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The Canadian Engineer

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THE NEW QUEBEC BRIDGE

AN INTERESTING ACCOUNT OF THE METHOD TO BE EMPLOYED IN HOISTING THE SUSPENDED SPAN INTO PLACE — THE WEIGHT OF THE SPAN IS APPROXIMATELY FIVE THOUSAND TONS.

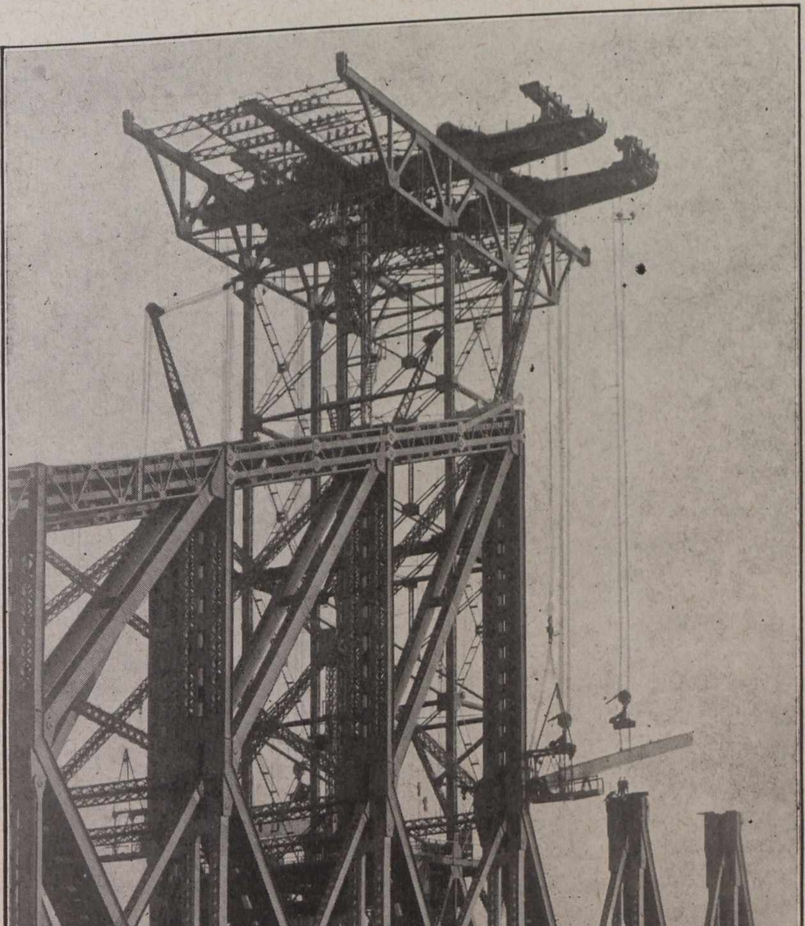
By A. J. MEYERS,
Chief Draftsman, Board of Engineers, Quebec Bridge.

THE contract for the construction of the piers for the Quebec Bridge was awarded to M. P. and J. T. Davis, of Quebec, in February, 1910. This phase of the work was very fully described in the issue of July 9th, 1914, in an article by Mr. H. P. Borden. The close of the year 1914 found considerable progress had been made.

During the season of 1915 most satisfactory progress was made, a detailed account of which was published in *The Canadian Engineer* September 23rd, 1915.

On July 8th, 1915, the erection of the main shoe on the south shore started. Work in connection with this part of the construction was greatly facilitated by the experience gained.

On November 12th, 1915, when the erection programme for the new Quebec Bridge was finished for the season, the north shore anchor and cantilever arms and the south shore anchor arm including the main post, had been completed. The total tonnage erected up to that time amounted to approximately 46,000 tons, about 30,000 tons of which had been placed during the 1915 working season of seven months, from the middle of April to the middle of November. The total quantity of steel in the bridge will weigh in the neighborhood of 65,000 tons, so that the programme for the season of 1916 calls for the erection of about 19,000 tons, a comparatively easy task, judging from the records of the past summer. Of this 19,000 tons, the south shore cantilever arm contributes 13,000 tons and the suspended span 6,000 tons.



View Showing 1,000-ton Traveler and Progress of Erection.

Work on the erection of the south shore cantilever arm was properly started about the middle of April, 1916, and at the time of writing this article, the first panel and a half, adjacent to the main pier, is practically completed. It is expected that the progress of erection of the south shore cantilever arm will be approximately as stated in the schedule on the following page.

The method of erection of the south cantilever arm is entirely the same as that followed on the north cantilever arm, and, as noted above, it is expected that this work will be finished by the end of the first week in September, 1916, when the bridge will be in readiness for the floating in and hoisting into place of the suspended span.

The suspended span is a double-track, curved top chord span, 640 feet long, 110 feet high and 88 feet wide, and weighs in the floating in condition approximately 5,000 tons. The greater part of the floor steel, being left off while the span is being floated and hoisted into place, will be placed by

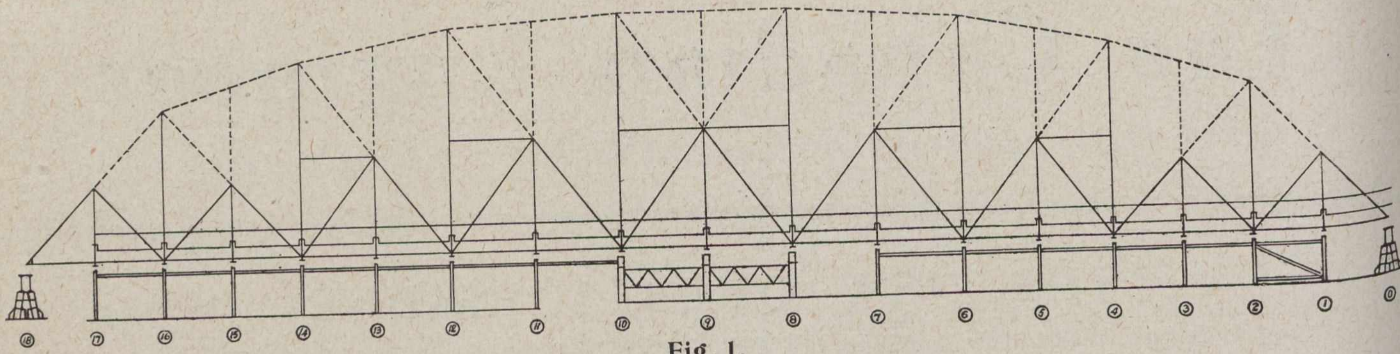


Fig. 1.

means of a derrick car after the span has been coupled up to the ends of the cantilever arms.

Schedule Showing Approximate Progress Expected in Erection of South Shore Cantilever Arm.

Main panel.	Days required.	Date of completion	Tons of steel to be erected.
16-14	40	May 10th	3,100
14-12	30	June 9th	2,650
12-10	22	July 1st	1,960
10-8	16	July 17th	1,460
8-6	12	July 29th	1,300
6-4	9	August 7th	850
4-2	14	August 21st	630
2-0	15	September 5th	650
Total....	158		12,600

This span will be erected in the shallow waters of Victoria Cove, on the north shore of the river, about three miles below the bridge site, the work of erection proceeding simultaneously with that of the south shore cantilever arm.

The foundations for the falsework bents supporting the trusses and approach track were prepared during the season of 1915 at the periods of low tide. This work was rather difficult, considerable blasting having to be done, and could not be carried on with any very great speed as the time available was only from two to four hours each day.

As shown in the accompanying Figs. 1 and 2, the span will be supported during erection on staging bents placed under each panel point. The traveler, which is the same one that erected the north shore cantilever and anchor arms, but with the top trusses and travelling cranes left off, will be first erected on bents 19 and 20, immediately adjacent to the staging of the span. The steel will be handled by means of four 70-foot 30-ton booms, placed one at each of the four corners.

With the traveler at bent 19, the staging bents 0, 1 and 2, the longitudinal bracing between bents 1 and 2, and the bridge material in panel 0-1 will be placed. The traveler will then move forward, erecting staging and

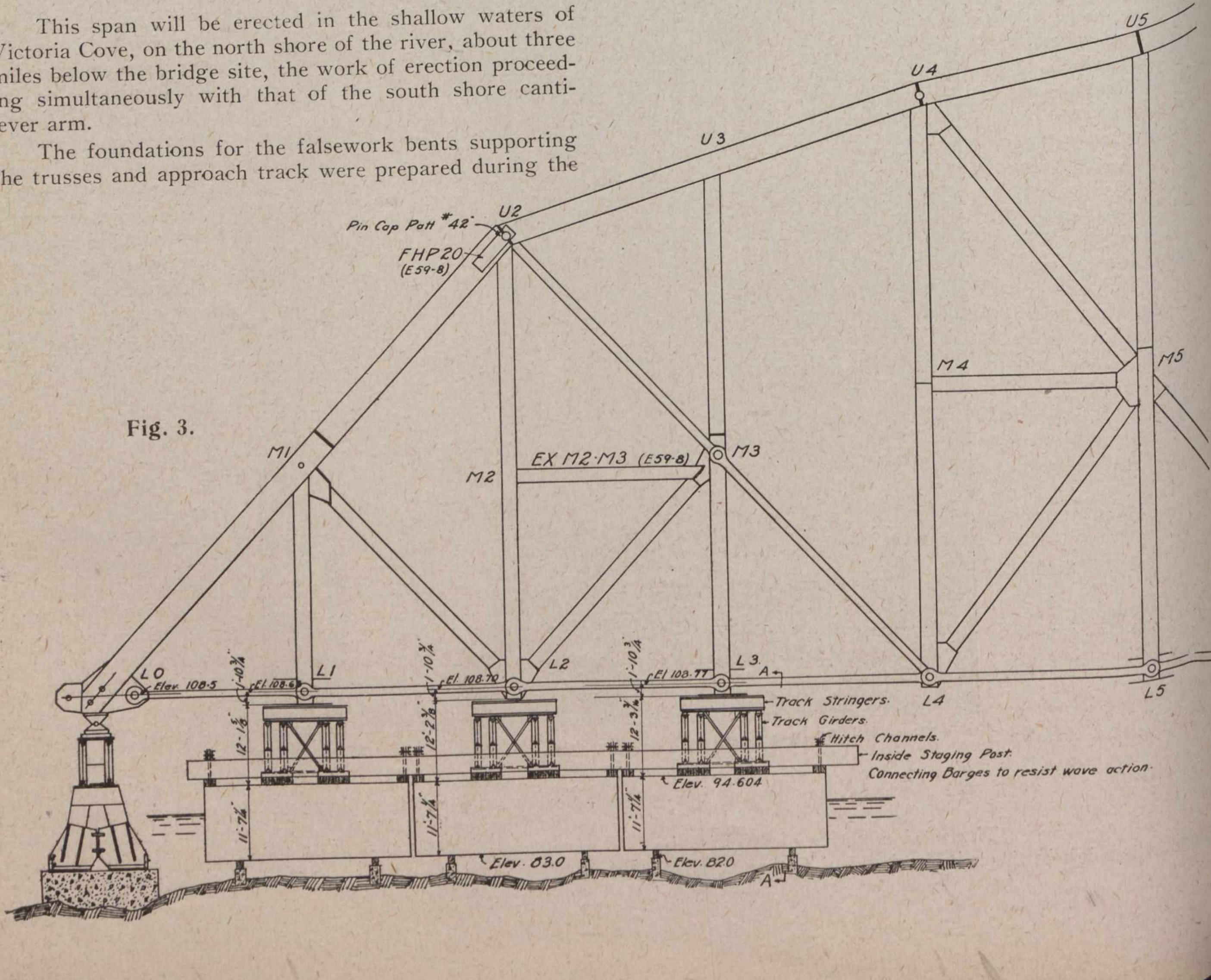


Fig. 3.

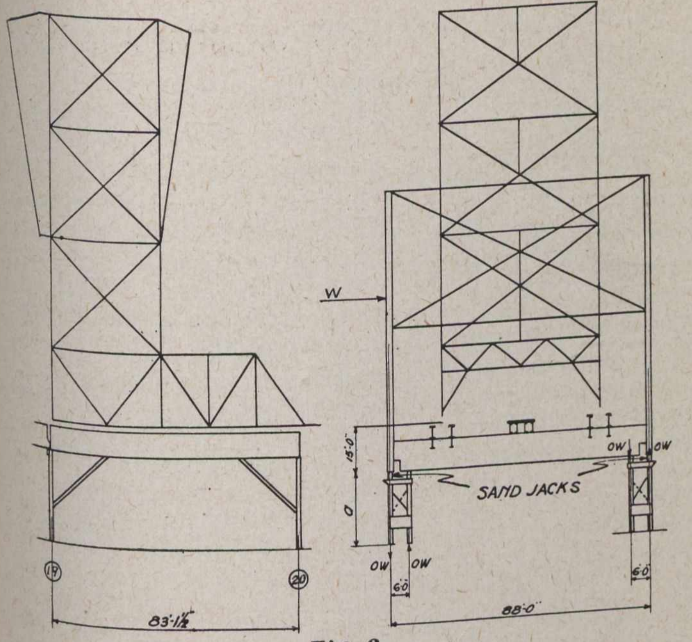


Fig. 2.

longitudinal bracing, floorbeams, bottom chords, bottom laterals and web members, except the upper half of the main diagonals and vertical sub-posts, as it advances until it reaches bent 17. It will then move backwards, completing the erection of the truss members, top laterals and sway bracing.

In Fig. 1 the members erected as the traveler advances are shown in full lines, the members placed on the return trip are shown by dotted lines.

Sand jacks will be used at the even panel points, directly under and with top bolted to the vertical posts, to transfer the load to the outer columns of the staging. Timber blocking will be used for the same purpose at the sub-panel points and also between the floorbeams and inside columns of the staging at all panel points.

The span being completely erected, the timber blocking at the intermediate staging supports will be removed, the sand jacks lowered, and the span will rest on the end bents at L_0 and L_{18}. In this condition, as shown in Figs. 3 and 4, six scows 32 feet wide, 160 feet long, and 11 feet 7 inches draft, will be floated in and placed under the panel points L_1, L_2, L_3, L_{15}, L_{16} and L_{17}. The valves in the bottom of the scows will be opened and the scows sunk until they rest on their foundation supports. The cross-girders and bracing which transfer the loads to the scows will then be placed.

To raise the span from the end supports at L_0 and L_{18}, preparatory to floating out, the scows will be drained at low tide, the bottom valves closed, and as the tide rises the span will be gradually lifted and be in readiness for proceeding on its journey to the bridge site, if the weather and tide conditions are considered favorable. If conditions are not considered favorable, arrangements will be made by means of timber crib guides, tackle running to anchorages on the shore and tugs, so that the span can be returned to its supports.

While the span is on its way to the bridge site, it will be kept under control by means of tugs of sufficient power capacity to overcome all anticipated resistances due to wind and current.

Arriving at the bridge site, the span will be anchored to the ends of the hanging trusses shown in Fig. 5, coupled up to the hanger slabs provided at each of the four corners of the cantilever arms, and raised into its final position by means of the movable jacking girders and eight 1,000-ton hydraulic jacks, two at each corner, as shown on Fig. 3.

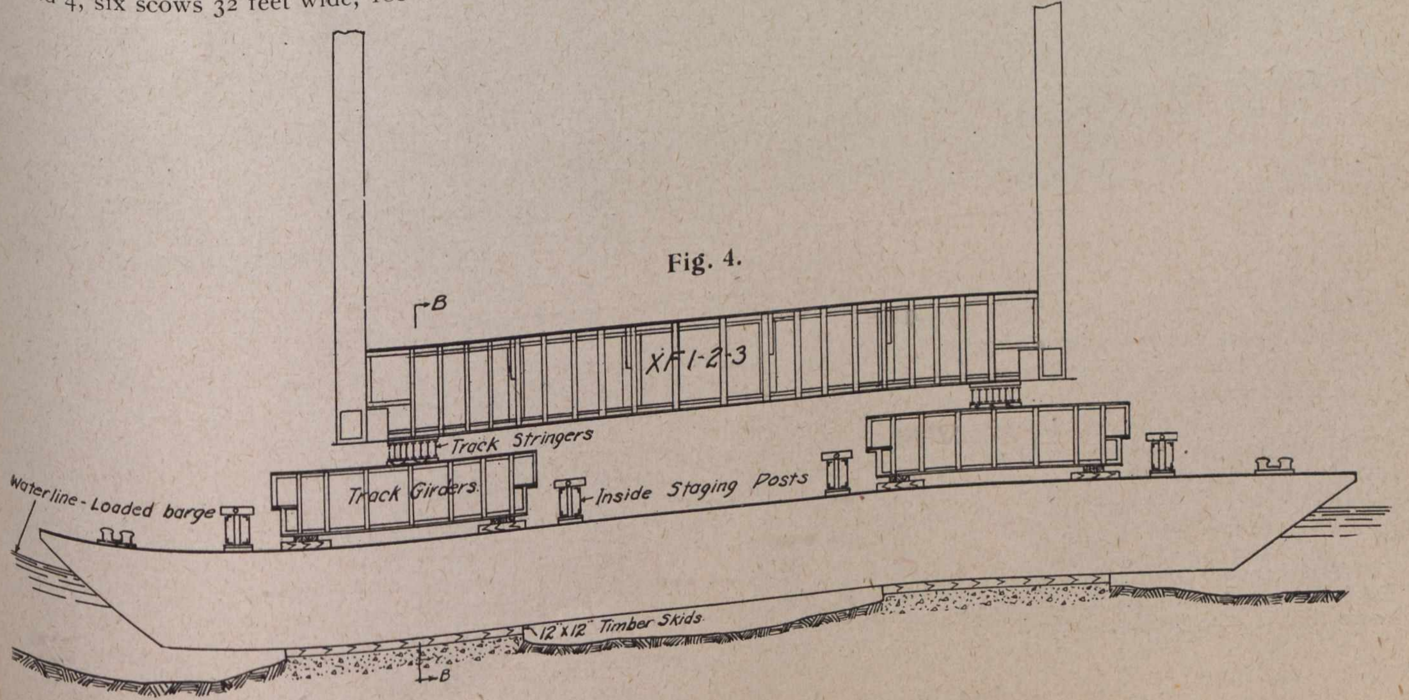
It is expected that this span will be floated into place sometime during September or October, 1916. If this programme is carried out, it will be possible to run trains over this great steel bridge, the largest in the world, and the last link in the National Transcontinental Railway system between the Atlantic and the Pacific, before the close of the year 1916.

The work is being executed under the supervision of the Board of Engineers, Quebec Bridge, composed of C. N. Monsarrat (chairman and chief engineer), Ralph Modjeski and H. P. Borden.

The St. Lawrence Bridge Company are the contractors for the superstructure, George F. Porter being engineer of construction, W. B. Fortune, superintendent, and S. P. Mitchell, consulting engineer of erection.

NOTE:—The construction of the new Quebec Bridge is replete with unique engineering methods and has been

Fig. 4.



closely followed since its beginning in the columns of *The Canadian Engineer*. Interest in this work is practically world-wide and engineers in all countries will rejoice in its successful completion. In the foregoing article Mr. Meyers gives a review of what has already been accomplished and gives some interesting information as to the methods to be employed in placing the suspended span. For further details of the substructure and superstructure of the enterprise, readers are referred to the following issues of *The Canadian Engineer*: July 14 and October 6, 1910; June 13, 1911; October 31, 1912; February 13, 1913; April 9, 1914; November 12, 1914; December 31, 1914, and September 27, 1915.—[EDITOR.]

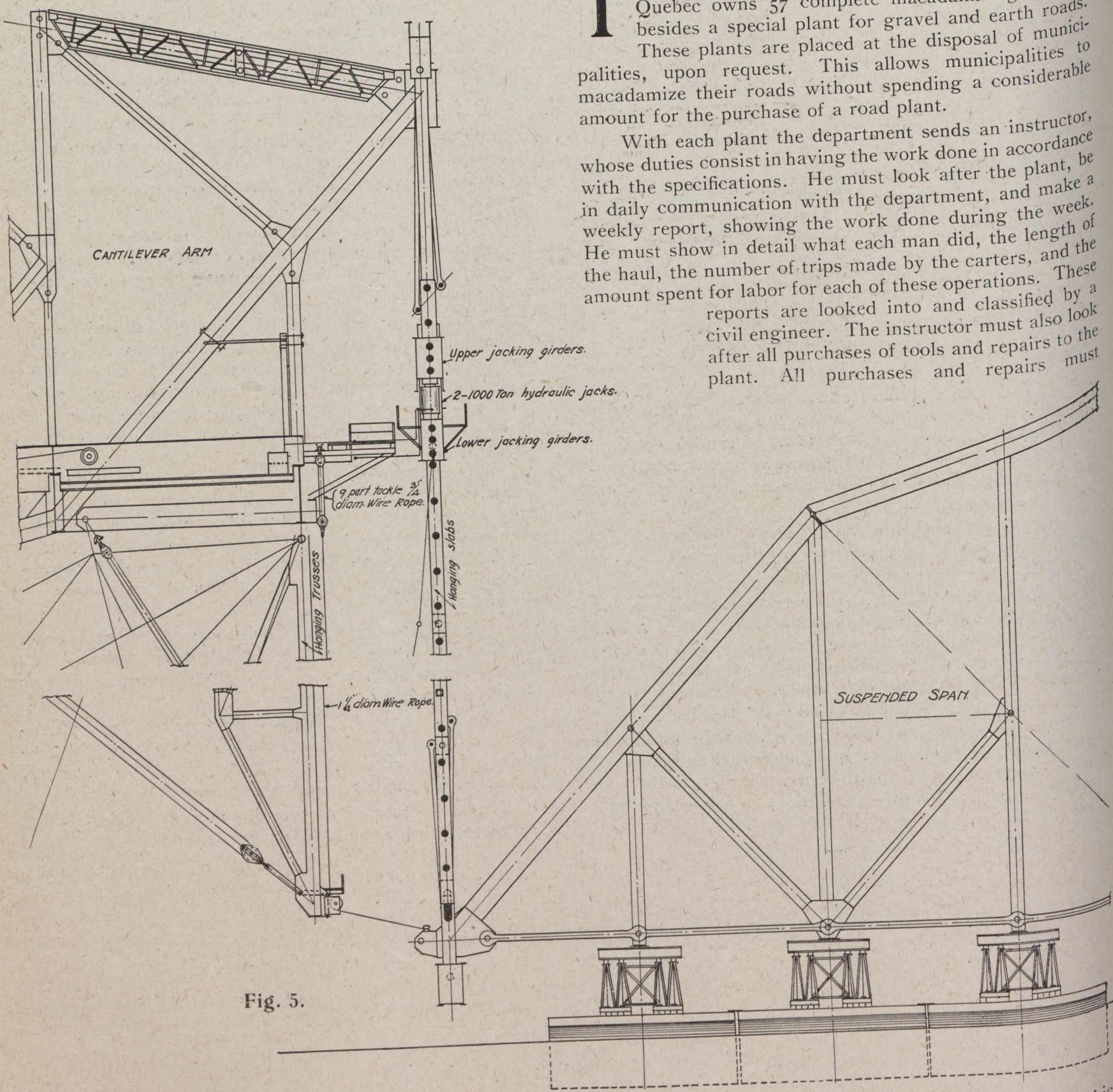


Fig. 5.

The London United Tramways Company, of London, England, last year carried 63,145,000 passengers, or 1,701,000 more than in the previous year.

PRACTICAL MAINTENANCE OF ROAD PLANTS.*

By M. E. Fafard,
Supt. of Road Plants and Construction, Province of Quebec.

THE Department of Roads of the Province of Quebec owns 57 complete macadamizing plants, besides a special plant for gravel and earth roads. These plants are placed at the disposal of municipalities, upon request. This allows municipalities to macadamize their roads without spending a considerable amount for the purchase of a road plant.

With each plant the department sends an instructor, whose duties consist in having the work done in accordance with the specifications. He must look after the plant, be in daily communication with the department, and make a weekly report, showing the work done during the week. He must show in detail what each man did, the length of the haul, the number of trips made by the carters, and the amount spent for labor for each of these operations. These reports are looked into and classified by a civil engineer. The instructor must also look after all purchases of tools and repairs to the plant. All purchases and repairs must be requisitioned on special blanks signed by him, which are given to the merchants or to those making repairs. Such requisitions must correspond with the accounts that are sent each month to the department to be audited; otherwise the accounts are refused. The instructor must also keep the department posted regarding the state of the plant and of the repairs made or to be made. The advantage given to the municipality of either renting or borrowing the government plant obliges the department

*Abstract of paper read at Third Canadian and International Good Roads Congress, Montreal.

to move many plants from one municipality to another every year.

Repairs and Maintenance.—The method followed at present has been studied and modified, and gives entire satisfaction. We have a head machine repairer, who formerly built plants and road machines, and he has with him another machine repairer of experience. They each have a tool-box containing all the necessary tools to make the repairs on the spot. They also each have a portable smith's forge, because in most cases the plants are far from villages and workshops. They also have the necessary utensils for melting metals, and casting babbitt bearings.

The large parts, which can not be repaired on the spot, are sent to the department's store of spare parts, which attends to the repairs to be made. The repairers work all the season repairing road plants, following instructions of the department. They must go only where the department orders them to go; they must report daily; every Saturday, they must, on a special form, report to the department for each day of the week, use of their time, the places where they worked, the work done each day in each place, the distance covered daily, and whether on a railroad or in a wagon; they must inform the department, by telephone, on Wednesday of each week, of the place where they are, what they have done, and what remains to be done to the plant; they must telephone to the department as soon as repairs are finished, so that they may receive instructions to go elsewhere.

At the beginning of the season before work is started, and in the fall after work is stopped, they are accompanied by four men who have experience in repairing. They are given an itinerary to repair the plants which have suffered the most damage, and to put them in good working order, because, each in their turn, all these plants have to be examined and overhauled. In the fall the head machine repairer inspects the plants which he did not see during the summer, and reports to the department the parts which will have to be repaired during the winter, and he ships to the department's store of spare parts in Quebec, all the parts which will have to be repaired. A linen tag is attached to each part, and the number of the plant from which it comes is written in ink, as well as the name of the municipality. These tags remain attached, so far as possible, to the parts while they are being repaired; thus, there is no confusion in returning the parts.

At the end of the season, the instructor must make a complete inventory, on a special form, of the machinery and spare parts which he has on hand. Moreover, he must explain in detail, for each machine, the repairs necessary. So, should the head machine repairer be unable to inspect all the machines, or should the plant be too far away, the department still knows what repairs have to be made to each machine and to each plant. The spare parts which can be repaired are sent to the store. Before they arrive a new part is shipped to the plant, and the department only charges the municipality with the cost of repairs. This is very economical and also often prevents work being stopped in the busy season. To obtain this result, we require the instructor to telephone to the department every time the plant is out of order to such an extent that he cannot repair it. It is his duty to find out, before telephoning, the exact number of the part. If it has no number, he must be able to describe it accurately, giving its size, etc., so that we can send the right part. If he is unable to give the necessary information, he has to pay for the telephone or the telegram, and is likely to be dismissed, as this would denote carelessness or incompetence.

Connection at Panel Point A L2—Bottom Chord, South Anchor Arm, Quebec Bridge.

—See article "The New Quebec Bridge," page 583.

Our store of spare parts carries a stock of the parts most in use, as we now know the parts which wear out quickest or are likely to break often. Jaws, metals, packings, fittings, oil, etc., are specially chosen. The store has over $20,000 worth of stock. Three employees receive and ship goods. By systematized accounts each part, whether sent from the store, from the shop or by a manufacturer, is charged to the plant which has asked for that part. A record is kept of everything coming in to the store, and nothing is delivered unless requisitioned by the office on a special form.

Shipping of Plants on Cars.—I will briefly explain the orders given to our instructors when it is necessary to ship a plant on cars. The first thing to do is to order the cars in advance, generally three flat cars. While waiting for the cars, all the machines, spare parts, etc., are taken to the station. When the time has come to load the machinery, the wheels of each car must be blocked very carefully, after which a strong platform is built long enough to facilitate the loading of the heavy machines. Too much care cannot be taken in the construction of this platform, which will have to carry loads varying from 6,000 to 25,000 lbs.

Excepting the roller, which goes onto the platform under its own power, the machinery is hauled onto the car by means of a tackle solidly attached to the car and to the machinery, the cable being drawn by horses. While loading the machinery, two men must follow the hind wheels of each machine with good blocks which they slide behind the wheels all the time that the machinery is going up the platform. This precaution has certainly avoided serious accidents, both to men and to machinery. If the cable should break when a machine weighing 6,000 or 8,000 lbs. is at the top of the inclined platform, what would happen if we did not take the necessary means to prevent its coming down?

When all the parts are loaded, every wheel of all machines must be blocked. The best way is to place good blocks, solidly nailed on the floor of the car, in front, behind and on each side of the wheels; special care must be taken in regard to the bin, on account of its great height and the excess of weight at top.

The same instructions apply to the unloading of the machinery.

Installation.—First look over the ground where the plant is to be placed, choose the driest spot, and see to it that water is abundant and not too far away. Do not place the crusher too far from the stone piles, but quite a distance from buildings in order to prevent danger from fire and the inconvenience from the dust and the noise of the machinery.

To set the machinery in place, we have spruce deals from 10 ins. to 12 ins. square, which belong to the plant and are used for supporting the plant. These deals are much preferable to planks placed on top of each other.

The ground must be levelled, then the deals must be set down and the portable engine and boiler placed on top of them. The machinery is all set plumb with a level, and in a straight line by means of a rope. The wheels must be blocked. In order to avoid all trouble, it is wise to see to it frequently that the machines are plumb. When the machines are out of plumb, this can easily be remedied by means of wooden wedges.

Care of Boilers.—For the care of the boiler and of the roller, we give the men special illustrated instructions. As this is the most important part of the machinery, we insist upon having these instructions carried out to the letter, and the results obtained since we have inaugurated this system are surprising, so far as fuel saving and repairs are concerned. It is the instructor's duty to watch and also to help when the boilers are cleaned each week. He must also be familiar with the working of the machines, he must help to cast babbitt bearings if necessary, help to tighten the bolts of the boiler, and to block all leaks through which steam is escaping. While the work is going on, he must be able to know if the machines are in good order by the noise they make. He must be familiar with the working of the pumps, injectors, etc.

The boiler and roller engineers must have a certificate of competence. They must carry out to the letter written instructions, given them by the department, with reference to the most economical way of heating. (Heating a boiler full of cold water too quickly would be sure to cause its early destruction.) They must see to it that they have sufficient water and that the supply is regular and constant; they must take care of monometers, test the safety valves at least once a day, know how to put out the fire should the water become low in the boiler, and know how to empty the boiler properly.

The boiler and engine are always under shelter of a portable shed, which is large enough to be able to hold oil, straps, belts, spare parts, etc. This shed is also used as shelter for the men during showers, but it is required especially to keep the machines free from the dust coming from the stone-crusher. This dust would rapidly damage the bearings and the shafts.

Road Roller.—To keep a roller in good order its boiler requires more attention than does the portable boiler, because the roller is always moving. The driver must especially look after the tubes of the boiler; if they leak, he has a tube expander which enables him to repair them very quickly. He must clean his machine every morning, and while making steam, clean all the mechanical parts such as the oilers, the grease cups, etc.; see that the bolts are tightened; see that there is no part worn out, and see that the exhaust is working well. The exhaust is sometimes blocked by rust, and trouble results.

The roller driver must look after the eccentrics, pistons and packings. When scarifiers are attached, the instructor must not forget to remove the scrapers from the wheels. This is very often overlooked, and then the scrapers are broken. The boiler tubes must be cleaned every day. A roller should never be placed in the hands of an inexperienced operator. Speeds should not be changed roughly, but only when the roller is stopped. This will prevent the slide of the eccentric from spreading.

Stone-crusher.—After ground has been levelled, deals are set in exactly the same manner as for the boiler. The crusher is placed perfectly level. Owing to the vibration, it should be set down solidly and should be levelled very often. Under the bottom part of the elevator, a hole must be dug large enough to facilitate the removal of the stones which fall out of the buckets. It is preferable to surround this hole with wood so as to prevent the earth from sliding.

The crusher requires particular attention, especially so far as oiling and greasing are concerned. The grease cups must be cleansed with gasoline, as this machine is always working in a cloud of dust, which makes the grease cups and oil-cans dirty very quickly, and prevents the oil and grease from reaching the bearings. The bearings of the connecting rod must be well connected with the crank and must be renewed properly. The department gives written instructions, with plans and sketches.

When the crusher is in operation, the instructor must prevent the men from using sledge-hammers on stones which are a little too big to go between the jaws. It sometimes happens that by using these hammers the jaws are broken. Sometimes the hammer drops in, thus breaking the jaws or the deals on which the crusher is set.

Elevator, Screen and Bin.—The elevator chain which holds the buckets must be greased often. If this is neglected it will wear out quickly and cut the teeth of the sprockets. The grease cups of the bearings of the revolving screen must be cleaned and filled with oil every day, as well as the teeth of the gears. The bin, like the other machines, must be set plumb, on deals. The screen sorts out the different sizes of stone, according to the specifications. During that time all the stone and dust in the screen is mixed like concrete in a concrete mixer. A large quantity of fine dust is taken up by the wind, and sometimes spoils neighboring properties. To avoid this loss, a light framework is put over the bin, covered with cotton or linen.

It is economical to build a large platform close to the crusher, so as to enable wagons to haul the stone up to the level of the opening of the crusher. This reduces the cost of handling.

Sprinkler.—The sprinkler is used for distributing the water necessary for cementing the stones during the last operation of the construction of water-bound macadam. There is a pump attached to the sprinkler, but as this method of filling takes considerable time, it is preferable to use an auxiliary gasoline engine with pump and tank.

The tank is placed on a solid frame 6 or 7 feet high, near the part of the road that is under construction, and it feeds through a 3-inch pipe and valve. By this system the sprinkler is filled in a few minutes, there is always enough water on the road to do good work, and the roller is never behind.

A plant which is not so organized as to have plenty of water at all times, does poor and expensive work. If there is plenty of water and it is close to the machines, it would be cheaper to take the pump off the sprinkler and put it on the boiler, and it will then only be necessary to have a tank.

We have adopted a new arrangement for that part of the sprinkler which distributes the water. The old arrangement was too heavy and subject to frequent breakage, the cost of repairs each time being high. The new arrangement is much lighter, costs less and does not break. Iron wheels are replaced by wooden wheels, which are much preferable. The gear of the front wheels is arranged in such manner that it can turn completely under the sprinkler tank. In this way the sprinkler can turn in a very limited space without destroying the macadam.

Grader and Drag.—With each plant there is a road grader which is drawn by horses; but it is used cheaply and advantageously when attached to the steam roller. In rural municipalities it is hard to find teams to give continuous time to this kind of work. With this machine, the road can be put in form, the roadbed made, the shoulders levelled, and, in some places, the ditches cleaned, much cheaper and quicker than with a shovel or an ordinary plough, and the work is done much better. It is necessary to have had experience to be able to use this machine, and we therefore recommend choosing a good man and always taking the same man, so as to give him more experience. The department gives to municipalities instructions as to how to make earth roads with the grader, and illustrations showing how to use the split-log drag, which should be used after the road has been put in form with the grader.

During the construction of the Levis-Jackman road, a split-log drag was used to spread the gravel dumped from the wagons, and to keep in form the road which was being rolled. It was also used to advantage in the maintenance of the road, which was divided into sections of 4 to 5 miles in length. A sectionman was appointed to look after each section. When the department deemed it advisable, after a storm especially, it gave instructions to the sectionman by telephone, to pass the split-log drag over the section of which he was in charge. In this manner the drag was passed over the whole road on the same day. The superintendent would go over the road in an automobile, seeing that every one was on the job, etc. The instructions given by the department to the sectionmen were to pass first on the side, close to the ditch, to level the shoulder, and on the second turn to pass the drag towards the centre, so as to bring the loose gravel on the road towards the centre. This makes the surface of the road very even, fills in small ruts and holes, and facilitates drainage in rainy weather. The ruts made by the wheels and the tracks made by the horses are scraped off, so that the teams do not always pass in the same place. Thus the wear of the road is more evenly divided.

Generally a gravel road, well-rolled and cemented, is so hard that it is impossible for the drag to give it a crown when it has been broken up. In that case, the grader must be used early in the spring; that is, as the earth begins to thaw, and before it hardens. Despite the rolling, certain qualities of gravel take a long time to bind. In this case, the use of the drag is necessary, so as to keep the crown of the road until it is completely cemented. The sectionman must carry a shovel, and if he discovers a rut or a hole which the drag cannot fill, he can use his shovel to fill it. During the years 1914 and 1915, split-log drags were used for the maintenance of the Levis-Jackman road. One man, with two horses weighing 1,300 lbs. each, can scrape in one day a section 4½ to 5 miles long.

The department has distributed to municipalities an illustrated circular showing how to use the split-log drag.

On the road leading to Valcartier, at the request of the Federal Government late in 1914, the department took charge of the maintenance over a length of nearly 5 miles. The soil was sandy and of the hardest variety for an earth road. After having put the road in form with the grader, it was kept in good order by using the split-log drag, although there was a heavy traffic of automobiles, trucks and other vehicles. All the heavy artillery passed over this road. I passed a few minutes after some of the big guns. The heavy loads were pulled at a gallop, yet the road was not in very bad condition; there were at the most five or six ruts. Generally it is thought that when the drag has gone over the road once, that it has been repaired for the whole season. This is a serious error, because, in order to obtain the best results, the drag must be used often, especially when the weather conditions are most favorable; that is, after a rain, not when the earth is all wet and muddy, but just as it begins to dry and before it becomes hard.

Experience teaches us that an earth road maintained by a split-log drag will not reach its maximum of perfection until after three years. The split-log drag was first used in 1853.

Pick Plow.—The plant has also a pick plow, which is used to tear up old macadam or to break up the ground.

In a paper entitled "Top Contact Unprotected Conductor Rail for 600-volt Traction Systems," Mr. Charles H. Jones says: The conductivity of the rail will vary inversely with the percentage of carbon or manganese allowed to remain in it. The ordinary run of Bessemer rail has a conductivity of about one-tenth that of copper, while a rail with a low percentage of carbon has a conductivity one-eighth that of copper representing an increase of about 25 per cent. in conductivity. The price increases from 18 per cent. to 20 per cent. Increasing the conductivity makes the rail considerably softer, thus requiring more careful handling to prevent it from being kinked during installation. There is no appreciable difference in the rate of wear between the low carbon and ordinary steel in the class of service referred to in this paper. Nothing is to be gained by using a rail weighing less than 80 lb. Above 80 lb. the question requires careful consideration, since the gain in conductivity will cost almost as much as equivalent conductivity obtained by adding to the copper in the feeding system paralleling the rail.

SEWAGE DISPOSAL BY THE ACTIVATED SLUDGE PROCESS.*

By T. Chalkley Hatton, M.Am.Soc.C.E.,
Chief Engineer, Milwaukee Sewerage Commission.

At the May meeting in 1914 of the Manchester Section of the Society of Chemical Industry of Great Britain, Messrs. Ardern and Lockett published the first notice that a new process of sewage treatment was being developed by them with great promise of success. They termed it "M 7." Shortly after the paper was published the process was mentioned in England as the "live earth" process, but when it reached America it was given the name of "activated sludge," as representative of the usual American expressiveness.

Professor Phelps, of the Massachusetts Institute of Technology, and Col. Black, of the U.S. Army, had been making, about this time, some very interesting experiments on enforced aeration in connection with their studies of the sewage disposal problem for the City of New York, the results of which indicated that enforced aeration might be used with advantage to remove the major portion of the suspended solids from the New York sewage and thus secure sufficient clarification to discharge the effluent into the harbor without appreciable nuisance.

In fact, for a great many years investigators from time to time have been experimenting with sewage treatment by means of enforced or natural aeration, and with more or less success. The modern percolating or sprinkling filter is but a form of enforced aeration by which the oxidation of the organic matters contained in the sewage is accelerated, and the nitrifying organisms are given that excess oxygen necessary for performing their best work.

But until the development of the "activated sludge" process the virtue in the sludge itself was never recognized. In all other processes the aim has been to separate the suspended matters as quickly as possible from the sewage, reduce them to the form of sludge, and then get rid of the sludge without bringing the two into further contact.

Plain sedimentation, chemical precipitation, septic process and the Imhoff tank fermentation process are all based upon a complete separation, so far as possible, of the solids from the sewage and within the shortest time. On the other hand, the activated sludge process aims to keep the sludge in the most intimate contact with the sewage throughout the whole period of treatment up to the point of final sedimentation; most of the purification having been effected when the process reaches this point.

Every sewage treatment investigator knew that fresh sludge contained myriads of reducing and nitrifying bacteria, but it remained for Dr. Fowler to discover the art of making those bacteria contained in the sludge produced from one day's sewage to separate from and turn into willing co-workers the bacteria contained in the next day's sewage, thus separating from the sewage itself the very medium which nature has provided for its ultimate purification and intensifying the numbers and work of such media, so that the purification may be accomplished in the shortest time.

Knowing, as we now do, that all organic matter is finally reduced to some form of mineral matter through decomposition, and that this decomposition is accomplished by micro-organisms of many kinds provided by nature for the ultimate protection of mankind, it seems quite logical to use artificial means to create and multiply such micro-organisms to the fullest extent to reduce as quickly as possible the filthy organic matter produced by the human body. Now, this is just what the activated sludge process aims to do.

With a sewage containing, say, one million bacteria per cubic centimeter it will produce sterility, if carried out to its ultimate possibilities, and these bacteria, so separated, will become attached to the flocculent sludge, every particle of which is in intimate contact with the sewage as it passes through the aerating tanks, until it contains from 15 to 20 millions bacteria per cubic centimeter, and when the sludge reaches this activated condition good purification is bound to result.

Let us stop here just a moment to consider the character of those bacteria which, it is believed, perform the major part of the purification. There are at least three classes of bacteria which are known to be highly efficient in reducing organic matter if given their natural environments: anaerobic, aerobic and facultative. The first exists and works in the absence of oxygen. The second, to do its best work, must have a plentiful supply of oxygen, while the third partakes of the nature of both of the others and can work either with or without oxygen.

Plain sedimentation, chemical precipitation, septic and Imhoff tank processes use the anaerobic and facultative bacteria which reduce the organic matters by fermentation processes, and thus produce odors to a greater or less extent.

Percolating or sprinkling filters, sand filters, contact beds, land treatment and activated sludge process use the aerobic and facultative aerobic bacteria and thus produce no odors. Those of you who have smelled the odors from a sprinkling filter are likely to doubt this statement, but consider that the influent fed to the modern sprinkling filter has first passed through an anaerobic process of some kind which has started fermentation which must be overcome before the aerobic bacteria can reduce or dissolve the odors.

Therefore, in the modern sprinkling system, the two processes of sedimentation and aeration are diametrically opposed to each other, and therefore the highest efficiency cannot be expected.

The activated sludge process consists of surrounding the aerobic and facultative aerobic bacteria with those natural environments which produce an intensified creative and working power, and it is the only process, except land treatment, producing a similar effluent wherein the sewage is given but one treatment.

The raw, coarse, screened sewage is run into and through a tank which contains a certain quantity of activated sludge. During its passage this sludge is intimately mixed with the sewage by means of air in the form of small bubbles forced through the mixture.

A small portion of this air is consumed by the mixture of sludge and sewage, but the major portion passes off unused except for its mechanical power. It is believed that the colloids contained in the sewage are largely removed by the scrubbing action due to the violent disturbance of the liquid, and are absorbed by the activated sludge. Whether this is or is not the manner in which the colloids are removed it is true that the process produces a sparkling effluent long before nitrification occurs.

After the sewage has been in intimate contact with the activated sludge for a certain period (depending entirely upon the character of effluent required), it passes

*Extracts from a paper read before the Fifth Annual Meeting of the Ontario Health Officers' Association, May 31st, 1916.

into a final sedimentation tank, carrying with it such portion of the sludge as may be mixed with it.

Owing to the flocculent nature of this sludge most of it settles very rapidly to the bottom of this tank from which the clarified liquor passes to its ultimate point of disposal. That portion of the sludge which settles in the sedimentation tank is highly activated, and in order to keep the aerating tanks constantly supplied with the proper proportion of activated sludge, some of it must be returned to the raw sewage as it enters the aerating tanks, the balance must be removed at frequent intervals in order to maintain the proper sedimentation area in the tank and to prevent septic action which occurs if sludge of this character is subjected to anaerobic influences, as it would be in the bottom of a deep tank.

One of the primary features of this process is that it is susceptible of producing any standard of effluent required to meet the local conditions, and its first operating costs are almost directly proportional to the degree of purification demanded. The three principal items which affect the degree of purification and the cost are volume of air, period of aeration and volume of activated sludge required in the mixture. The greater the volume of air per gallon of sewage treated the greater the fuel cost. The longer the period of aeration and the greater the volume of activated sludge required in the aeration chamber, the greater the size of the tanks and their first cost.

One of the most comprehensive statements of the results obtained by variation in volume of air mixed with the sewage is that published by Mr. E. E. Sands, city engineer, in his report of his experiments conducted for the city of Houston, Texas, issued February 1, 1916, and from which the following table is extracted in brief:—

Table I.

Table Extracted from Page 44 of Mr. E. E. Sands' Report on Sewage Disposal for the City of Houston, Tex.

Item.	Crude sewage, parts per million.	Percentage of removal in 1 hr.	2 hrs.	3 hrs.	4 hrs.
Total organic nitrogen	5.5	64	65	66	67
Free ammonia	6.32	60	82	90	95
Dissolved oxygen consumed	103	97	98	98	98
Suspended matters	253	98	98	98	98
Nitrites and nitrates	Trace	4	8	10	11
Bacteria at 20° C. per c.c. ..	2,800,000	93.7	95.8	95.8	95.8

These results are averages from a large number of samples. The aerating tanks contained from 20 per cent. to 30 per cent. of activated sludge, and the mixture of sewage and sludge was treated with 0.437 cubic feet of free air per hour per gallon of sewage.

Diagnosing this statement it can be plainly distinguished that in Mr. Sands' experiments the clarification and bug removal were effected in the first hour with less than one-half cubic foot of free air per gallon of sewage treated; but it required four hours to reduce the free ammonia to nitrates. In other words, if a clear effluent with few bugs fit the local conditions one hour's aeration is all that is required, whereas if a stable effluent is demanded, four hours' aeration must be given.

From this statement it must not be concluded that in order to secure the results shown in Mr. Sands' statement for the first hour all that is necessary is to furnish 0.437 cubic feet of free air and aerate the sewage one hour, because this small volume of air and short period of aeration would soon impoverish the activated sludge which requires much more air than the raw sewage if the process is to be uniformly maintained.

While Mr. Sands makes no statement of this fact in his report, he has made provision for this in the large plant which he has recently designed for treating the sewage of the city of Houston by the activated sludge process wherein he provides for an average aeration period of one hour and fifty minutes for the sewage and four hours and thirty minutes for the sludge.

The investigations in Milwaukee upon the changes occurring in the sewage during the process gave somewhat similar results to those secured at Houston, although they were not as rapid.

The following table shows the average results obtained:—

Table II.

Statement of Certain Characteristics of Activated Sludge Process as Observed at Milwaukee, Wis.

Item.	Crude sewage, parts per million.	Characteristic changes in 1 hr.	2 hrs.	3 hrs.	4 hrs.	5 hrs.
Free ammonia ..	20.3	14.9	13.2	11.1	9.3	7.4
Nitrites	0.12	0.25	0.84	1.25	1.37	1.56
Nitrates	0.09	0.69	1.24	3.28	5.71	7.90
Dissolved oxygen	0.03	0.51	2.30	4.14	5.56	5.70
Stability in hours	0.0	9.4	45	120	120+	120+
Bacteria at 20° C. per c.c.	466,000	71,800	27,000	11,800	6,800	2,900

The aerating tanks contained from 20% to 30% of activated sludge. The sewage was treated with 0.375 cu. feet of free air per hour per gallon of sewage.

Attention is particularly called to two or three things appearing in Table II., *viz.*:—

The progressive steps required to convert the free ammonia into nitrites and finally into nitrates. How little is accomplished the first and second hours, and how much during the third, fourth and fifth hours. Following this characteristic is the rapid increase in dissolved oxygen and the stability of the liquor, indicating pretty clearly that if a stable effluent is required good nitrification must be established.

The greatest effect upon bacterial removal occurs during the first hour. This is doubtless due to two things: the rapid digestion powers of the organisms in the activated sludge, and the flocculent character of the sludge to which these bacteria naturally adhere, just as they do in the floc produced by chemical precipitation.

The amount of activated sludge mixed with the raw sewage as it is being aerated affects the degree of purification to an important extent. To obtain an equal standard of effluent, if the sludge volume is reduced the volume of air must be correspondingly increased and the period of aeration. The Milwaukee experiments indicate that a clear and stable effluent can be obtained from the Milwaukee sewage by mixing from 20 to 25 per cent. of activated sludge for four hours with about 1.75 cubic feet of free air per gallon of sewage treated.

As the sludge is precipitated to the bottom of the sedimentation tank it contains approximately 98 to 99 per cent. water; therefore, to get a mixture of 25 per cent. of sludge back into the aerating chamber a volume equal to about 40 per cent. of the raw sewage must be returned; that is, the mixture of sewage and sludge passing through the aerating chamber will approximate 140 per cent. of the raw sewage being treated. This fact must not be lost sight of in determining the size of the aerating chambers in allowing for a certain period of detention.

In order to determine the percentage of sludge in the aerating chamber the Milwaukee practice has been to fill a calibrated tube with the mixture, and at the end of one-half hour determine by volume the percentage of sludge settled.

One of the important features of this process is the proper design of the sedimentation tanks. The sludge is quite different in character to that produced from any other sewage treatment process. If allowed to come to rest in a test tube or bottle 95 per cent. will settle out in five minutes, but there is a very fine floc of a low specific gravity which remains in suspension for a much longer period, and if disturbed by the slightest current will continue in suspension.

This fine floc, with much of the coarser light floc, will remain in suspension in a properly designed tank in the form of a sludge blanket which can be maintained with its surface within six inches to one foot below the surface of the liquor in the tank. If the influent is discharged into the tank a few feet below the surface of this blanket so as to produce an upward velocity of not over 12 to 16 feet per hour the fine floc will be caught and retained by the blanket and prevented from passing out with the effluent.

It is therefore believed that the vertical upward flow sedimentation tanks producing slow velocities with ample capacity for precipitated sludge are far more applicable for satisfactory operation than horizontal flow tanks, and that the sludge blanket above referred to is essential if clear effluent is desired.

In Milwaukee many experiments have been made to determine the best apparatus and method for diffusing the air through the mixture of raw sewage and sludge. So far the "filtros" plate as manufactured by the General Filtration Company, of Rochester, New York, appears to be the best media, but we believe this can be greatly improved. As now manufactured, the uniformity of porosity is not satisfactory and the loss in friction of the air passing through the plate is too great. This company is now carrying out a line of experiments to correct these difficulties.

We have been experimenting recently with a wooden block cut across grain from basswood which appears to give some promise. There is no doubt, however, as the demand for a satisfactory diffuser grows greater such a one will be produced.

Some experimenters suggest a perforated pipe for diffusing the air. We have tried that experiment pretty thoroughly, and while very satisfactory results were obtained, it required much more air and longer period of aeration to secure the same amount of nitrification. If the filtros plate, or other type of diffuser is likely to cause serious trouble to maintain, it may be less expensive to use the perforated pipe even though more air is required.

Many queries have been received as to whether these diffusers become stopped up by the dust carried in the air or by absorption of the sludge. In answer to this it might be said that, after nine months continuous use in Milwaukee we find no evidence of such stoppage, although all the air supplied to the diffusers passes through a wood wool filter, and the blower producing the air is so designed that no lubricating oil can reach the air discharge pipe.

One of the difficulties we have found should be mentioned. The heavier sludge, composed of wastes, small pieces of leather, hair and entrails from the packing houses accumulate in masses and settle upon the surface of the diffusers until the air builds up enough to partially remove them. This has required the removal of these large masses by hand at infrequent intervals. It is a matter which must be considered in operating this process, and to overcome the difficulty it may prove desirable to pass the raw sewage through medium fine screens, although fine screens are to be avoided if possible.

In an American industrial city those employed in machine shops seem to be very profligate with waste. This appears to be particularly true in Milwaukee where, from one intercepting sewer, there has been removed from the coarse bar screens, during five hours a bushel basket half-full of waste. This material has been one of the most troublesome to deal with in all processes of sewage treatment. An educational campaign amongst the shops might partially correct the difficulty.

Whether this heavy sludge which now remains near the bottom of the aerating tanks can be more effectually lifted and mixed with the whole body of the sewage by inserting vertical cross baffles in the tanks is a matter now being investigated. It may be such baffles will play a quite important part in more thoroughly mixing the sludge and sewage by the expenditure of less air. The fundamental principle of the aerating tank is thorough mixing and practical means of accomplishing this result will add to the efficiency of the tank.

The sludge disposal problem has been the most difficult one to solve in all modern sewage treatment plants, and it was a specially hard one for Milwaukee until the activated sludge process was developed, because there is absolutely no waste ground in or around the city upon which sludge could be deposited, and while, for a few years perhaps, it might be dumped into the lake several miles from shore, it is to be devoutly hoped that the Federal Government will shortly prohibit this method of sludge disposal in all fresh water under its jurisdiction.

One only has to inspect a few of the more modern sewage disposal plants in England to realize what a problem the disposal of sludge is bound to become if we must depend upon wasting it. Fresh or dried sewage sludge is not a thing of beauty under the most favorable conditions, and it does give off more or less unpleasant odors. No one desires it upon or nearby his property, and unfortunately it keeps producing every day in the year until its disposal becomes a nightmare to those responsible for its disposition.

So far, sludges produced from plain sedimentation, chemical precipitation, septic and Imhoff tanks have contained so little ammonia, phosphoric acid, and potash, that their value as a fertilizer is too small to warrant the cost of reduction, although it is true that during the favorable seasons of the year farmers can be induced to take some sludges as tankage, but, on the whole, such disposition cannot be relied upon and so far no profit worth noting has been made from it either in Europe or America.

It is believed by us in Milwaukee that this new process has solved the sludge disposal problem advantageously even to the smaller cities. During our experiments a large number of sludge analyses have been made, not only by our own chemists, but by those in the fertilizer departments of the Chicago Packing Companies, and these have all shown a high value available as a fertilizer. The following is a representative analysis with the commercial values set forth as given by those in the employ of the fertilizer producers:—

Analysis of Activated Sludge, Milwaukee.

Ingredients.	% dry basis.	Pounds per ton.	Value per ton.	Total value.
Fats	2.00	40.0	$ .04	$ 1.60
Available phos. acid	1.66	33.2	.005	.17
Insol. phos. acid	0.54	10.8	....	....
Total phos. acid	2.20	44.0	....	....
Nitrogen	5.71	114.2	....	....
Ammonia	6.94	138.8	.10	13.88
Potash	0.43	8.6	.03	.26
				$15.91

The apparent value of this sludge is $15.91, but the writer believes from the information secured from the fertilizer producers, the only real value to the city of Milwaukee will be the available ammonia, upon the basis of which the dried sludge will be sold. This amounts to $13.88, but because of the probable variation in the ammonia content, and in order to be conservative, he has estimated an average value of $12 per dry ton.

Where sludges contain less than 10 per cent. of fat its value hardly pays for the cost of extraction, and such a quantity does not injure the sludge for a fertilizer.

The Milwaukee sewage produces from 3,000 to 5,000 gallons of sludge per million gallons of sewage treated, and when removed from the sedimentation tanks contains from 97 per cent. to 99 per cent. of water. About one-half a ton of dried sludge is produced from this volume of sludge or one-half ton of marketable fertilizer per million gallons of sewage treated. It is, therefore, believed the sludge can be sold for $6 per million gallons of sewage treated.

At the present time we are experimenting with a Berrigan press manufactured by H. R. Worthington, of Harrison, New Jersey, and find no difficulty in dewatering this sludge to 74 per cent. moisture. Mr. Winthrop R. Pratt at Cleveland is also experimenting with a centrifuging machine of the laundry type, and so far appears to be securing promising results. In neither case has it been found necessary to use lime, or other substance, in pressing this sludge to an one-inch thick cake.

While its further dewatering through direct or indirect driers has not been tried out by us, there seems to be no doubt from the daily experience of the Chicago packing houses in the drying of their tankage and liquid manure that this sludge can be quite as easily and economically dewatered to 10 per cent. basis, which is the moisture content allowable in fertilizer. In fact there are several driers in use in many industrial establishments which are satisfactorily operating on a similar material, and the writer has secured from some of the manufacturers of driers guarantees which cover the cost of drying the sludge we are producing from 80 per cent. to 10 per cent. moisture, exclusive of handling.

While we have not completed our dewatering experiments we have secured sufficient information to warrant us in believing that $6 per dry ton will cover the cost of dewatering and shipping the material to Chicago, including overhead charges.

Estimating the average value of the marketable sludge to be $12 per ton, there will be a profit of approximately $3 per million gallons of sewage treated.

I appreciate that these are estimates only, and the public will look upon them as such, and while we in Milwaukee are much concerned in getting all the profit possible from the sludge, we are primarily more concerned in finally disposing of the sludge without nuisance, even though no profit is realized.

That the sludge is valuable as a fertilizer has been physically proven by Dr. Edward Bartow, Director of Illinois State Water Survey, in his laboratory at the State University, where he made several pot cultures of wheat and garden vegetables according to the standard method employed by the United States Agricultural Department.

The writer has gone into the sludge question in considerable detail because of the doubt expressed by so many interested parties that the sludge can be successfully disposed of. There is great reason for this doubt, because in no other artificial process of sewage disposal has it been possible to dispose of the sludge without expense and growing nuisance.

Two of the important features which appeal not only to the engineer, but to the average layman are the low first cost of installing the activated sludge process and the high standard effluent procurable.

So far as the writer knows, the only artificial process which produces an effluent at all comparable with the activated sludge process is sedimentation, followed by percolating filters and final sedimentation with sterilization.

The first cost of the activated sludge process is practically the same as the first cost of sedimentation tanks of the Imhoff type of like capacity. The cost of the percolating filters, final sedimentation and sterilizing equipment must be added. This cost is approximately $14,000 per million gallons of sewage treated. This adds largely to the overhead charges. In addition to this the cost of sterilization must be considered. We have found in Milwaukee that it costs $2.50 per million gallons to sterilize the effluent from an 8-foot deep sprinkling filter to the same standard of bug removal as secured by the activated sludge process.

The activated sludge process requires one acre to treat ten million gallons, whereas the sprinkling filter process requires five times as much. Available lands in or near a city are expensive, and this additional cost must be considered.

ULTRA-VIOLET RAY STERILIZER IN CANADIAN BOTTLING PLANT.

Probably the first non-portable ultra-violet ray water sterilizing outfit installed in Canada was at the York Springs bottling plant, near Toronto.

The water supply is obtained from five springs at York Mills. These springs are within a few hundred feet of each other, and the water flows by gravity to the bottling plant, which is built in a hollow or ravine. They have a capacity of 14,000 gallons per 24 hours. The water flows into a concrete cistern, from which it is pumped to the first upper story of the plant. There it is filtered, under pressure, through three small filters of about 1,000 gallons per hour total capacity. From the filters the water passes to two slate tanks which act as reservoirs. From these tanks it flows by gravity through an E2 type R.U.V. special casting, and is sterilized by a single lamp, which operates on a 230-volt d.c. line, 2.2 amperes.

The sterilizer has a capacity of about 1,000 gallons an hour, but is operated at only 700 gallons per hour. From the sterilizer the water passes by gravity direct to the bottling, aerating and flavoring machines. Daily samples for bacteria count are taken from the pipe line just ahead of and just after the sterilizer, to check its operation, although the management state that this precaution has not proven necessary to date, as the water has shown a low bacteria count with no pathogenic organisms, even before sterilization. The sterilizer was deemed advisable, however, as an extra safeguard.

Mr. P. A. Boeck, in a paper before the Chicago Section of the American Society of Mechanical Engineers, suggested that since heat was a form of energy consisting of molecular vibration of a periodic character, the introduction in a furnace wall of bricks of different density would help to break up or change the wave length. Layers of insulating powder may also be used, or air spaces; but care should be exercised in this application of the last-named, as large voids have the effect of propagating heat by convection and radiation.

WINNIPEG RIVER POWER AND STORAGE INVESTIGATIONS.*

Reviewed by Mr. T. H. Hogg,
Assistant Hydraulic Engineer, Ontario Hydro-Electric Power Commission.

THE report on the Winnipeg River Power and Storage Investigations, published as Water Resources Paper No. 3 by the Dominion Water Power Branch in connection with its administration of the water powers of Manitoba, Alberta, Saskatchewan and the Northwest Territories, will be received with interest by both the engineering profession and the public in general.

The hydro-electric development installed by the city of Winnipeg a few years ago directed attention in a measure towards the power resources of the Winnipeg River. This, together with the publicity given the proposed development of the Winnipeg Street Railway at Great Falls, has focused a good deal of attention on the potential possibilities of the river.

The report has been prepared by Mr. J. T. Johnston, chief hydraulic engineer of the Dominion Water Power Branch, acting under the direction of Mr. J. B. Challies, superintendent. It covers investigations carried on since 1911 by the Branch, on the power possibilities of the Winnipeg River in Manitoba, undertaken with a view to devising a consistent scheme of water power development, and to allow the drafting of a general policy under which such a scheme might be carried out. Mr. J. R. Freeman, of Providence, R.I., and Mr. J. B. McRae, of Ottawa, advised on the organization and scope of the surveys, the latter being retained to act as consulting engineer throughout the full period of field and office investigations.

The report comprises two volumes—Volume I. of about 370 pages, containing the text, and Volume II. the topographic field plans. The text begins with a summary of the investigations, followed by a description of the Winnipeg River watershed and the field investigations covered. Following a discussion of meteorological and run-off phenomena is a critical analysis covering the possible means of obtaining, by storage, the flow required for the ultimate development of the total power possibilities of the river. A full chapter is devoted to a description of the existing power and industrial plants. Following this, each of the possible power concentrations are described in detail, giving costs. To compare the cost of power obtained from coal, gas and oil, with hydro-electric power, estimates are given for the cost of fuel power in Winnipeg and the cost of hydro-electric power developed at one of the sites and transmitted to the city.

A section is devoted to a discussion of the present and future market for power in Manitoba, and the report closes with an analysis of the influence of the Lake of the Woods and the possible storage there, on the power concentrations as outlined in the report. This discussion is of particular interest in connection with the International Joint Commission reference to the Lake of the Woods levels.

Seven appendices are included, covering the report of Mr. J. B. McRae, the consulting engineer; the proposed development of the Winnipeg River Power Company; a report on the geology of the Winnipeg River watershed by Chas. Camsell; the Dominion water power regulations; list of bench marks; temperature precipitation and evaporation tables, and run-off tables.

*Water Resources Paper No. 3 of the Dominion Water Power Branch, Ottawa.

The report seeks to demonstrate as the principal result of the study undertaken, that a minimum flow of 20,000 cubic feet per second is obtainable at all seasons, with an efficient and systematic control of the run-off, and that it is possible to concentrate practically the total fall of the river in Manitoba at seven power sites, with a minimum output of 175,000 continuous 24-hour power under present conditions of flow, and of 313,000 horse-power with the total river regulation installed. A total ultimate capacity of 420,000 continuous horse-power would thus be available, with the existing plants. It can only be determined by long-term observations of flow, and under operating conditions, whether these figures for the ultimate developments are optimistic, and as to the necessity, if such total developments are installed, of supplementing them by steam or oil auxiliaries, in a succession of years of low flow.

To Manitoba, one of the finest agricultural districts on the continent, but practically without fuel resources, the above facts are of vital importance. At no distant date the full economic developed capacity of the Winnipeg River will be required. The centre of gravity of the power supply is less than 65 miles from the city of Winnipeg and within easy transmission distance of the larger demand centres of the province.

Estimates of cost at each possible site have been prepared in detail. These costs, which have been made up on the basis of low-tension power at the power house switchboard, should prove most attractive, both from the viewpoint of the capitalist looking for investment, and from that of the consumer who desires cheap power. The average capital cost of the total final output of the seven power concentrations is $42.80 per horse-power, based on machinery installed, with an annual cost per horse-power of from $4.50 to $5.50 per horse-power-year. The capacity of installed machinery is based on 50 per cent. excess over the continuous capacity of the sites, at 75 per cent. overall efficiency. These estimates show careful preparation and appear to be conservative, the large capacities involved and the geological and topographical features of the power sites being responsible in a large measure for the extremely low costs. No charge is included for the operation of the necessary storage dams of the ultimate developments, and the power rentals to the government are omitted.

The value of the data collected and presented in this report need not be emphasized to the engineer. Too many failures exist as monuments to the lack of sufficient information necessary for adequate design. The acceptance of a unified power development scheme for the whole river, and the establishment of the necessary authority for the supervisory control preparatory to development of a particular site, is the only way in which the full measure of the power resources of the Winnipeg River may be realized.

The necessary storage for the ultimate developments must be secured on the headwaters of the river in the Province of Ontario. Necessarily, as the report suggests, some independent government board, such as joint control by the Hydro-Electric Power Commission of Ontario and the Dominion Water Power Branch, must exercise supervision. Independent control will be necessary also for the regulation of local pondage, as control by conflicting and independent interests located at any of the various power sites would almost certainly jeopardize the efficient operation of the plants below.

At all power sites, provision has been made for the future installation of locks, if it is deemed advisable to canalize the river. The feasibility of canalization arises from the fact that slack water will exist practically from

Lake Winnipeg to the Manitoba-Ontario boundary, when the full potentiality of the river has been developed. The navigation features have been fully worked out for the total distance, and have been approved by the engineers of the Dominion Department of Public Works.

One necessary and vital factor for the success of such a scheme of development as outlined, is that the regulations under which the leases are granted are fair and generous to the investor and at the same time protect the public. Lack of space forbids a discussion of the regulations governing the granting of leases; it is sufficient to say that these are eminently fair and should induce capital to invest with guarantees of just treatment on the part of the government.

No review of this volume would be complete without a reference to the policy of the Water Power Branch as outlined in the report. The policy is "to encourage desirable development of water power resources; to discourage and prevent the initiation and development of uneconomic and wasteful projects; to ensure that river systems are developed along comprehensive lines wherein each unit is a component link in a system; to ensure adequate storage measures in the interests of all powers affected; to prevent unnecessary and costly duplication of expenditures on the part of competing plants and dams; to safeguard the public from monopolistic control, by regulation and periodical revision of rates; to see to the early carrying into effect of agreements issued by the department for the development of power; to compel the development of existing plants to their limit when the market demands; and to promote in every way the fullest conservation of the power resources of the West."

The investigations, as outlined in this report, are among the first of their kind to be made by the Dominion Government. The manner of their presentation leaves nothing to be desired; the thorough way in which the field data were obtained, and the concise and interesting manner in which the results are presented are in most refreshing contrast to the ordinary stereotyped departmental report.

To summarize, a comprehensive scheme of water power development to the maximum extent of the unusual power possibilities of the Winnipeg River has been mapped out, and a general policy for the proper control of the same is enunciated, by which the needs of the future can be met, through increased storage and the regulation of run-off. The report reflects great credit on the superintendent and hydraulic engineer of the Dominion Water Power Branch, their officials, and the consulting engineer, Mr. McRae.

It is understood that the present studies will be aggressively continued, since proper future control of the water resources of the river are dependent on continuous hydrographic and meteorological data, on accurate knowledge of storage requirements and possibilities, and upon the compilation of such miscellaneous information as is necessary for proper and economical design.

Companies interested in obtaining accurate information preparatory to financing an individual development on the river will undoubtedly find the greatest use for the report. For the preliminary purposes of finance the information presented is quite sufficient to determine the feasibility of any of the sites for the needs of the interested parties. It should save the usually unavoidable expense of reconnaisance and preliminary survey, often a serious item, and will allow an accurate forecast without loss of time. Should conditions suggest the possible use of sites other than those shown, sufficient information is given in the shape of topographic plans and hydrographic data, to allow the engineer to prepare his own estimates, thus entailing a great saving of expense and time.

From this standpoint alone, the report is amply justified. The result of its publication will doubtless be the acceleration of water power installations on the river, and the consequent development of manufacturing industries which always follows in the wake of cheap power.

NOTE—We hope to publish very shortly in these columns further articles dealing with the general administrative policy of the Dominion Government with respect to water power administration, with especial reference to the investigations on the Winnipeg River, also dealing with the more technical and engineering features as brought out by the report just issued by the Dominion Water Powers Branch, herein reviewed by Mr. Hogg.—[EDITOR.]

STANDARD SPECIFICATION FOR CEMENT.

A revised standard specification for Portland cement has been issued by the Canadian Society of Civil Engineers. This specification was adopted by the society at its last annual meeting, the specification having been prepared and recommended by a committee consisting of E. Brown (chairman), J. A. DeCew, Walter J. Francis, P. Gillespie, J. A. Jamieson and G. E. Perley.

The specification requires cement to be delivered in bags each containing 94 lbs. net weight, four bags to constitute a barrel. The bags are to be plainly marked with the net weight of the cement and the name of the manufacturer and the brand of the cement or the name of the mill where it was manufactured.

All tests are to be made in accordance with the American Society of Civil Engineers' report on uniform tests of cement. Detailed instructions for testing cement are appended to the specification.

The required minimum specific gravity is 3.10. The cement must not leave a residue of more than 8 per cent. by weight on a No. 100 sieve, nor more than 25 per cent. by weight on a No. 200 sieve. The cement shall not develop initial set in less than 30 minutes or final set in less than one hour or in more than ten hours. The cement must not contain more than 1.75 per cent. SO_3, nor more than 4 per cent. MgO. The minimum required tensile strengths of briquettes of various ages are tabulated for ready reference.

Copies of the specification are sold at a nominal fee by the society, 176 Mansfield Street, Montreal.

The supply of creosote, because of its use in preserving sleepers, telegraph poles, and other timber employed in railway purposes, is a matter that appertains to railways. It will, therefore, be of interest to know that, according to statistics published by the Bureau of Foreign and Domestic Commerce, the amount of creosote imported into the United States fell from 48,839,020 gallons in 1914 to 34,432,028 gallons in 1915, a decrease of 34 per cent. Owing to the average value per gallon having increased from 6.2 cents to 7.8 cents the imports only decreased 11 per cent. in value. In 1914 33,873,137 gallons came from the United Kingdom, 9,861,996 from Germany, 3,868,786 from Belgium, 777,662 from the Netherlands, 3,000 from Sweden, and 454,430 from Canada. In 1915 only four countries were concerned in the supply—the United Kingdom with 31,695,587 gallons, Germany 5,527 gallons, Canada 2,680,809 and Japan 50,105.

ROADS AND PAVEMENTS DATA FORMS.

THE committee on roads and pavements of the Canadian Society of Civil Engineers has sent out to many highway and city engineers throughout Canada, a form requesting data concerning the construction of pavements. Following are the questions to which answers are requested:

General Information.

Kind of Pavement? Month and Year of Construction?
Province? County? City or Town?
Name of street or road? From? To?
Engineer to Municipality? Present address?
Was work by contract or day labor?
Total width of street allowance? Bearing of street?
Length of pavement? Width? Area in sq. yds.?
Grade of pavement, minimum? maximum? ordinary?
Crown of pavement, minimum? maximum?
Character of street, residential, manufacturing, business, etc.?
Is pavement shaded or exposed?
Average daily traffic in terms of traffic schedule, before and after improvement?
Details of catch basins, if any?
Cost of pavement per sq. yd., exclusive of subgrade, curb and gutter?

Climatic Conditions.

Summer temperature, maximum? minimum? average?
Winter temperature, maximum? minimum? Average?
Annual rainfall, inches? Annual snowfall, inches?

Subgrade.

Subsoil? Crowned or flat? Watered or dry?
What provision for drainage of subgrade?
Were sewers, watermains, etc., laid before construction of pavement, and if so, for how long?
Location of these with respect to pavement?
Cost of preparing subgrade per sq. yd. of finished pavement?

Foundation.

Kind? Cost per sq. yd.?
Materials, proportions and methods of applying?
Thickness?

Binder Course or Cushion.

Kind? Cost per sq. yd.?
Materials, proportions and methods of applying?
Thickness?

Surface Course.

Kind? Cost per sq. yd.?
Materials, proportions and methods of applying?
Thickness?

Top Dressing.

Kind? Cost per sq. yd.?
Materials, proportions and methods of applying?
Thickness?

Curb.

Kind? Width? Depth? Cost per lineal foot?
Materials, proportions, etc.?

Gutter.

Kind? Width? Thickness? Cost per lineal foot?
Materials, proportions, etc.?
Dimensioned sketch of cross section of pavement, photograph also desirable.

Another form is also being sent out to cover maintenance work. The questions on this form are as follows:

GENERAL INFORMATION

(for purposes of identification with previous reports.)

Province? County? City or Town?
Name of street or road? From? To?
Kind of pavement?
Period covered by this Report—From? To?
Date of completion of work?
Date road was opened to traffic?
Has the surface begun to disintegrate, if so what was the cause?
Has the surface become displaced in the form of ruts, waves, etc.?
Is the surface objectionably soft in hot weather?
Is it objectionably slippery at any time, if so, under what conditions?
Has the surface shown undue wear next to curb or track allowance?
During what period covered by this report was the surface covered by snow or ice?
Has the surface been artificially watered?
Has the surface been cleaned, if so to what extent?
Methods of repair?
Methods of maintenance?
Cost of repair per sq. yd.?
Cost of maintenance per sq. yd. of pavement?
Average daily traffic in terms of traffic schedule?

TRAFFIC SCHEDULE.

AT the annual meeting of the Canadian Society of Civil Engineers in January, 1916, the following schedule for the description of traffic was adopted, as simple, comprehensive and adapted for universal use. Each class of traffic is designated by a letter and the degrees of traffic by a number. Combinations of one of the letters and any of the numbers representing degrees of traffic will therefore represent the amount of traffic of that class of vehicle. The sum of two or more of these combinations will then represent the total traffic on any road. The schedule is as follows:—

1. Horse drawn, steel tires	A. Light vehicles	(1) Light—up to 100 (2) Medium—100 to 200 (3) Heavy—200 upwards
	B. Heavy vehicles wagons, trucks	(1) Light—up to 75 (2) Medium—75 to 150 (3) Heavy—150 upwards
2. Self propelled, rubber tires	C. Passenger Automobiles	(1) Light—up to 100 (2) Medium—100 to 400 (3) Heavy—400 to 800 (4) Severe—800 upwards
	D. Motor trucks and buses	(1) Light—up to 10 (2) Medium—10 to 20 (3) Heavy—20 upwards
3. Self propelled, steel tires	E. Steam lorries and tractors	(1) Light—1 (2) Medium—2 to 6 (3) Heavy—6 upwards

Example—The traffic on a road having 150 horse-drawn light vehicles, 80 horse-drawn heavy vehicles and 25 motor trucks, would be indicated by the expression A2 + B2 + D3.

RAILWAY EARNINGS.

The following are the railway earnings for the first two weeks of May:—

Canadian Pacific Railway.

	1916.	1915.	
May 7	$2,763,000	$1,594,000	+ $1,169,000
May 14	2,592,000	1,604,000	+ 988,000

Grand Trunk Railway.

May 7	$1,030,768	$ 863,195	+ $ 167,573
May 14	1,076,436	922,106	+ 154,330

Canadian Northern Railway.

May 7	$ 677,400	$ 419,600	+ $ 257,800
May 14	748,300	364,800	+ 383,500

POLLUTION OF BOUNDARY WATERS

ENGINEERING INVESTIGATIONS SHOW THAT EXTENSIVE SEWAGE TREATMENT IS REQUIRED ONLY IN THE BUFFALO AND DETROIT DISTRICTS—COARSE SCREENING WILL SUFFICE FOR MOST OTHER BOUNDARY RIVERS.

PROF. EARLE BERNARD PHELPS, consulting sanitary engineer to the International Joint Commission,* has made a report, consisting of 159 large pages and 67 plates, upon remedial measures for the present conditions of pollution of boundary waters between Canada and the United States.

After extensive field work, the Commission issued a progress report, early in 1914, indicating to what extent and by what causes and in what localities the boundary waters have been polluted so as to be injurious to public health. A board of three Canadian and three United States sanitary engineers then compiled fourteen principles which, in their opinion, should guide the commission in its further studies.

Under direction of Prof. Phelps investigations were then undertaken in order to secure data upon which to base a report upon the following question:—

In what way or manner, whether by the construction and operation of suitable drainage canals or plants at convenient points or otherwise, is it possible and advisable to remedy or prevent the pollution of these waters, and by what means or arrangement can the proper construction or operation of remedial or preventive works, or a system or method of rendering these waters sanitary and suitable for domestic and other uses be best secured and maintained in order to insure the adequate protection and development of all interests involved on both sides of the boundary, and to fulfil the obligations undertaken in Article IV. of the waterways treaty of January 11, 1909, between the United States and Great Britain, in which it is agreed that the waters therein defined as boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health or property on the other?

Stripped of its explanatory matter the reference becomes:

In what way is it possible and advisable to remedy or prevent the pollution of these waters, on either side, to the injury of health or property on the other?

The answer just made is not final. Public hearings will be held at Buffalo June 21st, 1916, and at Detroit June 26th, 1916, at which all interested authorities will have opportunity to present evidence and criticisms. The final conclusions of the commission will probably be based upon its engineers' reports and the evidence produced at the hearings. The following abstracts have been taken from the advance proofs of Prof. Phelps' report:—

Advisability of Remedial Measures.

Satisfactory recommendations upon the advisability of remedial measures must be based on the one hand, upon the results of a thorough examination of existing conditions of pollution; upon the feasibility and cost of remedying these conditions wholly or in part; and upon a careful comparison of the relative value and cost of the benefits to be derived thereby. On the other hand, such an inquiry must be guided in the present reference by the terms of the treaty that the boundary waters "shall not be polluted on either side to the injury of health or property on the other."

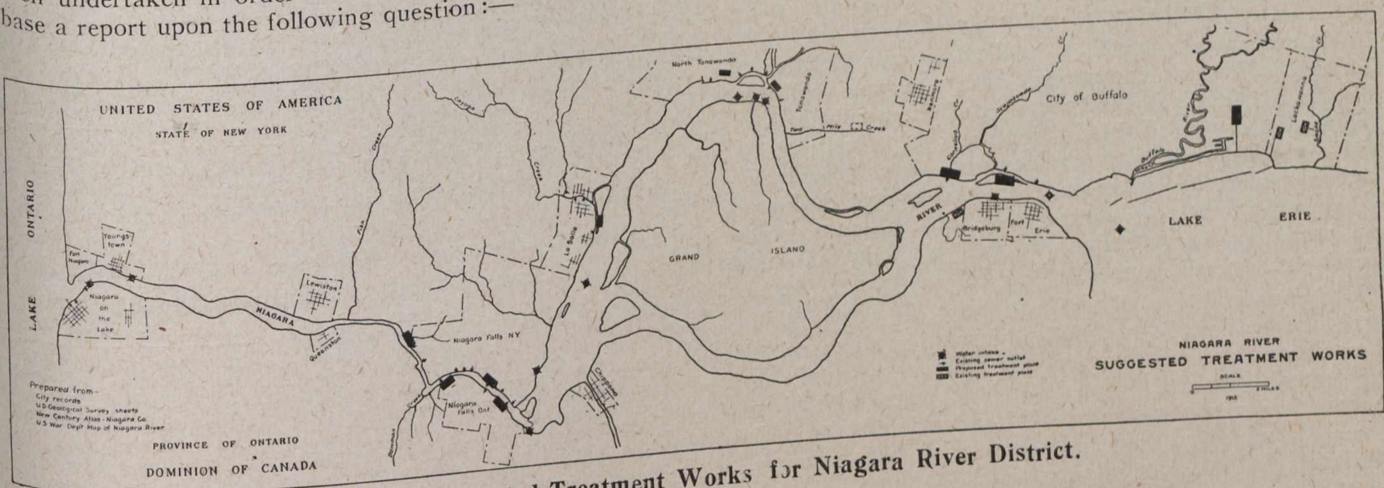


Fig. 1.—Suggested Treatment Works for Niagara River District.

It is understood that the advisability of this requirement itself is not in question and that it would be without the scope of the present reference to consider the merits of alternative projects, such as new sources of water supply for the lower communities, which would not accomplish this specific requirement.

It will be necessary, therefore, in this discussion of the advisability of remedies, to review the results already obtained and reported upon by the commission, relative to existing pollution of these waters, and to examine these results with special reference to the nature and extent of any injury to health or property which may be attributed to pollution crossing the boundary.

Such a review involves the interpretation of bacteriological results in terms of injury and necessitates in turn a discussion of reasonable and permissible limits of pollution, the extent and character of pollution from natural drainage, the efficacy of water purification plants, and the effect upon the safe operation of such plants of increasing

*Members of the Commission are:—Canada, Charles A. Magrath, chairman; Henry A. Powell, K.C.; P. B. Mignault, K.C. United States, Obadiah Gardner, chairman; James A. Tawney; R. B. Glenn. Organized in 1912, by treaty, as a court of arbitration to settle all questions regarding boundary waters and other similar frontier matters.

pollution loads. Upon these questions the commission has had the advice of a board of consulting engineers. Upon the basis of these two lines of investigation—the bacteriological studies and the engineers' recommendations—it is possible to formulate specific recommendations for a minimum requirement for the treatment of sewage entering the boundary waters. This requirement, however, is expressed in terms of bacteria and organic improvement, and will still permit the application of alternative measures to obtain the desired results. There remains also the question of "possibility" of the required measures, which is interpreted in this case to mean the practical possibility or the feasibility of the projects, having due regard to the engineering phases and to reasonable limits of cost.

[Prof. Phelps' report at this point extensively reviews the report made in 1914, and discusses extent and seasonal distribution of pollution and the significance of the pollution data. An endeavor is made to strike the proper balance of responsibility to be borne by water purification and by sewage treatment.

The minimum allowable treatment in any case is indicated by requiring for raw sewage 4 second-feet of diluting water per capita of contributing population. This requirement is subject to modification by local conditions and by the oxidizing capacity of streams.

Engineering Investigations.

Offices were established at Buffalo and Detroit, in charge of assistant engineers,* and data were collected showing the feasibility and cost of collection and disposal. The results of these investigations are given in great detail in the appendices to the report. It is stated that further studies may develop more economical drainage, and that the treatment suggested is not final, as no study has been made of certain advanced methods that hold promise of further economies.]

The general type of treatment adopted, with suitable local modification, is essentially the same in all cases. It comprises coarse screening for the removal of large floating material, sedimentation in Imhoff tanks, with simultaneous chemical disinfection with chloride of lime. The necessary auxiliary plant, sludge drying beds, chemical mixing tanks, etc., are also provided.

The estimated costs of construction have been treated in the usual manner as invested capital against which an annual charge for depreciation based upon an assumed life (sinking-fund allowance) and an interest charge have been made. This annual charge has been increased by the estimated annual operating expenses to give a total annual expense, and this in turn has been reduced to a per capita basis for purposes of comparison. These figures are set forth in detail in the report. They are summarized in Tables 1, 2 and 3.

The weighted average annual charge for the entire population of the Detroit district is found to be $0.57, for the Buffalo district $0.68, and for the two combined $0.61 per capita per annum. For comparison with this figure it will be of interest and value to determine the total charge for water supply and sewerage in certain cities. Sewage disposal is properly to be regarded as the final step in a complete system which begins with the collection, purification, and distribution of the water supply, includes the collection of domestic and industrial sewage, and ends with the disposal of the sewage. Without water supply there would be no sewage and with water supply, sewers and final disposal are essential. The system, regarded as a whole, is necessary to the well-being of the community; the proper disposal of the final product is a necessary part of the system, and its cost a part of what the community

Table 1.—Summary of Costs and Annual Charges for Sewage Treatment, Detroit District.

City.	Population designed for.[1]	First cost.	Annual Charges: Fixed.	Operating.	Total.	Per capita
Detroit, Mich	950,000	$5,932,024	$294,901	$215,545	$510,446	0.54
	[2]2,631,350	12,905,350	635,016	525,445	[2]1,160,561	.44
Windsor District, Ontario	55,000	392,286	21,291	16,000	37,291	.68
	[2]110,000	779,187	40,868	25,000	[2]65,868	.60
Port Huron, Mich.......	25,000	291,135	15,781	9,000	24,781	.99
	[2]40,000	356,677	19,249	11,000	[2]30,249	.76
Sarnia, Ontario...	16,000	100,250	5.414	6,000	11,414	.71
St. Clair, Mich.	3,000	28.063	1,620	1,200	2,820	.94
Marine City, Mich. ...	4,000	62,940	3.655	1,700	5,355	1.34
Algonac, Mich	1,700	14,650	928	1,400	2,328	1.37
River Rouge, Mich. ...	15,000	63,635	3,204	4 500	7,704	.51
	[2]30,000	115.385	6.105	7,000	[2]13,105	.44
Ecorse, Mich.	4,000	23,078	1,331	1,400	2,731	.68
Ford City, Mich.........	5,000	32,287	1,814	1,600	3.414	.68
Wyandotte, Mich.......	16,000	68,560	3,911	5.000	8,911	.56
	[2]30,000	101,960	5,714	8,000	[2]13,714	.46
Trenton, Mich.	1,200	2,650	132	500	632	.53
Amherstberg, Ontario	3,000	17,056	1,079	1,300	2,379	.79
To al...............	1,098,900	....	....	....	620,206	.565

[1] For treatment. Interceptor designed for greater populations in practically all cases.

[2] These quantities excluded from the totals and general average per capita charge.

Table 2.—Summary of Costs and Annual Charges for Sewage Treatment, Buffalo District.

	Population designed for[1]	Total first cost	Annual charges: Fixed.	Operating	Total	Per capita
Buffalo, N.Y.	600,000	$3,598,751	$203,457	$187,411	$390,868	0.648
Tonawanda, N.Y.	11,500	70,685	4,241	6,650	10 891	.947
North Tonawanda, N.Y....	18,000	130,166	7,451	8,900	16,351	.885
La Salle, N.Y.............	3,500	38,648	2,320	1,500	3,820	1.091
Niagara Falls, N.Y.......	69,000	535,950	30.730	28,457	59,187	.857
Niagara Falls, Ontario ..	18,000	83,637	5,108	8,960	14,068	.782
Lackawanna, N.Y.[2]	16,342	4.000	240	1,200	1,440	.088
Bridgeburg, Ontario[2]	2,110	2,000	120	500	620	.294
When needed.						
Fort Erie, N.Y.	2,000	13,600	816	1,500	2,316	1.16
Kenmore, N.Y.	2,500	10.000	600	1,500	2.100	.84
Chippawa, Ontario	850	28,050	1,680	520	2,200	2.59
Queenston, Ontario......	300	4,300	258	500	758	2.53
Lewiston, N.Y.	900	5,600	336	500	836	.929
Youngstown, N.Y.	1,000	20,000	1,200	500	1,700	1.07
Total....	746,002	......	......	......	507,155	.68

[1] For treatment. Collectors designed as for population to be expected in 1950.

[2] Additional to existing treatment.

Table 3.—Average Annual Charge Per Capita for Sewage Treatment, Detroit and Buffalo Districts.

	Population	Total annual charges	Per capita annual charges
Detroit district......	1,098,900	$620,206	$0 565
Buffalo district..	746,002	507,155	.68
Total......	1,844,902	1,127,361	.611

must pay for the benefits of water and sewerage. The statistics of the United States Census Bureau are available for the purpose of this comparison. There are there given the present value and annual operating costs of water supplies and sewerage. In certain cities the cost of disposal is included, but this has been subtracted in the more important cases and the remaining items do not affect the

*Detroit River District—H. C. McRae, district engineer; Irving P. Kane, assistant engineer. Niagara River District—F. C. Tolles, district engineer; H. S. Phillips and B. F. Perry, assistant engineers. Acknowledgment is made of valuable assistance by M. E. Brian, Owen McKay, J. J. Newman, Dr. J. W. S. McCullough, Prof. John Amyot, F. A. Dallyn, R. S. Lea, Theodore Lafrenier and other Canadian engineers and health officials.

result materially. An arbitrary interest and depreciation rate of 5 per cent. of the present value has been used, which gives annual charges that are at least not too high. The tabulated figures follow in Table 4:—

Table 4.—Present Value, Operating, Fixed and Total Annual Charges of Water and Sewerage Works in American Cities. (Weighted Average Per Capita.)

Cities with population of—	Present value.	Annual capital charge, 5 per cent.	Annual operation.	Total annual charge.
Over 500,000	50.83	2.54	1.44	3.48
300,000-500,000	53.31	2.66	1.35	4.01
100,000-300,000	53.12	2.66	1.26	3.92
50,000-100,000	44.97	2.25	1.46	3.71
30,000-50,000	43.83	2.19	1.46	3.65
All over 30,000	50.92	2.55	1.39	3.94

In comparison with these costs, which are fairly representative, and, because of their number, subject to less error than those of individual cities, the cost of sewage disposal as a part of this total cost of water and sewerage does not appear to be an unreasonable or disproportionate amount.

Conclusions as to Remedies.

Application of the criterion of effective dilution to the Detroit and Niagara Rivers lead to a certain specified degree of sewage treatment in the two cases. The costs of the required remedial measures have been determined and found to be reasonable in view of the results to be attained, and not disproportionate in view of the general costs of water and sewerage works in American cities. The application of these measures upon these two streams is therefore recommended as both "possible" and "advisable" in the terms of the reference.

Similar studies of cost were also made in the case of the St. Clair River communities upon the same basis of the requirements.

The criterion of effective dilution, applied to this and the other boundary rivers to determine what, if any, sewage treatment is required in each case, showed that except in the case of the Detroit and Niagara Rivers no further treatment is at present required to satisfy the general international requirements. The application of the measures outlined for the St. Clair River, which is the next most seriously polluted stream, is not justified by the evidence of transboundary effect, this stream being in a better condition than that to which it is feasible to bring the Detroit and Niagara Rivers by present-day methods of sewage treatment. This conclusion, however, is of a general nature and must be modified according to each local situation. There must be considered, first, the conclusion of the advisory engineers to the commission, that a minimum requirement for discharge of sewage into these waters should be the removal of gross floating material by coarse screens. Treatment to this extent is indicated wholly upon the grounds of the immediate local effect of sewage discharge in a purely esthetic way. In addition to this minimum requirement, there is also to be considered the proximity of near-by waterworks intakes and the question of so dispersing the sewage throughout the volume of the stream that not only the average conditions may comply with a reasonable criterion of purity, but that the concentration of sewage at any one point or in any one line of flow shall not be excessive. On the other hand, local conditions may determine that concentration of sewage near the shore and location of waterworks intakes in the centre of the stream represents the most economic solution. These are matters which are primarily of local interest and need not, in the first instance at least, come under the general administrative control over these boundary waters from an international standpoint.

In the development of a systematic policy of stream protection, however, it may very well appear that the future requirement of the situation may be best met by bringing the entire control of stream pollution under one administrative organization. Whatever may be the solution of this matter in the case of those streams which are not at present so polluted as to demand remedial treatment under the terms of the treaty, it is evident that the organization responsible for carrying out this work in general must also be responsible for the making of routine observations upon all the boundary waters with sufficient frequency to permit the establishment of the facts of pollution and of its extent with increasing population, and to indicate the future need of remedial requirements sufficiently in advance of their actual necessity to permit proper engineering studies and the construction of the necessary works. In this sense, therefore, the jurisdiction of whatever administrative body may be appointed to take charge of this work should be coextensive with the entire system of boundary waters. In the case of the St. Clair River, the detailed engineering studies already alluded to

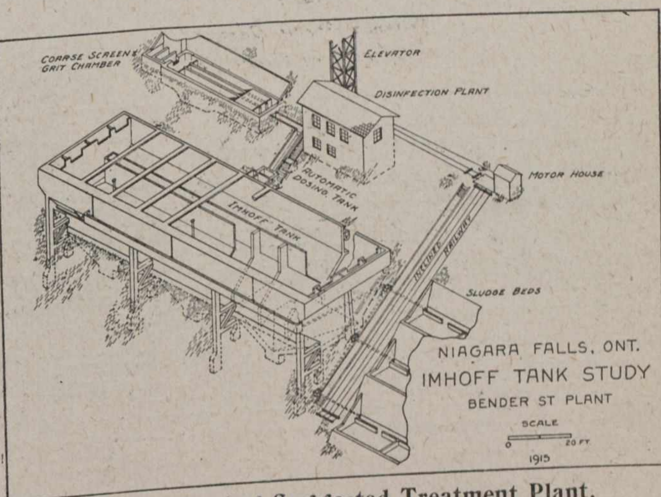


Fig. 2.—Typical Suggested Treatment Plant.

have been made with the same degree of care as has been employed upon the more seriously polluted rivers, although, judged solely from the terms of the reference, the application of general remedies is not called for at the present time. These studies, however, have been made to serve a twofold purpose. In the first place, the relation of sewage disposal to water supply on either side of the river is one demanding some definite and immediate local consideration, independent of any international questions involved. These lead necessarily to minimum requirements of treatment and can not reduce the local requirements, which are in general more exacting. In the second place, this river probably will be the first of the remaining streams to fall within the limits of effective dilution, and the studies that have been made will serve to point out the requirements of the future toward which drainage studies and allied problems should be directed. Studies of this character are needed and should be made in the near future in the case of all of the other communities upon the boundary rivers. It is worthy of suggestion that in the interest of economy and uniformity of administration, studies along these lines might well be continued by the International Joint Commission or by the administrative organization appointed to deal with this matter. In this way the problems of the future will be more definitely brought to the notice of these communities and their general solution will be better correlated along similar lines.

Guiding Principles in Control of Pollution.

The following general principles should guide in the formulation of regulations for the control of pollution in the boundary waters in its international aspects:

1. The boundary waters shall not be polluted on either side to the injury of health or property upon the other.

2. In the case of the boundary rivers the interests of the two countries are so closely bound together as to be mutual and the quality of the streams as a whole shall be considered in determining upon limits of permissible pollution.

3. The limit of permissible bacterial pollution shall be deemed to have been exceeded when the effective dilution as hereinafter defined shall be less than 4 cubic

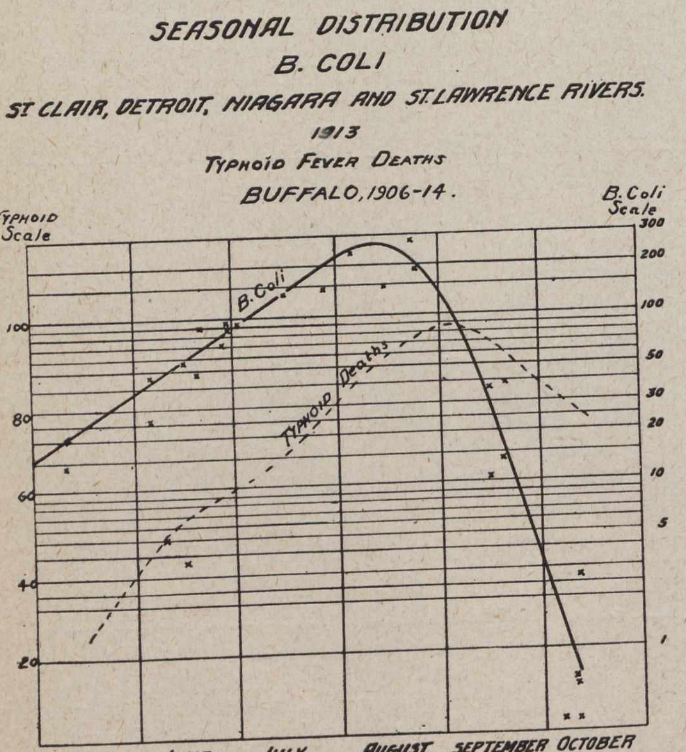


Fig. 3.—"There is an agreement between these curves that is more than mere co-incidence."

feet per second per capita of contributing population, based upon mean river stages during the season May to September, inclusive.

4. The effective dilution shall be taken as the quotient of the actual physical dilution divided by the residual fraction of the total bacteria remaining after treatment, provided that in the case of the St. Lawrence and other rivers where the time element is such as to permit some degree of self-purification between points of successive pollution, this factor shall be considered as an element of treatment entering the determination of effective dilution at the lower point.

5. In all cases where the actual stream flow below any one point of pollution is less than 4 cubic feet per second per capita of contributing population, or where the net effect of successive pollution with proper allowance for self-purification in the intermediate stretches exceeds the equivalent of one contributing person per 4 cubic feet per second of stream flow, sewage treatment shall be employed to reduce the net bacterial pollution to a basis of an effective dilution of 4 second-feet per capita, as defined.

6. Sewage treatment, while based primarily upon bacterial pollution, shall also include the removal of suspended solids capable of settling to approximately the same degree as is called for in the case of bacteria; provided that this requirement shall not be extended to an unreasonable degree in the light of good engineering practice; and provided further, that in the case of combined sewer systems, ordinary mineral detritus shall be excluded in computing the degree of removal.

7. In all cases where sewage treatment to a specified degree is demanded, the entire contributory population shall be dealt with upon the same basis of relative improvement required, so that the net residual pollution from each community shall be proportional to its population; provided, however, that where the factor of self-purification is an element in the degree of pollution at any point the population above shall be reduced to equivalent population at that point by the self-purification factor, and the burden of responsibility shall be apportioned in terms of these equivalent populations.

8. Steamboats which pass by waterworks' intakes shall be regarded as being capable of discharging sewage in the near vicinity of those intakes without appreciable dilution. The application of the rule leads in this case to a complete bacterial purification or sterilization before discharge. Equivalent removal of solids capable of settling will not be required in the case of steamboats.

9. No garbage, city waste, offal, or other like material capable of polluting or rendering offensive the waters shall be deposited in the boundary rivers, or in such places as will permit their reaching these rivers.

[Prof. Phelps states that the administrative control of boundary water pollution is obviously a federal rather than a state or provincial matter. It is recommended that the federal health authorities of the United States and Canadian governments would naturally and logically constitute, or nominate, a joint administrative body for the direct enforcement of a continuing policy of stream protection. In the matter of cost of the improvements proposed it is assumed that the burden of responsibility is individual and to be borne equally per capita by all concerned.]

In order to discover how well the train-operating rules and signals were being obeyed on the Pennsylvania Railroad system, considerably more than four million tests and observations, covering the work of both officials and employees, were carried out during last year. The results, which have just been compiled, show that only one error occurred in every 1,110 trials, or that the working in this respect was 99.9 per cent. of absolute perfection. In four classes of tests, including the most important test of obedience to various "stop" signals, no failure on the part of any employee occurred throughout the year. An exceptionally good record was also made in the observance of rules especially intended for the protection of employees. In connection with the moving of trains 68,941 observations were made and 17 errors recorded, while with regard to the safety rules for track workmen the 342,991 tests made showed only 73 cases in which the rules were disregarded in any way. Failures strictly to observe the rules governing watchmen stationed at grade crossings occurred on only eight occasions, though 62,934 observations were made. The attention given to the matter of safety regulations is doubtless largely responsible for the fact that last year was the third in succession in which no passenger has been killed in a train accident on the system east of Pittsburg and Erie. Accidents to employees also continue to show a highly satisfactory diminution in numbers; those occurring last year were 11 per cent. less than in the previous year.

Editorial

WINNIPEG RIVER POWER AND STORAGE INVESTIGATIONS.

In this issue of *The Canadian Engineer* there appears a review of a most valuable report recently issued by the Dominion Water Powers Branch in connection with the Winnipeg River power and storage investigations in the Province of Manitoba, which investigations have been carried on for the last three or four years. It may interest many of our readers to know that these investigations were commenced on the advice of prominent consulting engineers of both the United States and Canada, following a reconnaissance trip down the Winnipeg River, and were made necessary because of the Government wanting a well-defined administrative policy covering the physical features of the use of the various falls of the Winnipeg River for power purposes.

When one considers the great agricultural wealth of a province like Manitoba, but which is more or less without fuel resources, and that water is practically the only natural resource within the province for the development of power, the importance of the facts which are brought out by these lengthy investigations will be realized.

It is interesting to find that the net results of the investigations show that the Winnipeg River power situation is a most promising one from both an engineering and an economic standpoint.

COLLECTING HIGHWAY DATA.

Forms are being sent to many of the city and highway engineers throughout Canada, requesting data concerning the construction and maintenance of pavements. This data will be compiled by a committee of thirteen members of the Canadian Society of Civil Engineers. W. A. McLean, Toronto, is chairman of the committee, and G. C. Parker, secretary of the Department of Public Highways, Parliament Buildings, Toronto, is secretary of the committee.

The object is to get full data concerning the construction of pavements of every kind, and then to keep a record of their serviceability as shown by the subsequent annual reports regarding maintenance, traffic, etc.

In order to take into consideration all conditions of climate and traffic, these forms are being sent to many different towns and cities in every part of the Dominion. As there will be a score or more of different pavements to be reported upon, the work will likely involve considerable detailed clerical effort. If successful, the results will be very instructive and may lead to standard specifications for some types of pavements which will enable the engineer to predict, before the pavement is laid, just how many years it will last under any given condition of traffic.

To be successful, however, it is absolutely necessary that complete, careful and intelligent information be furnished by every man who receives these forms, and *The Canadian Engineer* would urge all engineers who are asked to co-operate in this matter, to do so promptly and fully, in the interest of the advancement of highway engineering.

The questions asked by these forms are published in full upon another page of this issue. Any engineer who does not receive a copy of the official form, and who would like to report from year to year upon any pavement, should correspond with Mr. Parker.

ANOTHER WATER POWERS INVESTIGATION?

Duplication of effort by various government organizations and commissions has frequently resulted in considerable waste of time and money. This overlapping has not been confined to any one political party. It has been more or less prevalent at all times.

With the heavier duties that Canada has undertaken during the past two years, it is important that every possible lesson of efficiency be learned from past mistakes.

Unless *The Canadian Engineer* is misinformed in this matter, the Federal Economic Commission plans to investigate the water powers of the Dominion. Such investigation would seem to be gross waste of effort, unless it is meant to imply that the work that has already been done in that field has not been sufficiently thorough.

Water power investigations have been made by the Dominion Water Powers Branch, and we do not believe that the work of that department has been lacking in any reasonable particular.

Moreover, many of the provincial governments have made considerable headway in similar investigations: Nova Scotia, through the Nova Scotia Water Power Commission; British Columbia, by close co-operation with the Dominion authorities; Ontario, through the Hydro-Electric Power Commission; Quebec, through the Quebec Streams Commission; etc. Besides these, the Commission of Conservation has made various voluminous reports upon the subject; and excellent papers were prepared for the International Engineering Congress at San Francisco last year by various well-known engineers, each one reporting upon the water powers of the province with which he is most familiar.

Does the Federal Economic Commission propose to ignore all this previous work accomplished by experts? If so, why? If not, whom does the commission intend to appoint who is recognized as a hydraulic authority able to review the work previously done, and sufficiently well versed in the theory and practice of hydraulic engineering to be able to reject as invaluable any of the work which these various other bodies have accomplished? If the Federal Economic Commission proposes to delve into engineering investigations of this sort, it will certainly have to add materially to its staff and to its funds.

We hope that our information regarding the commission's plans is incorrect, but anyway we would most respectfully advise the commissioners to reconsider the matter and to devote themselves exclusively to the main purposes for which the commission was created, namely, to handle immigration problems, to increase agricultural production and to improve facilities for marketing farm products.

COAST TO COAST

Quebec, P.Q.—The following gentlemen have been appointed by an order-in-council to form the newly created Road Commission: Mayor Lavigueur, N. Giroux, Mayor of Beauport, Mr. Frank Carrel, and ex-Mayor Drouin. It is understood that Mr. Nap. Drouin has been slated for the chairmanship of the commission.

Calgary, Alta.—The largest clean-up campaign in the history of the city was the one recently completed. During the clean-up period 11,509 cubic yards of rubbish was handled. Of this, 8,629 cubic yards was dumped at the city dump and 2,280 was handled by the city incinerator, according to the report of Sanitary Inspector Dunn, made to Commissioner Garden. The whole of the city, from the centre to the extreme outskirts, was covered.

Angus, Ont.—It is the intention of the Militia Department to instal at Camp Borden a complete sewerage system on the water carriage basis. The camp will be supplied with water either from artesian wells or from the Pine River. As the camp will have a summer population of approximately 40,000 soldiers, the problem of installing a complete sewerage and water supply system for what is nearly a city of that size within a period of from four to five weeks is one of most unusual character. T. Aird Murray, M.Can.Soc.C.E., is consulting engineer in connection with this installation.

Ojibway, Ont.—It is understood that construction work is likely to begin soon on the Canadian plant of the United States Steel Corporation. The following statement, regarding its plans in Canada, has been given to *The Canadian Engineer* for publication, by the United States Steel Corporation: "The Canadian Steel Corporation, Limited, which has been organized in the interest of and is controlled by the United States Steel Corporation, has acquired about 1,750 acres of land at Ojibway, Ontario, opposite the city of Detroit, Mich. The property has a frontage of about a mile and a half on the Detroit River. On this site it is hoped to construct a modern steel plant. The plans for the scope of the plant have not yet been fully developed. The plant should include blast furnaces, open-hearth steel works, rail mill, wire mill, structural and bar mills, sheet mill and perhaps some other mills, together with all necessary plant auxiliaries such as docks, by-product coke plant, power stations, pumping plant, machine shops, foundry, etc. A portion of the property acquired is intended for a townsite and it is planned to improve and develop the same by platting and constructing streets, laying water mains, installing sewerage system and a gas and lighting system; also to construct necessary dwellings for employees and others. A considerable amount of preliminary development work has already been done and during the balance of the present year initial construction work will be prosecuted. The officers of the Canadian Steel Corporation, Limited, are: Elbert H. Gary, president; Ward B. Perley, vice-president; Richard Trimble, treasurer; W. J. Filbert, secretary. Vice-President Perley will be immediately in charge of the active construction work and his office will be at Ojibway, Ontario." It is reported that the contract has been awarded to the Williamson Construction Company, of Walkerville, for fitting up the Lloyd House in Ojibway as an office headquarters for the company. Some extensive building is contemplated and a substantial sum has been appropriated.

PERSONAL.

R. M. HANNAFORD, assistant chief engineer of the Montreal Tramways Company, has been elected president of the Canadian Railway Club.

R. V. NICHOLSON, heretofore bridge and building master of the Canadian Pacific Railway at Schreiber, Ont., has been appointed bridge and building master at Ottawa.

CAPT. BARRY has been appointed engineer in charge of the waterworks and sewerage system for the new military camp at Angus, Ont.

T. AIRD MURRAY, M.Can.Soc.C.E., has been appointed consulting engineer in connection with the waterworks and sewerage system for Camp Borden, near Angus, Ont.

A. C. VOLKMAR, forester of the Riordan Paper Company, St. Jovite, Quebec, has been elected an associate member of the Canadian Society of Forest Engineers.

CHARLES L. D. CONKLIN, until recently president of the Digger Machinery Co., Inc., has severed his connection with that concern and is now with the John F. Allen Co., New York, as superintendent of their contractors' machinery department.

OBITUARY.

ELMER LAWRENCE CORTHELL, Dr.Sc., president of the American Society of Civil Engineers, died May 16th. In the passing of Dr. Corthell the engineering profession has suffered a real loss. He was a man who had attained to unusual heights in that profession. His fame as an engineer was almost world-wide; his reputation as a consulting engineer was national and international. He was born at South Abingdon, Mass., in 1840. While attending Brown University the Civil War broke out. He immediately enlisted and after serving four and a quarter years with the army re-entered Brown University and received the degrees of B.A. and M.A. From his alma mater and in recognition of his attainments as an engineer he received the degree of Doctor of Science. During his life he was connected with some very large and important engineering enterprises. Among these might be mentioned the following: The improvement of the harbor at Tampico, Mexico; the National Railroad of Tehuantepec, the completion of which was entrusted to him by the Mexican government; the Boston, Cape Cod & New York ship canal; the river and harbor improvements in Argentine, and many other national and international projects. Out of respect to the memory of Dr. Corthell the regular semi-monthly meeting of the American Society of Civil Engineers, which was held May 17th, was immediately adjourned after the announcement of his death had been received.

CALGARY ENGINEERS ENLIST.

The following members of the Calgary Branch of the Canadian Society of Civil Engineers have enlisted for active service:—

Members.—H. B. Muckleston, F. R. Burfield, Col. Paul Weatherbae.

Associate Members.—P. J. Jennings, H. R. Carscallen, F. S. Dyke, G. R. Elliott, J. A. Symes.

Juniors.—R. L. H. Goodday, J. H. Jones.

Students—J. B. McLean.

Associate of Branch.—G. H. Whyte.