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Contents of this issue on page 151

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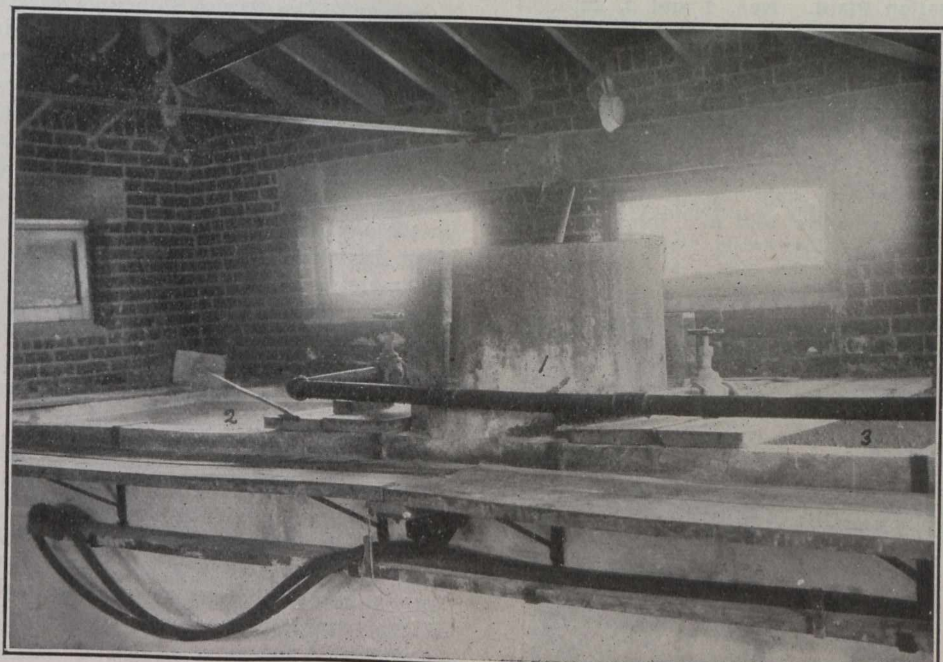
THE TORONTO WATER CHLORINATION PLANT.

Toronto is supplied by water from three sources, two of which are more or less intermittent. One of these, in East Toronto, where the water supply is obtained from the open lake opposite Balmy Beach, supplies from one-half to one million gallons a day. This water is chlorinated by a small temporary plant of little mechanical interest.

The West Toronto Pumping Station, which formerly supplied the Junction district, is capable of pumping one and a half million gallons of water per day, and draws this supply from the Humber Bay, about 700 feet from shore. As this water is usually contaminated with sewage, it is only operated when absolutely necessary to maintain a sufficient supply of water. This supply is chlorinated by means of injectors attached to the piston rods of the pumps, so that each gallon of water forced into the main is given at the same time a sufficient quantity of chlorine to practically sterilize it.



Toronto Water Chlorination Plant. No. 1 shows mixing tank. Nos. 2 and 3, solution tanks.

The main chlorinating plant is situated over tunnel shaft number two on Toronto Island near Hanlan's Point. Formerly the water flowed directly by gravity from Lake Ontario, through a pipe across the Island, and fell into the tunnel at this point. Since the first of January, 1912, however, the water is intercepted by the slow sand filters, through which it passes, and again flows to the tunnel, clarified, and with a large portion of the bacteria removed.

The plant consists of four tanks, namely, a mixing tank, two solution tanks and a constant head tank, which is divided into two, so that one can overflow into the other, or they can be operated independently.

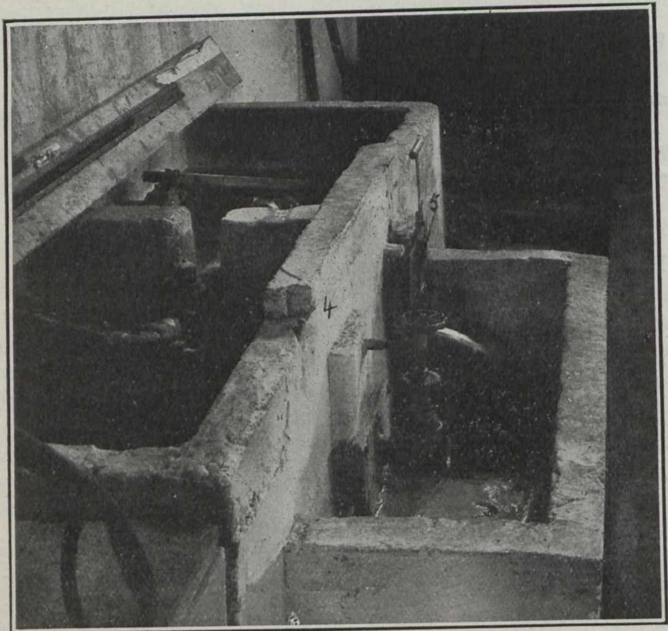
The weighted charge of calcium hypochlorite is placed in the mixing tank, a little water is added, and the mass pounded smooth and then filled to the top with water. The thick milky solution is then run into the solution tank, which is about half-filled with water. The solution tank is then filled, and the mixture stirred at intervals until an hour and a half before it is to be used, so that the sediment can completely settle out. The clear, supernatant fluid, which is alone used, flows into the constant head chamber. At first this was kept at a constant level by a valve operated by a ball float, but not proving satisfactory, a hand valve was substituted. The overflow from the chamber is caught and dipped back into the main tank whenever this becomes necessary.

A calibrated valve allows the solution to flow from this constant head chamber into the pipe leading to the grid in the tunnel shaft. A needle connected to a registering device points out the amount of water flowing along the pipe into the tunnel shaft, the mechanism having been previously calibrated by the amount of water pumped at the main pumping station. The operator opens or closes the gate valve to the proper notch, according to the flow registered by the needle.

The grid consists of a two-inch iron pipe, containing cross arms of ½-inch pipe perforated at intervals. The grid is hung across the stream of water just as it falls into the tunnel shaft, and where it gets a thorough mixing.

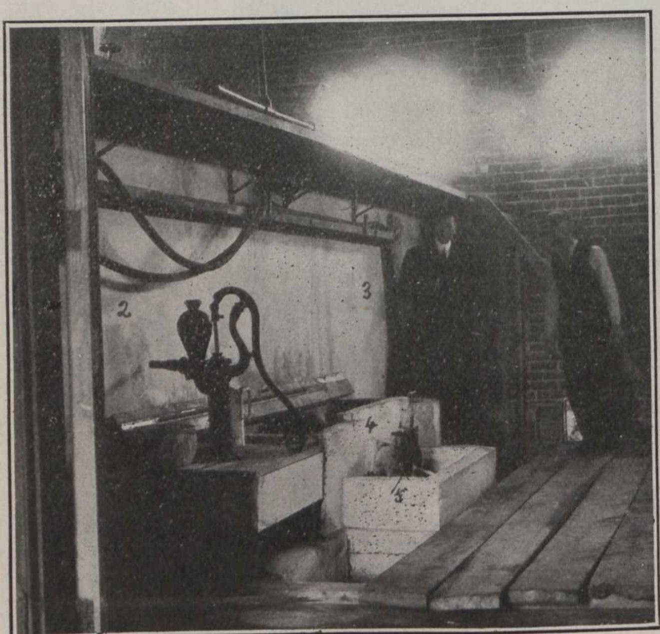
The plant is by no means a perfect one, but it has, on the whole, worked satisfactorily since the device for registering the flow of water has been installed. Lake Ontario water is peculiar in this, that the amount of free chlorine required to sterilize the water is very close to the amount which can be detected by taste, i.e., about .3 parts free chlorine per million parts of water. If this amount is reduced, its bactericidal effect is also reduced; if increased, it can be detected by the consumer. The application has, therefore, to be closely watched, and two men are maintained on each twelve-hour shift, night and day, one of whom has always been a chemist, to check up the strength of the hypochlorite, solutions, etc.

The efficiency of the plant may be gauged from the fact that B. coli, though frequently present in the unchlorinated water before the filtration plant was installed, and for some time after, has not been obtained in the laboratory tap since last October, a period of eight months. Fairly high counts have sometimes been obtained in districts supplied by the water after it has been passed through the reservoir or through the high-level pumping station, due to after growths of bacteria, but these are without significance. During May,



Toronto Water Chlorination Plant. Nos. 2 and 3, solution tanks. No. 4, constant head tank, and No. 5, calibrated valve.

for instance, the average bacteria count from the laboratory tap on gelatine was only 5 per c.c., which is quite extraordinary. The results seem to prove, moreover, contrary to the experience of Stokes and Hachtel of Baltimore, that the action of chlorine upon B. coli is selective, and that this organism is more readily destroyed than some of the other organisms present.



Toronto Water Chlorination Plant. No. 4 shows constant head tank, and No. 5, the calibrated valve.

The chlorination of the city water supply is under the direction of Dr. G. G. Nasmith, the Director of the Laboratories, who is held responsible for the results.

The value of the method may be gauged from the fact that while in 1910 the death rate in Toronto from typhoid was 45 per 100,000, it was only 20 per 100,000 in 1911, in spite of the fact that for several weeks in 1911, on account of a broken intake pipe, consumers had to drink bay water, heavily contaminated with sewage.

BRITISH COLUMBIA

Application is being made by the International Railway and Development Company for a water right on the Fraser River and for a license to dam that river at a point above Yale at what is known as the canyon. The company is a new one, and the idea is also new. Local men are interested, the names of Mr. H. H. Stevens, M.P., Mr. E. W. Leeson, of Vancouver, and Mr. H. T. Thrift, of Ladner, are mentioned, with Mr. D. M. MacDuff as the company's consulting engineer. It is stated that $5,000,000 is immediately available for development purposes, and that capital up to $20,000,000 will be supplied from Great Britain. The plan outlined is to construct lines of electric railway throughout the lower mainland.

Waterpowers abound at different points on the lower mainland, close to Vancouver the centre of activity and where the biggest market for electrical energy would be found. The promoters of the company must be optimistic, or are building on securing money from Great Britain and going ahead with the project for what there is in it. At present, the field seems covered by the British Columbia Electric Railway Company and the Western Canada Power Company. The British Columbia Electric Company is constantly increasing its supply and building reserve auxiliary plants to obviate any serious loss or inconvenience loss to its patrons through a breakdown of any of its units. Still it is aggressively in the field after business, indicating that it is able to furnish power for more customers. The Western Canada Power Company has its plant thirty-five miles east of Vancouver, considerably less than half the distance to the Yale canyon of the Fraser. This company has spent three million dollars developing the power on the Stave River and is now supplying electrical energy for industrial purposes. It has a very large amount yet to place before it will have exhausted its capacity. To secure use for its power, the company has agitated the construction of an electric tram line between Vancouver and Mission, paralleling the Canadian Pacific Railway. It was in connection with the financing of this that Mr. John Hendry sounded the London market when in the Old Country in the spring.

In addition to these operating plants close to the lower mainland market, or rather in it, there is power on the Lillooet River, this side of Stave River, which has often been suggested but as yet undeveloped. There is a magnificent power on the Squamish River, a little over thirty miles from Vancouver, at the head of Howe Sound. Then there is the big power at Powell River, 80 miles up the coast, where the pulp and paper mills of the Powell River Pulp and Paper Company are located. All these are easier of development than the Fraser canyon proposition, though there is no denying the fact that once a dam was built to withstand the turbulent flow of that mighty river at its flood a great amount of power would be available. To secure adequate returns on their money, the company must expect a large increase of population on the lower mainland. In the meantime, the companies already established will not have been inactive. There is no field north or east of the site, proposed, so that what power is placed would have to be utilized in the district lying between Yale and Vancouver. The scheme is no doubt feasible from an engineering point of view, though the construction of a dam to restrain the Fraser will be no easy task. The proposal is certainly ambitious.

THE VALUE OF A CONTINUOUS SETTLING BASIN.*

By Alexander Potter.†

The City of Muskogee, Oklahoma, has under construction a number of improvements to its water supply and sewerage systems. The water improvements consist of an intake tower in the Grand River some 2,000 ft. above its junction with the Arkansas River, a 54-in. concrete-lined intake 2,500 ft. long constructed in rock tunnel under the Arkansas basin, the installation of additional pumping units, a water purification plant, the reinforcement of the water distribution system, and a 6,000,000-gal. equalizing reservoir, consisting of a 50-sided polygon whose walls are built entirely above the ground. That portion of the water purification plant now under construction is sedimentation assisted by coagulation with ferrous sulphate and lime. Provision is made so that ultimately mechanical filters can be introduced if they should be found necessary. In this article the settling basin only will be discussed.

The new settling basin is a reinforced concrete structure, 212 ft. square on the inside. When filled to a depth of 18 ft. this basin holds over 6,000,000 gal. A curtain-wall of reinforced concrete divides the basin into two compartments. The first or smaller of these compartments, 212 ft. long and 52½ ft wide, has its bottom perforated and underdrained. A distributing trough, supported upon the counterforts, extends the entire width of the first compartment. The water enters the first compartment from the distributing trough through a series of 8-in. openings spaced two in each panel formed by the counterforts; the counterforts are on 13 ft. 4 in. centres. A 4-in. concrete baffle or stilling-wall in front of the distributing trough extends the extire length of the basin. The water passes through the first compartment over the curtain-wall into the larger compartment. Balanced valves in the bottom of the curtain-wall equalize the pressure on the wall during filling. A collecting channel of the same size as the distributing channel is located at the far end of the basin. The water enters this collecting channel through a series of 2-ft. weirs located one in each panel. The basin is designed to operate continuously.

Advantages of Continuous Settling.—A settling basin operating continuously possesses a number of advantages over a basin which is operated intermittently. There is first a considerable saving in the size of the settling basin. This saving may amount to as much as 50 per cent. over an intermittent installation in which two basins are used, decreasing, of course, somewhat with the number of basins. When a settling basin is operated continuously, the capacity of the basin, except for the sludge displacement, is always available, which is not the case with the intermittent type. There is no reason why in a properly designed basin the settling efficiency should be impaired by the disturbance at the inlets and outlets.

Removal of Sludge.—At the Muskogee settling basin the sludge from the first or smaller compartment is removed without interfering with the efficient continuous operation of the plant by a system of underdrains in the small compartments. These underdrains consist of 3-in vitrified pipe drains, each perforated with a hole 9/16 in. in diameter. The underdrains are laid with Pioneer asphalt joints, and are arranged in five zones. The collecting channel for each zone is 8 in. deep and 14 in. wide. Each channel is covered with a 24-in. square reinforced concrete slab, perforated with a 9/16-in. hole in the centre.

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* Abstract of paper read before American Waterworks Association at thirty-second annual convention, Louisville, Ky., June 3-8, 1912.

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The sludge valves are 12-in. hydraulically-operated valves of the Rensselaer make. Each valve controls a zone approximately 212 ft. long and 10½ ft. wide. In each zone are 405 perforations, each 9/16 in. in diameter, spaced 2 ft. on centres in rows 27½ in. apart. As the amount of sludge deposit depends principally upon the distance from the distributing trough, the arrangement of the zones is such that the sludge will be fairly uniformly deposited over the area of any one zone.

Operation.—The intervals between openings of the valves and the length of time they remain open at the outlet end of the sludge drains will vary with the condition of the raw water. The precipitated solids should not be allowed to accumulate long enough to pack over the openings. The sludge valve should be closed at once when the discharge, which is visible at all times, begins to show up clear. After the sludge is drawn off there is formed a cone-shaped depression in the deposit at each perforation. Between the perforations some of the sludge is left standing in the form of wedges and pyramids. Assuming a side slope of 45 deg. for the sludge, which is considerably steeper than most sludges stand in water, the amount of sludge that is out of reach of the underdrains in this particular case would cover the bottom, if considered uniformly distributed, to a depth of 6 in. This means a decrease in the capacity of the first compartment of approximately 2.8 per cent.

Great care should be exercised in the design of a system of underdrains such as has been outlined to insure its successful operation. The underdrains and perforations must be designed so as to give the same amount of suction for all of the perforations or holes in any one zone. Otherwise, clean water will be drawn in at those points where the suction is greatest, while sludge is still covering a large part of the opening. Such a condition not only leads to a great waste of water, but results sooner or later in the partial clogging of the perforations, and ultimately in the permanent breakdown of the underdrain system. To be efficient, the water must enter the perforations at as high a velocity as it is practicable to obtain. This means that, especially in a shallow tank, the frictional losses in the underdrains and effluent pipes and the velocity head at the discharge end must be kept down as much as possible. In the average plant the area of each valve should approximate the total area of the perforations tributary to the valves, preferably less, although this proportioning is claimed to be protected by patents. Quick-opening valves should also be used for economy. Ample provision should be made to prevent excessive pressures developing in the effluent pipe from water hammer. Valves 8 in. or smaller can be readily operated by hand; larger valves should be either hydraulically or electrically operated.

This system of sludge removal was installed by the author at McKeesport, Pa., and Georgetown, Ky.

The larger compartment of the settling basin comprises three-quarters of the total capacity of the basin. It has a sloping bottom draining to a sump. A 12-in. cast-iron sludge pipe is carried from this sump to a 24-in. vitrified pipe drain located outside of the basin. It is expected that fully 85 per cent. of the suspended solids will settle out in the first compartment. For this reason it was considered unnecessary to underdrain the larger compartment. Whenever the sludge reaches a depth of several feet or more in the larger compartment the operation of the basin will have to be suspended and the basin cleaned. The turbidity of the river water, however, is normally low, and it is not expected that this will happen more than once in several years.

The cost of constructing the underdrain system for the removal of sludge is not great when compared with the economy resulting in the cost of operation. By removing the sludge daily the capacity of the basin is not impaired as is the case when the deposits are allowed to accumulate. The emptying and cleaning of a basin is a costly operation, especially in winter time, and is to a very great extent avoided even if only a portion of the basin is properly underdrained.

Water Required in Cleaning.—The amount of water that passes off with the sludge in the system just described for Muskogee, it is estimated, will not exceed one-sixth of 1 per cent. of the water treated.

Discussion of Reinforced Concrete.—The basin is being constructed of reinforced concrete. It is possible to construct a monolith of considerable proportions of plain concrete. However, it is but a question of time when the unequal settlement of the foundation, always possible except when the foundation is solid rock, and the shrinkage and temperature stresses set up in the mass, destroy the continuity of the structure. On the other hand, it is possible to construct and maintain as such, a reinforced concrete monolith of very large proportions.

There appears to be some doubt that thin sections of reinforced concrete are suitable for water-tight structures. There need be no fear whatever that there will be any trouble if the work is carried out as it should be. The water-tightness of concrete depends principally upon the amount of cement present, provided the sand and stone or gravel are properly proportioned. Six bags of cement per cubic yard of concrete is ordinarily sufficient to produce a water-tight mixture. This amount, however, should be increased when the hydro-static head is considerable.

The author is opposed to the use of waterproofing ingredients or waterproofing applications. Both increase the cost of the concrete work considerably. It is far better to put the value of the waterproofing materials into the concrete itself by adding more cement. The use of a waterproofing ingredient or application tends to poor construction work, the contractor counting upon the waterproofing to help out careless construction.

The author, from his study and experience in the construction of tanks and reservoirs, has reached the conclusion that leakage may be due to any one of the following causes:

(1) Faulty construction, (a) Lean and porous concrete work. (b) Inexperience and carelessness in carrying out the construction.

(2) Faulty design. (a) Weak details at the connections. (b) Excessive secondary stresses at connections. (c) The use of too high unit stresses in steel and concrete.

Faulty construction can be rectified to some extent, but often only at a considerable cost, by waterproofing the structure from the inside. Leaks developing through faulty design are, on the other hand, always difficult to master, and in many cases very little can be done to remedy the unsatisfactory condition of the completed structure. To guard against the production of lean concrete work, the author's specifications provide that all cement used in the work should be paid for separately.

As 10 ft. of the basin is constructed below the original surface of the ground, it was decided to use counterforts instead of buttresses to save excavation. The counterforts are 15 ins. thick, spaced 13 ft. 4 ins. on centres. The side walls of the basin are 12 ins. thick on the top, widening out to 18 ins. at the bottom. The floor of the basin is 6 ins. thick in the larger compartment, and in the smaller and underdrained one, 9 ins. The basin, including the floor, is constructed and reinforced as a monolith. No expansion joints whatever are provided. There will, however, be an expansion joint between the present basin and future extension.

The author would like to get the opinion of the members on their experience with extensive monolithic construction, both plain and reinforced, especially with reference to the conditions under which such construction has given more or less trouble.

Details of Design of Basin.—The success of a reinforced concrete structure of any magnitude depends primarily upon the thoroughness with which the various structural details, especially the connections, are worked out. The connections should receive the same careful attention that is given them in structural work. The author, therefore, thinks it advisable to dwell as some length upon the design of the structure.

The Muskogee basin is being constructed of gravel concrete. The gravel is washed river gravel obtained from the bed of the Arkansas River. Its size is limited to 1 in. in the side walls and counterforts, and to 2 ins. in the bottom. The sand is a very coarse river sand, obtained from the same river. It is clean, coarse and sharp, and makes a splendid concrete sand. The concrete is being mixed approximately in the proportion of one part of Portland cement, two parts of sand, four parts of gravel. The mixture is changed slightly from time to time to meet slight changes in the quality of the aggregate.

In the design of the structure, the unit stresses were assumed as follows:

fc = The maximum allowable working compression in the concrete in flexure, 650 lbs. per sq. in.

fs = The maximum allowable tension is the steel, 14,000 lbs. per sq. in.

v = The maximum intensity of transverse shear in concrete (assuming a uniform distribution of the shear) 50 lbs. per sq. in.

u = The maximum working adhesion or bond stress between the concrete and deformed bars, 80 lbs. per sq. in.

e = The ratio of the modulus of elasticity of steel to concrete, 12.

These values are conservative. They limit the percentage of the steel to be used in the structure to 0.83 per cent. of the area of the concrete above the steel.

The following equations, with numerical constants, have been developed in accordance with the now universally recognized theory:

$$q = \sqrt{\frac{M}{8.54}} \qquad \text{(Equation 1)}$$

$$As = \frac{M}{1020 \times q} \qquad \text{(Equation 2)}$$

Where q is the distance from the compression side of the beam to the steel, known commonly as the effective depth of the beam; M is the bending moment in foot-pounds per inch width of beam, and As is the area of the steel required.

Equation 1 gives the effective depth of the beam when the bending moment is known and the reinforcement is fixed at 0.83 per cent. of the area of the concrete above the steel.

Equation 2 gives the amount of the steel reinforcement when the bending moment is known and the depth of the beam (q) is fixed. It can only be used when the percentage of steel reinforcement is 0.83 per cent. or less.

Design of Side Walls.—The reinforcement in the side walls and their construction makes them partially continuous. The common theory of flexure as we know it is applicable to this case, but not with the numerical constants familiar to us. The allowance that is usually made in reinforced concrete construction for the increase in strength due to the partial continuity is a reduction of from 25 to 50 per cent. in the bending moment computed on the basis of a simple beam. The exact amount of the increase in strength due to partial continuity can be computed in any one case when all the factors are known. The process, however, is a very tedious one, and entirely unnecessary. A fair assumption as to the allowance can nearly always be made. In this case, on account of the small amount of reinforcement in tension over the counterforts, this reduction has been taken as 25 per cent.

For the design of a tank, equations 1 and 2 can be put in a more convenient form, as follows:

Replacing M by its value $\frac{(w \times X \times L)^2}{10 \times b}$, where w is the weight of the water, $62\frac{1}{2}$ lbs. per cu. ft., X the depth of the water, L the clear span between counterforts, b the width considered, namely 12 ins., we get,

$$q = 0.247L \times \text{square root of } X \qquad \text{(Equation 3)}$$

$$As = \frac{(.00051XL)^2}{q} \qquad \text{(Equation 4)}$$

Equation 3 gives the minimum effective depth of the beam or slab at any depth (X ft.) below the surface of the water. Equation 4 gives the amount of the steel reinforcement required per inch width of beam when the effective depth (q) is fixed. It cannot be used, however, when the percentage of steel reinforcement exceeds 0.83 per cent.

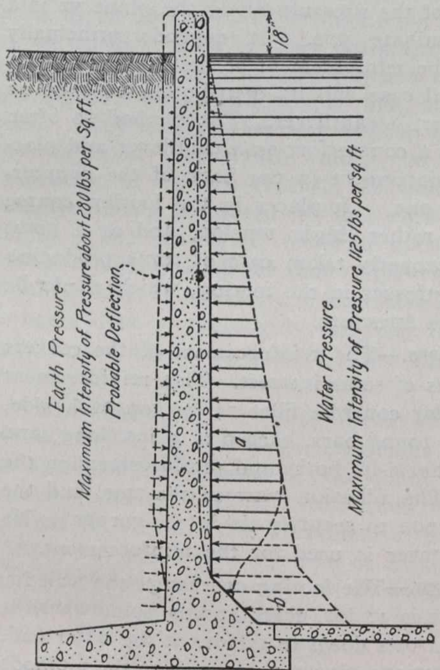

Fig. 1.—Diagram of Forces Acting on the Walls.

Figure 1 shows the forces that are acting on the walls. The water pressure increases from zero at the water surface to a maximum of 1,125 lbs. per square foot at the bottom. Only a portion of this pressure, namely, that portion marked a, is carried by beam action to the counterforts. That portion marked b and shown by the dashed arrows, is carried by cantilever action directly to the footing. The diagram shows that the walls receive their maximum stress as a beam at a point approximately 15 feet below the water level. The minimum thickness of concrete wall that it is possible to use under the conditions assumed is computed as follows from equation 3: Substituting in this equation, we have

$$q = 0.247 \times 12.08 \times \text{square root of } 15 = 11.55 \text{ ins.}$$

Allowing $2\frac{1}{2}$ ins. of concrete to cover the steel, we obtained a minimum thickness of 14 ins. The plans show the thickness of the wall at this depth to be 17 ins. On account of the low cost of the concrete materials and the comparatively high cost of the steel reinforcement, it was deemed more economical to use a heavier section than the minimum that could be used. In places where concrete materials are costly, it would be possible to construct the side walls 8 ins. thick on the top and 15 ins. thick at the bottom.

The amount of steel reinforcement, As, that would be required 15 ft. below the water level can be readily obtained by means of equation 4: $As = \frac{.00051XL^2}{q}$.

Substituting for X, 15 ft; for L, 12.08 ft., and for q, 14.64 ins., we obtain, As = .0763.

The spacing of ¾-in. round rods will be .4418 (the area of a ¾-in. round rod divided by .0763 (the amount of steel required per lineal inch), giving 5.79 ins. as the spacing. The drawing shows the spacing to be 5.5 ins. at this point.

In Fig. 1 is shown graphically by dotted arrows the earth pressure acting against the wall from the outside. It is proposed to back up the walls of the basin on three sides, as shown on the plan. As there is a possibility that this backing may be removed at any time, no allowance whatever has been made for the additional stability given to the tank by this backing.

Attention is called to the connection of the walls of the tank to the bottom. The pressure from within forces the side walls outward, the deflection reaching the maximum half-way between the counterforts. The connection of the walls to the footing must be either a sliding joint to permit of this movement, which is impracticable, or sufficient reinforcement must be provided to prevent the possibility of rupture at this point. Fig. 1 shows diagrammatically, but in a somewhat exaggerated form, the deflection of the side walls at the centre of the span when the reservoir is full of water. The rigid connection spoken of is a concrete fillet 18 ins. on the side, reinforced with ½-in. round bars spaced 12 ins. on centres. This rigid connection transfers by cantilever action some of the hydrostatic pressure against the lower portion of the wall directly to the footing. The amount of this pressure transfer is shown diagrammatically by the dashed arrows in Fig. 1, marked b.

Figure 2 shows all of the forces except the earth pressure, acting on a section of the tank 13 ft. 4 ins. long, including one counterfort and half of the clear span of the walls on either side of it. The total weight of the concrete for this section is 106,150 lbs., with its centre of gravity located 9 ft. from the heel (o) of the footing. The total horizontal water pressure against this part of the tank is 135,000 lbs. and the weight of the water resting on the footing is 150,000 lbs. Let us assume for the present that the sliding of the wall is prevented by the tension in the bottom. This tension amounts to 10,100 lbs. per lineal foot of footing and is shown acting 1.25 ft. above the bottom of the footings. All these forces are shown in their true positions in this figure.

Since the forces shown acting on this portion of the structure are in equilibrium, we have

$$z = \frac{\Sigma M_o}{\Sigma W} \text{ or}$$

$$\begin{aligned} 106{,}150 \times 9 &= +955{,}350 \\ 150{,}000 \times 5 &= +750{,}000 \\ 135{,}000 \times 7.5 &= 1{,}012{,}500 \\ -135{,}000 \times 1.25 &= -168{,}750 \\ \Sigma M &= 2{,}549{,}100 \\ z &= 9.95 \\ \Sigma V &= 256{,}150 \end{aligned}$$

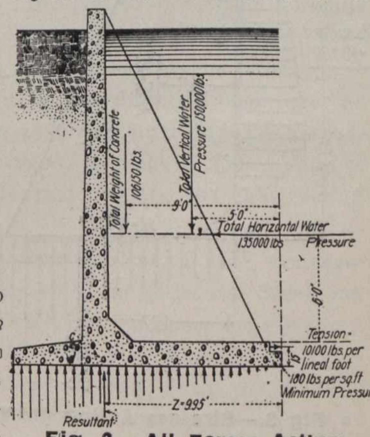

Fig. 2.—All Forces Acting Except Earth Pressure.

This shows that the resultant pressure on the footing, namely, 256,150 lbs., pierces the base 9.95 ft. from the heel, which is practically two-thirds of 15½ ft., the width of the base. Consequently, the distribution of the foundation pressure on the footing is in the form of a triangle, about as shown in the figure. It reaches a maximum pressure of 2,300 lbs. at the toe and nearly zero at the heel. Sufficient steel is provided for in the bottom to take care of a tension of 10,100 lbs. per lineal foot of footing where it joins the 6-in. concrete bottom. This reinforcement consists of ⅜-in. round rods spaced 6 ins. centres. The plan erroneously shows these bars to be placed 12-in. centres. This amount of steel is sufficient to resist this tension at a unit stress well within the elastic limit of these steel bars. The author does not wish to convey the idea that this tension is developed to the extent shown in Fig. 2. A very large proportion of it will be developed by friction between the footing and the supporting earth, and some by the earth backing, which, however, will not be always present.

Design of Counterforts.—Figure 3 shows the forces acting on the counterforts proper. The reaction of the walls, tension in this case, amounts to 93,500 lbs., and its distribution is about as shown in the figure. It reaches its maximum 15 ft. below the water level. This tension is taken care of by thirty-two ½-in. round bars at an average unit stress of 14,900 lbs. This is not a very high value. In the discussion we have ignored the additional stability received from the earth pressure, and also the tensile strength of the concrete in the counterforts, which may be considerable.

The greatest of care must be taken to anchor the walls to the counterforts. In this case, this has been done by threading the ends of the ½-in. tension bars and fastening them with double nuts to two 2½-in. by ⅜-in. plates, 18 ft. long, embedded in the walls, as shown in the reinforcing plan. The object of the double nut is to prevent the possibility of play at the joint.

A study of this figure shows that the counterfort is not a cantilever at all. In a cantilever, the internal resisting forces acting on the plane yz, must balance algebraically, that is, the total tension must be equal to the total compression. This is not the case in the counterfort, as can be readily seen. The forces that act on the counterfort are as follows:

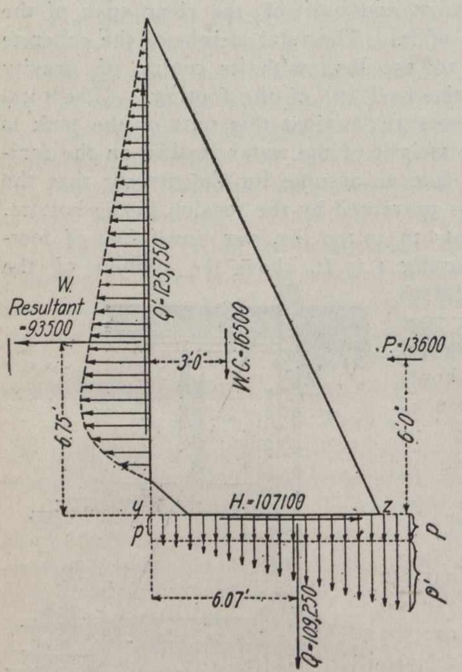

Fig 3.—Stresses Acting on the Counterfort Proper.

W, the tension exerted by the walls on the counterfort, 93,500 lbs.

P, the horizontal pressure of the water acting against the counterfort proper, 13,600 lbs.

W^c, the weight of the counterfort proper, 16.500 lbs.

Q, the total tension between the footing and the counterfort along the plane yz, 109,250 lbs., shown acting 6.07 ft. from the point y.

Q^1, the shear between the counterfort and the wall of the basin, 109,250 lbs. plus 16,500 lbs.

H, the horizontal shear acting along the plane yz, 107,100 lbs.

The determination of the amount of the pressure Q and its distribution with reference to the plane yz, is a very interesting one, and is for this reason given in detail. Taking moments about a point, y, we obtain the following equation:

$$93,500 \times 6.75 + 13,600 \times 6 - 16,500 \times 3 - p \times 10 \times 5 - \frac{p^1}{2} \times 10 \times \tfrac{2}{3} \text{ of } 10 = 0.$$

In this equation, there are two unknown quantities, p and p^1. A safe assumption to make, since there is no tension at the heel (c) is that $p + p^1$ cannot exceed the sum of the weight of the water above the footing and the weight of the concrete itself. This amounts to 1,350 lbs. per square foot of footing, thus giving the additional equation

$$p + p^1 = 1350 \times 13.33$$

From these two equations we obtain

$$p = 3,850 \text{ lbs. and}$$
$$p^1 = 14,150 \text{ lbs.}$$

The total resultant tension Q, and its location, can now be readily found, and is given in the figure as 109,250 acting 6.07 ft. from y.

This tension of 109,250 lbs. is taken care of by sixteen ⅞-in. round bars at an average unit stress of 11,350 lbs. The maximum stress in these bars probably reaches 14,000 lbs. per square inch. The bars are anchored in the concrete footing by two 2½-in. by ⅜-in. plates 8 ft. 6 ins. long, to which they are fastened by double nuts.

The distribution of the pressure along the plane yz is a more or less indeterminate one. It depends principally upon the shape and the reinforcement of the footing course. Only in a very special case will its distribution be such as to make the counterfort a cantilever. The method so often followed of designing a counterfort as a cantilever and placing all the steel reinforcement in the back of the counterfort, is an erroneous one. It places in the footing course a concentrated and rather high tension, and at a point where it cannot be properly taken care of, thus producing enormous secondary stresses in the footing, which would be a serious defect in the structure.

Design of Corners.—The reinforcement of the corners of the settling basin is of some interest. This reinforcement consists of a triangular concrete fillet 24 ins. on each side, reinforced with ⅜-in. round bars, each 6 ft. 3 ins. long, and spaced the same as the ¾-in. horizontal reinforcement in the walls of the basin. The adhesion between the steel and the concrete is counted upon to securely tie in the corner. No rigid connection whatever is used for the reinforcement.

Design of Footings.—The footing overhangs the wall for a distance of 4 ft. It is 18 ins. thick at this point where it joins the wall and narrows down to 12 ins. at the outer end. The following computations give some idea as to the methods used in designing this footing.

The upward pressure on the overhanging portion ranges from 2,300 lbs. per square foot to 1,750 lbs. per square foot. The thickness of the footing at c-d, Fig. 2, should be sufficient to keep the shearing stress down to a safe working value. The total upward pressure per lineal foot of footing course, amounts to 8,100 lbs. This gives an average value for the shear of 37.5 lbs. per square inch—a very safe value. Equation 2 can be used to compute the amount of steel required, as follows:

$$As = \frac{M}{1020 \times q}$$

where M represents the bending moment in foot-pounds per lineal inch of footing at the plane c-d, which amounts to 1,410 foot-pounds.

q is 18 ins. minus 3 ins.

Substituting in this equation, we obtain for As, 0.0922 sq. ins. This amount of steel requires a spacing of 4.80 ins. for ¾-in. round bars. A spacing of 6 ins. is shown on the plans. This spacing used is considered ample, as the computations just outlined do not take into consideration the weight of the overhanging footing nor the weight of the earth backing.

The above general outline of the methods used in designing the settling basin conveys some idea of the thoroughness and carefulness with which a structure of this type must be designed.

Horizontal construction joints are used freely. The unfinished surface is always left in as rough a condition as possible, but never roughened up after the concrete has partially set. The author has found that this roughening often loosens the stone in the concrete, but not sufficiently so that they can be removed, a condition which is apt to impair the water-tightness of the structure. To start a day's work, the surface is thoroughly cleaned with wire brushes and water, and a cement liquid mortar mixed in the same proportions as the mortar in the concrete, is poured over the old work to a depth of ½ in. This method always gives a good water-tight horizontal construction joint.

Vertical joints are permitted only in certain places, as these joints are very difficult to make water-tight. All vertical joints in the walls are made directly over the counterforts.

The specifications call for two coats of neat cement wash to be applied with a white-wash brush on the inside of the basin. Both of these coats are to be applied to the concrete when damp but not wet, and the second coat must be applied before the first one has had time to get very hard. Any leakage that may develop in the basin previous to its final acceptance must be repaired by the contractor, at his own expense, no additional compensation whatever being permitted for this work under the specifications. The contractor, realizing the importance of doing conscientious work all the time to prevent subsequent trouble from leakage, is producing a first-class structure. The work is beind done so thoroughly that very little leakage, if any, is expected when the basin is filled for the first time this summer.

The contract for the construction of the basin was let to W. W. Fuller, of Muskogee, Oklahoma. The following is an approximate estimate of the quantities of material required, together with the contract unit prices:

18,000 cu. yds. of earth excavation at $0.40	$ 7,200.00
1,930 cu. yds. 1:2:4 concrete at $6.25	12,062.50
820 cu. yds. 1:3:6 concrete at $5.40	4,428.00
4,000 bbls. of cement at $1.40	5,600.00
220,000 lbs. of steel at $0.035	7,700.00
3,520 ft. 3-in. vitrified sewer pipe at $0.20	704.00
800 ft. 6-in. vitrified sewer pipe at $0.20	160.00
220 ft. 24-in. vitrified sewer pipe at $3.50	770.00
1 manhole complete	50.00
160 ft. 12-in. cast iron pipe at $2.25	360.00
40 ft. 18-in. cast iron pipe at $4.00	160.00
380 ft. 36-in. cast iron pipe at $8.00	3,040.00
28,000 lbs. cast iron specials at $0.05	1,400.00
5 12-in. gate valves at $10.00	150.00
6 18-in. press. equalizing valves at $12.00	72.00
1 24-in. tidal valve at $18.00	18.00
485 ft. 1½-in. pipe railing at $0.60	291.00
Superstructure for valve chamber	500.00
1,000 lbs. wrought iron and steel at $0.05	50,00
300 ft. ¾-in. galv. w. i. pipe at $0.30	90.00
Total	$44,805.50

The imports of iron and steel from the United States for the fiscal year ended March 31st, 1912, totalled $36,382,725, as against $29,307,039 for the previous year. This total does not include machinery, agricultural implements, nor many other articles properly classified as iron and steel. The gain in imports from the United States the last fiscal year in the above items of iron and steel was $7,075,686, or more than 27 per cent.

SOME NOTES ON BAND CONVEYORS.

By F. Tissington.

This is the first of a series of articles by Mr. Tissington on Band Conveyors.—Editor.

At the present time band conveyors are used for conveying all kinds of material, and they can be found scattered all round the world generally fulfilling their duty comparatively with little cost for maintenance providing the original designing of their various parts has been carefully considered to suit their requirements.

The following is a list of a few of the uses to which they have been put and this is only given to show their adaptability.

In collieries, docks, store yards, storage bins, etc., for transportation of coal from one point to another, also for the purpose of cleaning and sorting same into various grades.

In gasworks for charging retorts, conveying coke and other substances.

Also for the conveyance of all kinds of earth, clay, rock, ore, sand, gravel, cement, plaster, paper and pulp.

They are also used for transporting sugar, wet charcoal, grain of all descriptions, postal packets and letters, and even invade our workshops to handle small repetition parts collecting same from the machines and delivering them to the store or any other point desired.

There are, of course, dozens of other purposes for which they are or can be utilized, and if any manufacturer has a conveying problem of any kind that involves any quantity of hand labor he would do well to consider the idea of installing either a band conveyor or a mechanical conveyor of some other type, because of all costs in the process of manufacture, generally speaking, that of hand labor is the highest, and a machine, unlike the ordinary human being, does not require to stop for a time every now and again to rest a while. A little oil and a small amount of adjustment occasionally being sufficient.

Its adaptability is again emphasized by the fact that it will not only run horizontally in one direction but may be made to reverse the direction with very little additional gear. Also it may be inclined to almost any angle, depending, of course upon the nature of the material and the construction of its top surface.

For instance, the writer has known of one conveyor working at about forty degrees with the horizontal conveying flat packages, the only addition to the ordinary type being a number of wooden slats bolted on to the working surface of the belt to prevent the packages sliding down the incline. Going further still, we find the band conveyor turned into an elevator with buckets attached to the band and working vertically.

The construction of these belts is very simple, consisting only of two terminals, generally one being the driving end and the other the tension end, the supporting rollers for the carrying and return sides, the belt itself, and the framing to carry the gearing and rollers.

Sometimes, however, the gearing may be placed with advantage in the middle of the belt owing perhaps to this position being near the source of power for driving same, but this is by no means usual. If this is done, it is generally necessary to arrange the driving drum on the bottom or return strand.

Further, it is practicable to arrange the driving gear at either the loading or delivery end, but where possible it is an advantage to place it at the delivery end especially in long conveyors.

The tension gear may be either of an adjustable screw design or an ordinary weighted tension, and this, like the driving gear, may be placed almost anywhere taking into account, of course, local conditions and the general disposition of the plant. It is preferable in the case of long conveyors to use a weighted tension as there is a certain amount of lengthening and shortening of the fabric of the belt due to atmospheric conditions, and this alteration in the case of a long belt would necessitate constantly adjusting the tension gear if it was of the screw type, whereas with the simple weighted tension this arrangement automatically makes its own adjustment. The weighted tension gear has also another advantage and that is, it is impossible for the attendant to overstress the fabric which could be done with the other type.

The supporting rollers, idlers, as they are usually called, are made in various designs according to the fancy of the manufacturer or purchaser, but, generally speaking, they consist of a roller, or series of rollers, mounted on a spindle caried in bearings having grease lubrication. If a troughed top strand is required, each set of rollers is then generally made up of a series of small ones, some being set at the necessary angle to form the top strand into the trough shape. This type is much to be preferred to the conical roller all in one piece as the full width of the band is travelling at the same speed all across its surface. But on the roller either the outer edge of the cone is travelling faster or the smaller diameter is not running as fast as the band, and this sets up quite a considerable amount of friction liable to wear the band out very rapidly. The return strand is always carried on flat rollers similar in construction to the top rollers.

Some firms make a practice of putting in guide rollers. These are set at right angles to the edge of the belt and are intended to keep the band running true on the rollers. These are generally omitted on belts of short length and a common practice is to place a pair (one on each side of the belt) about every sixty feet. It is claimed that these are necessary owing to the belt having a tendency to run up the inclined rollers forming the trough in a similar manner that an ordinary driving belt keeps in the centre of a crowned face pulley.

Another method adopted to keep the belt in line is to set the top idle rollers at a very slight angle with a line drawn at right angles to the length of the band, that is, one would be set slightly out of line one way and the next the opposite way.

The conveying bands are manufactured in a number of different ways and consist of woven cotton, canvas or duck, either plain or impregnated with some kind of waterproofing material such as Salata, tar, or rubber coating. For most purposes, however, a rubber impregnated belt with an additional rubber covering will give the best results, as this method is more likely to produce a belt impervious to water. If the belt is being continually exposed to the action of rain it will soon rot away. Further, the rubber covering is a factor in preventing an undue lengthening and shortening of the belt due to the dryness or humidity of the atmosphere. Generally it may be said that the life of the rubber covering is somewhere about half the life of the belt as a whole even though the rubber may only be about one quarter of the thickness of the rest of the belt.

Another point that is also in favor of the rubber covering is the resistane this has to the abrasive action of the material carried, and its effect is to act as a cushion for the material to fall upon.

The writer has known of a case where an ordinary cotton belt used as a picking conveyor for coal at a colliery only lasted about seven or eight months, and the expense of renewing it so often made the maintenance cost very high, but rubber faced belts used for similar purposes will last you two, three and perhaps four years if they are properly handled.

There seems to be quite a difference of opinion as to the desirability of making the belt of even plies right across its width, or of reducing the plies in the centre of the belt and thickening the rubber facing.

The general practice in this country seems, however, to lean towards the even ply belt, whereas in England the reverse is the case.

The writer's opinion inclines towards the uneven ply belt with an additional thickening of rubber in the centre where all the abrasive action takes place, because as soon as this protective covering is destroyed the final destruction of the belt is soon brought about. It is a good plan to overhaul the belt periodically and repair any bad cuts with a good stiff rubber solution; also where any sand or grit slobs have been made under the surface they should be taken out and the cut repaired in a similar manner.

If this is done it will be found that the life of the belt will be much longer and will repay the expense incurred. The rubber coating varies from about one-sixteenth to a quarter of an inch, and the ples of the canvas or duck vary from about three to seven or eight according to the kind of material to be conveyed, the width and the length of the belt.

If material of a sticky or wet nature is being conveyed it is a wise plan to arrange a brush under the delivery shoot to clean the face of the belt, otherwise rapid wear is liable to take place owing to the gritty matter being carried round on the underside and thereby come into contact with the snub or gripping rollers and the bottom guide rollers. Further, this grit is likely to get into the bearings of the rollers and cause trouble with these also.

Another good point in an installation of this kind is to avoid all sharp reverse bends of the belt as far as possible, although sometimes this is not altogether practicable. The framing for these conveyors is generally of a very simple character simply consisting of cross supports for the rollers carried on longitudinal stringers of iron or steel. The latter are usually made to suit the general layout of the rest of the structure.

When starting to design a plant it is necessary to know the kind, quantity, general size of the material required to be handled, the magnitude of the largest pieces; whether the material is of a sticky or wet nature. The general layout of the surrounding structures. The points at which the material will be loaded on the band and also where it is required to be delivered, and the relative elevations of these two points, if they are not at the same height. Also whether it is proposed to drive by electric motor, steam engine, or from an existing shaft, and if the latter is the case, the size, speed and direction of rotation should be given and the position of same should be shown on a small sketch in relation to the rest of the other particulars required as to the location of the belt and the surrounding plant. With this information it will be possible for the designing engineer to submit a scheme suitable for the purpose required.

Having now got a general idea of the uses of belt conveyor installation with some of its general features, it is proposed to discuss a few of the smaller parts and then give some data on the capacities, horse-power required to drive same, etc.

THIRTY YEARS' PROGRESS IN THE ELECTRIC FURNACE.*

By F. A. J. Fitzgerald.

There has been so much written about the electric furnace since it entered into regular commercial use about 20 years ago that the presentation of a paper on the subject treating it in a general way is not apt to be interesting. But a promise to attempt the preparation of such a paper having been given, it was thought that there might be some interest attaching to a review of the development of some furnaces during the past 30 years. Moreover, it is often useful to look back over ground that has been covered in order to obtain suggestions as to the best direction to be taken in attempting further advances.

It is now 30 years since Sir William Siemens melted about 20 pounds of steel, as well as platinum in notable quantities in an electric furnace with which he had been experimenting since 1878, and since then the electric furnace has so far developed that there are great numbers, both in Europe and this country regularly engaged in the commercial manufacture of steel. While it is true that others had made some use of electrothermic methods at a much earlier day, for example Despretz, whose source of current was 600 Bunsen cells, yet Siemens' furnace must be considered the first really practical one, coming as it did after the invention of a cheap source of energy—the electric generator.

Siemens' work is of particular interest because he saw the possibility of using the electric furnace for steel manufacture, and, so far as the principles are concerned, they are the same as those in actual commercial use to-day. One of his furnaces was made of a graphite or other refractory crucible enclosed in a jacket of heat insulating material. Inserted in the bottom of the crucible was an electrode of iron, platinum or carbon, while passing through the cover of the crucible was another electrode. The latter was connected to automatic regulating device consisting of a solenoid, this serving to vary the length of the arc and thus keep the rate of generation of energy constant. In working the furnace the steel or other metal was introduced into the crucible and made contact with the lower electrode, while an arc was drawn between the upper electrode and the charge. In such a furnace Siemens melted steel in quantities of more than 20 pounds.

In another form of electric furnace devised by Siemens, the electrodes entered the crucible in a horizontal direction near the top and opposite one another so that an arc was formed between them and heated the charge below by radiation.

Siemens' work must be considered as the forerunner of at least two well-known kinds of electric steel furnaces which are in existence to-day in actual comercial use for the manufacture of steel, although he never was able to do commercial work with his apparatus because electrical engineering was not sufficiently advanced.

The growth of the Siemens' electric furnace for steel making was at first slow for numerous practical difficulties in its working had to be overcome, but so many of these have at last been met successfully by men like Heroult Girod, Stassano and others who have modified the apparatus in various ways, that now we have furnaces like those of the Steel Corporation in Chicago and Worcester working on charges of 15 tons of steel.

Siemens in his furnace used direct current and laid particular stress on the point that the charge should be connected to the positive side of the circuit, since it is well known that in the electric arc it is at the positive electrode the main generation of heat occurs. In the modern furnaces, however, alternating currents are used for obvious reasons, and the surface of the molten bath is covered with a layer of slag which becomes intensely heated, not only by the arc but by the current which it carries. In this way ideal conditions are obtained for refining the metal as the steel and the molten slag between which chemical reaction is desired are intensely heated at their surfaces of contact. Moreover, the slag effectually prevents the introduction of carbon from the electrodes into the metal. The problem of regulating the electrodes automatically has also been successfully worked out by means of the well known Thury regulator, though it would seem that this could be simplified.

There were, of course, a large number of metallurgical problems to be worked out in connection with the steel furnace, but these have apparently been met successfully, and we finally have the electric furnace working alone commercially, or what is perhaps more generally important, acting as an auxiliary to fuel heated furnaces. The most serious problems connected with furnaces of this type at the present time are those relating to electrodes and roofs. Some years ago when the electric furnace was working on a much smaller scale than is demanded to-day, the strongest argument advanced against it was that the cost of heating by means of an electric current must of necessity be so excesive that the idea was impracticable. That, however, is criticism seldom heard to-day for it has been found that in actual practice the furnace can be so used that the question of cost of electrical energy is by no means of the first importance. On the other hand, little used to be said about electrode cost, but now that is a most vital question and is apt to enter into the total cost of working as a much larger item than power.

The manufacture of large carbon electrodes, say 20-in. (50.8 cm.) square and from 7 to 10-ft. (2.3 to 3.04 m.) long, is by no means easy, and even when they are successfully made in the electrode factory they may go to pieces in the furnace. Even if they do not break there is the problem of "butts." Suppose a large electric steel furnace with the roof three ft (0.91 m.) away from the bath, then it is safe to say that when the electrode holder is lowered down and comes in contact with the roof of the furnace, that there will be a carbon "butt" about four ft. long (1.22 m.) which must go in the scrap pile. Apparently this serious difficulty is going to be overcome by electrodes which can be fastened end to end so that they may be continuously fed into the furnace, and thus there will be no waste from "butts." Within the last few months there has been a good deal of work done in this direction and the results are very promising. The electrodes are made with a circular cross-section instead of square and have threaded sockets in the ends so that by means of threaded plugs the electrodes may be fastened together and thus fed continuously into the furnace without any waste.

This, as has been said, is promising, but has the limit of the electric steel furnace been reached as regards size? Except as regards electrodes there is no reason to believe that it has, but the 15-ton furnaces working now, need electrodes about 20 in (50.8 cm.) in diameter, and if the size is doubled and the general design is kept the same,

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electrodes 27 or 28 in (68.5 or 71.1 cm.) in diameter will be required. Perhaps these can be made and can be used continuously as described above, but the writer believes that development in this direction is a mistake, and that far better results can be obtained by multiplying the number of electrodes and keeping the size within reasonable limits. This is not merely a question of avoiding the difficulties of large electrode manufacture, but involves more efficient and satisfactory working of the furnace. It will readily be seen that distribution of temperature in the furnace is bound to be better as we multiply the relatively small areas where the heat is generated, and this is an important consideration. The objection that is raised to this proposal is the difficulty of regulating the rate of generation of energy at the various electrodes. It does not seem that this difficulty is a real one.

The roof problem is altogether a different one. It must be remembered that the heating effect in the steel furnace is generated in an arc and in a resistor formed by the slag, and that consequently the surface of the slag is intensely hot, particularly where the arc strikes it. These conditions are very severe and combined with the corrosive action of the lime which is vaporized from the slag, make the roof renewals a heavy item in the cost of electric steel.

This problem has recently been the subject of careful study in two research laboratories, with one of which the writer is connected. As a result of a great deal of experimental work a brick made of silicon carbide has been manufactured which it is believed will have a much longer life in the steel furnace than the silica brick now used. The brick is made by taking powdered or granular silicon carbide, mixing it with a suitable temporary binder, such as a solution of dextrine, molding and then heating in an electric furnace to the temperature at which silicon carbide is formed. Bricks made in this way have been used in the roof of an experimental steel furnace in one of these laboratories and then put to the severest test possible. The bottom of the furnace was purposely raised well above the normal level so as to bring the surface of the slag as close to the roof as possible, the actual distance in some experiments being only 10 in. (25.4 cm.) Then the furnace was worked at double the normal rate of generation of energy so that the heating of the roof was very intense, so much so that an ordinary silica roof would melt down rapidly and be completely destroyed in a single heat. Even under these very severe conditions the silicon carbide roof stood up perfectly. Experiments have also been made in other steel furnaces and these results confirmed. The most serious objection to a roof of this kind is its relatively great cost, but if it lasts a sufficiently long time it is nevertheless economical.

Twenty-five years ago Ferranti in England and Colby in this country worked on the very interesting furnaces known as the induction type. In this the secondary of a transformer consists of the metal to be melted. As in the case of the Siemens furnace the original inventors were too far ahead of the times and it was not till 10 or more years later that any commercial application of the furnaces was made. Since then the induction furnace has developed considerably and is now used with success in the manufacture of steel. An objection to the induction type is that its first cost is very great and certain problems connected with it become very serious when it is desired to build furnaces of large capacity.. The worst of these is the very low power factor of the furnace. To overcome this objection it is necessary with large furnaces to have a generator furnishing currents of excessively low frequency. Thus, at the Völklingen steel works a generator giving a current of 15 cycles is used, and for larger furnaces it has been proposed to use a five-cycle current. In an experimental induction furnace plant built by the writer's laboratories for an electric furnace company at Niagara Falls, the low power factor was corrected by using a synchronous motor as a condenser.

Nearly thirty years ago the Cowles brothers were working with the electric furnace in attempts to heat the charge of zinc retorts by electrical means. The principle involved in this case was mixing with the ore to be reduced a certain amount of carbon which not only acted as a reducing agent, but made the charge as a whole a conductor of the current. This furnace may be considered the forerunner of an immense number of electric furnaces in operation to-day, furnaces for making calcium carbide, the ferro alloys, iron ore smelting, graphitizing, etc. The Cowles furnace was a small one, but since its day the development of the electric furnace helped by the corresponding development of electrical apparatus has led to the construction of units of continually increasing size. To follow up the development of these furnaces would certainly trangress the limits of this paper, and instead, the development of a somewhat different type will be considered because the writer has been more intimately associated with it, and because it contains points which are, perhaps, of more particular interest to the electrical engineer.

In Acheson's first experiments which led him to the discovery of silicon carbide (carborundum) he used a furnace of the Cowles type. It consisted of a small brick box with carbon terminals at each end so arranged that they could be moved in and out in a horizontal direction. This box was then filled with the mixture of sand and coke (clay and coke in the earlier experiments) and the terminals brought together, or very close to each other, and then gadually withdawn as the furnace heated. It was soon observed that a more satisfactory way of constructing the furnace was to have stationary terminals connected to each other by means of a resistor composed of granular carbon and then surround this with the charge. With such an arrangement it was necessary to have some means by which the voltage could be regulated so as to keep the rate of generation of energy in the resistor constant throughout the run. This was found by Acheson to be a much more satisfactory way of working the silicon carbide furnace, and by experiment he found the best dimensions for his resistor. In the original small plant, where the furnaces had a capacity of about 100 kilowatts, the generator supplied current to a great bank of small transformers so that variations in the voltage could be obtained by suitable connections of the secondaries. When, however, a plant was established at Niagara Falls using furnaces of 750 kilowatts, the problem of varying the voltage at the furnace terminals became important. This was solved by the construction of a large induction regulator to be used in the secondary circuit of the transformer which stepped down the primary current of 2200 volts to 160 volts. The induction regulator then made it possible to vary the e.m.f. by 60 volts on either side of this, so that at the furnace terminals the total range was from 100 to 220 volts. For furnaces of this resistant type the induction regulator is an ideal apparatus, and it is to be regretted that it is not more generally used. The objection raised to it is usually its relatively high cost, but the convenience and simplicity of the apparatus far more than compensate for the extra cost. In working with a furnace having a carbon resistor the resistance when starting is high and, consequently, to save time it is necessary to start the furnace with a high voltage. When the resistor becomes hot its resistance progressively decreases and the voltage must then be decreased to keep the rate of generation of energy constant. If this is done in a series of steps the results are not satisfactory, for when the maximum kilowatts are reached and the voltage is lowered one step the kilowatts are decreased proportionally, and in large furnaces it is a long time before the resistance drops to the point where the desired rate of generation of energy is again reached. This is a most inefficient method of working and the consequent loss will more than pay the interest on the cost of suitable apparatus for regulating the voltage.

Even at the time when these much larger furnaces were built the theoretical conditions involved in their construction were not understood, nor indeed for long afterwards. Thus, when the Niagara furnaces were first built the dimensions of the resistors were found to be altogether wrong, and about that time, when the writer took charge of the furnace department, experiments were tried with flat resistors, though an appreciation of the theoretical conditions of the problem shows at once that, other things equal, the resistor of circular cross-section must be best.

In any furnace in which the charge surrounds a resistor heated by means of an electric current it is obvious that the important consideration is the rate of generation of energy per unit surface of the resistor. The surrounding charge, or whatever it is desired to treat, can at a definite temperature absorb heat at a definite rate. Therefore, if it is desired to preserve the charge at a definite temperature it is necessary to generate the heat only so fast as the charge will absorb it. In other words, it is necessary that the watts should be a certain definite amount per unit surface of the resistor. The knowledge of the absolute value of the temperatures in such furnaces as those used in making silicon carbide is very scant, although some excellent work is now being done on this subject; but from the data obtained experimentally and the theoretical considerations of the working of such furnaces, it is possible to calculate relative temperatures with considerable accuracy.

This was well illustrated in the experimental work done by the writer in the difficult problem of making what Acheson called "siloxicon." This substance is formed by the reduction or partial reduction of silica and is combined in some way with carbon. The great difficulty in making the material is due to the fact that at a temperature very slightly above that at which the reduction of silica by carbon begins the process goes too far and the well known crystalline silicon carbide is formed. In order to calculate the dimensions of a resistor suitable for making the material the only data available were those which could be obtained from a study of conditions in the silicon carbide furnace. Without going into details it is sufficient to say that working in this way a furnace was soon designed which made large quantities of "siloxicon" without the formation of any serious quantity of crystalline silicon carbide.

The object in devoting so much consideration to this subject is because it illustrates in a marked manner the comparative ease with which electric furnaces can be adjusted to delicate temperature conditions. This is, of course, well known as regards small laboratory furnaces, but what we are considering now is a furnace about 30-ft. (9 m.) long, 12-ft. (3.6 m.) wide and 6-ft. (1.8 m.) high, having a capacity for a charge of about 60 tons.

The greatest progress in the electric furnace since Siemens' time has been in the arc furnaces of the kinds he used; in the induction furnaces of Ferranti and Colby; and in the resistance furnace of the Cowles type; but so far as the furnace depending on the use of a heating resistor, other than the charge, is concerned there has not been any great advance as regards apparatus of large capacity. The explanation of this is found in the structural difficulties involved. It is believed, however, that those can be overcome, and, moreover, that it is well worth while spending considerable effort in this direction. In the laboratories with which the writer is connected much time has been devoted to a study of this type of furnace, and more or less successful furnaces worked out. This kind of furnace for example lends itself very readily to a form of apparatus which is bound to be developed sooner or later where the heating is accomplished by means of fuel as well as the electric current. This has been done with success in furnaces on a large scale where the preliminary heating is carried on by means of fuel until a temperature is reached where it becomes economical to use the electric current to get the higher temperatures desired. Moreover, in such furnaces we may usefully employ nearly all of the electric current by jacketing with burning gases which eliminates nearly all radiation from the interior of the furnace by supplying the inevitable heat losses from fuel rather than electricity.

The question of the loss of heat through the walls of electric furnaces is a matter that is now attracting a great deal of attention for its importance is very great. The writer has recently had occasion to give this matter careful consideration owing to the inefficient working of an electric furnace designed for some special smelting work. The testing of this furnace showed that the heat losses amounted to 50 per cent. but merely covering 25 per cent. of the outer surface of the furnace with a moderately good heat insulator reduced this loss nearly 20 per cent.

Before closing the remarks on this type of furnace it may be of interest to note some experiments recently carried out with an electric kiln at the writer's laboratories. The kiln is the invention of Mr. John L. Harper and is of the continuous channel type. Two long channels run parallel to each other and through each of these passes a train of trucks in opposite directions. The centre part of the kiln is heated electrically. With this arrangement, the trucks with their contents passing from the high temperature part of the kiln, give up their heat to the trucks going to the high temperature part. Theoretically with an arrangement of this sort all that is required of the electric energy is to supply the heat losses from the kiln. Various experimental furnaces of this kind have been built, the chief object in view being a study of the structural features of the kiln, such as the best form of resistor, refractory linings, etc., also tests of the control of temperature maximum temperature available, control of atmosphere, heat insulation, etc. The kiln was used for various purposes, but the prinicpal experiments were made on porcelain with the production of "biscuit" and glazed ware. The control of temperature was found to be very good and the kiln was extremely simple to work, requiring very little attention.

It is not pretended that in this paper the subject of the development of the electric furnace has been more than superficially treated, the attempt being simply to take a few examples which would illustrate how the electric furnace has developed and indicate some of the problems involved in its construction and working to-day. This, naturally, confined the subject to a certain extent to matters within the writer's own experience; but it is hoped that this may prove somewhat more interesting than a mere catalogue of modern furnaces compiled from the literature on the subject.

CULTURE IN THE EDUCATION OF ENGINEERS.*

By William L. Saunders.

At one of the meetings of the American Institue of Mining Engineers, held in the hall of the Sheffield Scientific School at New Haven, a discussion arose as to whether or not sufficient importance was given to cultural studies in our scientific schools. A diagram was exhibited showing graphically the relative proportion that culture bore to other studies in the various colleges. In some there was a wide distribution of cultural work, in others the proportion was small, and in a few cases it was shown that these studies were entirely omitted in the curriculum. During recess a group of students were discussing the subject; one of them, a senior, said, "I don't see why they should learn a person culture in a scientific school." This remark, made in my presence, so impressed me as a concrete example of neglect in true educational lines that it has been chosen as a text for what is to follow.

Education in its broadest sense is mental and moral training. High schools and colleges differ from common schools in that they aim at higher planes of mental and moral life. The small boy is taught by stuffing, as one puts sawdust in a doll; this is because his mind has not grown to the stage when it can think for itself. Impressions are received and transfixed by memory; the process is one of mental photography; the moral code is learned by rote as though it were the multiplication table. Not so with the older, the college student; his highest aim in education is to learn to think for himself. "If you are a student force yourself to think independently; if a teacher compel your youth to express their own minds," writes Dr. Osborn of Columbia; and again, "The lesson of Huxley's life and the result of my own experience is that productive thinking is the chief means as well as the chief end of education.

Now what is productive thinking? Let me answer this question by giving you Huxley's definition of culture: "The pursuit of any art or science with the view of its improvement." The storage process is of paramount importance only when applied to elemetary education. It is but the auxiliary of the scholar who has passed from the junior to the senior stage of student life, and who aims to do things in the world. The pursuit of facts is a mathematical study. We learn of things that exist as a result of divine and human creation. The earth is round and it is composed of land and water. Water is hydrogen and oxygen combined. The square of the hypotenuse of a right angle triangle is equal to the sum of the square of the other two sides. How elementary are these facts! It is important that we should know them; but even a large volume of facts when stored in the human mind is powerless to add one cubit to progress. It is like putting a pair of legs on the Encyclopedia Britannica and expecting it to do something. Knowledge is power, but reason is power in action.

Dr. James Gayley, of the United States Steel Corporation, told me recently that the professor at Lafayette College who taught him how to think made so deep an impression upon him that it has lasted throughout his life. Mr. Gayley is distinguished for what he has done as a metallurgical engineer. His life has been one of productive thinking; he has pursued science with the view of its improvement. That teacher, Mr. Gayley said, once gave him a solution containing iron, and instead of instructing him how to best precipitate the metal he told him to try three or four ways of doing it and report which was best. This led directly to thought and resason and built up a master mind among engineers. We may still heed the voice of old Carlyle crying from the heathery hills of Dunscore; "Produce! Produce! Were it but the pitifullest infinitesimal fraction of a product, produce in God's name! 'Tis the utmost thou hast in thee; out with it then."

Where among all the professions do we get the results that come through productive thinking as from engineering? The engineer is the architect of the world's progress. Transportation in railways and ships, in motor cars and aeroplanes, is the productive thinking of mechanical engineers woven into our industrial life. The men who did these things were students of science, not that they might be mere storehouses of knowledge, but that they might produce. Civil, electrical, chemical and mining engineers are fields which afford infinite opportunities for research and progress. If you men of the future do not rise to your chance in these lines it is not because the fields are not still open for cutivation and growth, but rather through your own inefficiency or perhaps your top-heaviness.

"In vain our toil,
We ought to blame the culture, not the soil."

Even Huxley feared that men might be over-fed scientifically when he said: "An exclusively scientific training will bring about a mental twist as surely as an exclusively literary training. The value of the cargo does not compensate for a ship's being out of trim; and I should be very sorry to think that a scientific college would turn out none but lop-sided men."

All this bears upon culture in its broadest sense. Productive thinking is the most important form of culture. It makes for power, refinement, progress, knowledge, taste, civilization. The subject, you see, is a very broad one; the obligation upon you as students of science is equally broad. Take care that you be not "lop-sided men." A graduate of the Colorado School of Mines, like all graduates of the higher institutions of learning, misses his opportunities and discredits his college if he does not carry throughout all his walks of life the imprint of the educated man. Noblesse oblige is a degree and an obligation which is uniformly conferred upon all college men. To carry this obligation properly one should study culutre in all its phases and in its broadest sense. Study it as an undergraduate and study it still harder and more fully through all your post-graduate life. To this end let us accept and profit by that definition of culture given us by Matthew Arnold: "Acquainting ourselves with the best that has been known and said in the world." A professor at Wellesley College defined culture to the students as that which is left after all else learned at college is forgotten.

Virtue and moral training belong to cultural work in the education of engineers. It is a mistake to suppose that schools and colleges are places for mental training only. Physical exercise through athletics is just as much a part of one's college life nowadays as the study of mathematics; the one helps the other. Emerson said, "Archery, cricket, gun and fishing rod, horse and boat, are all educators, liberalizers." To the engineer physical training is of value in order to fit him for outdoor work. Moral training is of even greater importance. Locke has placed virtue first in defining the objects of education. Wisdom he puts next, and then good breeding; last of all learning. It is more the province of the teacher than of the student to safeguard and train the character by precept and example, for, after all, "the foundation of culture, as of character, is at last the moral sentiment. This is the foundation of power."

It is a common saying that manners make the man. Good manners afford us easy weapons with which to win

*Address delivered at the 38th Annual Commencement, Colorado School of Mines, Golden, Colo., May 24, 1912.

friends and to conquer enemies. Manners adorn the gentleman and smooth the way of the educated man through the world. Manners are never born in men; but they are bred by association and study. Like oil on the journals of an engine, they avoid friction and aid efficiency. There are many reasons why we should be polite, but the best reason is because it pays; it costs nothing. It is said of William Earl of Nassau that he won a subject from the King of Spain every time he put off his hat. So engaging were the manners of Charles Fox that Napoleon said of him on the occasion of his visit to Paris in 1805: "Mr. Fox will always hold the first place in an assembly of the Tuileries." "My gentleman," said Emerson, "will outpray saints in chapel, out-general veterans in the field and outshine all courtesy in the hall. He is good company for pirates and good with academicians; so that it is useless to fortify yourself against him; he has the private entrance to all minds, and I could as easily exclude myself as him."

Good speech is a rule of manners. It always avoids exaggeration. Moderation in language and tone is the trademark of good breeding, and good breeding is after all mainly a mater of self culture. Madame de Staël valued conversation above everything, and so engaging was she in that art that a prominent lady of France said of her: "If I were Queen I should command her to talk to me every day." The man of education mixes with the right kind of people and reads good books. Books lead us into pleasant paths of culture and happiness. Read that you may avoid worry; read that too much hard thinking may not dull the edge of intelligence and sap the roots of memory; read that you may know what has been done in the world; read that you may acquire that power which comes from knowledge; read that you may learn to value the example of great men's lives; that through them you may know that the grave is not the goal of life. Montaigne had a passion for books and never travelled without them; he said that reading roused his reason and employed his judgment rather than his memory.

But of greater importance than good speech and reading, of higher value to the engineer than manners, is ability to write good English. Engineers are not given to public speaking; they pride themselves in being workers; they compare themselves with General Grant who did things. It is very true that the engineering profession is one of practical work; but no one can hope to achieve prominence in this profession who cannot write good understandable English. An engineer may not talk, but he must make reports, he must write letters; he should draw specifications and plans. To do these things properly he must command and know how to use the tools of language. Lord Bacon tells us that "reading makes a full man, conversation a ready man and writing an exact man." Engineering is an exact science; accuracy is the one column on which the whole structure is reared. To write clearly and accurately can hardly be called an accomplishment; it is really a necessity. No college course is complete, whether it be a classical, scientific, medical or law course, without a thorough training in English. No graduate is worthy to be called an educated man who does not speak and write good English. It lifts a man above the common; it makes him bigger than his business or profession; it trims the ship of knowledge and puts oil on rough places; it makes the man.

Margaret Fuller said that the object of life is to grow, and James Freeman Clarke has written a lecture upon this subject, "Man's Duty to Grow." A post-graduate course in self-culture will tend to upward growth. Such a course is open to every one. The greatest opportunities for that education which unfolds the whole nature of man are those which are opened when we close the college door behind us. Graduation only marks the beginning of education to one whose face looks forward and upward. Let us build high; "they build too low who build beneath the stars." Build so that life and strength and growth may vitalize the whole structure; build on lines that are straight; build so that every root and branch of the tree of knowledge lends support and does not add a twist to the whole; build that men may see in you not alone skill and wisdom, but honor, culture, manhood, example; study to improve self—

"For virtue only makes our bliss below,
For all our knowledge is ourselves to know."

DRILLING 1 1/16-INCH HOLES IN ONE-INCH PLATES IN FOUR SECONDS AT THE PANAMA CANAL.

For the final riveting of the enormous lock gates at the Panama Canal the McClintic-Marshall Construction Company, of Pittsburg, has installed sixteen special electrically operated machines for drilling and reaming rivet holes. Each of these machines weighs about six tons, and is capable of doing the work of five ordinary type reamers.

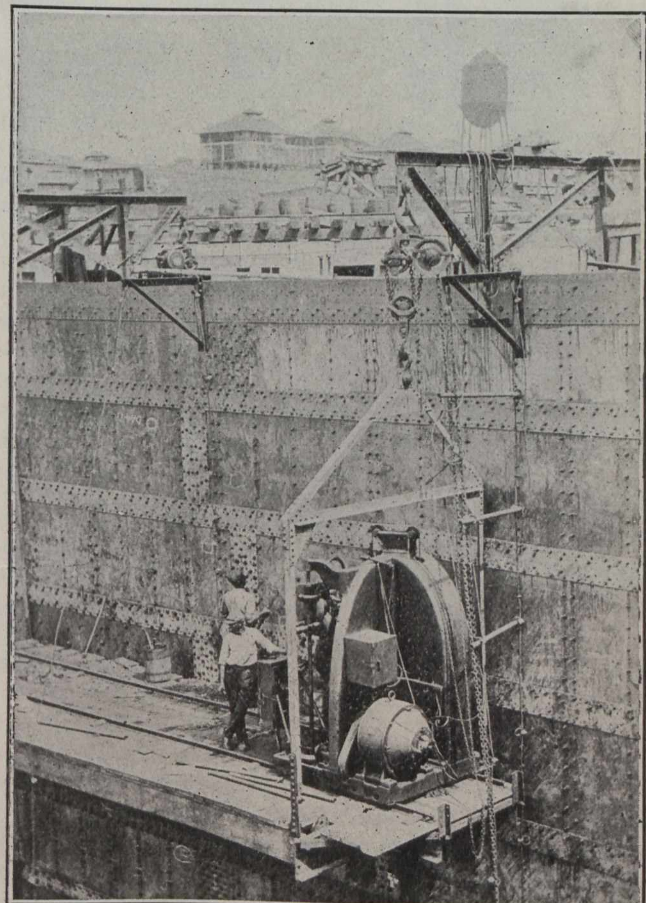

Fig. 1.

The machines are designed to run on a standard gauge track and are mounted on broad adjustable scaffolds, which are suspended from brackets by chains from the top of the gate, as shown in Fig. 1.

The inclined hand wheel shown in Fig. 2 operates through a train of gears and moves the machine along the track. The tool can readily be moved as roller bearings are used.

It will be noticed from Fig. 2 that the entire controlling mechanism is placed within easy reach of the operator. The horizontal hand wheel actuates suitable reduction gearing and a screw which raises or lowers the spindles, while the quick return motion through the spindles is actuated by means of the spider hand wheel, or by any of four levers. These levers automatically engage the quick return mechanism and enable the spindles to be run in and out.

Each machine is provided with four changes of power feed, which are instantly available through the quick-change gear mechanism. The length of the power feed is 16 inches, and the machine is so arranged that either one or both of the spindles can be fed independently.

The clutch lever for placing either spindle in operation is located on the head of the machine, while the feed changing lever is just above the clutch lever. This hand wheel is used for raising and lowering the head, which in turn is accurately counterbalanced, so that this raising and lowering is done with the least possible effort.

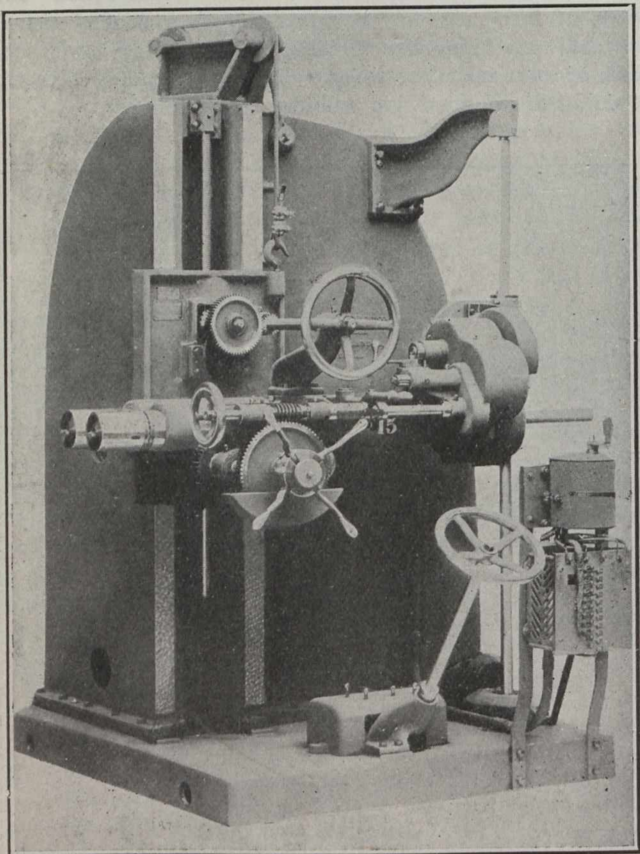

Fig. 2.

A shackle at the top of the machine serves to attach the crane hook for raising and lowering. Westinghouse direct-current, adjustable speed, shunt wound motors, rated at 10 h.p., 220 v., are used.

These machines were placed in operation in February, 1912, on the main gates of the upper lock at Gatun, and it is intended to use them on all of the gates in the three sets of locks. They were designed and built by the Foote-Burt Company, of Cleveland, Ohio, especially for use on the Canal. The distinguishing features are their great capacity, a total of nine speeds, varying from very slow for heavy drilling, to very high for lighter reaming; and fixed spindles arranged to suit the uniform spacing of rivet holes in the lock gates. On tests made at Gatun, one of the machines drilled 1 1/16-inch holes through 1-inch plates in four seconds, or at a rate of 15 inches per minute.

COSTS OF STEAM POWER PLANTS.

At the January meeting of the Engineers' Society of Western Pennsylvania some general unit construction costs of turbo-electric power plants were presented by R. W. Stovel and O. S. Lyford, Jr. These costs were based upon the maximum continuous capacity of the plant instead of on the "normal" rating. In this way the costs became comparable with those of gas-engine and hyrdo-electric installations. For coal-burning plants ranging from 2000-kw. to 20,000-kw. capacity the costs were stated to vary between the following limits:

Table I.—Cost of Steam Turbo-Electric Generating Stations from Say 2000-kw to 20,000-kw Capacity, Based on Maximum Continuous Capacity of Generators.

	Dollars per kw High.	Low.
Preparing Site.—Dismantling and removing structures from site, making construction roads, tracks, etc.	$0.25	$0.00
Yard Work.—Intake and discharge flumes for condensing water, railway siding, grading, fencing sidewalks, etc.	2.50	1.00
Foundations.—Including foundations for building, stacks and machinery, together with excavation, piling, waterproofing, etc.	6.00	1.00
Building.—Including frame, walls, floors, roofs, windows and doors, coal bunker, etc., but exclusive of foundations, heating, plumbing and lighting	12.00	4.00
Boiler-room Equipment.—Including boilers, stokers, flues, stacks, feed-pumps, feed-water heater, economizers, mechanical draft and all piping and pipe covering for entire station except condenser water piping	24.00	12.00
Turbine Room Equipment.—Including steam turbines and generators, condensers with condenser auxiliaries and condensing water piping, oiling system, etc.	22.00	12.00
Electrical Switching Equipment.—Including exciters of all kinds, masonry switch structure with all switchboards, switches, instruments, etc., and all wiring except for building lighting	5.00	2.00
Service Equipment.—Such as cranes, lighting, heating, plumbing, fire protection, compressed air, furniture, permanent tools, coal and ash handling machinery, etc., etc.	5.00	2.50
Starting Up.—Labor, fuel and supplies for getting plant ready to carry useful load	1.00	0.50
General Charges.—Such as engineering, purchasing, supervision, clerical work, construction, plant and supplies, watchmen, cleaning up, etc.	6.00	3.00
Total cost of plant to owner, except land and interest during construction	$83.75	$38.00

Some of the group costs in this table do not have any very specific relation to the kilowatt capacity installed in the plant and the probable range in such costs is given. This refers to such groups as "Preparing Site," "Yard Work," "Electrical Switching Equipment" and "Service Equipment." For instance, the electrical switching equipment costs depend much more on the extent and the scope of the electrical distributing system than upon the actual capacity of the plant. Again, the largest item of the "Service Equipment" costs—namely, that of coal handling—depends upon the existing physical conditions much more than upon the capacity.

The foundation costs will run from $1.25 to $4 per square foot of building plan area, depending on the character of the soil, the lower cost covering simple concrete footings on thoroughly good bearing soil, while the necessity for piling, waterproofing, excessive rock excavation, etc., will run this cost toward the higher limit. Then the plant area will vary from 0.8 sq. ft. to 1.5 sq. ft. for each kilowatt of capacity installed, depending upon the size of the units and upon their arrangement, the combined effect of these two cost ranges giving the range in price per kilowatt shown on the table.

The building costs will vary from 8 cents to 12 cents per cubic foot of over-all building volume, according to the size of the building, the character of construction and the local price of building material and labor. Depending again upon the size of the units and upon the efficiency used in arranging them, there will be required from 50 cu. ft. to 100 cu. ft. of volume per kilowatt of capacity. The combined effect is to make the building costs range from $4 to $12 per kilowatt as shown.

In boiler room equipment the cost of material and labor will generally be between $30 and $40 per nominal boiler horse-power, and generally there will be installed between 0.4 and 0.6 boiler horse-power per kilowatt of capacity, resulting in the cost range shown in the table.

It is seen that the cost of such stations under normal conditions may range in price from $40 to $85 per kilowatt of maximum continuous generator capacity. The minimum is possible only with an extremely fortunate combination of circumstances, such as natural advantages of location combined with most favorable sizes and arrangement of apparatus.

Table II. shows a probable high and low range of costs for detailed boiler room equipment. It will be noticed that the totals here shown cover a wider range than used in preparing Table I., where the price per horse-power was taken as from $30 to $40; this is because, while the wider range is possible, the costs in generating stations generally lies within the narrower range. The unit costs in this table are related to rated boiler horse-power instead of the kilowatt as used in Table I., as these costs vary almost directly with the rating of the boilers, regardless of how much boiler capacity may be installed.

Table II.—Boiler Room Equipment Costs per Rated Boiler Horse-power Using Coal for Fuel.

	Dollars per hp High.	Low.
Boilers exclusive of masonry setting	$11.00	$8.00
Superheaters	3.00	0
Stokers	5.50	3.00
Masonry settings for boilers	3.50	2.00
Flues	1.50	0.75
Stacks	4.00	2.00
Economizers	4.00	0
Mechanical draft	3.00	0
Feed pumps	1.50	0.50
Feed heaters	1.00	0.40
All piping and pipe covering	10.00	6.00
Coal chutes and ash hoppers	1.25	0
Various, such as indicating and recording devices, damper regulator, ladders and runways, painting, etc., etc.	1.00	0.50
Total	$50.25	$23.15

Note—The above costs are for labor and material only. They do not include any "general charges" such as engineering or supervision. The piping item includes all piping in the entire plant except condenser water piping.

Table III. indicates generally the range of ordinary operating results. Coal of 14,000 b.t.u. per pound is assumed in both cases for convenience.

Table III.—Summary of Operating Results.

	Range of Common Practice.	
British thermal units per pound of fuel	14,000	
Average yearly over-all boiler and furnace efficiency	50	70
Effective British thermal units per pound of fuel	7,000	9,800
Boiler pressure, pounds per square inch, gage	125	190
Superheat, degrees Fahr	0	125
Average feed-water temperature, degrees Fahr	120	200
British thermal units per pound of steam (approximate)	1,100	1,100
Pounds of water evaporated per pound of fuel, actual	6.36	8.91
Pounds of fuel per standard boiler hp (33,305 b.t.u.'s)	4.76	3.40
Average over-all station water rate kw	30	20
Pounds of coal per kw generated	4.72	2.25
British thermal units in coal per kw generated	66,000	31,500
Thermal efficiency of station	5.2%	10.8%

INCREASED USE OF WATER-POWER.

Of the 30,000,000 horse-power used in industrial and public-utility enterprises in the United States, reports the Commissioner of Corporations, 6,000,000 horse-power is now developed by water. At a conservative estimate, this saves 33,000,000 tons of coal per year. Several million more horse-power could profitably be developed from the same inexhaustible source.

Of the 6,000,000 horse-power now developed, 3,270,755 is generated for sale (that is, not for private use, as in manufacturing) by companies or groups of interests having 50,000 horse-power or more actually developed or under construction. The report concludes that it is not feasible to regulate the price of water power by itself but rather to control the sites, or their uses.

TO WHAT DEGREE MUST SEWAGE BE PURIFIED?*

By Chester G. Wigley, of the Division of Sewerage and Water Supplies, State Board of Health, New Jersey.

The economic disposal of sewage resolves itself into a problem of deciding what degree of purification is to be obtained and this degree of purity should depend primarily upon the size and character of the body of water into which the effluent is to be discharged. It too frequently happens that the effluents from disposal plants are not of acceptable quality and this condition can often be traced directly to inefficient supervision over the operation of the works. If a political officeseeker, without knowledge of the requirements of sanitary engineering, be placed in charge of the plant, there is small chance of securing satisfactory results.

Sometimes it has happened that engineers after designing and constructing a sewage disposal plant depart without leaving any directions for its proper maintenance. This has sometimes resulted in a rapid deterioration of the plant and a consequent loss to the municipality. It is for this reason that one of the chief functions of a board of health or sewerage commission is to see that the disposal plants are operated in a satisfactory manner. This is one of the most difficult phases of the sewage disposal question to-day, especially in connection with small installations.

In the design of any disposal plant there are two questions of economy. The first deals with the relative economy of the various types of any of the units comprising the plant, for example, the relative advantages of various types of settling tanks, and the second to a consideration of the general public welfare and the interrelations of groups of municipalities situated upon the same body of water. It is these latter relations which are directly affected by the limitations of the degree of purification of sewage and the most economic method of disposal is the one in which the best relations may be maintained at the smallest cost. It would appear that we are fast approaching, if we have not already reached the point, at which the large quantity of sewage from populous districts is compelling a bacterial standard of efficiency rather than one of sight and odor.

We may first consider the disposal of sewage with reference to the waters, according to their geographical classifications, such as the ocean, bays, rivers, brooks and lakes. Any system of disposal must be viewed from the several sanitary standpoints of liability of infection, creation of nuisances, and the effect upon the environment.

It is generally conceded that the purification of sewage discharged into the ocean shall be of a rudimentary nature. This is so because the ocean is so large that it requires a large amount of sewage to cause even a local nuisance. Another reason tending to make elaborate disposal plants unnecessary is that the salt water appears to have the power of more readily oxidizing organic matter than does fresh water. Where surf bathing is a pecuniary asset it is necessary to remove from the sewage floating grease, garbage and fecal matter by screening or sedimenation and discharge the effluent at a distance from shore suffiicent to prevent its immediate return. Where bathing does not enter into the problem, sewage may be satisfactorily taken care of by discharging into the ocean at some distance from shore and below the surface of the water.

In the case of a bay or sound the degree of purification demanded is higher than in the case of an ocean outfall.

* Abstract of paper read before American Waterworks Association at thirty-second annual convention, Louisville, Ky., June 3-8, 1912.

Here the protection of the shellfish from contamination sometimes must be provided for. The currents in the bay will ordinarily be less strong and because of its land-locked nature the sewage is discharged into a more or less restricted volume of water in which it is carried back and forth by oscillating tides. In most cases, where shellfish are not present, rough screening and sedimentation, or possibly very fine screening will be satisfactory if the effluent is discharged at some distance from the shore and the outlet at all times submerged.

In the case of rivers disposal by dilution sometimes may be adopted advantageously, but an important point to keep in mind is that the outfall should be designed to diffuse the sewage in deep running water and not to discharge it at a single point near the shore line.

Some people claim that it would be cheaper to allow a water purification plant, which should be installed in most cases where the supply is taken from a river subject to pollution, to take care of the additional burdens caused by the sewage. It is difficult to see why the burden should be shifted from the sewage disposal works to the water filters. The only place in which such a procedure would be permissible is where the quantity of sewage to be purified would cost considerably more than to purify a comparatively smaller amount of water. While this would be strictly an economic arrangement there are several things that would argue against such a practice.

The chief of these objections is this: Water purification plants are not perfect. They will at certain times fail to produce a satisfactory effluent, especially with filters of the pressure and mechanical type. Those who advocate the purification of water instead of the purification of sewage are not allowing a large enough factor of safety. The failure of the Schmutzdecke, the entrance of wash-water into the clear water, failure in the supply of alum, soda or hypochlorite are all apt to occur and then the barriers are down. Would it not be better to relieve the burden of the water purification plant as much as possible and wherever possible destroy the pathogenic bacteria in sewage? Would it do any harm to have a factor of safety of two and purify both the sewage and water? Then in the event of the failure of one plant the consequent results would not be as bad as though all the burden were placed on one installation.

With respect to rivers, then, we may conclude that where the river could be used as a water supply any of the methods of purification which would prevent nuisances and greatly reduce the number of pathogenic bacteria would be satisfactory means of disposing of sewage. This might mean simply the settling and sterilization of the sewage or its purification by settling tanks, sprinkling filters and disinfection. The latter method would only be necessary where the amount of sewage discharge is small in proportion to the flow of the river.

TERMINUS FOR HUDSON'S BAY ROAD.

The Dominion Government has decided upon Fort Nelson as the terminus for the Hudson's Bay Railroad from La Pas. It is also announced that the North Railway Company of Canada, with a capital of $10,000,000, furnished by a number of Montreal financiers, will construct a new line from Montreal to Nottawa, on James Bay. This road, with a 700-mile water trip on Hudson Bay, will afford connection between Montreal and the Northwest. Five different survey parties have been placed in the field to make the preliminary surveys and location.

SALE OF QUEBEC WATER-POWERS.

The announcement was made some time ago that henceforth no more water-powers would be sold in the province of Quebec. On the other hand, it will be the policy of the government to lease the water-powers for a term of years at a fixed annual rental. Accordingly, for some time past the Provincial Government has been advertising the lease, by auction, of some fifteen water-powers, for a term of seventy-five years. A number of these were disposed of at the Parliament Buildings at Quebec on June 26th. Just before the bidding, three of the powers were withdrawn, leaving twelve to be competed for. Of these, apparently only four were wanted, that, at any rate, being the number taken. These were as follows:—

At $51 per annum, power on the Assemetquagon River, near Metapedia River, Bonaventure Co., leased by James Hall, New Carlisle, in trust.

At $53 per annum, Riviere des Aux Nortes, in Hackett township, Champlain county, by Charles LeBrun, of Shawinigan.

At $3,800 per annum, Chute de la Martine, Metabetchuan River, Lake St. John county, by Herbert Moisan, of Quebec.

At $1,001 per annum, Riviere aux Outardes, Saguenay county, by St. Lawrence Industrial Company.

It is not stated what amount of power can be developed on the different falls, so that the work of making comparisons between the different leases is impossible. However, the very fact that the government will get over $5,000 per annum out of the four leases which formerly would quite possibly be given away free, is most encouraging from the standpoint of public interest, and the knowledge that all the powers of Quebec will in future be treated in this manner is very gratifying.

THE C.N.R. TRANSCONTINENTAL LINE.

The Canadian Northern Railway's transcontinental line will positively be ready in 1914.

The C.N.R. tunnel under Mount Royal will be ready in two years' time, about.

Montreal, Toronto, Ottawa and other important points will be linked up by the C.N.R. line this year.

The C.N.R. has just obtained the money to complete its transcontinental line.

These are some of the statements made by Sir William Mackenzie while in Montreal en route to England. It was the common thought among financial circles that Sir William was going to England for the purpose of obtaining additional capital for carrying out the projects of the Canadian Northern Railway, and it is still thought that this actually is the case, although the president of the company states the company has just obtained the money to complete the line. It is assumed that he does not refer to the cost of constructing the tunnel under Mount Royal and various other schemes more or less essential to the completion of the C.N.R. Transcontinental line.

It was the general idea in Montreal that the C.N.R. hoped to be able to build the tunnel out of the profits reaped in the rise of land values at the northern portal of the tunnel, a large area of which the company purchased as farm land before announcing its project, and the bulk of which has probably since been sold as building lots at prices ranging to upward of $1 per square foot. In any case, Sir William intimates that he may have something of importance to announce upon his return.

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CONTENTS OF THIS ISSUE.

Editorial:

PAGE

The Late Cecil B. Smith 151
The International Geological Congress 151
The Internal Combustion Engine and the Gas Producer 152

Leading Articles:

Toronto Water Chlorination Plant 135
British Columbia 136
The Value of a Continuous Settling Basin 137
Some Notes on Band Conveyors 141
Thirty Years' Progress in The Electric Furnace 143
Culture in the Education of Engineers 146
Drilling 1 1/16-inch Holes in One-inch Plates in Four Seconds at the Panama Canal 147
Cost of Steam Power Plants 148
To What Degree Must Sewage be Purified? 149
Letters to the Editor 153
Pig-Iron and Steel 154
The Construction of Distribution Systems for Outlying Systems and Small Plants 155
Precise Levelling in Canada 159
International Geological Congress 163
The New Chief Commissioner of the Dominion Railway Board 164
Western Canada Irrigation 6th Annual Convention 164

Personals 152
Coming Meetings 166
Engineering Societies 166
Market Conditions 24-26
Construction News 67
Railway Orders 74

THE LATE CECIL B. SMITH.

By the death of Cecil B. Smith the country has lost one of its most successful and brilliant engineers. Mr. Smith was one of the first of a new type of consulting engineer to enter the professional field in Canada. Many of the older men of the profession were men educated under the pupilage system who obtained their knowledge of engineering through practical experience. This class are steadily becoming in the minority, the newer class being men trained in the technical colleges before taking up practical engineering. Mr. Smith was one of the first of the college-trained men to enter the consulting field in Canada. He was educated at McGill University, and, after having obtained considerable experience, was appointed assistant Professor of Civil Engineering there. As a man Mr. Smith was well liked by everyone. The younger men of the profession, who at different times have been employed under his direction, have always parted from him with the greatest liking for his personality and with the highest respect for his ability. As an engineer he ranked with the leaders of the profession on the continent. The work which will probably be remembered most to his credit was that which he did as chairman of the Temiskaming and Northern Ontario Railway Commission and as Chief Engineer of the Ontario Hydro-Electric Commission in its early days.

THE INTERNATIONAL GEOLOGICAL CONGRESS.

The programme of the twelfth International Geological Congress, which is to be held in Canada in 1913, will be found in this issue of *The Canadian Engineer.* This Congress is of great interest to Canadians in general. The value of the annual mineral output of Canada has steadily increased year by year for the last thirty years, and is now over one hundred million dollars. Considering, however, the known resources and the enormous territory whose resources are unknown, this output is small, and Canada needs more men and more money for prospecting, development and operation. This she can best secure by attracting, not the general public, but those people whose business it is to engage in such industries and who understand their management. Geologists and mining engineers are obviously those best able to influence opinion in their own countries on the subject in which they are recognized authorities; hence the opportunity afforded by the meeting in Canada of so many eminent specialists should not be neglected. Every effort should be made to show to the world that, while our known mineral resources are large, we have an immense undeveloped territory awaiting the advent of the trained prospector. Meetings of various geological and other scientific societies have been held in Canada in the past, but this is the first occasion on which the International Geological Congress has met here, and the opportunity will not occur again for many years, since the meetings are held triennially in the different countries of the world.

Canadian geologists are fully alive to the high honor paid them and their country by the selection of Canada for the meeting, and they are being generously assisted in preparing for it by the Dominion and Provincial Governments and by the railway and mining corporations, as well as by individual business and professional men, all of whom are contributing liberally both money and time.

THE INTERNAL COMBUSTION ENGINE AND THE GAS PRODUCER.

There has been considerable discussion recently concerning the longevity of the coal fields of the country. With the increasing depletion of the coal deposits there has been a momentum given to hydro-electric installations, and an increasing demand for information concerning the possibilities of power from the internal combustion engine and the gas producer. Only last week we noted in *The Canadian Engineer* that the Province of Saskatchewan had appointed a consulting engineer to make an exhaustive report on the lignite deposits of that Province and their power-producing possibilities. The United States Bureau of Mines has been conducting investigations into the possibility of generating producer gas for power purposes in a commercial way from the various mineral fuels of the country. These investigations have been associated with steaming, briquetting, coking, and other tests, all of which supplemented an examination into the nature, extent, and distribution of the fuels used. The tests have been made with carefully selected representative samples and carload lots of coal, lignite, etc., procured especially for the purpose by experienced collectors.

The investigations have shown the adaptability of the gas producer for the utilization of low-grade coal, lignite, peat, etc, As mined, these fuels cannot be used in boiler furnaces and will not bear long transportation, but the gas producer makes them of potential value. Where deposits of low-grade coal, lignite, and peat are found, the present cost of power, as developed in steam plants with coal that has been shipped a considerable distance, can be materially reduced by placing producer plants at the mines or bogs so as to utilize these low-grade fuels without cost of shipment by generating electric current, which can be easily transmitted to desired points within a wide radius.

The tests in the gas producer have shown that many fuels of so low grade as to be practically valueless for steaming purposes, such as slack coal, bone coal, and lignite, may be economically converted into producer gas, and may thus generate sufficient power to render them of high commercial value.

It is estimated that on an average each coal tested in the producer-gas plant developed two and one-half times the power that it would develop in the ordinary steam-boiler plant. Investigations into the waste of coal in mining have shown that it probably aggregates 250,000,000 to 300,000,000 tons yearly, of which at least one-half might be saved. It has been demonstrated that the low-grade coals, high in sulphur and ash, now left underground, can be used economically in the gas producer for the ultimate production of power, heat, and light, and should, therefore, be mined at the same time as the high-grade coal. The investigations also show that the general use of gas producers for the development of power means the elimination practically of the smoke nuisance. This result is especially important in cities that are compelled to use bituminous coals. The great saving in fuel obtained through the gas producer has led to the installation within the last decade of several hundred of these power plants throughout the country. These producer plants are practically smokeless during operation. The establishment of producer-gas plants at the mines and the distribution of electric energy or gas over large areas will also tend to eliminate smoke. When a large percentage of the small, isolated power and heating plants and all steam locomotives have been removed from the larger cities, the atmosphere of these cities will be much clearer and heavy financial losses directly traceable to smoke will be eliminated.

EDITORIAL COMMENT.

We are publishing in this issue the first of a series of articles on band conveyors. The importance of the use of conveying machinery in connection with engineering work has increased to such an extent that we feel the publication of such a series should be of considerable interest to our readers.

* * * *

The new Commissioner of Works at Toronto appears to have grasped conditions in connection with the Waterworks Department. He has just recommended that a new position be created, that of mechanical and electrical engineer of the Waterworks Branch of the Works Department. There is little question that if the right man is obtained for the position, great economies will be effected in the Department. The operation of the waterworks is one which demands a knowledge which only a mechanical man of considerable experience can furnish, and we feel sure that a much higher standard of efficiency will obtain under the new condition.

GENERAL NOTES.

Precipitation was deficient throughout Canada except very locally in the Central Valleys of British Columbia, and in southern parts of Vancouver Osland and the lower mainland, where the normal amount was slightly exceeded; also very locally in Alberta, especially in the neighborhood of Calgary, where the fall was considerably more than usual. The deficiency was particularly pronounced in Manitoba, where the fall was only a very small percentage of the normal.

The table shows for fifteen stations, included in the report of the Meteorological Office, Toronto, the total precipitation of these stations for June, 1912:

	Depth in inches.	Departure from the average of twenty years.
Calgary, Alta.	4.3	+1.03
Edmonton, Alta.	3.0	—0.41
Swift Current, Sask.	2.8	—0.25
Winnipeg, Man.	0.9	—2.54
Port Stanley, Ont.	1.3	—1.41
Toronto, Ont.	1.75	—1.04
Parry Sound, Ont.	1.7	—1.26
Ottawa, Ont.	0.8	—2.95
Kingston, Ont.	1.1	—2.1
Montreal, Que.	1.6	—2.42
Quebec, Que.	3.1	—1.2
Chatham, N.B.	2.3	—0.73
Halifax, N.S.	2.6	—1.3
Victoria, B.C.	1.0	+0.04
Kamloops, B.C.	1.5	+0.22

PERSONALS.

DR. W. E. GEORGE, of Haileybury, has been appointed medical health officer for the eastern section of Northern Ontario.

MR. B. RIPLEY, A.M. Can. Soc. C.E., A.M. Am. Soc. C.E., who for the past two years has been in charge of bridge construction and renewals on the Dominion Atlantic Railway, has been appointed engineer of grade separation for the Canadian Pacific Railway at Toronto.

LETTERS TO THE EDITOR.

CONCRETING IN COLD WEATHER.

Sir,—While looking over the titles to articles in the last half year of *The Canadian Engineer* I noticed one entitled "First Reinforced Concrete in Cold Weather." As the laying of concrete in cold weather is probably an interesting subject to many engineers and contractors in Canada, I might say that the Ambursen Hydraulic Construction Company were engaged all last winter in the construction of a dam across a river called the "Magpie," in Michipicoten district, Ontario, and that concrete was laid, and perfectly taken care of there in weather of the severest description, temperatures of 30 deg. to 50 deg. below zero being common during the nights.

An Ambursen type dam is a reinforced concrete hollow dam, consisting of a number of buttresses, in this particular case 14 in. to 18 in. thick, 60 ft. long at the bottom and 36 feet high, and spaced 12 ft. centres, upon the sloping front of which buttresses a deck slab 30 in. to 21 in. thick is poured. This deck slab, resting on the buttresses, of course holds back the waters, the space between buttresses and under the deck being hollow.

Rock for the concrete was crushed in a crusher and ran from the crusher mouth into a large timber bin, on the floor of which was laid a grillage of steam pipes, pipes being about three feet centres up and down the sloped floor of the bin. The pipes were drilled with ¼-in. holes at close intervals, and the steam escaping from these holes heated up the rock in the storage bin. Sand was similarly treated or heated in an adjoining bin.

The material was run from these bins in a car to the mixer house, some distance away. In the mixer house, directly above the mixer, a water tank, holding about 10 or 12 barrels of water, was built. A steam pipe from the mixer boiler heated this water to a high temperature. Of course the water pipes from the pump at the river to the tank were protected from the frost, being laid in a box of manure with a steam line running beside the water line in the manure box.

The sand, cement and water were all, therefore, heated before entering the mixer; the concrete coming out of the mixer being generally steaming hot.

Concrete was only poured when the sun was up during the day as a precaution against being frozen before it was taken care of in the forms.

The forms were ordinary forms, built of 1-in. lumber in panels 12 ft. high and 6 ft. wide. The forms for two buttresses, 12-ft. centres, were set up and braced together. A car running along the top of these buttresses dumped the concrete into the forms. When the two buttresses were poured, which generally meant a five-hour run, a large tarpaulin was hauled across the top and let drop over the sides and ends, completely covering in the buttresses newly poured. In the space between the two buttresses several large Peterborough "lumberman" stoves fed with cord wood were kept going all night and heated the space enclosed by the canvas with such success that on several occasions, after nights during which the temperature was as low as 40 deg. below zero, forms were taken off 24 hours after the 18-inch concrete walls were poured. Of course the use of stoves necessitated cutting stove pipe holes in the canvas roof. This might probably be done away with and the canvas roof probably better preserved by the use of salamanders, using coke instead of the clumsier heavy stoves and stovepipes.

"READER."

RE PONTE DEL RISORGIMENTO.

Sir,—I have read with great interest the historical sketch on the evolution of the building of reinforced concrete arch bridges given in your issue of June 27th by Mr. H. G. Tyrrell and his remarks on the new Tiber River bridge, about which I have given a description in the same number.

There is, however, one point to which I would like to take exception. Mr. Tyrrell writes namely: "In the new Tiber River bridge with curved arch slab without hinges, rigidly connected to seven vertical ribs, it would seem that the stress condition was indefinite and the amount of thrust taken by the vertical ribs indeterminate.

I do not think that many engineers, with experience in reinforced concrete arch bridges and the use of the elastic theory would agree with that. As far as I know there has not yet been a single one of the numerous bridges figured out in that way that has shown any considerable disagreement between the calculated stresses and deflections and those actually measured on the bridge by test loads.

The circumstance that the cross section of the Tiber bridge is an inverted T does not introduce in itself any special difficulties to figuring out the forces in the slab and in the ribs. The bridge being fixed at its ends, there are three quantities which must be determined by the equations of elasticity. Maxwell's rule has very materially simplified those equations and by the choice of a special point at which we let these three quantities act we get the following practical equations:

$$X_a = \frac{\delta ma}{\delta aa}$$

$$X_b = \frac{\delta mb}{\delta bb}$$

$$X_c = \frac{\delta mc}{\delta cc}$$

X_a, X_b, X_c. mean the unknown qualities, δma, δmb and δmc are the deflections at the various points m of the main system for forces 1 acting in the direction of X_a, X_b and X_c respectively.

Whatever deflections are to be found by calculations or graphically (Villiots method) the proper moment of inertia for each section has to be used and thus the acting bending moments, normal and transversal forces can easily be found and thereafter the stresses in the steel and concrete in the sections.

V. J. ELMONT, C.E.

* * * *

Sir,—Replying to the comments of Mr. V. J. Elmont, on my report concerning the Ponte del Risorgimento over the Tiber River at Rome, it is very doubtful if any practical benefit is derived from the use of the elastic theory for computing stresses in masonry arches. The Romans used no such theory, and yet their bridges as far as endurance is concerned are far superior to many that are being built in recent years, proportioned perhaps by the elastic theory or some other equally gratifying to mathematicians, though of no greater use.

Sonstructive forms in which stress conditions are uncertain have been well exploited during the past 60 years since Mr. Whipple first published his methods of computing bridge stresses in 1847, and as far as economy of material is concerned, such forms are often quite economical, but experience has shown that conditions of uncertain stress are undesirable and such forms are now avoided by conservative designers. Many types, such as trusses with multiple web systems, or combinations of truss and arch, unquestionably have some points of merit, but because of their indefinite action they have gradually been discarded and other uncertain forms will doubtless follow in the same course. "Simplicity" is a fundamental principle of bridge design which should not be violated.

The latest Tiber River bridge is unquestionably a fine structure, reflecting great credit on its engineers and originators, but the unfortunate practice of competitive designing too often reduces the dimensions and strength almost to the danger point. Limitations in money appropriation and time, are also responsible in many cases for slender proportions, and the absence of features which might otherwise be most appropriate.

H. G. TYRRELL.

PIG IRON AND STEEL

An increase of 5.58 per cent. is shown in the production of pig iron in Canada in 1910 over the production of 1909, as compared with an increase of 20 per cent. in 1909 over that of 1908, according to the report of the Department of Mines, Ottawa.

At the close of the year Canada had seventeen completed furnaces and two under construction, grouped in ten separate plants and operated by eight separate companies or corporations.

The total production in 1910 was 800,797 short tons (714,998 long tons), valued at approximately $11,245,622; as compared with 757,162 short tons (676,038 long tons), valued at $9,581,864, in 1909, and 630,835 short tons (563,246 long tons), valued at $8,111,194, in 1908. The Londonderry furnace was not in operation during either of the past two years. These figures do not include the output from electric furnaces making ferro-products which are situated at Welland and Sault Ste. Marie, Ont., and Buckingham, Que. Ferro-silicon was made at Welland during 1910, but the Sault Ste. Marie and Buckingham plants were not in operation during the year.

Of the total output of pig iron in 1910, 17,164 tons, valued at $333,956, or $19.78 per short ton, were made with charcoal as fuel, and 783,633 tons, valued at $10,911,674, or $13.92 per ton, with coke. The amount of charcoal iron made in 1909 was 17,003 tons, and in 1908, 6,709 tons; while the quantity made with coke in 1909 was 740,159 tons and in 1908, 624,126 tons.

The classification of the production in 1910 according to the purpose for which it was intended was as follows: Bessemer 219,492 tons, basic 425,400 tons, foundry (including miscellaneous) 138,741 tons.

The classification of the production in 1909 was: Bessemer 221,931 tons, basic 400,921 tons, foundry (including miscellaneous) 116,307 tons.

The American Iron and Steel Association reported the production of Bessemer pig iron in 1908 as 126,348 short tons, as against 173,499 tons in 1907; and the production of basic pig iron in 1908 as 375,659 short tons, as against 382,208 tons in 1907.

In Nova Scotia a large proportion of the pig iron is directly converted to steel, and as a very small portion of the metal is sold as pig iron it is somewhat difficult to place a satisfactory valuation upon the output. For statistical purposes a value of $12 per short ton has been placed upon this production in 1910. The Quebec production is entirely charcoal iron, which has for many years commanded a high price.

With respect to prices of pig iron in Canada during 1910, a firm of iron merchants in Montreal gives the following information. It is practically impossible to give information respecting iron prices in detailed form since much depends on the quantity purchased, brand of iron, prevailing freight rate, etc.; nevertheless it may be said that good average brands of Scotch iron sold in Montreal during the first three months of 1910 at about $20 per gross ton. Later in the year, particularly after the opening of navigation, prices eased up somewhat and an average price would be $19.50 per gross ton. On the other hand good foundry iron of English manufacture could have been purchased during the early part of 1910 at $18 per gross ton, then shading down to $17.25 per gross ton during the summer months. There was little competition from Canadian made iron in the Montreal district during 1910, the Sydney furnaces not marketing anything there during that period.

In Toronto the situation was somewhat different. It costs approximately $2 per ton more to lay down Scotch and English iron at that point than it does in Montreal, and during the early part of the year such advance in price was obtained. Later in the year, however, the Amreican situation seriously affected prices in Ontario, and United States pig iron competed very keenly in the Toronto-Hamilton district, practically cutting out Scotch and English iron and compelng the local furnaces to reduce their prices to an equivalent of $18.50 and down to $18, f.o.b. cars Toronto, for good average grades of foundry iron.

In Pittsburgh, Bessemer iron was quoted at $19 per gross ton in January, 1910, falling to $17.50 in March, $17 in May, $15.75 in June, and $15 from the latter part of August to the close of the year. Basic iron ruled from $1.75 to $2 per ton less.

Previous to 1896 pig iron was made entirely from Canadian ore. Since that date, however, increasing quantities of imported ore have been used as well as imported fuels and fluxes, and in 1910 about 89 per cent. of the ore charged, 49 per cent. of the coke, and 18 per cent. of the limestone, were imported. This condition is due largely to questions of cost and transportation affecting each furnace. The Newfoundland iron ores can be cheaply and conveniently laid down in Sydney, N.S.; in fact the iron industry here has been built up on the basis of these ores and of the local coal supplies. In Ontario, also, large quantities of imported ores are used. In 1910 the imported ores used in Ontario amounted to 681,918 tons and the Canadian ores 143,283 tons, the imported ores being derived from Michigan and Minnesota deposits; thus during 1910 about 83 per cent. of the ore used in the province was imported, as compared with 71 per cent. in 1909, and about 67 per cent. in 1908. The fuel used in Ontario was also almost altogether imported as well as a portion of the limestone flux.

According to returns made to the Department of Trade and Commerce in connection with claims for bounty, 84,759 tons only of the total pig iron production in Canada in 1910 were credited to Canadian ore and 659,891 tons to imported ore and bounty paid upon it as such. In 1909 bounty was paid upon 126,298 tons of pig iron from Canadian ore, and 607,718 tons from imported ore. No bounty is paid on the iron credited to the mill cinder, scale, etc., charged, so that the above figures do not represent the total output of the furnaces.

There has been comparatively little pig iron exported from Canada. During 1910, the exports were 9,763 tons, valued at $296,310, or an average value per ton of $30.35. The exports during 1909 were 5,063 tons, valued at $186,778, an average of $36.89; while during 1908 the exports were 290 tons, valued at $10,614, an average of $42.45 per ton. These exports probably include ferro-silicon as well as ordinary pig iron.

Considerable quantities of pig iron are annually imported into Canada. During 1910, the imports of ordinary pig iron were 227,753 tons, valued at $3,122,695, an average of $13.71 per ton, and of charcoal pig iron 16,106 tons, valued at $242,152, an average of $15.03 per ton; or a total importation of 243,859 tons, valued at $3,364,847. During 1909 the imports were: ordinary pig iron, 147,925 tons, valued at $1,798,172, and charcoal pig iron, 413 tons valued at $5,727; and 1908, the imports were: ordinary pig iron 57,343 tons, valued at $771,715, and charcoal iron 1,022 tons, valued at $18,818. The duty, or general tariff, on pig iron is $2.50 per ton.

THE CONSTRUCTION OF DISTRIBUTION SYSTEMS FOR OUTLYING SYSTEMS AND SMALLER PLANTS.*

By S. Bingham Hood.

Toronto Electric Light Company.

In establishing an electricity supply service in small villages, or the more or less scattered population surrounding our larger cities, the problem becomes much more complex, both commercially and electrically, than that of the supply within the city itself. Most of the earlier small systems were constructed in a crude makeshift manner and gave at best anything but what we class to-day as reliable service. The men who financed these small plants seldom had any electrical knowledge and frequently operated the systems as a side line to their regular business—the power plant being located in some local mill or factory with the idea, generally, of using the prime mover for factory operation during the day and making it work overtime to earn its salt by driving a small generator at night. The operator of the plant, a local jack of all trades, attended to inside wiring, did the construction work on the lines; installed, read and repaired the meters (unless it was a flat rate proposition), and in his spare time operated the plant. The natural result was generally that, where the system was growing he had no time to attend to operating duties and the service became unreliable in proportion to its prosperity—at least until such time as the unreliability overshadowed the prosperity and the whole undertaking went on the rocks. This was the favorite time for the big fish to swallow the little one and has resulted quite generally in the present-day suburban systems being owned and operated by the large system of the nearest city, the local plant under these conditions being abandoned and supply obtained from the large central station.

The result of this has been of great benefit to the local suburban community, in that they not only obtain the primary supply from a modern station giving the highest class of service, both as to reliability and efficiency, but also have at their command a skilled, specialized force to design and supervise the local distribution and operation.

To successfully and profitably operate a large scattered suburban load the construction of the distribution system must be the very best that can possibly be obtained, in order that an uninterrupted service may be given. This requirement is even more imperative than within the larger community, as the suburban system must to a considerable extent be automatic in its operation owing to the difficulty, time, and expense, necessary to restore interrupted service due to line failure at points remote from the operating headquarters. Combined with this requirement the annual overhead charges must be kept as low as possible in order to make the distribution profitable. These annual charges reach a minimum where the design and construction of the distribution system is such that a maximum life is obtained with a minimum capital expenditure. Failure to realize this point was the downfall of the early systems where every effort was made to "make it cheap," with the result that the life of the system was limited to but a few years. At just what point maximum efficiency results is hard to determine. Local conditions may make a design adapted to one locality an expensive one for another. The best materials may be selected to cover the mechanical construction, but an electrical system may be adopted which may be so expensive that the combined cost becomes prohibitive. Generally speaking, however, maximum economy has been reached where the interest charges equal the ones for depreciation. In other words, the cheaper you can get your money the more you can afford to spend to lengthen the life of the distribution system.

In addition to this the first cost of current plays an important part. In water-power plants or large turbine steam plants the cost of current at the bus bars is very low, and, consequently, the line losses in transmission may be made somewhat high to advantage, particularly in suburban work where the load factor is generally low. Right here, however, a word of caution is opportune. You can make your line losses between the source of current and the point where first load is taken off anything within reason; but between the nearest and furthest load your total drop in pressure, including both primary and secondary, as well as transformer drop, must not exceed five per cent. if you expect to give service in its true sense. You can't operate a feeder with a drop if anywheres from ten to twenty-five per cent. and start loading it at the city limits and leave off at Farmer Jones' half a mile beyond the next village. We all know this, but still seem to keep on trying, with results similar to our railway friends with their efforts to eventually make a single track line operate successfully without sidings.

If we analyze the cost of suburban transmission we find that the pole line (such systems being nearly always overhead) represents the greatest proportionate investment. We also find that this portion also has to carry the larger share of the depreciation, due to its limited life under ordinary conditions. We, therefore, intend to take up first of all this part of the work and endeavor to show where maximum economy can be obtained. In suburban and semi-suburban work a thirty-foot pole line is amply high enough where the run is free of trees or other obstructions. Special cases will, of course, require higher poles, but the average condition is covered by the sizes shown in table 1. The prices here apply to average conditions of labor and material costs in the vicinity of our larger cities.

The cost of pole in the rough is that of good clear B.C. cedar, with an increase in diameter of one inch for every ten feet. The cost of shaving, framing and treating covers shaving from ground line to roof, taper or wedge roofing, cutting and boring of gains and boring for steps and sockets. The treating, where same is included, consists of a double immersion of the butt, to one foot above ground line, in carbolinum oil. First immersion to be in hot oil and second in cold.

Painting is for one coat, in pole yard, of entire pole above ground line. This coat preferably to be of a light body paint or stain, such as shingle stain, which will penetrate into the surface for an appreciable distance. The object of painting is primarily to improve the appearance of the pole, as any pole line is objectionable from the public's standpoint and anything which renders it less so is a first-investment. In addition a coat of stain undoubtedly does act as a preservative to a considerable extent. The object of stepping and socketing the pole is also to prevent its being cut up by continual climbing with spurs, which not only spoils the appearance of the line, but leaves countless little holes or pockets to collect water and drain it right into the heart of the wood of the pole. Steps are, or should be, standard ⅝-in. by 9-in. hot galvanized and have a life far beyond that of the pole in which they are to be used. The best form of socket is a malleable iron or wrought iron thimble which will drive into a ⅞-in. hole. The hole in thimble will take a ½-in. lag screw or pin which is slipped in by the lineman when about to climb a pole, and taken out when he comes down. Four of these sockets are required

* Abstract of paper presented at the Twenty-second Annual Convention of the Canadian Electrical Association, Ottawa, June 19-21, 1912.

for each pole, making the first step come seven feet from the ground. As the sockets are not readily removable after once driven, their life is, of course, that of the pole into which they are placed.

The cost of setting given in the table is that for average digging in hard clay or loam. This column for items 9 to 14 is original cost of setting plus the cost of cutting off, digging out old butt, and dropping down and retamping the balance of pole.

The life of pole is taken as that point where the butt rot at ground line has decreased the sound diameter to that

Item	Size and Kind	Cost in Rough	Shaving Framing Treating	Hauling	Painting and Stepping	Setting	Total	Life (Years)	Annual Cost
1	30'x6 Plain	$3.05	$1.10	$0.45	$1.56	$3.50	$9.46	6	$2.05
2	30'x6 Treated	3.05	2.20	.45	1.35	3.50	10.56	11	1.49
3	30'x7 Plain	5.00	1.10	.45	1.39	3.50	11.44	7	2.81
4	30'x7 Treated	5.00	2.30	.45	1.39	3.50	12.64	12	1.69
5	35'x7 Plain	6.00	1.30	.48	1.64	3.75	13.17	8	2.30
6	35'x7 Treated	6.00	2.60	.48	1.64	3.75	14.47	13	1.84
7	35'x8 Plain	7.50	1.30	.48	1.68	3.80	14.76	10	2.81
8	35'x8 Treated	7.50	2.75	.48	1.68	3.80	16.21	15	1.80
9	35'x7 Plain, Reset	6.00	1.30	.68	1.84	7.35	17.17	15	1.89
10	35'x7 Treated, Reset	6.00	2.60	.68	1.84	7.35	18.47	20	1.71
11	35'x8 Plain, Reset	7.50	1.30	.68	1.88	7.40	18.76	18	1.87
12	35'x8 Treated	7.50	2.75	.68	1.88	7.40	20.21	23	1.76
13	35'x7 Treated Retreated, Reset	6.00	3.80	1.33	1.69	7.35	20.17	25	1.67
14	35'x7 Treated Brush Retreated, Reset	6.00	3.60	.48	1.64	7.35	19.07	23	1.65
15	30' Steel Pole Painted	8.75		.40	* 7.50	5.00	21.65	30	1.62
16	30' Steel Pole Galvanized	12.75		.40		5.00	18.15	25	1.63

* Every 3 Years

Table I.—Investment and Annual Cost on Poles.

of the top of pole. This life varies widely with different conditions of soil, climate, etc., but figures given represent a fair average. For treated pole the life is uncertain owing to lack of definite data. The writer has taken the increased life as being five years for a pole with 7-inch top, as poles so treated have been under observation for this length of time and some are starting to show signs of decay, while others are as good as the day they went into the ground. Where this decay has started there is no means of telling whether it is going to be the same as an untreated pole, or faster or slower. Five years increased life is, therefore, taken as the known increase.

Table 1 shows sixteen sizes or combinations of poles suitable for suburban or semi-suburban conditions, fourteen of which are wood. In figuring the annual costs it is assumed that the value of pole will be entirely wiped out at expiration of given time. The steps can probably be used over again and the pole may have a slight resale value, but these at best will only cover removal costs. It will be noted that while the investment costs vary by over 100 per cent. the annual costs only vary about 35 per cent. Taking the average of these annual costs, which is $1.84 and eliminating all above the average we have the following to select from:—

	Cost.	Annual Charge.
30' x 6" treated	$10.56	$1.49
30' painted steel	21.65	1.62
30' galvanized steel	18.15	1.63
35' x 7" treated, brush re-treated and reset	19.07	1.65
35' x 7" treated, re-treated and reset	20.17	1.67
30' x 7" treated	12.64	1.69
35' x 7" treated and reset	18.47	1.71
35' x 8" treated and reset	20.21	1.76
35' x 7" treated	14.47	1.84

It is interesting to note that no untreated pole comes below the average. The 30 by 6 appears to be the winner, although such a pole is hardly strong enough for supporting transformers, corner poles, etc. Assuming that every fifth pole should be 7-inch top we get an average cost per year of $1.53. This clearly shows that butt treatment is a great economy, and if such treatment should turn out to give a life as long as the makers of the carbolinium claim the economy will be very much greater. For this class of work the writer recommends the use of 30-ft. treated poles for branch secondary lines, using 6-inch for straight runs and 7-inch for strains and corners. For trunk lines requiring primary wires a 35-ft. pole should be used, 7-in. tops meeting all usual requirements. While the table gives the annual cost of such a pole as $1.84, the actual cost with above suggested arrangement is less owing to our having a good framed 30-foot pole left from the old 35-foot when it requires renewing at the end of 13 years. This brings the annual cost of the 35-foot pole down to $1.33 or less than the 30-foot poles. This saving would, however, not be possible unless we used 30-foot for standard branch lines, as otherwise the old cutoff 35-foot poles would be dead wood on our hands.

The theory of wood preservation must be clearly understood by those attempting the treatment if success is expected. Wood rot is caused by a living microbe, and to sustain life we must have all of three things—LIGHT, AIR and WATER. Each one of these microbes throws a tendril or thread to the point where all three of these conditions exist, and these tendrils may be many feet in length, as they are in the case of dry rot, or heart rot. Deprive these organisms of any one of the three essentials to life and we have solved the problem of preservation. If we keep our pole above ground in good condition to shed water, by filling all exposed end grains and preventing damage to the exterior surface, we have eliminated water from this part of the pole and insured against surface rot. A short distance below the ground line both light and air are eliminated, so that our danger zone is confined to a few inches above the ground and about one to one and one-half feet below the ground. It is this portion which requires preservative treat-

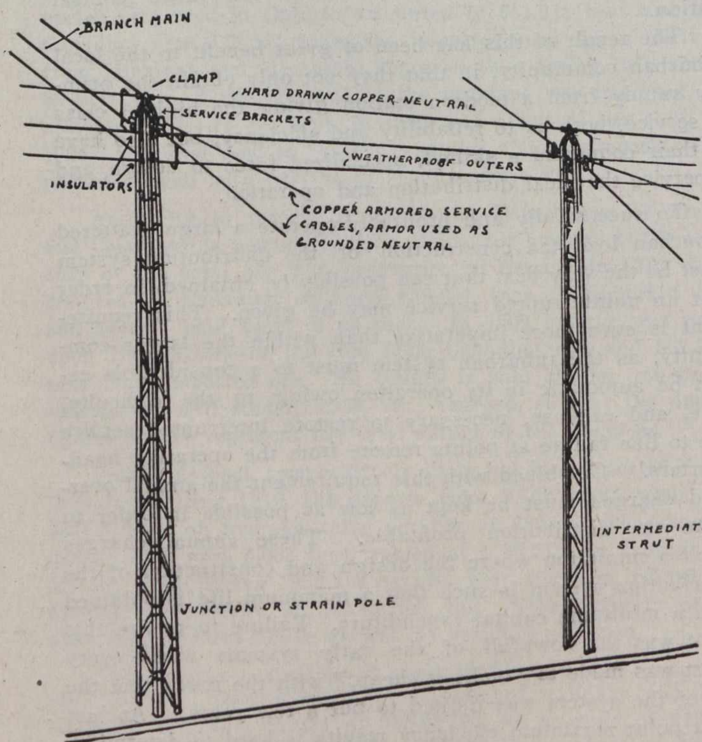


Fig. 1.—Steel Pole Secondary Distribution.

ment and any compound which will permanently exclude the air fulfills the purpose, and it is not necessary that this extend entirely through the pole as the organism in going down through the heart can not obtain light and can not live. The only really successful compound for this purpose appears to be some of the coal tar by-products, of which the dead oil, known to the trade as carbolinium, appears the best. A brush treating process can meet with but indifferent success owing to all timber being more or less filled with season cracks or checks, the interior of which can not be reached with a brush. The immersion treatment requires two open tanks, one for hot and one for cold oil, each capable of holding eight or ten poles, which are hoisted by a derrick and their butts set vertically in the tank. In addition a storage tank is desirable and a small circulating pump with suitable piping and valves connecting all three tanks. For heating the oil a furnace may be built under the hot tank, or, better still, a small steam boiler provided and steam coils immersed in the tank. Where current can readily be obtainable the heating can be done conveniently by means of low pressure resistance coils placed directly in the bottom of the tank, a suitable grid being placed to keep the weight of poles off the coils. Such an equipment should be installed for from $1,500 to $2,000, and will pay for itself in a very short time.

The growing scarcity of timber suitable for poles is rapidly forcing up the price until it seems that a few short years will make it necessary for us to use some other material with which to support our overhead lines. For voltages between those that can be handled with bare hands and those too high to handle alive a wooden or other form of insulated pole has its advantage. For high tensions transmission and for low tension secondary distribution, however, a metal pole has no objectionable features. It would seem, therefore, that we should conserve our remaining forests for use where wood is advantageous, and substitute some other material for the balance of our requirements. The past few years have seen many improvements along these lines, steel towers for transmission lines being used to-day almost exclusively. For trolley systems the tubular iron pole has been in use for urban lines for many years. Reinforced concrete has also been tried with varying success and gives promise of ultimately being successful.

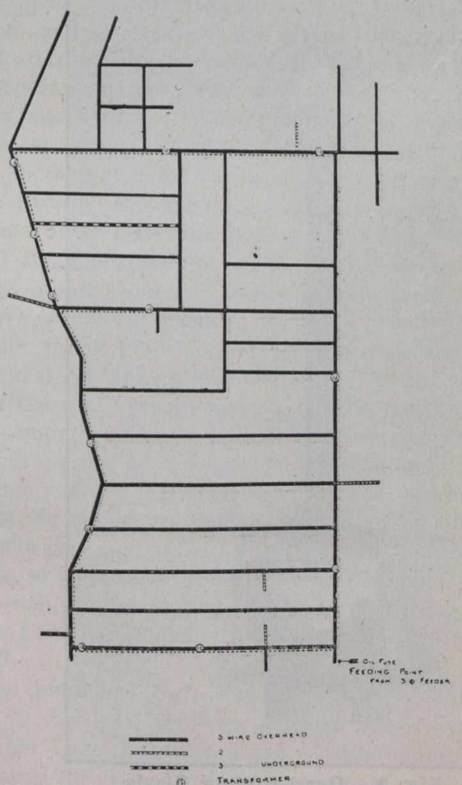


Fig. 2.

The concrete pole has been adopted for all secondary distribution by one of our larger Canadian cities, and we can well afford to wait and see how these work out before experimenting ourselves to any great extent. These poles are from 25 to 30 feet in height, of square section with beveled corners. They run about six inches at top and eight to nine at the butt. Reinforcement is with four one-half inch rods, one in each corner, about one inch from the surface. The cost in position is about the same as that of a treated cedar pole, and, theoretically, there should be no limit to their life. Personal observation, however, precludes their being recommended by the author. It is surprising the amount of rough handling these poles will stand and the extent to which they will bend without breaking. The peculiarity seems to be their failure after they are in position and the wires in place. Where they can be head-guyed so that practically no strain is placed on them they work admirably considered simply as props, with a vertical load only. Two forms of failure have been noted; first, that where the head guy has given and allowed a strain to come on the pole. In this case the beam has its fulcrum at the ground line and a tremendous leverage takes place, which draws the reinforcement, on the side under tension, right out of the concrete. This could be overcome by fastening the lower ends of the reinforcing rods in some kind of a plate, but would probably result in the strain breaking the rods instead of pulling them out. The other failure appears to be due to a torsional strain from uneven balancing of the wire pull at the top. In this case the outer shell of concrete near the top is entirely broken off and the rods with the concrete core piece twist around until the strain is equalized. On straight runs they may prove successful provided the use of numerous anchor guys is not objectionable; but in taking off service lines serious difficulties come up, as it is hardly practicable to side guy every pole where a service line is required.

Another apparent inherent defect in these poles seems to be the shrinkage cracks in the concrete. In many cases these are quite prominent and extend over three sides of the pole, being very pronounced on the side opposite the strain. It is very evident that the reinforcement is carrying all the strain and equally evident that water is getting at the rods, as well as air. As to just what effect this is going to have on the life of the pole time alone will tell.

The writer's idea of what would be a successful reinforced concrete pole would be to have a circular cross section, the reinforcement to be in the form of a tapered tube of either expanded metal or electrically welded mesh. To avoid deterioration this could be hot galvanized as a whole at small expense. The concrete would be moulded around this tube, which should be covered not less than one and one-half inches. To lighten the pole and save concrete a tapered mandril about two inches smaller than the inside of the reinforcing tube could be placed in the mould and withdrawn after the concrete had partially set. A pole of this kind would require pouring with the mould set on end, the entire proposition of development being one almost too great for any individual company to handle alone. Some of our enterprising manufacturers will, no doubt, eventually take up the development of such construction and put it in commercial shape.

Tubular steel poles up to 30 feet are now a standard product. A pole of this height and heavy enough for distribution strains can be set in concrete at a cost of about $30.00 each. Where provided with a reinforcing band at the ground line and the concrete carried up sufficiently above ground to act as a water shed the life should be at least 25 years. With this life and allowing for its scrap value the annual charge would be $2.46, or about two-thirds greater than for a wooden pole. At the rate the cost of timber is going up a few years will put iron and wood on an equal footing for such use.

Structural iron poles can be developed easily along the same lines as standard transmission towers, but on a smaller scale. One company is now making a light three-legged tower at very moderate cost and numerous designs could be brought out using galvanized standard shapes and giving a pleasing appearance with ample strength. A built up pole can be made at a cost in position not exceeding twenty dollars. The life should be at least twenty-five years with an annual cost of less than $2.00 or little greater than a wood pole line. In fact, the writer has in mind at the present time a system of construction in which about every fifth or sixth pole would be of the tower type (see Fig. 1), the intermediate poles being simply latticed struts set to take up a right angle strain due to service lines. The tops of these poles would be solidly connected by a hard-drawn copper wire which would act as a stay wire, and also a grounded neutral for the distribution system. The annual cost per pole for this idea will run approximately $1.60, or about the same as the wood pole line. These costs can probably be further cut down by bolting new ground sections to the old poles at the expiration of the original life, as little or no depreciation should occur above the ground if four test galvanizing is insisted upon.

Pole Fittings and Hardware.—The permanency, reliability and overhead charges of a distribution system depend probably more on the hardware and fittings used than upon any other item of construction. In the days of early development very light poles were the rule and their life was generally not over five years; consequently, any fitting which would last as long as the pole was considered good enough.

With the adoption of a treated pole giving a life of twelve years or more very different fittings are required. For high tension lines, or those of over 600 volts, the wooden cross arm is probably the best means of supporting the wires, as its insulating qualities are of considerable advantage. Cross arms of standard dimensions as specified in the overhead line committee's report of the National Electric Light Association, together with the hardware for cross-arm attachment as specified in this report, should be used by all electrical distribution companies where the wires are supported on cross-arms. The standard sizes are not only those which practice has shown to be suitable for the work; but, even with the greatest care, accidents are bound to happen and an acknowledged standard method of construction is of considerable advantage in defending a lawsuit. The ordinary cross-arm, however, even where of standard dimensions, is not good enough for use with treated poles unless specially selected and treated. An exception to this may possibly be made if the arms are of genuine hard yellow pine. This grade of wood is expensive and very heavy to handle, and, while strong, is not nearly as strong as its weight would seem to indicate. The softer woods, such as stock arms are generally made from, are absolutely worthless unless treated. These arms generally show heart rot first, and may appear perfectly good on the outside and actually be but a shell, which indicates that the weak point is the exposed end grain in the pin holes. To overcome this it naturally follows that any method of treatment must be before the pins are inserted and also that a brush treatment is useless. For treated cross-arms straight grain clear spruce is without doubt the best material. Arms of this wood are very light and exceedingly strong and tough for their weight. If treated with carbolinium oil the wood should be first kiln dried and then immersed in the hot oil until it refuses to absorb any more, several successive baths being given: the final one being in cold oil. The best treatment for cross-arms is, however, that of "Kyanizing," in which the timber is rendered absolutely sterile and will give a life of twenty years or more under most severe climatic conditions. Kyanized timber is to all appearance the same after as before treatment, and must be painted to give a good appearance if used in built up localities as in villages or towns. A Kyanized spruce arm will cost approximately 50 per cent. more than the common stock arms, but, when it is considered that it has from three to four times the life, it becomes an excellent investment, particularly when it is considered that the labor cost of changing an arm may exceed the actual cost of the arm itself. For pinning cross-arms only locust pins should be used and only those with 1½-inch shanks. Oak pins are just about as treacherous as stock cross-arms as they rot off at the shoulder in a short time. When it is considered that a broken pin may cause an interruption to an entire distribution system, and that the proportionate costs of the pins in comparison with total cost of the line is infinitesimal, any attempt at economy on this article is worse than poor engineering, and is, in fact, criminal if the pole line is on a public highway. For the same reason, too much dependence should not be placed on a single pin, and double arms should be used at all angles and junctions, and, preferably, also on the first pole on each side of a strain pole. These double arms should be provided with two spacing or spreader bolts in addition to that holding the arms in position. Various forms of spreaders have been tried out from time to time; but the writer has found the best form to be a wood block with a transverse hole to receive a standard through bolt. These blocks are frequently made in the field from a section of standard cross-arm, but a far better practice is to have them made from 3-inch by 4-inch surfaced stock, treated the same as the arm. The blocks may be made in lengths of from 18-inch to 24-inch, and can then be cut to proper length as required; the 11/16-inch hole being bored through the entire block at the mill.

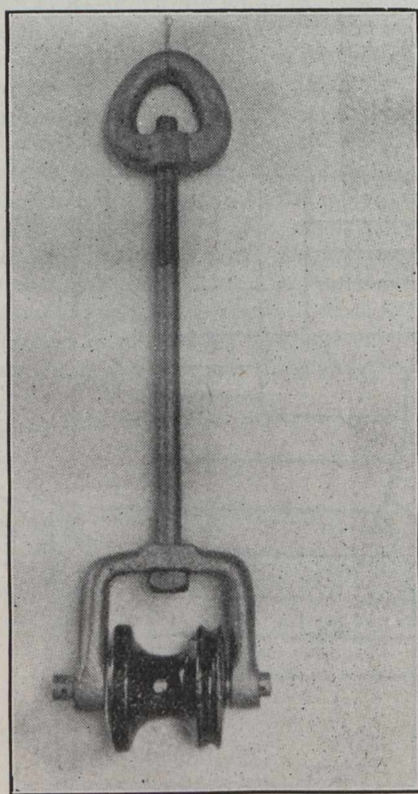


Fig. 3.—Dead Ending Clevis.

Locust wood suitable for pins is becoming so scarce, and, at best, a wood pin is the weakest point in our suspension system, that metal reinforcement or entire metal pins are being used more and more as the demand for permanent construction increases. These pins range all the way from the ordinary wood pin with a ⅜-inch iron rod inserted in it to the all metal pin. Attempts have been made to standardize a metal pin of malleable iron having a 1½-inch shank to fit the old style of arm. This style has not found favor, however, owing to the arm then becoming the weakest point. Malleable pins have also been found objectionable owing to the tendency to split the insulator due to unequal expansion between the iron and the glass or porcelain. In order to overcome this, metal pins with wooden tops are used extensively, the common form being simply the old wood pin cut off at the shoulder and bored to receive a ½-inch carriage bolt. A similar style uses only the threaded portion of wood, the base being a porcelain spool which slips over the bolt. Probably the oldest style of metal pin is the Western Union, which has been standard for many years with telegraph companies. This pin has not, however, the necessary stiffness for electric light work.

(To be continued.)

PRECISE LEVELLING IN CANADA.*

By F. R. Reid, D.L.S.

While this paper has the rather comprehensive title of "Precise Levelling in Canada," it should be explained at the outset that it has special reference to the methods employed and the territory covered by the Geodetic Survey and it is intended to merely touch upon the work of other branches of the Government service along these lines. In this country, the only precise levelling of any extent, so far as I am aware, is that which has been carried out by the Government, though in the United States some of the railways, notably the Baltimore and Ohio and the Pennsylvania Railroad, has undertaken precise level lines of considerable extent on their own account.

This fact, namely, that some of the leading American railroads have gone to the expense of running precise levels for their own benefit, does much to prove the demand for levels of a high degree of accuracy; also, I might say, that while the work has been carried on for only a comparatively short time in Canada—the first work by this Department was done in 1906—and is therefore not very widely known, yet we have had a large number of enquiries for the results, from railway corporations, city engineers, suveyors, consulting engineers and others. While the work is of great use to the public at large it is of equal importance to the Geodetic Survey in the extension of its system of triangulation, and to the various topographical surveys carried on by the Militia and other Government Departments; also to the International Boundary Survey. The making of accurate contour maps of any country is very greatly facilitated by a line or a net of precise levels.

If any further proof were needed for the necessity of this work, a perusal of White's dictionary of "Altitudes in the Dominion of Canada," would furnish a good deal of it. This is a very comprehensive work and has been prepared with great care from the best available information, obtained from many sources. In this preparation, however, many very large discrepancies in the elevations of junction points of railways, &c., were discovered, which it was found impossible to overcome by the use of the information at hand. I will instance three or four cases on the main line of the Canadian Pacific Railway from Vancouver to St. John, N.B.

The elevation published for Donald, B.C., by levels from the Pacific Ocean is 2,586 feet above the sea level, and by levels from Lake Superior, 2,574, a discrepancy of 12 feet. At Cartier, the first divisional point west of North Bay, there is a similar descrepancy of 34 feet between the levels from Lake Superior and from Montreal. At two points on the line through the State of Maine, also, there are discrepancies, one of 18 feet and one of 7 feet. These discrepancies all have the same sign and therefore accumulate in the same direction, to the total amount of 71 feet. While there may be a slight difference in elevation between the Atlantic and Pacific oceans along the respective coast lines, it would certainly amount to but a small fraction of this difference, and an investigation by means of precise levelling would seem to be in order.

Precise levelling is, whenever possible, carried along railway track, rather than along highways or across country, the advantages of this practice being many. The rate of rise and fall of the track is usually fairly uniform and no steep hills are encountered, thus allowing longer average sights to be taken and allowing the backsights and foresights to be easily kept of equal length. The rails furnish excellent support for the levelling rods and thus the time is saved which would otherwise be consumed in putting artificial turning points into the ground. The masonry structures—bridges and culverts—situated along the railways are utilized for placing permanent bench marks; this is of great advantage both to us and to the railway companies. Again, the use of a hand-car for going to and from work and for moving along from point to point during the day affects a great saving of time and labor, and the transportation of the camping outfit from camp to camp by freight is cheaper and more convenient than the method by horse and wagon. Against these and many other advantages may be set the fact that the refraction and boiling of the atmosphere in the heat of the bare ballast and rails of a track is worse than on a highway. Dodging fast trains coming through rock cuts and around curves lends a spice of danger and excitement to the work which would not be found on a country highway.

The levels of the Geodetic Survey in Ontario and Quebec have been started from a bench mark established by the United States Coast and Geodetic Survey at Rouse Point, N.Y. This bench mark is included in an elaborate net of precise levels and water transfers which are based on mean sea level at New York and its adjusted elevation is believed to be very close to the truth. At any rate it is the best available datum at present; eventually the Geodetic Survey may have a mean sea level datum of its own but this is something which requires several years of gaugings to determine accurately.

From Rouse Point two lines of levels have been extended, one westerly through Lacolle Junction, Coteau Junction, St. Polycarpe Junction, Kemptville, Prescott, Hamilton, London and Chatham to Windsor, with a branch from Hamilton to St. Catharines and Bridgeburg; the other line easterly through St. Johns and Sherbrooke to the International Boundary, 15 miles east of Megantic, Que.; branches have been extended from this line to the International Boundary from Farnham, Foster, Sherbrooke and Lennoxville, and from Megantic to the St. Lawrence River at Levis via the Quebec Central Railway. A considerable amount of levelling has been done in New Brunswick and Nova Scotia; starting from the town of St. Stephen a line has been extended northerly to the St. Lawrence River at Riviere du Loup, this line runs for most of its length within a short distance of the border of the State of Maine and branches have been connected at intervals so as to furnish accurate levels for the International Boundary survey. Easterly from St. Stephen the line has been extended through St. John and Moncton and through Nova Scotia as far east as Mulgrave, on the Strait of Canso.

All the elevations in the Maritime Provinces are based—provisionally— on a bench mark at St. Stephen, N.B., established by the United States Corps of Engineers; connections have been made at Riviere du Loup and Moncton with the precise levels of the Public Works Department of Canada which have been carried from Montreal to Halifax via the Intercolonial Railway; these levels are connected with the Rouse Point bench mark and also with mean sea level at Halifax. The fact that our levels agree very closely with theirs goes to show that the St. Stephen bench mark is very near correct and that the elevations of our bench marks throughout the Maritime Provinces are very close to the truth and of far greater accuracy than is necessary for ordinary engineering and surveying purposes. Last summer a start was made at levelling along the Grand Trunk Pacific Railway, from its junction with the Quebec Central Railway on the Megantic-Levis line to the town of Edmundston, N.B., on the St. Stephen—Riviere du Loup

*Paper read before the Ottawa Branch of the Royal Astronomical Society.

line, a distance of some 230 miles— through a very rough country. It is hoped that this link may be finished during the present season and then all the bench marks in the Maritime Provinces may be corrected by a small constant quantity, which will reduce them to the same datum as those throughout Ontario and Quebec, and will form one net of levelling extending from the Maritime Provinces to Western Ontario.

In Western Ontario, two circuits, composed entirely of our own levelling, have been completed, and the excellent results—shown by the small closing error—are a source of great satisfaction. As mentioned above, a main line of levels extends from Toronto to Windsor, along the Grand Trunk Railway through Hamilton, London and Chatham; a branch line leaves this at Toronto and extends along the Canadian Pacific Railway to Owen Sound, thence southerly along the Grand Trunk Railway, through Palmerston, Listowel and Wingham to a connection with the main line at Hyde Park Junction, 4 miles west of London. Another line leaves the Owen Sound-Hyde Park line at Lucan Crossing, 15 miles north of Hyde Park Junction, and extends through Sarnia to Chatham, where a second connection is made with the main line. The new elevation found for the bench mark at Hyde Park Junction is 0.15 feet higher than the original elevation and at Chatham 0.11 feet lower than the original. The length of the Toronto-Hyde Park circuit is about 436 miles and the length of the Toronto-Chatham circuit about 595 miles so it may easily be seen that the levelling shows a high degree of precision in actual practice.

In the spring of 1910 levelling was inaugurated in the Western Provinces. To secure a sea level datum for this work it was found necessary to go to the town of Stephen, Minn., about 45 miles south of the International Boundary at Emerson, Man. The precise levels of the United States Coast and Geodetic Survey having been extended to this point, furnished what was desired. It was necessary to carry the levels through United States territory to the International Boundary at Emerson, the boundary was then followed to Gretna, a few miles west, and the railways paralleling the boundary followed westerly from that point. As in the case of the Maine and Vermont boundaries, so here, branch lines have been run at convenient intervals for the benefit of the International Boundary Survey. The levelling, at the close of last season, had reached the village of Frobisher, Sask., about 27 miles east of Estevan, on the Canadian Pacific Railway.

Returning to Ontario, the programme for the present season, includes running from Bolton on the Toronto-Owen Sound line, towards Sudbury via Canadian Pacific Railway, and it is hoped that this line will eventually be extended west to connect with the line mentioned above as running west from Emerson; this will, however, be the work of several years owing to the great distance involved.

From a consideration of the various routes outlined above, it will be seen that the general policy has been to extend main trunk lines of levels throughout the country at first, putting in branches where necessary for the immediate use of the Boundary Survey or other public works; as these lines are completed, duplicate lines may be run and circuits of levelling closed. In selecting routes between terminal points it has been usual to follow the line which passes through the best settled country and includes the greater number of towns and cities; though in a few cases this policy has been departed from in order to connect with outside bench marks or to avoid paralleling work which has been done by the Public Works Department, as in the case of the line between Coteau Junction, Que., and Prescott, Ont.; that Department had levelled from Coteau to Cornwall, consequently, to avoid duplication, the levels of the Geodetic Survey were carried around by St. Polycarpe and Kemptville an extra distance of about 19 miles.

The Public Works Department has conducted precise levelling at intervals since 1883. During the years 1904-05-06 a long line of levels, starting from the Rouse Point bench mark, was extended through Ottawa and Pembroke to North Bay, for use in the extensive surveys undertaken by the Department for the purpose of locating and determining the cost of the projected Georgian Bay Ship Canal; this line was checked by a line from Toronto to North Bay, starting from a bench mark at Toronto which had been established by means of water transfers from Tibbett's Point, N.Y., at the eastern end of Lake Ontario.

Precise levelling was carried on by the International Boundary Survey in connection with the survey of the 141st meridian, the boundary between Canada and Alaska, in 1908-09-10. Starting from White Pass, B.C., levels were carried along the White Pass and Yukon Railways to White Horse and thence by wagon road to Dawson and over the glacier trail to the 141st meridian; the total distance levelled was in the neighborhood of 500 miles, but this distance does not give a proper idea of the amount of labor involved, owing to the fact that most of the work was not on a railway track but on rough trails through an uncivilized country.

The instruments and methods employed on this work were practically the same as those in use by the Geodetic Survey, modified when necessary to suit the different conditions under which the levelling was performed.

Bench Marks.—In the foregoing, mention has been made of the bench marks established; it will now be in order to say something of the nature of these—the only permanent field records of the work performed.

The standard bench mark established by the Geodetic Survey, previous to the year 1908, consists of a copper bolt ½ inch in diameter and 4 inches long, stamped on the end with the letters "B.M., D.A.O." (Bench Mark, Dominion Astronomical Observatory). During 1908 and since then the standard bench mark has been a copper bolt, ¾ inch in diameter and 4 inches long, stamped on the end with the letters "G.S.C., B.M.." (Geodetic Survey of Canada, Bench Mark). In either case the bolt is sunk horizontally in rock or masonry, a hole being drilled of the exact size of the bolt or a shade larger and the latter hammered in till it completely fills the hole, the end being flush with the surface of the masonry or projecting slightly; properly put in, it is impossible for anyone to remove it without destroying the surrounding rock or masonry. After the exposed end has been planed to a smooth surface by means of a file it is stamped with a steel die containing the above mentioned letters; then a horizontal cross mark is made with a cold chisel, upon which the elevation is taken; finally a number is stamped with other steel dies. The question is often asked "Why do you not indicate the elevation of the bench mark also?" In reply to this I would say that the elevation of a bench mark in a precise levelling net may never be finally determined; the closing of circuits and introduction of new cross lines will always call for adjustments which will make changes of greater or less magnitude in the elevations; it would therefor be impossible to place more than an approximate figure upon it. Also the computation of the elevations from the field notes is a work of some magnitude and would delay the operations of the parties were it performed in the field, and is therefore left to be done in the office after the notes have all been carefully checked. I might say also that an engineer would not usually attempt to look for the bench marks haphazard, but would secure descriptions of their locations; when getting these, the elevations can always be secured at the same time without difficulty. Bench marks are placed in the stone and concrete structures along the railways, sometimes in large boulders and in rock cuts, and when towns or cities are situated within a reasonable distance of the line, branch lines are run to them and bench marks placed in public buildings such as post offices, court houses, and churches. Levellers are instructed to place bench marks at distances of three miles apart, or less. It has been found impossible however, in many cases, to secure good locations for bench marks at anything like this distance apart, so the expedient was adopted by us in Manitoba in 1910, and in this part of the country in 1911, of building concrete piers, specially for bench marks.

These piers are 6′ 3″ high, 9″ square at the top and 15″ square at the bottom, resting on a 6″ concrete footing; the whole pier is buried to within about 9″ of the top and the copper plug built in, near the ground surface, having been previously stamped and numbered. The piers are usually built on the railway right-of-way, within 3 or 4 feet of one of the fences and on fairly level ground, where they will not be exposed to danger from future alterations in the railway grade. The concrete consists of a mixture of one part cement, 2 parts sand, and 5 parts gravel, the latter ingredients can often be secured by sifting the ballast on the track. Portable wooden forms are employed which can be removed after the concrete has set and used over again; the total time consumed building a pier, including the excavating, removing the forms and back-filling, averages between half a day and one day, probably nearer the latter.

The piers are not built at any definite distance apart; it is left to the discretion of the leveller to put them in where they appear to be necessary.

Temporary bench marks are placed at intervals of one mile or thereabouts, they consist usually of spikes, driven horizontally into telegraph poles, and, as their designation implies, they are used only for convenience while the work is progressing; they are not embodied in the final office record.

The permanent bench marks above described are neat and unobtrusive, not likely to be discovered and defaced by unauthorized persons, but easily found by anyone furnished with a description, and are therefore well adapted for use in a settled country like that in which most of the work of the Geodetic Survey has been carried on.

For use along the Alaska Boundary, however, they were not considered suitable, owing to the absence of masonry structures and for other reasons, so a different form of bench mark was employed, being a circular copper plate 4″ in diameter with a stem at right angles to the plate and about 3″ long; the plate was placed flat on top of a surface of rock, the stem being solidly cemented into a hole drilled for that purpose; the elevation was taken on top of a knob at the centre of the plate. When suitable rock could not be found the copper plate set on the top of an iron post which was firmly planted in the ground, projecting a short distance above the surface. Bench marks were put in at distances of 10 miles or thereabouts.

The bench mark used by the Public Works Department is similar in form to that of the Geodetic Survey, but contains no mark on its exposed surface but the cross mark upon which the elevation is taken, the number of the bench mark is cut in large Roman numerals upon the masonry adjoining it.

Instruments.—The instrument adopted is a precise level very similar in design to that used by the United States Coast and Geodetic Survey. It may be described as a modification of the engineer's dumpy level in that the telescope is firmly attached to its supports and is not removable as in a wye level. The materials used are nickel-iron, an alloy consisting of 36 parts nickel and 64 parts iron and nickel-steel (or Invar) an alloy of the same proportions of nickel and steel. The latter alloy is used for the mountings of the level vial, for the collars, diaphragms, adjusting screws and any other parts required to retain their relative positions as nearly as possible. The co-efficient of expansion of these alloys—especially nickel-steel is exceedingly small.

The instrument base is a single piece of hard and finely grained cast-iron and is supported by the three levelling screws. The instrument centre is of unusual length and passes down through a hole in the tripod head, thus allowing the telescope to rest low down—near the tripod— and giving greater stability to the instrument when used in a wind. The telescope itself is completely enclosed in an outer tube in which it is allowed a small motion vertically; it is supported at the object glass end by a horizontal pivot and at the other end rests on the point of a fine micrometer screw by means of which it may be raised or lowered by an exceedingly small amount. When the instrument is not in actual use and is being carried from station to station the telescope tube is lifted from the point of the micrometer screw by means of a small lever; this keeps the telescope pressed tightly against the upper part of the casing and saves the point of the screw from wear. At the lower end of the screw a drum or micrometer head, subdivided by a hundred graduations, is provided. The upper part of the outer casing has cast into it a rectangular opening with a framing surrounding it; a piece of plate glass fitted into this framing in grooves closes the opening against dust or air currents, but can be quickly removed, when necessary, for the purpose of adjusting the level. The tube containing the level vial is set within this opening, as close to the line of collimation as possible. This position of the vial has the advantage of protecting it, to a large degree, from sudden changes of temperature. A small rectangular mirror placed above and parrallel to the level tube, reflects the bubble into two prisms placed in a tube immediately to the left of the telescope tube. By this means the observer is enabled to watch the action of the bubble with his left eye while reading the rod with his right eye; that is, he can transfer his attention instantaneously from the one to the other. The level vial is constructed with a small chamber at one end communicating with the body of the vial by an opening at the edge of the tube; by tilting the instrument so as to raise one end of the vial the spirit can be raised to run to or from the chamber; in this way the length of bubble used may be kept constant throughout the varying temperatures of the day or the season. This adds to the refinement of the work, as the grinding of the vial is more accurate near the centre and it is consequently not well to allow the bubble to lengthen out too much. One division on the level vial has a value of about 2½ seconds in arc.

Three cross wires of fine spider web are placed in the diaphragm, in order that three readings of the rod may be made at each observation. Two eye-pieces, of different powers of magnification, are provided; the high power to be used under ordinary atmospheric conditions, and the low power when the trembling and boiling of the atmosphere, due to heat waves, is unusually severe.

Great care has been expended on the construction of the rods used up on this work. They are built up of separate pieces of white pine giving a cross section in the form of a symmetrical cross so as to prevent bending and warping; they are boiled thoroughly in paraffin which tends to keep them of constant length under varying conditions of atmosphere and temperature. Silver plugs are inserted in the face of the rod approximately at the three, six and nine foot points and the exact position of these points marked by a fine scratch on the face of the plug; the rod is then subdivided into feet, tenths and hundreths in alternate white and black spaces of one one-hundreth of a foot. When observing the rod the readings are made to thousandths, the hundreth spaces being subdivided by estimation. As it is impossible to subdivide a black space accurately at the distance the rod is usually observed, two sets of graduations are placed, side by side, one on each side of the centre line of the rod, the white spaces of one adjoining the black spaces of the other; thus the observer has always a white space to subdivide by reading on the right hand or the left hand set of graduation marks, as the case may be. The bottom of the rod is formed of a cast steel foot block with a hemispherical knob on the bottom, suitable for holding on flat surfaces.

Another piece of apparatus which can hardly be classed under the heading of instruments, but which is very necessary nevertheless, is a large carriage umbrella with a handle about 8 feet long, provided with a spike at the end to insert it in the ground. The umbrella is used whenever the sun is shining while observations are in progress to shade the instrument from its rays; without this the parts would become unequally heated and irregular and unreliable action of the bubble would follow.

While carrying the instrument between sights a cover of duck or cravenette is used for the same purpose, this also is used to protect it when working during a light rain; in a heavy rain the work has to be discontinued.

Field Operations.—A precise levelling party consists of 7 men, the observer, the recorder, umbrella man, two rodmen, cook and railway man, usually a section man or brakesman, to pilot the hand-car. Camps are made at the stations along the line, the distance apart of camps varying from ten to twenty miles according to the location of towns and villages and to the condition of the intervening track or to grades. The levelling is carried continuously forward, day by day through the camp and to a point about half way to where the next camp ahead will be; permanent and temporary bench marks being put in so as to divide the line into sections of one mile or less. From this point backward levelling is commenced and carried along to the point where the line was taken up, probably about half way from the previous camp, all bench marks being checked upon on the backward run.

I will quote from the general instructions issued to levellers:—"All lines are to be levelled twice, in opposite directions called forward and backward levelling. Backward shall in every respect be independent of forward levelling and the same tuning points shall not be used. If the forward levelling is made in the forenoon, the backward—over the same section—should be made in the afternoon. In this respect the opposite conditions as to intensity of light are desirable, but the work must not be delayed for this purpose........................ When a discrepancy in the thread intervals, or any other error is discovered, even although the nature of the error may appear to be self-evident, the section involved must be re-levelled from the preceding bench mark, and the word "cancelled" written across the page of the level book containing the readings along the discarded section.

"The field books shall in every respect be self-evident records of the work on the ground. The difference of elevation, as indicated by forward and backward levelling—between two permanent bench marks—shall correspond within 0.017 square root of M—feet, M being the distance in miles between the benches.

"If the difference between a forward and backward levelling is greater than allowed, the section shall be levelled anew, both forward and backward, until two measurements within the limit of error are secured. In this way, four, six, or more measures are made, the mean of all being taken and the individual residuals determined. Reject all those results whose residuals are greater than 0.015 feet; then take a mean of the remaining measures for a final result."

This requirement, that the discrepancy shall be within 0.017 times square root of the distance in miles has been adhered to as closely as possible through out the work; this means that for 1 mile forward and backward levels shall correspond within 0.017 foot, for 4 miles within 0.034 foot, for 100 miles within 0.170 foot and so on. Quite frequently the total discrepancy of a line shows a constant, and often unaccountable, tendency to accumulate in one direction. Various precautions are used to guard against this. If, when reading from the successive instrument stations, or set up points, the rear rod were always read first and the forward rod last, any settlement of the level between the backsight and foresight would have a constant tendency to make the foresights too small in comparison with the backsights, and on the backward levelling this effect would be repeated, causing the discrepancy to accumulate rapidly; this is obviated by reading on the rear rod first at one station and on the forward rod first at the next station so that any settlement at one will be counteracted by the settlement at the next; this method also has the advantage of eliminating the effect of a uniformly changing refraction in the atmosphere, such as usually occurs most noticeably in the early morning and late afternoon hours. It of course has the effect of holding back the progress of the work considerably, a at every second set up the leveller has to wait for the front rodman to reach his turning point, and afterwards wait for the rear rodman to ovetake him before going forward (these remarks are intended to apply where the levelling is carried along a railway track and a hand-car used between sights). However, in precise levelling, accuracy is the first consideration and speed is secondary.

(To be continued.)

EDMONTON INVESTIGATES TOFIELD'S GAS SUPPLY.

A heavy flow of natural gas has been struck at the town of Tofield, on the main line of the Grand Trunk Pacific, forty miles east of Edmonton. The town has been conducting boring operations as a municipal enterprise for about a year past. For some time strong indications of gas were evident, and it was obtained in comparatively small quantities, and could not be considered a commercial proposition until a few days ago, when there was encountered an enormous flow under very heavy pressure. The volume of the flow is variously estimated at from 1½ to 2 million feet per day. Edmonton city council has taken action with a view to obtaining expert information as to the practicability of piping this gas into the city. The city is about to embark on the installation of a municipal gas plant. The work will be immediately proceeded with so far as the mains are concerned; but action on the ordering of the generating plant will be suspended until the possibilities of the Tofield discovery have been investigated.

Practically at the same time a strike of gas in large volume and under heavy pressure was made at Pelican Rapids, about 175 miles north of Edmonton, on the Athabasca River. Boring has been going on there for oil in the interests of a syndicate of Edmonton capitalists, and will be proceeded with, with the expectation of finding oil in strata below.

ELECTRIC POWER FOR ST. JOHN, N.B.

An engineer has stated that a head of 100 feet of water could be got at Silver Falls on the line of the city waterworks system, and a constant pressure secured by the construction of storage dams. The city council is considering the question of generating electricity at this point, in order that the city might provide its own electric light system. The council has awarded contracts for permanent paving on portions of several streets, and this policy will be continued from year to year. City government under the commission plan is thus far working out satisfactorily in St. John, and much more so than the old city council system with ward representation.

Mr. D. McNicoll, general manager of the Canadian Pacific Railway, visited St. John last week and stated that the plans for the new million-bushel elevator had been completed, and the contract would be awarded very soon. A crib-work has been constructed, and the Maritime Dredging Company has been awarded the contract to fill in a section of the shore flats at West St. John, where the elevator will be built.

At East St. John the sub-contractors for the breakwater and the excavation for the drydock have just installed the heaviest construction plant ever seen in St. John. It was brought from Ohio and includes a steam shovel weighing 110 tons. Hundreds of men are now employed there. At West St. John Contractor Michael Connolly has brought from Quebec a complete modern plant for concrete wharf construction, and has the heavy crib-work foundations for the new wharves which he is to build well under way.

The Furness steamer Rappahannock has just taken from St. John a shipment of fifty thousand bushels of grain for London. It is expected that each steamer of this line during the summer will take about the same quantity, and this will be a test of the suitability of St. John as a summer port for grain shipments.—W.E.A.

PERSONAL.

MR. DE GASPE BEAUBIEN has been appointed as representative of the city of Montreal on the Electric Service Commission, to succeed Mr. Beaudry Leman.

CORRECTION.

In May 9th issue of The Canadian Engineer, on page 636, the formulae should read as follows:

$$\frac{\left\{\frac{A^{I}B^{I} + A^{II}B^{II}}{2} \times A^{I}A^{II}\right\} + \left\{\frac{C^{I}D^{I} + C^{II}D^{II}}{2} \times C^{I}C^{II}\right\}}{2} \times$$

$$\frac{(C^{I}C - A^{I}A) + (D^{I}D - B^{I}B) + (D^{II}D - B^{II}B) + (C^{II}C + A^{II}A)}{4}$$

$$\times \frac{62.5}{2{,}000} = \text{Displacement in tons.}$$

which can be expressed in a somewhat simpler manner:

$$\frac{\left\{\begin{matrix}\text{Area of boat}\\ \text{on loaded water lines}\end{matrix}\right\} + \left\{\begin{matrix}\text{Area of boat}\\ \text{on light water lines}\end{matrix}\right\}}{2} \times$$

$$\left\{\begin{matrix}\text{distance}\\ \text{between the}\\ \text{two planes}\end{matrix}\right\} \times \frac{62.5}{2{,}000} = \text{Displacement in tons}$$

INTERNATIONAL GEOLOGICAL CONGRESS.

The International Geological Congress, on the joint invitation of the Government of Canada, the Provincial Governments, the Department of Mines, and the Canadian Mining Institute, will hold its twelfth meeting in Canada during the summer of 1913.

For purposes of organization, a meeting of representatives from various scientific bodies of Canada was held in Toronto, Ontario, on December 2nd, 1910.

Field Marshal, His Royal Highness the Duke of Connaught, Governor-General of the Dominion of Canada, has graciously consented to become honorary president.

It is proposed to hold the meeting of the congress in Toronto, beginning on or about the twenty-first day of August. The congress will continue in session for eight days.

Since the first meeting of the congress in Paris, in 1878, meetings have been held in Italy, Germany, England, the United States of America, Switzerland, Russia, Austria, Mexico and Sweden. At the last congress held in Stockholm, in 1910, there was on attendance of 850, and it is expected that this number will be exceeded in Canada next year.

An extensive series of excursions is being arranged to illustrate the typical geology and mineral resources of Canada. These excursions will take place during August and September and will extend from Cape Breton and Halifax on the Atlantic to Prince Rupert and Victoria on the Pacific, and from Niagara Falls on the southern boundary to Dawson City near the Arctic Circle.

Geologists from every quarter of the globe will attend the congress, and for many it will be their first visit to Canada. They will include professors from the leading universities and mining schools, officers of the various government geological surveys and mining departments, and geologists and mining engineers in private practice.

Topics for Discussion.—The following topics have been selected by the executive committee as the principal subjects for discussion:—

1. The coal resources of the world.
2. Differentiation in igneous magmas.
3. The influence of depth on the character of metalliferous deposits.
4. The origin and extent of the pre-Cambrian sedimentaries.
5. The sub-divisions, correlation and terminology of the pre-Cambrian.
6. To what extent was the Ice Age broken by interglacial periods?
7. The physical and faunal characteristics of the Palæozoic seas with reference to the value of the recurrence of seas in establishing geologic systems.

The executive committee of the eleventh congress, held in Sweden, compiled and published a comprehensive report on the Iron Ore Resources of the World. The present executive has undertaken the preparation of a similar monograph on the Coal Resources of the World. In order to make the work as complete as possible the co-operation of all the principal countries of the world has been invited. This invitation has met with a cordial response, and it is hoped the volumes will be ready for distribution before the meeting so that they may constitute a basis for discussion at the congress.

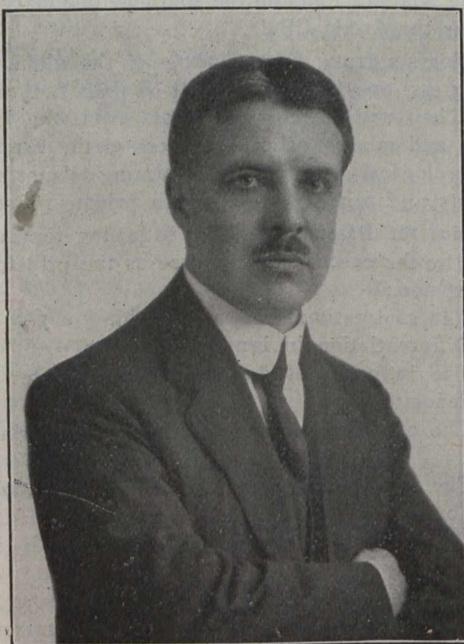
The secretary will be pleased to answer all enquiries regarding the arrangements for the congress. Correspondence should be addressed as follows:—

The Secretary, International Geological Congress,
Victoria Memorial Museum, Ottawa, Canada.

THE NEW CHIEF COMMISSIONER OF THE DOMINION RAILWAY BOARD.

Henry L. Drayton, K.C., one of Canada's representative attorneys, was born at Kingston, Ontario, Canada, April 27th, 1869. His father, Philip Henry Drayton, K.C., is of English birth and ancestry, and came to Canada as captain of the 16th Rifles of England, being stationed at Kingston, Ont. He retired from the Rifles in 1871, moving to Barbadoes, residing there until 1874, when he returned to England, and in 1877 moved to Toronto, entering the law firm of McMurrick and Drayton. He is at present official arbitrator of the city of Toronto. On the maternal side Margaret S. (Coventon) Drayton, is of Irish-Canadian lineage.

Henry L. Drayton was educated at the schools of England and Canada, and began his career as a law student in 1886, at Toronto, with the legal firm of Lount & Marsh. He was admitted to the Bar of Ontario in 1891, and at once entered in the practice of his profession. In 1893 he became assistant city solicitor, under C. R. W. Biggar, K.C., and subsequently under Sir William Meredith, K.C., and J. S. Fullerton, K.C. In September, 1900, he retired and went into partnership with Charles J. Holman, K.C. On the 29th of January, 1904, he was appointed county crown attorney for county of York, resigning from that office in November, 1909, to resume the practice of law with C. J. Holman, K.C. On January 20th, 1908, Mr. Drayton was appointed a K.C.



Mr. Henry L. Drayton, K.C.

April 25th, 1910, he was appointed counsel to corporation of Toronto, which position he now ably fills. He was appointed by the Ontario Government a member of the Toronto Power Commission on May 11, 1911.

He is a member of Toronto Club, Toronto Hunt Club, Ontario Jockey Club, Rosedale Golf Club, Glen Major Fishing Club, Toronto Racquet Club, and Engineers' Club, of Toronto.

Mr. Drayton was married to Edith Mary (Cawthra) daughter of Joseph Cawthra, of Toronto, September 14th, 1892, and they are the parents of three children, Grace Drayton, Nora Drayton and Margaret Drayton.

Mr. Drayton will take up his duties as chief commissioner of the Dominion Railway Board about September 1st.

WESTERN CANADA IRRIGATION ASSOCIATION.

SIXTH ANNUAL CONVENTION.

The Western Canada Irrigation Association will hold its sixth annual convention in the city of Kelowna, Okanagan Valley, B.C., August 13, 14, 15 and 16. The meeting will convene on the evening of the 13th, at 8 o'clock.

An excellent programme of addresses has been arranged, papers having been promised by the following:—

Professor Alfred Atkinson, Department of Agronomy, Montana Agricultural College and Experimental Station, Bozeman, Montana, "The Irrigation of Alfalfa."

Rev. E. McQueen Gray, foreign secretary, National Irrigation Congress, professor University of New Mexico, Albuquerque, N.M., "Foreign Government Reclamation."

William Pearce, former president of the association, and member of present executive.

Professor C. I. Lewis, State Agricultural College, Oregon, "The Relation of Irrigation to Fruit Growing."

P. H. Moore, superintendent Government Experimental Farm, Agassiz, B.C., "Stock and Dairying, with Special Relation to Irrigation Farming."

M. L. Dean, State Horticulturalist, Missoula, Montana, "Apple Culture and the Baldwin Spot."

A. E. Ashcroft, chief engineer, White Valley Irrigation and Power Co., Vernon, B.C., "Public Ownership and Irrigation Systems."

R. D. Prittie, superintendent Forestry, Department Natural Resources, C.P.R., Calgary, "Irrigation as Applied to Forestry."

R. M. Winslow, Provincial Horticulturist, Victoria, B.C., "Some Climatic Conditions Influencing the Duty of Water in British Columbia."

Professor Elliott, Superintendent of Agriculture, Department of Natural Reosurces, C.P.R., Strathmore, Alberta, "Irrigation and Intensive Farming."

F. H. Peters, Commissioner of Irrigation, Dominion Government, Calgary, "The Proper Duty of Water and the Necessary Irrigating Head in Western Canada."

N. E. Webster, with Messrs. Niles and Niles, public accountants, New York, "Irrigation Accounting."

John T. Burns, executive secretary, International Dry Farming Congress, Lethbridge, Alberta.

Dr. Samuel Fortier, chief of irrigation investigations, Experimental Station Branch, United States Department of Agriculture, one of the foremost irrigation experts on the continent, whose advice in connection with administration of water matters in British Columbia has been solicited, will address the convention.

A list of delegates should be sent in to the secretary, P.O. Box 1317, Calgary, as early as possible, which list should contain, in addition to the names, the post office address and occupation of each delegate. Norman S. Rankin, permanent secretary.

OBITUARY.

CECIL B. SMITH, Ma.E.

By the death of Cecil B. Smith, Canada has lost one of her most promising civil engineers; taken suddenly just at the stage when his reputation in the special field of hydro-electric development was being recognized as international.

Mr. Smith was born at Winona, Ont., in 1865, his father, Sylvester Smith, being a respected farmer of Wentworth county. His first education was received at the Collegiate Institute, at Hamilton, whence he went to McGill University. He graduated in 1884, receiving first honors and being awarded the Governor-General's medal.

He at once entered on his chosen field in which he was to achieve such distinction. Beginning with railway work as resident engineer on the Northern and Pacific Junction of Ontario (now a section of the C.P.R.) he took work on the construction of the St. Catharines and Niagara Central Railway, and then, attracting the attention of the late W. T. Jennings, was offered work on the C.P.R. at London, Ont. He was next appointed locating engineer of the Toronto, Hamilton and Buffalo Railway in 1888-9. Having in the meantime done some work on the Welland Canal, under the late Thomas Munro, and on the Montreal harbor works under John Kennedy, Mr. Smith sought a wider field of railway experience in the United States, where, between 1889-93 he was divisional engineer of the C.C. & C.R. of Tennessee; chief assistant engineer of the Roanoke Southern Railway of North Carolina, and assistant engineer of the Baltimore and Ohio, in charge of construction, at Morganstown, West Virginia. Returning to Canada in 1893, he was appointed assistant professor of civil engineering at McGill University, being a lecturer on engineering and having charge of cement testing and strength of materials. In the following year he received the degree of Master of Engineering, and in 1895 he began a series of articles on railway work in *The Canadian Engineer*. These articles were in such request that they were reprinted in book form in 1899, under the title "Railway Engineering." This work won immediate recognition by being adopted as a text book in various universities and technical colleges in Canada and the United States. Mr. Smith's ambition could not be confined within college walls, and in 1899 he came to Toronto as assistant city engineer in charge of the sewage system. In 1901 he entered the hydro-electric field, having been appointed construction engineer of the Canadian Niagara Power Co., then one of the three greatest power installations of America. His clear insight into the problem of electric power and its distribution for public use led him to outline plans which, through the courage of Hon. Adam Beck, brought about in later years the Hydro-Electric Commission, which made Ontario the pioneer in legislative experiments in electric transmission. Mr. Smith himself became chief engineer of the Hydro-Electric Commission, and, though not personally in favor of the whole programme afterwards carried out, was a member of the commission through which electrical power was furnished to municipalities in Ontario under government auspices.

Upon the defeat of the Ross Government *The Canadian Engineer*, joined by many men of practical experience, advocated the abolition of political appointments in the control of the Ontario Government railways, and Mr. Smith was happily appointed to take charge of the Temiskaming and Northern Ontario Railway. Here his grasp of problems of railway operation, as well as of construction, were demonstrated, and he soon brought order out of confusion and established this road as the first profit-making government railway in Canada. In 1905 he was appointed chairman of the commission formed to manage this line, and held the post till 1907.

Mr. Smith's services were now in wide demand in hydro-electric work, and he was chosen by the council of Winnipeg to lay out the 60,000 horse-power transmission plant for that city. Having in the meantime formed the engineering firm of Smith, Kerry and Chace, Toronto, he and his associates laid out and, in some cases, financially organized various power plants, among which may be mentioned the Trenton Power Co., the Seymour Power Co., Sydney Power Co., Nipissing Power Co., British Canadian Power Co., supplying power to mines in Cobalt region; the Calgary Power Co., the municipal power plants at Lethbridge and Revelstoke, and other places. He also organized the Mount Hood Railway and Power Co., of Portland, Ore., of which he was general manager and vice-president; and the Crane Falls Power and Irrigation Co., of which he was president, and by which a great tract of heretofore arid land in Idaho is now being converted into a garden by irrigation, while urban comforts are distributed through the new settlement by electricity. Mr. Smith was managing director of the Calgary Power Co., and president of the Nipissing Power Co., as well as a director of other companies.

He was a member of the Institution of Civil Engineers of Great Britain, and a member of the American Society of Civil Engineers. He was a past vice-president of the Canadian Society of Civil Engineers, and among his contributions to this society was a paper describing the Canadian Niagara Power Co.'s plant, which was awarded the Czowski medal of

The Late Cecil B. Smith, Ma.E.

the society. Mr. Smith was not a voluminous participant in the discussions of the society, but his contributions were marked for their pertinence, simplicity of language and clearness of statement. He was president of the Engineers' Club of Toronto, but did not seek the presidency of the society as he held that such honors should be reserved for the elders of the profession.

In 1887 Mr. Smith married Miss Mary M. Dempsey, of Hamilton, whose grandfather was the first settler at Milton, Ont., in 1818. He is survived by his widow and two sons, now growing to manhood. His only brother is Mr. E. D. Smith, formerly M.P. for South Wentworth, who has attained a distinction in the Canadian fruit industry corresponding to that of his brother in the engineering field. Mr. Smith leaves also four sisters, Mrs. Shortt, wife of Dr. Adam Shortt, chairman of the Civil Service Commission, Ottawa; Mrs. H. Coon, Weston, and the Misses Gertrude and Violet Smith, of Hamilton.

Mr. Smith's death was comparatively sudden. During the last year or two he had complained of internal pains, but they did not affect his work till, on a trip to the Pacific Coast three weeks before his death, he was taken ill at Los Angeles and a specialist being consulted his malady was pronounced to be cancer and the specialist warned him that an operation would be fatal, as the cancer had invaded the liver and almost completely blocked up the stomach. On his return to his home in Toronto the best medical advice was sought but no hope could be held out that human skill would avail to prolong his life. Thus, a man in the very zenith of his intellectual powers, on the threshold of a world-wide fame, is cut down when the prizes of life are all within his grasp—an event that must humble the ambitious, and leave the mind in awe of the mysterious dispensations of Providence.

COMING MEETINGS.

THE WESTERN CANADA IRRIGATION ASSOCIATION.—Sixth Annual Convention Kelowna, Okanagan Valley, B.C., August 13, 14, 15 and 16, 1912. Secretary, Normon S. Rankin, P.O. Box 1317, Calgary, Alta.

THE UNION OF CANADIAN MUNICIPALITIES.—August 27, 28 and 29. Meeting at City Hall, Windsor, Ont. Hon. Secretary-Treasurer, W. D. Lighthall, K.C.

CANADIAN FORESTRY ASSOCIATION.—Convention will be held in Victoria, B.C., Sept. 4th-6th. Secy., James Lawler, Canadian Building, Ottawa.

CANADIAN PUBLIC HEALTH ASSOCIATION.—Second Annual Meeting to be held in Toronto, Sept. 16, 17 and 18.

ROYAL ARCHITECTURAL INSTITUTE OF CANADA.—Annual Assembly will be held at Ottawa, in the Public Library, on 7th October, 1912. Hon. Sec'y, Alcide Chaussé, 5 Beaver Hall Square, Montreal, Que.

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

EIGHTH INTERNATIONAL CONGRESS OF APPLIED CHEMISTRY.—Opening Meeting, Washington, D.C., September 4th, 1912. Other meetings, Business and Scientific, in New York, beginning Friday, September 6th, 1912 and ending September 13th, 1912. Secretary, Bernhard G. Hesse, Ph. D., 25 Broad Street, New York City.

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

ENGINEERING SOCIETIES.

CANADIAN SOCIETY OF CIVIL ENGINEERS.—413 Dorchester Street West, Montreal. President, W. F. TYE: Secretary, Professor C. H. McLeod.

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

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

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

TORONTO BRANCH—96 King Street West, Toronto. Chairman, T. C. Irving; Secretary, T. R. Loudon, University of Toronto. Meets last Thursday of the month at Engineers' Club.

VANCOUVER BRANCH—Chairman, C. E. Cartwright; Secretary, W. Alan, Kennedy; Headquarters: McGill University College, Vancouver.

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

WINNIPEG BRANCH—Chairman, J. A. Hesketh; Secretary, E. E. Brydone-jack; Meets every first and third Friday of each month, October to April, in University of Manitoba, Winnipeg.

MUNICIPAL ASSOCIATIONS

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

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

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

THE UNION OF CANADIAN MUNICIPALTIES.—President, W. Sanford Evans, Mayor of Winnipeg; Hon. Secretary-Treasurer, W. D. Lighthall, K.C., Ex-Mayor of Westmount.

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

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

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

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

UNION OF ALBERTA MUNICIPALITIES.—President, Mayor Mitchell, Calgary.; Secretary-Treasurer, G. J. Kinnaird, Edmonton, Alta.

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

CANADIAN TECHNICAL SOCIETIES

ALBERTA ASSOCIATION OF ARCHITECTS.—President, G. M. Lang Secretary, L. M. Gotch, Calgary, Alta.

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

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

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

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

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

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

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

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

CANADIAN FORESTRY ASSOCIATION.—President, John Hendry, Vancouver. Secretary, James Lawler, Canadian Building, Ottawa.

CANADIAN GAS ASSOCIATION.—President, Arthur Hewit, General Manager Consumers' Gas Company, Toronto; J. Keillor, Secretary-Treasurer, Hamilton, Ont.

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

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

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

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

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

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

CANADIAN STREET RAILWAY ASSOCIATION.—President, Jas. Anderson, Gen. Mgr., Sandwich, Windsor and Amherst Railway; Secretary, Acton Burrows, 70 Bond Street, Toronto.

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

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

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

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

ENGINEERING SOCIETY, TORONTO UNIVERSITY.—President, J. E. Ritchie; Corresponding Secretary, C. C. Rous.

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

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

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

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

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

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

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

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

ONTARIO PROVINCIAL GOOD ROADS ASSOCIATION.—President, Major. T. L. Kennedy; Hon. Secretary-Treasurer, J. E. Farewell, Whitby; Secretary-Treasurer, G. S. Henry, Oriole.

ONTARIO LAND SURVEYORS' ASSOCIATION.—President, T. B. Speight, Toronto; Secretary, Killaly Gamble, 703 Temple Building, Toronto.

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

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

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

ROYAL ARCHITECTURAL INSTITUTE OF CANADA.—President, F. S. Baker, F.R.I.B.A., Toronto, Ont.; Hon. Secretary, Alcide Chausse, No. 5. Beaver Hall Square, Montreal, Que.

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

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

UNDERGRADUATE SOCIETY OF APPLIED SCIENCE, McGILL UNIVERSITY.—President, J. P. McRae; Secretary, H. F. Cole.

WESTERN CANADA IRRIGATION ASSOCIATION.—President, Hon. W. R. Ross, Minister of Lands, B.C. Permanent Secretary, Norman S. Rankin, P.O. Box 1317, Calgary, Alta.

WESTERN CANADA RAILWAY CLUB.—President, R. R. Nield; Secretary, W. H. Rosevear, 115 Phœnix Block, Winnipeg, Man. Second Monday, except June, July and August, at Winnipeg.