whether the valve is opened or closed, regardless of the changing of the distance between the bridge span and the pontoon. This arrangement of water-tight compartment and sea valve is for the purpose of varying the depth at which the scow floats in the water. For pumping out the water from the compartment the scow will be provided with a vertical shaft, suction, centrifugal pump having a 5-in. discharge pipe and capable of raising 735 gallons of water 10 ft. high per minute. This pump will be driven with a 5-h.p. motor, by means of cut bevel gears. The starting rheostat will be located in the operating house and the motor will be located on top of the water-tight compartment, where it will be accessible for inspection and repairing. An extra armature and an extra field coil will be kept on hand for quick repairs in case of an accident.

The span will be raised and lowered with reference to the scow by means of a 10-h.p. motor, connected to a 2¼-in. shaft by means of a gear and pinion. Connected to this shaft, by means of steel roller sprocket chains, will be two countershafts, each 2¼ ins. in diameter, operating the four screw jacks with right and left hand worms and wheels. All four of these screw jacks will be operated simultaneously, so that the span will be kept in a horizontal position. These

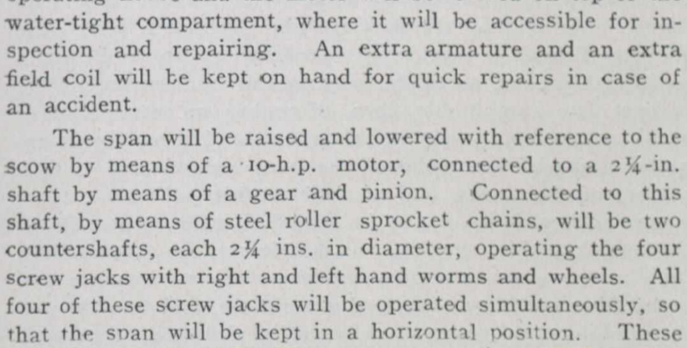


Fig. C—Elevation of Pile Bents and Pivot Pier Showing Half-Ball and Socket Pivot.

jacks will have a thread with length of 4 ft. and it will be possible to raise this end of the span almost that distance. Four heavy timbers, fastened securely to the span and sliding in grooves placed in the scow, will serve as guides to hold the span in the desired position. These timbers, as well as the pieces coming in contact with them, are planed to reduce friction. As in the case with the motor for operating the pump, the motor for raising and lowering the span will be located in the water-tight compartment, also the shafts and the countershafts. The motor will be series wound, water-proof, and provided with reversing device and controller located conveniently upon the scow.

The span will be swung by means of two paddle wheels, driven by a 40-h.p. motor, located near one end of the scow. The motor will be of the railway type, series wound, water-proof, and will drive the paddle wheel shaft through a gear and pinion. The controller for starting the motor will be located in the operating house and will be fitted with an interlocking reversing cylinder and a magnetic blowout. Suitable resistance will be furnished and installed so that the motor can be started from a standstill and run to full speed without permitting sparking at the commutator and without shock or jar to the bridge. The paddle wheels will be 8 ft. in diameter and will consist of eight blades built up from a

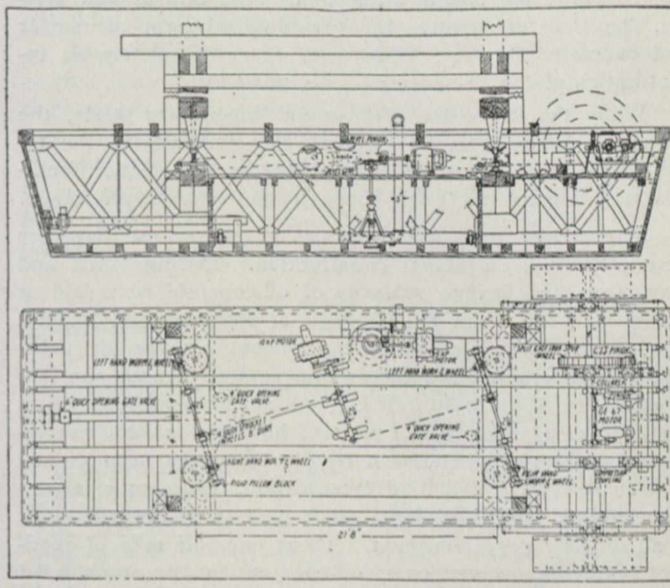


Fig. D—Plan and Section of Scow Showing Arrangement of Machinery.

cast iron spider. The wheel will be braced on each side by 2-in. by ⅜-in. iron from spoke to spoke, and the blades will be of 1¾-in. oak 1 ft. wide by 2 ft. 6 ins. long, dressed on all sides. These blades will be fastened to the 2¾-in. spokes with ⅜-in. bolts.

The bridge has been designed for both team and street railway use, as well as for the use of pedestrians. It is expected that the span can be opened in about the same time that is consumed in opening the other swing bridges, as it is to be opened with the current of the river. Closing the span will consume more time, but as the river traffic at this point of the city is light, the bridge will not have to be opened but a few times each day, and the total time lost will be small.

The bridge was designed by the Division of Bridges and Harbor of the Department of Public Works, City of Chicago, and will be built by contract.

The annual adjourned meeting of the Quebec Railway, Light & Power Company was held this week, with Mr. Rodolphe Forget, M.P., in the chair. The important announcement was made that in view of the heavy holdings by French investors it was decided to elect three Paris men as directors, and at the same time the resignation of Mr. J. W. McConnell of Montreal as director was accepted. The regular dividend of 1 per cent. has been declared on the common stock of Quebec Railway payable October 16 to holders of September 30. Gross earnings for the year ended June 30 are formally reported at $1,380,126, operating expenses $661,907, leaving a net balance of $718,219. Fixed charges amounted to $445,219, with a surplus of $273,000.

OIL-MIXED CEMENT MORTAR AND CONCRETE.

In the September volume of the Proceedings of the American Society of Civil Engineers, appears an article by Logan Waller Page, on some of the properties of oil mixed Portland cement mortar and concrete.

Mr. Page notes that oil in considerable quantities can be combined with wet Portland cement paste by a simple mixing process. When oil was added to the wet cement it disappeared completely when mixed for a few minutes, and furthermore, there was no apparent separation of the ingredients upon setting. The following tests were made with various kinds of oil and various mixtures of cement, mortar and concrete, the tensile strength of neat cement and mortar, the time of setting, the crushing strength of mortar and concrete. In fact, these tests cover completely an investigation of the properties of the mixtures.

While the tests are still in an incomplete state, the writer publishes them in order to give publicity to the results already obtained, so that engineers with better facilities may hasten the work through its experimental stage.

The service tests are of a special interest in that they were conducted on actual construction. During April and May, 1910, two bridge surfaces of oil-concrete were laid at Ridgewood, N.J. In the borough of Richmond, New York City, during May and June, 1910, about 400 feet of street surface was laid with different aggregates. About 300 feet of street in Washington, D.C., was surfaced in June, 1910. On another page of this issue will be found a Progress report of this experiment, with results that have been gained in dust prevention and road preservation. Numerous inspections of this work have been made and up to the present it is all in very good condition. About one-half mile of roadway laid with 10 per cent. oil-concrete in the suburbs of Harrisburg, Pa., in the summer of 1910, is also reported to be in very good condition.

A vault 112 feet long and 18 feet wide in the United States Treasury Department was built in the autumn of 1910. The side walls of this vault contained 10 per cent. of oil. Its roof was constructed of ordinary reinforced concrete, with about three inches of 10 per cent. oil-concrete on top. For several months this roof was subjected to a head of water of several feet without showing any signs of leakage. Another vault, in the north end of the Treasury, on account of leakage has never been available for storing anything of value. Its roof was treated with oil-concrete, and is now perfectly dry. Numerous floors in the sub-basement of the Treasury Department, and a floor in the office of Public Roads, have been constructed with 10 per cent. oil-concrete, and have remained absolutely free from dampness. A tank, about 12 ft. long, 4 ft. wide, and 4½ ft. high, constructed in the office of Public Roads during the winter of 1910, has been continually full of water, and has not shown the slightest signs of leakage.

Mr. Page, at the end of his paper, draws the following tentative conclusions as to the effect of the oils used in the cement and mortar:—

The tensile strength of oil-mixed mortar differs very little from that of plain mortar and shows a substantial gain in strength at 28 days and six months over that of seven days.

The times of initial and final set are delayed by the addition of oil, 10 per cent. of oil increasing the time of initial set by 90 per cent., and the time of final set by 60 per cent.

The crushing strength of mortar and concrete is decreased by the addition of oil to the mix, concrete with 10 per cent. of oil having roughly 75 per cent. of the strength of plain concrete at 28 days. At the age of one year the crushing strength of mortar suffers but little with the addition of oil in quantities up to 10 per cent.

The toughness of resistance to impact is affected but slightly by the addition of oil in quantities up to about 10 per cent.

The stiffness of oil-mixed concrete appears to differ but little from that of plain concrete.

Oil-mixed mortar and concrete containing 10 per cent. of oil have very little absorption, and, under low pressures, both are water-proof.

Oil-mixed mortar containing 10 per cent. of oil is absolutely water-tight under pressures as high as 40 lb. per square inch. Tests indicate that oil-mixed mortar is effective as a water-proofing agent when plastered or painted on either side of porous concrete.

Bond tests show the inadvisability of using plain bar reinforcement with oil-concrete mixtures. With deformed bars the bond is not weakened seriously by the addition of oil in quantities up to 10 per cent.

TREATING THE FOREST AS A CROP.

The progress of the conservation policy of Canada, as applied to forest resources, depends more upon the Forestry Branch of the Department of the Interior than upon any other organization. Upon the technical knowledge and executive ability of the officers of the Forestry Branch depends the future of the forest on 16,000,000 acres of Dominion Forest Reserves, as well as upon the large area of non-agricultural forest land in Western Canada, which for the good of the country may yet be set aside as permanent forest reserves. In addition to looking after Dominion lands, the Forestry Branch is now being asked by eastern land owners to furnish advice as to the best means of securing at the earliest date a profitable crop of timber on waste land or wood-lots. The proper administration of forest lands requires a special knowledge of the trees best adapted to each region, of their uses, and of their markets. Further, there is needed knowledge of the habits of all trees, especially of the merchantable species, so that it may be known how rapidly they grow, how they produce their seed, when and under what conditions the seed germinates, and in what way the seedlings and young trees are affected by their surroundings. Such knowledge is gained only by long study and experience In order that the new Rocky Mountain Forest Reserves may be administered according to the latest scientific knowledge and best experience, the Forestry Branch is now making detailed studies of the habits of the merchantable species of trees on the eastern slope of the Rockies in Alberta and has sent one of the men in charge of the work to study the systems of forest management practised during the past few years by the highly developed United States Forest Service in the National Forests of Montana. The United States foresters have spent large sums of money and availed themselves of the experience of many men in developing plans of lumbering which do not inconvenience the lumbermen, but which ensure the protection and reproduction of the forest and the Canadian Forestry Branch intends to benefit largely by their experience.

CLEOPATRA'S NEEDLE.

Government experts are attempting to preserve this monument from the deteriorating effects of London fog by washing and coating with parafin-wax. By this means it is hoped that the many colored hieroglyphics will be preserved indefinitely.

THE DESIGN OF EARTH DAMS.

The following discussion of the principles governing the design of earth dams has been furnished to the "Michigan Technic" by Prof. Clarence T. Johnston:

The dimensions of a typical form of earth dam, given in cross-section, may be represented in terms of the height of the dam, h (Fig. 1). The up-stream, or water slope may be $3h$, the lower, down-stream or dry slope may be $2h$ and the top width may be $h/5$. The area of the cross-section of this dam is $2.7h^2$. If h is reduced to yards, then the volume of material in the dam per running yard of length is $2.7h^2$ cu. yd. In making estimates, following preliminary surveys, it is often convenient to employ some such expression. Fig. 2 indicates graphically how the volume varies with the height and it is well for the engineer to have this curve in his mind while he is designing an earth dam.

The cost of constructing an earth dam varies with the volume of material and it is also influenced by the height of the dam independent of the volume. The increase in cost with the height is due to many small factors that can only be briefly referred to. The average haul is greater for high dams. The immediate shrinkage of earth work is greater. Time occupied in going to and from work and the time that is employed in raising machinery all go to increase the unit cost. If we assume that earth can be placed in a low dam for 20 cents per cubic yard, we might employ the following formula for obtaining the approximate cost of higher dams:

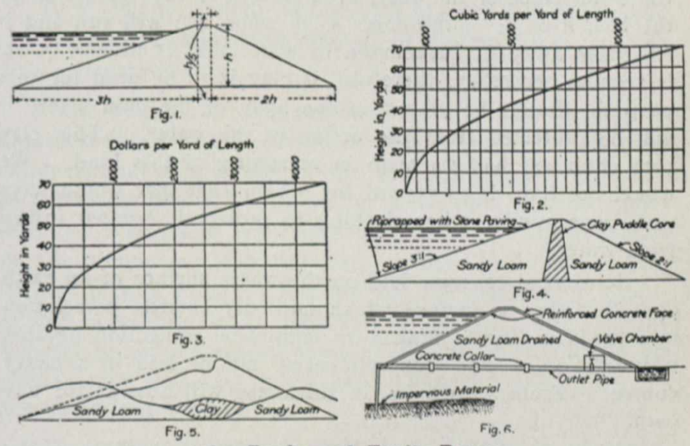
Cost per cubic yard equals $2.7h^2$ (20c plus $0.2h$c).

This formula would place the unit cost of a dam 30 ft. high at 22 cents while the unit cost for a dam 150 ft. high would be 35 cents. It should be remembered that h in the formula is in yards. Fig. 3 shows graphically the relation of the height of a dam and the cost per yard of length.

After we know what the form of the cross-section of the dam is to be and when we have made estimates to determine whether or not the proposed structure is feasible, we can consider some of the important details of the construction of the dam. The design of earth dams has not changed greatly until within the past few years. For a long time engineers have recommended and used cores in earth dams. A core is provided by placing within the dam a wall of material such as clay, which is more impervious to water than is any other material used in the construction of earth dams. This wall runs throughout the length of the dam and from the natural ground surface to an elevation well above high water. Many different kinds of cores have been devised aside from the clay wall. Timber has been employed for this purpose. Concrete and masonry walls have been built along the center lines of dams. When we study the nature and purpose of a core we must be excused for a little speculation. We must assume that the core is provided for the purpose of making the dam stronger. It is manifestly designed to reduce or prevent percolation through the dam. In other kinds of construction the mind of man has evolved plans that have led to something that is water resisting where such a condition is essential. For instance, our houses are built with the water resisting surfaces on the outside. We wear rain coats over our other clothing and not between our coats and our shirts. It does not seem reasonable that all of our ideas based on common sense should be discarded when we are called upon to design an earth dam. To place the water resisting material in a dam at a place where we know it only protects a part of the structure and where its beneficial function, if it has such, is not visible, does not appeal to one who has studied other kinds of construction. Considerations of this kind led the writer to make some experiments a few years ago. Of the twenty-nine model dams built and tested but one can be briefly described.

The dimensions we have already assumed for the cross-section of an earth dam are common in practice. Fig 4 shows the cross-section of the model dam to be described. This model was built for the purpose of determining the value of a clay core. The dam, aside from the core, was constructed of a sandy loam. It was finished early in April, the water turned in, and it remained unmolested until late in October. The water standing against the dam was kept at a uniform level, as nearly as possible, throughout this time. When the water was turned out of the small reservoir formed by the dam, the water slope of the dam was found to have settled as shown in Fig. 5. Beyond this the dam seemed in good condition. There was practically no water leaving the dam through seepage. To the casual observer the dam would have been pronounced a success. It had held water for nearly seven months.

The sandy loam on both sides of the core was removed so that the condition of the interior of the dam might be ascertained. The material between the core and the water face was completely saturated. This was to have been anticipated because the face was not protected and it was known that the core would prevent percolation to a large extent. The material on the other side of the core was in good condition. The core itself had absorbed water to such an



The Design of Earth Dams.

extent that when the sandy loam was removed on both sides it settled to the base and had the appearance of mortar as it is deposited by a hodcarrier. The location and appearance of the core and the other material of the dam after investigation is also shown in Fig. 5. Great care was exercised to remove the sandy loam without disturbing the core any more than necessary. If the model had been left undisturbed a few months longer it would have failed. The dam was gradually absorbing water and the clay core simply retarded operation.

It is plain that this kind of construction is not good. The writer was called soon after this to examine a dam in actual use which had been replaced several times. It was never overtopped by the water. It would simply absorb water until the saturation had reached a certain point when it would apparently float away. The slopes of the dam as it stood after replacement were too steep. The principal trouble, however, was in the construction of the dam as it stood. The material was of such character that water was slowly absorbed and there was sufficient clay in the interior of the dam to make drainage very difficult. By installing a few tile drains running from the lower toe of the dam to a point slightly more than half way through the structure and by flattening the slopes a little the dam has given good satisfaction and has been used continuously for the past eight or ten years. This experiment in draining a dam was very conclusive in its results. It is apparent that it is better to eliminate the core altogether and to substitute drainage even though no other precautions are taken to strengthen the dam.

The idea of draining an earth dam is not new, but it has not been given sufficient attention. It it manifest that some plan should be evolved and put in practice whereby the dam may be protected from the water and the rate of percolation reduced to the minimum. When this is accomplished the necessity for extensive drainage is lessened. Not only is it necessary to prevent water entering and remaining in the dam in large volumes, but it is essential that the water face of the dam be protected from wave action and erosion due to the rise and fall of the water surface. It has been customary to riprap the water face of the dam with hand-laid stone paving. This may protect the dam from the action of the water, but it is expensive compared with the beneficial function performed. The riprapping does not tend to make the dam more waterproof. It does not always prevent erosion on the water face, for often during high winds the wave action will wear away the fine material of the dam back of the paving and permit a stone to settle here and there. This brings about settlement in other places and before many months the face of the dam consists of ridges of paving material and broad stretches of unprotected earth. It is plain that it would be impossible to maintain a facing of clay on the water slope of the dam, even though it were protected by the best kind of riprapping. Clay when wet will run and it will pass away in suspension in water that is almost quiet. It seemed necessary, therefore, if clay is to be used for this purpose, that it be placed in the body of the dam where it will be protected from the action of the water. This clay core doubtless had its birth in reasoning of this kind. We would not have high regard for a rain coat that would have to be worn under other clothing to protect it against injury from water.

Reinforced concrete laid on the water surface of an earth dam furnishes a surface which not only retards percolation into the dam, but it makes an admirable protection against wave action. The concrete need not be laid in a heavy course. From 3 to 6 in. in thickness will answer for any dam.

It is advisable to carry the concrete of the face to the extreme toe of the dam and from there vertically until it enters some impervious material, such as rock or shale. Sheet-steel piling can be substituted for the concrete below the toe of the dam where conditions are favorable for pile driving. The steel reinforcing of the concrete facing above can be attached to the top of the sheet piling. By bringing the concrete wall down over the top of the sheet piling a very satisfactory union of the two materials can be made. Fig. 6 shows a dam constructed in this way. The water slope of the dam has been reduced to 2 to 1. This is often permissible where the concrete face is employed. The dam shown in cross-section in Fig. 6 is paved on both the dry and wet slopes This furnishes a spillway over the dam. A water cushion is provided at the toe of the dry slope. The drainage tile, the outlet pipes and the spillway all discharge into this cushion The controlling device for the outlet pipes is located under the facing on the dry slope of the dam and it is reached by a protected entry from one side of the depression in which the dam rests.

The intention has been to show general types of construction and not to enter into details. Concrete may be employed to advantage in building the box at the lower toe which provides the water cushion, in constructing collars about the iron pipe to prevent percolation along them and in the construction of the valve house and approach thereto.

It is well to permit an earth dam to stand for a year or longer before the concrete facing is applied. This gives the earth an opportunity to settle. The surface of the concrete can be protected by an application of coal tar and maintained by similar applications from year to year.

SPECIFICATIONS FOR FUEL OIL.

The United States Bureau of Mines has recently issued a bulletin discussing specifications for fuel oil. In view of the fact that this type of fuel is becoming more and more popular, suggestions such as embodied in this report are very welcome. An abstract of the specifications is given below:—

In determining the award of a contract, consideration will be given to the quality of the fuel offered by the bidders, as well as the price, and should it appear to be to the best interest of the government to award a contract at a higher price than that named in the lowest bid or bids received, the contract will be so awarded.

Fuel oil should be either a natural homogeneous oil or a homogeneous residue from a natural oil; if the latter, all constituents having a low flash point should have been removed by distillation; it should not be composed of a light oil and a heavy residue mixed in such proportions as to give the density desired.

It should not have been distilled at a temperature high enough to burn it, nor at a temperature so high that flecks of carbonaceous matter began to separate.

It should not flash below 60° C. (140° F.) in a closed Abel-Pensky or Pensky-Martens tester.

Its specific gravity should range from 0.85 to 0.96 at 15° C. (59° F.); the oil should be rejected if its specific gravity is above 0.97 at that temperature.

It should be mobile, free from solid or semi-solid bodies, and should flow readily, at ordinary atmospheric temperatures and under a head of 1 foot of oil through a 4-in. pipe 10 ft. in length.

It should not congeal nor become too sluggish to flow at 0° C. (32° F.).

It should have a calorific value of not less than 10,000 calories per gram (18,000 British thermal units per pound); 10,250 calories to be the standard. A bonus is to be paid or a penalty deducted according to the method stated under section 21, as the fuel oil delivered is above or below this standard.

It should be rejected if it contains more than 2 per cent. water.

It should be rejected if it contains more than one per cent. sulphur.

It should not contain more than a trace of sand, clay or dirt.

Each bidder must submit an accurate statement regarding the fuel oil he proposes to furnish. This statement should show: The commercial name of the oil; the name or designation of the field from which the oil is obtained; whether the oil is crude, a refinery residue, or a distillate; the name and the location of the refinery, if the oil has been refined at all.

The fuel oil is to be delivered f.o.b. cars or vessel, according to the manner of shipment, at such places, at such times, and in such quantities as may be required.

Should the contractor, for any reason, fail to comply with a written order to make delivery, the government is to be at liberty to buy oil in the open market and charge against the contractor any excess of price above the contract price of the fuel oil so purchased.

Copies of this Technical Paper may be obtained by addressing, the Director of the Bureau of Mines, Washington, D.C.

STATE IRONWORKS FOR NEW SOUTH WALES.

In pursuance of its policy for the establishment of industries for the requirements of the state, instead of purchasing the materials from local manufacturers or importing from abroad, the government of New South Wales has formulated a proposal for the erection of state ironworks. At present the government has in operation several brick and lime works. A state coal mine (like that in Victoria) is proposed and negotiations have been commenced for the establishment of a timber depot and building yards. All these services are intended for state requirements only (railways, public works, etc.), and not to compete with private enterprises for public demand. One of the leading British experts in iron and steel is now in New South Wales, under engagement to the government, to report upon the following matters:

(a) the suitability of Australian ores for the manufacture of iron and steel, and

(b) the cost at which the various sections of iron and steel required by the state could be produced from local ores.

(c) Whether the existing arrangement with the Lithgow, N.S.W. ironworks is a beneficial one in the public interest.

(d) The approximate cost of a plant capable of producing the iron and steel likely to be required by the Commonwealth and state governments, including rails and bridges for the Transcontinental Railway, plates for vessels, &c.

It is understood that in view of the high status of the British expert, it was found necessary to pay him a large fee for making the necessary exhaustive investigations.

PERSONAL.

Mr. H. R. Safford has been appointed chief engineer of the Grand Trunk, with headquarters at Montreal.

Mr. F. A. Yerburry, of the Canadian Boving Company, has returned to Toronto this week from a two months' trip through the West.

Mr. Grant Hall has been appointed assistant to Mr. George J. Bury, the new vice-president and general manager of the C.P.R.

Mr. H. B. Greening, who has been managing director of the B. Greening Wire Company, of Hamilton, for the last twelve months, was appointed president at a meeting of the directors held on September 28th.

Mr. Howard G. Kelley, chief engineer of the Grand Trunk Railway, has been appointed vice-president in charge of construction, transportation and maintenance departments on the Grand Trunk.

Mr. William Wainwright, formerly second vice-president of the Grand Trunk Railway and Grand Trunk Pacific, has been appointed senior vice-president of the Grand Trunk Railway and second vice-president of the Grand Trunk Pacific.

Mr. George J. Bury, general manager of the C. P. R. Western line, succeeds Sir William Whyte as vice-president and general manager. Mr. Bury began as a clerk in the Purchasing Department and has gradually worked his way up. He is a native of Montreal.

Mr. M. M. Reynolds, formerly third vice-president of the Grand Trunk Railway and the Grand Trunk Pacific, has been appointed vice-president of the Grand Trunk, in charge of financial and accounting departments, and third vice-president of the Grand Trunk Pacific.

SIXTH ANNUAL CONVENTION OF UNION MUNICIPALITIES OF SASKATCHEWAN.

Over fifty mayors, commissioners, aldermen, municipal officers and prominent citizens, representative of all parts of the province, assembled in Yorkton for the opening of the sixth annual convention of the Union of Saskatchewan Municipalities.

In the course of his presidential address, ex-Mayor Clark of Yorkton pointed out that several of the recommendations made at the Union's last annual gathering at Saskatoon have since become embodied in the Municipal Act. Among these was the single tax amendment. Saskatchewan has the honor of being the first province to take a forward step in this direction, and old Ontario seems to be following in our wake.

T. N. Bayne, Deputy Minister of Municipal Affairs, read a paper on municipal development in Saskatchewan, and in course remarked:

"The wisdom of your association continuing the discussion of sewage disposal cannot be questioned. I do not need to repeat that this is one of the great problems which will be before our prairie provinces for some time to come. We need the brains and experience of the best qualified experts on this important subject; for, in our level areas where streams of any great volume are not too common, a proper method of dealing in an inexpensive manner with sewage disposal is not the easiest thing in the world to find. I am glad to note that you are to have a lengthy discussion on this important subject."

Mayor Bee, of Lemberg, and Mayor Clinkskill, of Saskatoon, were unanimously elected president and vice-president respectively for the coming year, President Clark being returned as an honorary member.

The following executive committee was elected: Ald. Matheson, of Prince Albert; Mayor Craig, of Rouleau; Ald. Doerr, of Regina; Mayor Paul, of Moose Jaw; Mayor Dafoe, of Francis, and Secretary-treasurer Hilton, of Leross. Secretary-treasurer Heal, of Moose Jaw, was reappointed to this office on the union executive.

The next annual convention of the Union of Saskatchewan Municipalities will be held in 1912 in Prince Albert. This was decided by a vote at the closing session of the Union's two days' gathering in Yorkton.

ANNUAL MEETING OF OTTAWA BRANCH AND ELECTIONS.

Mr. Nolan Cauchon presided over the annual meeting of the Ottawa branch of the Canadian Society of Civil Engineers, held in the offices of the society, 177 Sparks street, Ottawa, Ont.

The annual report presented by the secretary, Mr. Victor Brayley, showed that the membership was at present 251 as against 212 at the same time last year. There had been added one full member, 14 associate members, 14 student members and 12 Ottawa associates. The financial report showed that the position of the society had considerably improved during the past year. The officers were elected as follows:—Chairman, S. J. Chapleau, in place of A. A. Dion; Managing Committee, Messrs. George J. Desbarats, R. F. Uniacke, John Murphy, Nolan Cauchon, R. de B. Corriveau; secretary-treasurer, Mr. Victor Brayley.

During the past year two business meetings, 17 meetings at which papers were read and two informal dinners were held.

ROYAL ARCHITECTURAL INSTITUTE OF CANADA.

The members of this society met in Montreal, P.Q., October 3rd and 4th, on the occasion of their Fourth General Annual Assembly.

The following officers were elected for the ensuing year: President, F. S. Baker, Toronto, (re-elected); Vice-presidents, S. Frank Peters, Winnipeg; G. A. Monette, Montreal, and Edmund Burke, Toronto, (re-elected); Hon. Secretary, Alcide Chausse, Montreal, (re-elected); Hon. Treasurer, J. W. H. Watts, Ottawa, (re-elected).

COMING MEETINGS.

* THE ENGINEERS' CLUB OF TORONTO.—Oct. 19, 8 p.m., 96 King Street West, Toronto. R. B. Wolsey, Secretary, Toronto.

CANADIAN SOCIETY OF CIVIL ENGINEERS.—Oct. 26. General Section Meeting, 413 Dorchester Street West, Montreal. C. H. MacLeod, Secretary.

CANADIAN INDEPENDENT TELEPHONE ASSOCIATION.—Nov. 15. Sixth Annual Convention, Toronto. F. Dagger, Secretary, 21 Richmond Street West, Toronto.

THE AMERICAN ROAD BUILDERS' ASSOCIATION (150 Nassau Street, New York).—Nov. 14-17. Annual Convention, Rochester, N.Y.

THE CANADIAN PUBLIC HEALTH ASSOCIATION.—Nov. 21-23, Montreal. F. C. Douglas, M.D., D.P.H., Secretary, 51 Park Avenue, Montreal.

AMERICAN ASSOCIATION FOR HIGHWAY IMPROVEMENT.—Nov. 20-24. First Annual Convention, Richmond, Va. Logan Waller Page, President, United States Office of Public Roads, Washington, D.C.

ENGINEERING SOCIETIES.

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

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

TORONTO BRANCH—
96 King Street West, Toronto. Chairman, H. E. T. Haultain; Secretary, A. C. D. Blanchard, City Hall, Toronto. Meets last Thursday of the month at Engineers' Club.

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

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

OTTAWA BRANCH—
Chairman, A. A. Dion, Ottawa; Secretary, H. Victor Brayley, N. T. Ry., Cory Bldg.

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

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UNION OF NOVA SCOTIA MUNICIPALITIES.—President, Mr. A. E. McMahon, Warden, King's Co., Kentville, N.S.; Secretary, A. Roberts, Bridgewater, N.S.

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

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

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BUILDERS, CANADIAN NATIONAL ASSOCIATION.—President, E. T. Nesbitt; Secretary Treasurer, J. H. Lauer, Montreal, Que.

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

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

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