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AN EXAMPLE OF DIFFICULT TUNNELING

THE COMBINED USE OF SHIELD AND COMPRESSED AIR ON WORK SUBJECTED TO UNUSUALLY COMPLEX CONDITIONS

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THE driving of a sewer tunnel under somewhat unusual circumstances arose in connection with one of the low-level intercepting sewers of the city of Glasgow. Starting from a shaft some 25 feet deep, the tunnel passed beneath the foundations of a very heavy retaining wall (clearing them by a foot or two) into running sand lying below an extensive freight yard bordering on the Queen's Dock. There were only 9 feet of cover between the top of the sewer and the rails, and at one point the centre line approached within 80 feet of the quay wall. To open-cut this section was out of the question owing to traffic conditions, and to drive a tunnel through quicksand with an unlimited supply of water close by was no light task.

It was decided that the tunnel should be driven with cast-iron segments, so as to minimize the ground opening; but, as the railway company had doubts as to the effect of their extremely heavy loads on the roof of the finished iron tunnel, a thick brickwork lining of these segments was insisted upon. This made the section one of great strength, but of an external diameter somewhat out of proportion with the inner diameter, as will be seen by reference to Fig. 1.

There were 420 linear feet of sewer immediately below the rails, and the ground throughout was clean sand, varying in fineness, and full of water.

Work Previous to Arrival of Shield.—A shaft was sunk, and from it the tunnel was driven, at first with cap-and-leg settings of timber and a brickwork lining. This did not prove a satisfactory method, the street showing signs of subsidence, owing, no doubt, to the exceedingly unstable condition of the bottom, rendering effective propping impossible. An attempt to tunnel with iron lining turned out equally unsuccessful, and, after the necessary plant had been put to work, a third trial was made with iron and compressed air.

About 30 feet of tunnel were driven thus under the deep cover of the street, but the openness of the ground and the large area of exposed face caused a great escape of air, little improvement being effected, therefore, in the conditions of the bottom. The air pressure gradually fell from 5 to 2 pds. per sq. in. as the tunnel approached the wall, and mining operations became exceedingly difficult toward the end, only one ring being built per day. It was evident from the disturbance of the surface that the miners were not holding the ground, and that the continuation of this method of tunneling beneath the retaining wall would be attended with great risks; so it was decided to try a shield.

Description of Shield.—The outer shell of the shield consisted of a cylinder of steel plates, the clear inside diameter being 8 ft. 8½ in. and the length over all 7 ft. 10 in. Inside this shell and about 2 ft. behind the cutting edge was a bulkhead or diaphragm formed of plates, stiffened with channels and angle gussets off the front upper portion of the shell, called the hood. This diaphragm had two openings, 1 ft. 7 in. by 4 ft. 8 in., separated by an I-beam in the centre, which, with the side channels, formed two sets of grooves, into which stop-planks might be placed, should it be necessary to close the face or reduce its area. Besides these working openings there were two small hand-holes in the lowest part of the diaphragm through which the sand was forced as the shield drove forward. In very bad ground a great amount of the excavation might have been taken out through them with the larger openings closed.

Below springer level the cutting edge receded from 2 ft. to 4 in. off the diaphragm; thus there was a hood above that portion of the ground being excavated, while it was still possible to reach the ground immediately in front of the lower portion of the cutting edge and so clear the way for the bottom of the shield, thus obviating the possibility of boulders damaging the cutting edge. The hood was stiffened with an additional plate, so that the cutting edge was really formed by the bevelled edges of three plates above springer, and of two below.

Behind the diaphragm there was a cast-iron ring formed of six flanged segments fixed to the shell by taps, while screws running through casting and shell held the ram castings in position. The rams, six in number, arranged symmetrically around the circle, were 4 in. in diameter, and had a maximum travel of nearly 2 ft. There was a sufficient length of shell (8 ft. 8½ in., inside diameter) behind the segments to admit of one ring being erected inside the tail of the shield with about 6 in. of the shell overlapping the iron already erected.

The main hydraulic feed-pipe was fixed to the shield on one side, about springer level, and from it the high-pressure water was separately distributed through smaller pipes to each ram, small valves on these pipes giving independent control of each ram. Thus the shield consisted of a steel shell divided into three portions—the hood with the cutting edge, underneath which the excavation was taken out, the body containing the means of propulsion, and the tail, in which the tunnel rings were built.

To obtain the necessary hydraulic pressure an air-compressor on the surface supplied an air-engine or pump in the tunnel. This pump was fixed in the side of the tunnel, near the face, and from it wrought-iron piping, with a flexible end-piece, carried the high-pressure water to the receiver on the shield, and a similar arrangement of pipes returned the exhaust water to a small tank below the pump. The whole mechanism was most compact, tank and pump occupying a space of less than 8 x 2 x 4 ft.

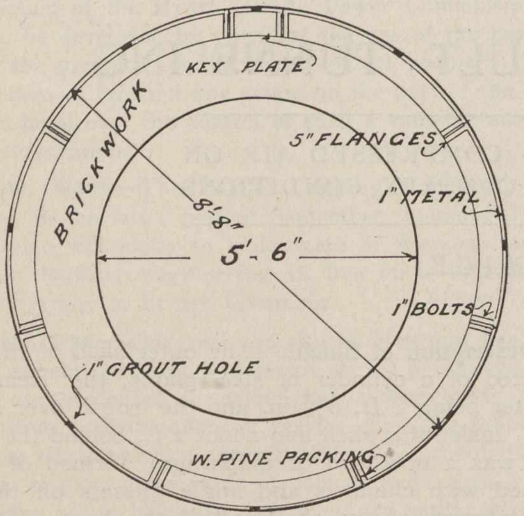

Fig. 1—Section of Sewer.

Erection of Shield.—As the use of a shield had not been contemplated in the original layout, the erection of this shield was carried out, not in a shaft as is usual, but in a specially excavated chamber in the tunnel, which was enlarged for a short distance to a diameter of 11 ft. This shield chamber might have been excavated ahead of the iron had it not been that the face was already very near to the wall; but in any case, it was probably safer to excavate around the outside of the iron—from which temporary propping could be erected—rather than to open up new ground.

In the last length of eight rings, seven were taken out, the eighth being left as a rib to support the longitudinal bars used in poling back. Two plates were broken to obtain an opening in the lining, and the key-plates of the unbroken rings were taken out first, the upper plates being supported by struts from the invert. A crown bar was put in through the lagspace and carried on short props from the leading and ninth rings. The upper plates were next taken out, those along one side at a time, and the ground poled back on bars similarly supported. Below springer the excavation was taken down and timbered outside the rings as far as possible before the removal of the plates.

All this temporary timbering had cement grout under pressure forced into the ground behind it. The bars were then sheeted inside, and the space was pressure-grouted. By this means the top was made practically air-tight, and a fairly good pressure maintained while the bottom was being excavated and poled with 3-in. sheeting.

The shell was taken into the tunnel in pieces and erected round the framework of the bulkhead. The taps fixing the cover-plates to the shell were cut and hammered flush with the inside face to allow the tunnel segments to fit closely. The body segments were also attached to the shell by means of screw taps. Bolts with counter-sunk heads held the angle-stiffeners to the shell and the bulkhead; thus the only variation from a smooth outside surface was the longitudinal cover-plates. A cradle of half-timbers supported the shield at its proper level, and on the completion of erection, the space between shell and walls of chamber was packed with dry brick and grouted with cement under pressure. There was now a set of crown bars held by the shield, forming cantilevers in support of the ground above the leading ring, which was taken down and the shield driven hard to the old face polings. These were bored out in small parts and clay put into pockets excavated ahead around the cutting edge of the shield, new face-boards being put in horizontally to form a circular shutter of timber about 2 ft. less in diameter than the cutting edge, as shown in Fig. 2.

Method of Excavating.—As a rule, the shield was driven forward until the diaphragm was within about 10 in. of the horizontal face poling-boards, these boards being supported during the period of movement by two raking struts off a cross-piece on the second last ring, and butting against two vertical soldiers running across the boards. Fig. 3 shows the shield ready to move ahead, and Fig. 4 shows excavation in progress. When the shield came to rest each poling-board was strutted off the diaphragm with short blocks and wedges. With the face thus supported the rakers and soldiers were taken down and excavation proceeded with by withdrawing the top poling and pulling out the sand with hand-tools.

A pocket or groove was cut out a little beyond and above the cutting edge, and clay rammed in, after which the first poling-board was carried forward and re-erected against the new face with long struts off the diaphragm. In this way each board in turn was carried forward and the face kept continually poled up. Below the lowest board the sand was roughly excavated down almost to the cutting edge, and, after erecting the rakers and soldiers, the struts were removed, leaving the shield again in position to travel ahead. The excavated sand was thrown upon a staging at the level of the sill of the openings, from which it was shovelled into wagons and taken through the air-locks to the shaft.

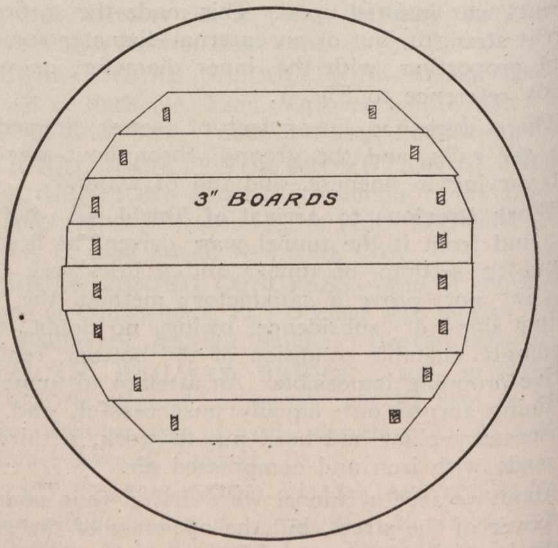

Fig. 2—Poling of Face.

In this ground the shield showed a decided tendency to go downward while in movement, but it was kept to proper level by using the 3 lower rams only during the first part of the movement. After the cutting edge was fairly buried the two upper side rams were brought into action as the first three did not give a force sufficient to drive the shield ahead. During the first period, with three 4-in. diameter rams working under a pressure of 1,500 to 1,600 pds. per sq. in., the total effort was about

24 tons, or 280 lbs. per sq. ft. of skin surface. When the cutting edge was buried the resistance was more than that due to mere skin friction, and, after applying 5 rams and increasing the pressure per sq. in., the total effort rose to about 48 tons. The highest pressure used was 1,900 pds. per sq. in., or a total push of nearly

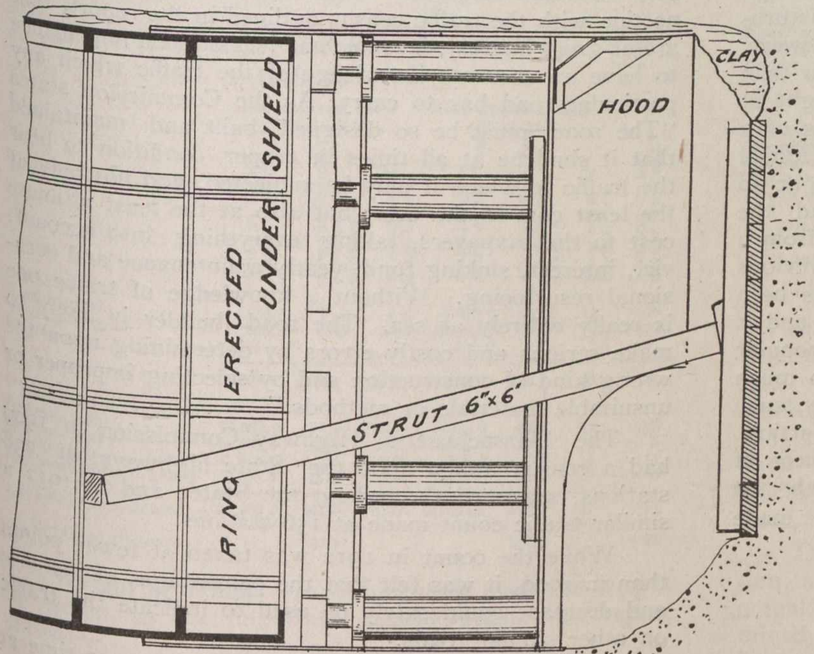

Fig. 3—Longitudinal Section of Shield—Excavation Completed.

60 tons. The average time of travel was 8 minutes in all. Though the air pressure kept the upper portion of the face dry, the bottom was always very wet, but, as it was exposed for a short time only, the water did little harm.

Immediately after the shield had been driven ahead the last ring was grouted with cement under pressure of 40 to 50 pds. per sq. in. Cement grout was used for the lowest plate, but lime grout for the upper portion of the tunnel, where the air pressure kept back the water. There was no escape for this pressure grout at the shield, since wooden buffer ribs, held firmly against the flange of the last ring by the rams, closed any opening between them and the skin. The next ring of iron tunnel lining was not erected until the whole face had been excavated and everything was ready to drive ahead, so the buffer ribs remained sufficiently long enough in position to permit of the mortar partly setting. Five pounds was about the maximum air pressure in the tunnel while beneath the deep cover, but on leaving this it fell to between 2 and 3 pounds, and sometimes less, partly due to slight leakage at the joints over some 50 or 60 yds. of unlined ironwork then exposed.

Grummets of string dipped in red lead and placed around the bolts beneath the washers proved effective in stopping leakage at bolt-holes. All joints had been plastered over with neat cement, previous to the adoption of red lead on grummets, but, as air continued to escape at the bolt-holes, the shield was stopped and brickwork built from the air-locks nearly up to the face, completely sealing the tunnel behind the shield.

Previous to this point no cement had been used for grouting the lower plate but with its use and the brickwork lining carried forward, another pound of pressure was obtained, making mining operations much easier. This slight increase in pressure probably allowed the grout to more completely encase the iron, for there was very little leakage through unlined ironwork from this point forward.

Mechanical Plant.—While under the deeper cover the air pressure averaged about 5 pds. per sq. in., with the engine running at 60 R.P.M., under 110 pds. of steam; and, in the lighter cover, 2½ pds. air pressure, with the engine running at 76 R.P.M., under the same steam pressure. A "Larmuth" compressor, with steam cylinder of 16-in. diameter and 24-in. stroke, coupled direct to a 15-in. diameter air pump, supplied air to the tunnel. The number of men on each shift was 3 miners and 4 laborers, excavating, setting segments and pressure grouting, with a locksman and two enginemen, 11 in all.

Points in the Use of Compressed Air.—The principal point of escape for the air was undoubtedly the working face, though this was kept as closely poled as possible. When the face was completely closed up and grouted, during the period when the brick lining was being brought up to the shield, the same working air pressure could be maintained with the engine running about half speed. This illustrates one of the many advantages of using a shield, as, even with the comparatively simple shield here described, it was possible to reduce the area through which air might escape to a few square feet of sand, and with more complicated mechanism, still greater control might be exercised over the area of escape. In placing the poling boards against the face it was usual to smear their edges with clay. A neat illustration of the course taken by the air could be obtained

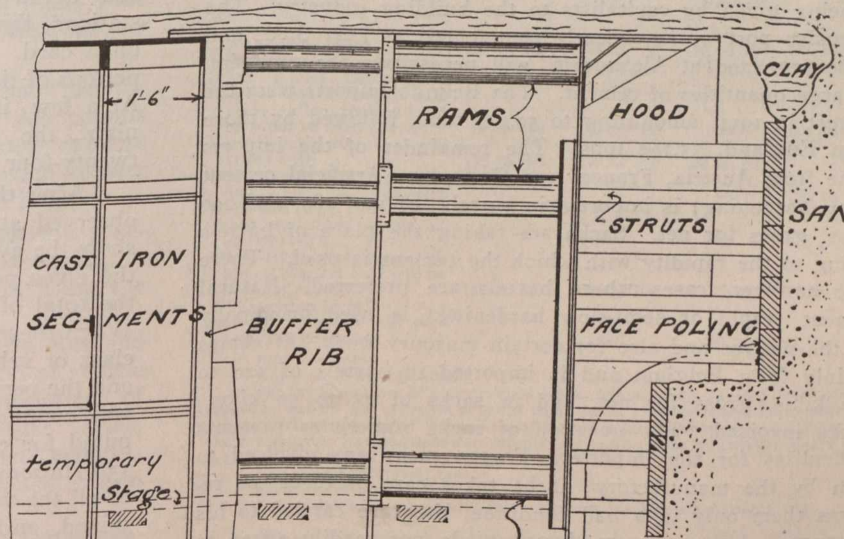

Fig. 4—Longitudinal Section of Shield—Excavation in Progress.

by removing a piece of this clay and holding a candle to the spot, when the flame would be drawn into the joint and extinguished. If the ground is very open compressed air alone may be of little use, especially under light cover, but with it in combination with a shield the most unstable ground can be negotiated.

Compressed air will travel great distances through open ground, and may set up quite unexpected disturbances, as, for instance, by getting into old, leaky sewers. It is never advisable to use a greater pressure of air than that which is just sufficient to balance the weight of water head. The writer has known of the waters of a pond being disturbed by compressed air from a tunnel more than half a mile away. In grouting with 30 or 40 pds. pressure it is quite a common thing to find the cement driven up to the concrete of the roadway from a depth of 20 feet, where pits had been sunk or previous excavation carried out. Of course, the shield has been used much in tunneling without compressed air, and it is a most useful mechanism, which might be more popular with contractors were it not that it has been so much associated with very difficult and expensive tunnels, such as the portion of sewer which is the subject of this article. Though the shield in this case was a costly piece of plant, its use was justified by the safety in which the work was carried out, the excellent progress made amounting to 42 feet per week.

CEMENT IN EGYPT.

The Bulletin Commercial, of Brussels, states that Egypt now offers an important market for cement. In 1911 the imports were 106,670 tons, valued at $800,000, as compared with 87,503 tons in 1910. The great vogue for buildings of ferro-concrete has largely contributed to the remarkable development of the import trade in cement, and this trade seems quite likely to be maintained, in view of the attention which is being given by capitalists to the building industry. The extensive port works recently commenced at Port Said, and those projected at Alexandria, will necessitate the provision of large quantities of cement. The Belgian imports were the largest in 1911, amounting to 50,257 tons, followed by those from England, 35,192 tons. The remainder of the imports came from Austria, France, and Germany. Artificial cement (slow hardening) is imported in barrels of 150, 180, and 200 kilos. gross for net. Sacks are taking the place of barrels owing to the rapidity with which the cement is used. There are, however, cases where barrels are preferred. Natural cement (rapid or semi-slow hardening) is used principally by the natives and also for certain masonry work. It comes mainly from Belgium and is imported in barrels of 140 to 150 kilos. gross for net, and in sacks of 45 to 50 kilos., sacks invoiced. The question of sacks sometimes presents difficulties for the importer. Empty sacks are invoiced to him by the manufactory; if he takes care of them, or returns them only in a bad condition, they are carried to his account. Cement users, however, do not readily agree to these conditions, and the importer eventually suffers the loss. English manufacturers are in the habit of shipping cement in very light bags, which are strong enough for one voyage and for which there is no charge. This method has given excellent results.

The Commission of Conservation, Canada, has prepared a summary of rail production in Canada from 1895 to the beginning of the present year. The increase shown in the intervening years has been from 600 to 423,885 tons.

TRAFFIC CENSUS IN MASSACHUSETTS.

A summary of that portion dealing with the construction and maintenance of roads, of the Massachusetts Highway Commission's report for the year ending November 30th, 1912, was given in October 9th issue of *The Canadian Engineer*. There are a few points in connection with the traffic census outlined in the report, that are of great interest, inasmuch as it is of such importance to have an accurate knowledge of the traffic which any particular road has to carry. As the Commission states "The road must be so designed, built and maintained that it shall be at all times in proper condition to bear the traffic to which it may be subjected, and not only at the least cost to the user, but also at the least ultimate cost to the taxpayers, taking everything into account, viz., interest, sinking fund, yearly maintenance and occasional resurfacing. Without a knowledge of traffic one is really entirely at sea. The road builder is likely to make serious and costly errors by determining upon the wrong kind of construction and by selecting improper or unsuitable materials or methods."

The Massachusetts Highway Commission in 1909 had a census taken upon the State highways at 238 stations, scattered throughout the State; and in 1912 a similar traffic count made at 156 stations.

While the count in 1912 was taken at fewer points than in 1909, it was felt that the percentages of increase and decrease could safely be used to indicate the traffic on other similar roads.

A traffic census was also taken at the same time at quite a number of points around the city of Boston on roadways in the metropolitan and Boston park systems.

The census was made in the following manner: The vehicles actually passing on the road were counted by observers, who were engaged for the purpose. All vehicles were counted for fourteen hours a day (7 a.m. to 9 p.m.) for seven consecutive days in August, 1909, and again for seven days in October, 1909, at 238 stations, the daily census at each station being tabulated on a card. This same census was made again for like periods of time in August and October of this year (1912). At a few important points a count was also made at night, the census at these places covering the whole twenty-four hours.

After the cards were received the number of vehicles observed at each point was tabulated and computed to show the average number of each class of vehicle passing the given point per day, the total number of vehicles and the total of each class, both motor and horse-drawn. When these figures were obtained the percentage of each class of vehicle using the particular road was computed, and the percentage of the total of each class at all stations was computed as well. After these averages were computed for each of the 238 stations in 1909 and for the 156 stations in 1912, the total average number of vehicles at all the various stations was added, the numbers ascertained, and from this was obtained the average number of vehicles passing each day at all the points where the count was made, as well as the average number of each class and kind, and the percentage that the vehicles of each class bore to the average total number.

The increases and changes in traffic from 1909 to 1912 are shown in Table I., which, by the way, shows that the traffic is changing much more rapidly than it is increasing. The figures represent a count taken in 1909 and 1912 for fourteen days of each year, and from 7 a.m. to 9 p.m. of each day. The report goes on to say that the significant feature of the census for the roadman is not the increase of traffic, but the change in the traffic.

It is that which he must consider and for which he must prepare. Another factor which further analysis brings out, and which is also important, is that light, single-horse vehicles decreased 25 per cent.; two-horse vehicles, 14 per cent.; heavy, single-horse vehicles, only 3 per cent., and heavy two or more horse vehicles, only 5 per cent.

Table I.—Increases and Changes in Traffic from 1909 to 1912.

	1909 Census, 238.5 Stations			1912 Census, 156.5 Stations			
	Average Total Number per Day	Average Number per Day per Station	Percentage of Each Class	Average Total Number per Day	Average Number per Day per Station	Percentage of Each Class	Increase or Decrease (per cent.)
Motors:—							
Runabouts	4,958.5	20.8	8.5	5,810.0	37.2	11	+79
Touring cars	17,950.5	75.3	30.5	27,178.5	173.5	49	+130
Trucks	—	—	—	1,800.0	11.5	3	—
Total	22,909.0	96.1	39.0	34,797.5	222.2	63	+131
Horse-drawn vehicles:—							
1-horse, light	17,033.0	71.5	29.0	8,380.0	53.5	15	—25
1-horse, heavy	11,762.5	49.3	20.0	7,458.0	47.6	14	— 3
2 or more horses, light	1,006.0	4.2	2.0	556.0	3.6	1	—14
2 or more horses, heavy	6,205.5	26.0	10.+	3,870.5	24.7	7	— 5
Total horse-drawn	36,007.0	151.0	61.0	20,264.5	129.4	37	—14
Totals of all kinds		247.1			351.6		+42

Weight of Traffic.—In commenting upon the weight of traffic as an important consideration, the report states:—

"After all, it is not numbers which tell the story, it is weight, and it is not weight alone, but the vehicle by which it is transported, whether by horses or by motor. It is not the tractive power alone that makes the difference, but the tires which support the vehicle; whether iron or rubber comes in contact with the road; whether the vehicle is pulled over the road or propels itself, and thus pulls upon the road surface. All of these considerations are probably not so important on many road surfaces as the actual weight imposed upon the road per inch width of tire resting upon the road.

"In other words, heavy loads supported upon narrow iron tires, having a weight of over 600 to 800 pounds for each inch in width of the tire, do vastly more damage to most, if not all of our roads than do very much heavier loads where the weight per inch width of tire is less.

"Such loads carried on such narrow tires will practically destroy any road surface, except a pavement, in a few months if there are many such vehicles using the road every day.

"After careful study they have adopted in England an assumed weight, or coefficient, for each kind of vehicle using the roads, in order to make a fair comparison of the traffic upon different roads where the traffic varies, and to more nearly show what the road must support. It is quite similar to the formula in use in France and on the Continent.

"It is, therefore, used both for want of a better one, and also because it gives a fair basis of comparison. Table II. shows the weight of the road traffic on Massachusetts roads computed in this way, with the coefficient reduced to tons of 2,000 pounds each in every case, both on the English and Massachusetts roads:—

"Here, again, not only are the changes in traffic notable, but the weights are even more important.

"The average weight per station per day of the motor vehicles in 1909 was 197 tons; in 1912 it was 512 tons. For horse-drawn vehicles it was 147 tons in 1909 and only 135 tons a day in 1912.

Table II.—Weight of Traffic on Massachusetts Roads.

	1909			1912		
	Average Number per Day per Station	Assumed Weight (tons)	Weight per Day per Station (tons)	Average Number per Day per Station	Assumed Weight (tons)	Weight per Day per Station (tons)
Motors:—						
Runabouts	20.8	1.43	29.7	37.2	1.43	53.2
Touring cars	75.3	2.23	167.9	173.5	2.23	386.9
Trucks	—	6.25	—	11.5	6.25	71.9
Totals	96.1	—	197.6	222.2	—	512.0
Horse-drawn vehicles:—						
One horse, light	71.5	.36	25.7	52.5	.36	19.3
One horse, heavy	49.3	1.12	55.2	47.6	1.12	53.3
Two or more horses, light	4.2	.54	2.3	3.6	.54	1.9
Two or more horses, heavy	26.0	2.46	64.0	24.7	2.46	60.8
Totals	151.0	—	147.2	129.4	—	135.3
Totals of all kinds	247.1	—	344.8	351.6	—	647.3

"The weight of automobile traffic has increased 160 per cent. in three years, while the weight of horse-drawn vehicles has actually decreased 8 per cent. in the same time. While this is true, note what happened: the motor truck has come in with an average number of trucks of 11½ per station, and their weight is nearly 72 tons a day. The weight of teams decreased 12 tons a day; trucks came in with a weight of 72 tons a day, making good the loss in team weight six times over."

The width of roadway is also given due consideration, as it is manifest that what wears out a road is the actual weight and volume of traffic that has to be sustained by each inch in the width of the road surface. The report contains tables showing the assumed actual weight in tons, per day, passing over each yard in width of the macadam roadway on certain roads in Massachusetts.

Table III.—Average Daily Traffic.

	Light Teams	Heavy Teams, One Horse	Heavy Teams, Two or More Horses	Automobiles a Day
A good gravel road will wear reasonably well and be economical with	50 to 75	25 to 30	10 to 12	100 to 150
Needs to be oiled with	—	—	—	Over 150
Oiled gravel fairly good either hot or heavy cold oil ½ gallon coating (cold oil must be used yearly)	75 to 100	30 to 50	20	500 to 700
Water-bound macadam will stand with	175 to 200	175 to 200	60 to 80[1]	—[2]
Dust-layer will prove serviceable on such macadam with	—	—	—	50 to 100
Macadam will then stand (but the stone wears, of course) with	—	—	—	300 to 500
Water-bound macadam with hot oil blanket coat will be economical with[3]	150 to 200	75 to 100	25 to 30	Up to 1,400
Will stand at least[5]	—	—	—	—
But will crumble and perhaps fall with over	—	100[6]	50[6]	—

[1] Perhaps more.
[2] Not over 75 at high speed.
[3] The large number of automobiles seems to keep the oil rolled down when it would be cut up and crumble without this traffic. Water-bound macadam with a good surface coating of tar will stand a very large number of automobiles, but the commission has not used tar extensively as a surface treatment where there is heavy team travel.
[4] And more with fewer teams.
[5] Fifty motor trucks, probably more.
[6] On narrow tires; or loaded farm wagons, ice and wood teams, etc.

The Commission emphasizes the necessity of a traffic study for the purpose of helping the road engineer determine the type of road to build, and the best method of maintenance. The experience in Massachusetts and elsewhere has shown conclusively that large numbers of swiftly moving automobiles cannot successfully be carried over a water-bound macadam road or over a gravel road. Such a road becomes ravelled very rapidly, rutted and disintegrated. Traffic studies indicate that from 50 to 100 automobiles a day make the use of some dust-layer or binder necessary, and its use would possibly prove economical on a road where there is even less motor traffic. With the motor traffic which Massachusetts already has it has been found necessary, both for economy and for efficiency, where a road has heavy team traffic as well, to adopt in construction or resurfacing some form of bituminous mixture for the upper two or three inches of the road surface, at least, or some stronger road, like concrete. In many places, the Commission believes, such construction or reconstruction, has been, and will be, economical.

Conclusions Summarized.—A table has been included in the report showing as nearly as may be the results which have been observed after four years of experience with bituminous materials, comparing these results with the traffic going over the road in 1909 and again in 1912. The Commission realizes fully that more experience will undoubtedly cause it to change or modify some of its present opinions, but they are submitted for what they are worth as indicating the result of its experience in Massachusetts.

The standard road is 15 feet in width of macadam, with three-foot gravel shoulder on each side.

RESISTANCE OF THICK CYLINDERS TO RUPTURE.

According to M. Malaval, in "Rev. de Metallurgie," in a tube of the proportions of gun practice, the thickness about equal to the calibre, there are two distinct periods besides the elastic range. This is followed by the range of semi-elasticity or partial failure, which is of sensibly the same duration in stress. With increasing applied pressures the area of overstressed metal widens radially outwards. Thus if the pressure is released the outer elastic zone is prevented from returning completely to its original shape by the permanent deformation of the inner plastic zone. The mutual action causes the unloaded tube to be stressed in tension in the outer region and in compression in the inner, so that it is in the condition of an ideal shrunk composite tube—i.e., one with an infinite number of indefinitely thin components whose mutual pressures are such that under rising internal pressure all parts reach the elastic limit simultaneously and bear equal parts of the load. The semi-elastic period ceases when the outside layer reaches the limit of elastic deformation and is followed by the periods of general failure. During this period, covering an increase of resistance much greater than those of the first two periods, all parts show an increase of resistance, the inner region being in compression and the outer in tension. It follows that the metal, whose capacity for deformation is greater in compression than in tension, can withstand very considerable internal strains. It is concluded that the ordinary shrinking process might be replaced advantageously by one involving initial overstraining of a solid tube. A gun so constructed would withstand a pressure of over 1,500 kilogrammes per square centimetre (213,300 pounds per square inch).

The statistics of the report of Mr. J. McLeish on Economic Minerals and Mining Industries of Canada, contains the following record of production of pig iron:—In Ontario, in 1911, 526,635 tons valued at $7,606,939, in 1912, 589,593 tons valued at $8,176,089; in New Brunswick in 1911, 31,120 tons valued at $69,464, in 1912, 71,520 tons valued at $127,716; in Nova Scotia, in 1911, 390,242 tons valued at $4,682,904, in 1912, 424,994 tons valued at $6,374,910; in Canada, in 1911, 917,535 tons at a value of $12,307,125, while in 1912 an increase is shown in the production of 1,014,587 tons at a value of $14,550,999.

LIQUID, SOLID, AND GASEOUS FUELS FOR POWER PRODUCTION.

In a paper presented a month ago to the Engineering Section of the British Association, by Prof. F. W. Burstall, of the University of Birmingham, the means by which carbonaceous substances might be treated to render them suitable for the production of power were touched upon. The address has just appeared in extracted form in *The Iron and Coal Trades Review*, and is reproduced herewith:—

The fuel of the world, he said, consisted of two forms—liquid and solid, both of which were closely related inasmuch as they consisted of compounds of carbon and hydrogen, together with small percentages of other substances, such as nitrogen. Most engineers looked upon coal purely from the point of view of fuel to be used in a furnace for the production of heat. It was, however, a complicated substance from which could be extracted a wide range of valuable products.

There were points in the use of gaseous fuel which led to serious difficulties. In order to secure efficiency the main mass of the air must be heated by compression before the principal heat supply was added. The combustible gas might be added before compression began, as in the well-known Otto cycle, but this introduced the possibility of the charge igniting before the correct time. It also required that the gas should be free from any liquid or solid substances, a state of affairs not easy to obtain on a large scale. If the gas were compressed in a separate pump there was a certain loss of heat due to necessary cooling of the pump. With a liquid fuel there was no difficulty in forcing the small amount of oil required into the pre-heated air, and the oil was readily freed from foreign matter; also, there did not appear to be any inherent reason why the oil engine should not be made in the largest sizes, beyond those of weight and cost, where it must always be inferior to the rotary machine.

Passing on to deal with the gas turbine, Prof. Burstall said it could readily be shown that the velocities which had to be dealt with were no greater than those encountered in the steam engine, but there were difficulties which, in spite of innumerable efforts, had so far proved insurmountable. The greatest defect was that, so far, it had not been found feasible to compress the air and gas in the turbine itself. Separate compression considerably increased the losses, so that in place of the negative work being one-third of the gross work it would probably be at least one-half. and perhaps more. The cooling of the rotating disc and blades offered difficulties, and further, no material had been found so far that would withstand the erosive effect of the burning gases. It seemed very doubtful if the gas turbine could be constructed to compete with the reciprocator in the present state of knowledge.

It was important to consider the amount of various fuels raised in various parts of the world. At present about 1,200,000,000 tons of coal of various kinds were brought to the surface every year; crude oil amounted to about 50,000,000 tons per year, and it was doubtful if there were any large oil fields yet to be discovered. It, therefore, followed that the supply of oil was totally inadequate in amount to replace coal for power production on a scale equal to the present steam-power production. The artificial production of oil was at present being considered seriously by engineers, and much yet remained to be discovered in this field. Every engineer was familiar with the fact that when coal was heated in a closed retort gas and tar were given off, and also that the higher the temperature at which gasification took place, the greater was the yield of gas and the smaller was the amount of tar formed.

Up to the present coal had been gasified with the object of obtaining the highest yield of gas, but it was quite possible to alter the conditions of carbonization so as to obtain a high yield of fuel oils and other compounds of value as by-products, and an important one was sulphate of ammonia, the use of which as a manure was steadily increasing in all countries of the world. Sulphate of ammonia was the most valuable manure where nitrogen was needed, and it was one of the greatest defects of the crude burning of coal that such enormous amounts of nitrogen were not only wasted, but turned into nitric acid in the atmosphere. Of course, the nitric acid was returned to the soil by the agency of rain, but not necessarily where required by the cultivator.

For one ton of coal gasified in a modern gasworks 11,500 to 12,500 cub. ft. of gas were obtained having a calorific value of about 550 B.T.U. per cub. ft., and also about ten gallons of tar and 25 to 30 lbs. of sulphate of ammonia. The gas had to be purified for domestic purposes; also a gasworks had to be near a great town where the working expenses were not so low as in a more rural part. For these reasons it was doubtful if town gas could be supplied under present conditions for much under 10d. per thousand cub. ft. Despite these facts, Prof. Burstall said he held the opinion after mature consideration, that the whole problem of fuel treatment would lie in the direction of heating the coal, peat or lignite in a closed retort; not necessarily under the conditions which were at present forced on to the gasworks, where the primary object was to produce a big yield of gas of a certain standard as laid down by Parliament. If it be granted that the quantity, quality and purity of the gas produced were a secondary matter, the problem of fuel treatment became one of the most fascinating problems which the engineer could encounter. It had long been known that the quantity and quality of the tar was largely influenced by the temperature at which the fuel was carbonized, the lower the temperature the better were the tars in both yield and composition. The amount of sulphate of ammonia recovered from the gas was only some 25 to 30 lbs. per ton of coal, whereas the amount of nitrogen present in the coal would give about 120 lbs. of sulphate of ammonia. In the ordinary process of carbonization some three-quarters of the nitrogen was left behind in the coke. Under present conditions this could not be avoided, but improvements in this direction were possible. If the gas and tar were withdrawn from the heat directly they were evolved from the coal, a set of products would be obtained of a different composition from those usually obtained.

Prof. Burstall then outlined a scheme of fuel treatment which he admitted was at present wholly beyond the region of practical realization. The first step was to obtain a coal field of wide extent yielding a coking coal, the essential point being to obtain a sufficient supply of coal to enable the capital charge to be repaid in a series of years—probably thirty. The works would have to be on a large scale to economize cost of working, but the carbonization plant would be placed near the pit-head, so that the tubs could discharge direct into the bunkers of the retort-charging machines. A convenient size for each plant would be about 2,000 tons per day, and there would be some five to six pits operating over quite a large area. There would be no gain from any point of view in not shipping the coke and sulphate of ammonia direct from the pit-head, as these would be ready for market without further treatment. Tar and gas would be taken by pipe lines to suitable points for their future treatment, depending upon geographical considerations. The tar from the whole of the works would be passed through continuous and automatic stills, where the various fractions would be obtained with the least expense. The fractions, after working with acid and soda, would pass to a second set of automatic stills, this process being continued until the pure produces ready for market were obtained without the necessity for storage and in the least possible time. As to how far the treatment of residuals should be carried, no definite answer could be given, as it depended on the current prices, but on the scale considered, viz., 120,000 to 140,000 gallons of tar per day, it would certainly be advantageous to treat the products to a finish.

That portion of the gas not required for firing the automatic stills and for colliery purposes generally would be led to a different point, perhaps many miles from the pit-head. This offered no difficulty as regards the power required, the great obstacle being the cost of the pipe line, which might to a large extent be reduced by gas-holders at the delivery end so as to improve the load factor on the pipe line. The gas would be free from tar, but would contain the sulphur compounds, and would be employed in gas engines for the generation of electricity at high voltages.

No doubt electrical engineers would look askance at gas engines, not only from the many failures that had occurred with some of the large engines, but also at the fact that at present some 2,000 h.p. was about the largest size that could be built, whereas a steam turbine could be constructed to give an output of 20,000 kw. at a low first cost. The gas engine could only compete with the steam turbine when its gas was delivered to it at a price which, when helped by its high thermal efficiency, would enable it to recoup its large capital outlay. But perfect as was the steam turbine as a mechanical machine, its thermal efficiency was half that of its rival, as the cost of the steam delivered to it could not be reduced. There were also no by-products. For these reasons it was quite possible for the gas engine to produce current more cheaply than the turbine, but the price of gas of a calorific value of 500 B.T.U. per cub. ft. would have to be 4d. per thousand cub. ft. if coal be taken at 20s. per ton. This would give for each fuel about 125,000 B.T.U. per penny, and taking the gas engine as 2½ times as efficient as a turbine, this should leave enough margin to compensate for the increased capital outlay. The exhaust gases would be washed so as to extract the sulphuric acid, which would be returned to the pit-head in the manufacture of sulphate and the washing of the tars, so that the only external material to be purchased would be the soda ash used to neutralize the excess acid. In this manner the whole of the products of the coal would be recovered in a form ready for the market, and if the coke were used as a domestic fuel a smoke-laden atmosphere would be impossible.

Producer gas for power and heating purposes had a large field in front of it, particularly when the factory was distant from the coal fields, and also where there was a steady load. In producer gas the whole of the fuel was converted into gas and tar, so that a large quantity of gas—120,000 to 140,000 cub. ft.—could be obtained per ton of coal. The ammonia yield was very high, being 80 to 90 lbs. of sulphate per ton; the calorific value of the gas was low, about 140 B.T.U. per cub. ft., and the tar was small in quantity and poor in quality, as it was nearly all pitch. The low calorific value and the difficulty of cleaning the gas were serious drawbacks to the transmission over long distances. In South Staffordshire, however, producer gas had been piped over a wide area for several years, and the undertaking now appeared to be on sound financial ground. The suction producer working on coke or anthracite coal had a very definite position for small plants in remote districts, where it formed a cheap and reliable source of power.

Taking the question of producer gas as a whole, it looked as though it would always have a definite use, but only a limited application, more especially in a country like Great Britain, where in time it would be possible in most parts to obtain electricity cheaply in bulk, and when this was the case no other source of power need be considered.

The case of coke ovens readily fell into the same class as the retorted gas, the only difference being that to obtain coke capable of carrying the weight of the iron in the blast furnace, the temperature of carbonization must be high—1,200 deg. C., and the period long—24 to 30 hour; thus the tars were poorer from being more split up, and the cost of repairs to the ovens was considerably higher than on a gasworks retort. As hard coke must be made, the place for it was in conjunction with the ordinary plant, so that the by-products might be readily worked up.

Discussion.—Mr. W. M. Mordey said that Prof. Burstall had held out little hope that the gas turbine would be a practical tool in the near future, but there was one solution which occurred to him, viz., the adaptation of the Humphrey gas pump with a water turbine, allowing the water to drive a dynamo. The overall efficiency of the Humphrey pump in water horse-power was said to be something like 30 per cent., which was very high, and if the pump could be used in conjunction with a water turbine which had an efficiency of about 85 per cent., an overall efficiency of the combined pump and turbine of 25 per cent. would be obtained. Such a solution would very much simplify the problems now presented by the gas turbine and provide at the same time a direct means of driving a dynamo by a simple rotating motor. This method would give an efficiency as high as any large gas engine would give in continuous work in a much more simple manner.

Dr. J. S. Owens, dealing with the suggestion of the carbonization of coal at high temperature in order to get all the possible by-products, said that this produced a coke which was unsuitable for domestic use. Coke would not burn well unless there were a certain amount of volatile matter left in it, and such coke gave a very unpleasant-looking fire. With reference to the loss of nitrates from coal, recent experiments on the deposit in London had shown that the soot and dust falling on a given area measured in three or four places in the city was six times as great as in the suburbs. The total deposit was 500 tons per square mile per annum. On the general question of the utilization of oil, gas or solid fuel, we were apt to forget that very much of the prosperity of England depended upon the utilization of its coal supply, and it seemed to him that we should almost eliminate—except as an academic question—the utilization of oil other than the oil derived from our own coal, because otherwise we would be cutting our own throats.

Prof. Burstall, in winding up the discussion, said he had not said anything about the Humphrey pump, because he did not think it could be made in sufficiently large sizes to warrant any application of the sort suggested. With regard to the coke mentioned by Dr, Owens, he did not wish it to be assumed that the method he had indicated would be the same as was at present employed in gasworks. Gasworks at present were terribly handicapped and did not do what they could if they were free from Acts of Parliament which saddled them with penalties not imposed upon any other industry. If the coal were burned in a retort at a temperature of from 800 to 1,000 deg. C. and means taken by which the gas and tar were at once removed, they got a substance which was quite unlike gas coke, because gas coke was usually quenched in water, which was quite wrong. If the coke were placed in a closed vessel and cooled by conduction alone on the Montreal system, a coke would be obtained which would burn perfectly and which gave a very bright and clear fire. The only difficulty with it was that it burned away more quickly than was desirable. It was possible to regulate the products by altering the pressure and temperature inside the retort more than the majority of people were disposed to think, and it really was a question of what happened to be the most valuable product at a particular time. The best results were 14 gallons of tar, from 2 to 2½ gallons of light spirit suitable for motor-car work, and 3 to 4 gallons of fuel oils suitable for Diesel engines, so that a very large proportion of useful substances could be obtained without sacrificing anything.

PLANT OF CANADIAN-VICKERS, LIMITED, MONTREAL.

Principally through the determination of the people of the Dominion of Canada to ultimately possess a navy under their own control, the opportunity of establishing a shipyard in Canada with brilliant prospects for continuous work has arisen. Quick to seize this opportunity Messrs. Vickers, Limited, of England, under the name of the Canadian-Vickers, Limited, are establishing a complete ship-building and ship-repairing plant in Montreal, capable of constructing and repairing the largest vessels using the port of Montreal.

For repair purposes a floating dock was sent out from England capable of lifting 25,000 tons and repairing a ship 700 feet in length.

For ship construction a slip 600 feet in length, but capable of extension, is being constructed on land reclaimed by the Harbor Commissioners at Maisonneuve.

For the walls of this slip and for adjoining machine shops and factories, approximately two thousand concrete piles are being used.

After exhaustive inquiries into the different types of concrete piles on the market, the owners decided that the most reliable was the Pedestal Pile, which had been used with most gratifying results by the governments of the United States and Canada and by the majority of large corporations in both countries. The pile is driven exclusively by the MacArthur Concrete Pile and Foundation Co., of New York, who possess the patent rights for the United States, Canada and other countries.

The general contract was awarded to Mr. E. G. M. Cape, one of Montreal's leading contractors, while the piling was placed in the hands of the MacArthur Concrete Pile and Foundation Co.

Seven hundred and forty-seven of these piles, averaging about 22 feet in length, have been driven under the ship-building slip. Four tests were made with most gratifying results, a load of 45 tons, 50 per cent. more than the load the piles were to bear, showing no appreciable settlement.

The piling required for the shops, etc., is now being driven.

IMPROVED MANAGEMENT OF WATERWORKS.*

Paul Hansen,
Engineer, Illinois State Water Survey.

THE object of this paper is to advocate the employment, on an annual basis, of consulting experts in connection with the operation of small waterworks installations for the purpose of improving the service, the equipment, and the economy of operation. This is by no means a new practice, but it is exceedingly rare, whereas it should be virtually universal.

The means by which the expert's services may be rendered are by occasional visits, say, monthly or quarterly, by the training of the men locally employed, by the periodic examination of records and accounts maintained in accordance with instructions furnished by the expert and finally, by reports with recommendations, submitted at regular intervals. Not more than a few days per month would be occupied by the work involved, and the service may be rendered at what, comparatively speaking, is a nominal fee. For supervising waterworks in a small community $600 should yield a fair compensation. Perhaps a more satisfactory method would be to base the fee upon the gross receipts, making it a suitable percentage thereof.

Need for Expert Supervision.—It is hardly necessary to point out that there is a real need for improved management of waterworks, for the reason that most engineers who have had anything at all to do with waterworks are aware of the very general slipshod methods employed. During the past eight years the writer has had occasion to visit or receive reports upon about two hundred small waterworks in the States of Ohio, Illinois and Kentucky, and not an instance is recalled of a small waterworks installation (that is to say, for a town having a population of about 25,000 or less), where thoroughly effective methods of management were being employed. This does not infer that all these waterworks installations were not giving good service. As a matter of fact, some were giving good service, but generally at unnecessarily large expense, and without adequate records and accounts to show where economies might be instituted. The great majority, however, were giving very inferior service, and showed every outward evidence of carelessness and neglect in management.

Possible Objections to Expert Supervision.—The method of improving the management herein discussed is not advocated for the purpose of increasing the business of consulting engineers, but because it seems the only practicable method whereby the desired results can at present be accomplished. In large waterworks, of course, it is perfectly feasible to engage the entire time of an expert and designate him as general manager. In small waterworks, however, it is not possible to afford the continuous services of an expert. The men ordinarily employed, while they may be intelligent and conscientious, have not had the opportunities of securing the necessary training and experience to render most effective service. But such men, backed by an expert, are as a rule capable of securing highly efficient results. More generally it is found that the waterworks has become a political football and is relegated to the mercies of very incompetent men. In such cases the consulting expert has a very difficult problem, but by tact and by appealing to the more enlightened sentiment of the community he may accomplish a great deal, and because of the very fact that things are in a run-down condition the results of his efforts will be all the more striking.

There may exist the feeling among some, that the supervision of waterworks should be entrusted to local engineers in general civil engineering practice. This would, as a matter of fact, be an injustice to such engineers for the reason that their numerous other duties and employments rarely permit them to acquire the necessary expertness in the restricted field of waterworks. It would appear, therefore, that no conflict of interest exists between the consulting expert and the local engineer. On the contrary, the local engineer should be the first to recognize the necessity of the services of an expert in waterworks operation.

Some persons lean to the belief that supervision over public waterworks should be maintained by some central State authority, and such supervision is certainly desirable, in so far as the sanitary quality of water supplies is concerned. But to enter into the economic phases of waterworks operation to the extent of giving the close supervision herein contemplated, would be altogether impracticable. It would involve the maintenance of an expensive and cumbersome bureau engaged in performing functions which are primarily of local concern, and, moreover, the mere fact that the services of such a bureau would be foisted on the local community would cause the local authorities to be generally antagonistic toward the bureau's requirements. It is not practicable for any central body to go further in this matter than to do just enough to demonstrate the value of expert services in waterworks operation and leave the rest to municipal and private enterprise.

Results Obtainable through Expert Supervision.—Specifically, the results obtainable through expert supervision of a waterworks are:—

1. Better service.
2. Reduction of cost of operation, which, of course, means increased earnings.
3. Anticipation of future requirements.
4. Improved design.
5. A professional and personal advantage to consulting engineers.

Better service means furnishing, throughout the community, an ample quantity of pure and clear water for domestic and industrial purposes, and providing a liberal safeguard against disastrous fires.

Decreased cost of operation means a supervision of all the details of operation in such manner that effective service will be rendered at minimum expense.

Anticipation of future requirements means that all necessary increases in the supply and equipment will be foreseen, so that they may be provided before the community is reminded of its needs by destructive fires, inadequate equipment, or disastrous epidemics due to the pollution of the water.

Improved design will result from a better knowledge of operating conditions than is ordinarily obtainable under present practice by those entrusted with the preparation of plans and specifications. The structural features can generally be readily taken care of, but a common fault is a failure to provide for contingencies encountered in operation. Under the present regime the consulting engineer's connection ceases at about the time that operation begins, and if he has any curiosity to learn if his designs are working out successfully he must satisfy his curiosity at his own expense.

A personal advantage accrues to the consulting engineer from supervision over the operation by giving him continuous and regular employment, thus enabling

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him to maintain his organization intact. Further, it benefits him professionally by enabling him to concentrate his practice within a limited field, and thus he has the opportunity of increasing his detailed knowledge along his chosen line; in short, he renders himself more expert. There are many men in consulting practice to-day who attempt to cover such a broad field that it may be frankly said they are not thoroughly competent in any one line.

Modus Operandi of Expert Supervision.—For the purpose of illustration and not with any intention of giving a treatise on how to supervise waterworks operations, a brief description will be given of the manner in which expert supervision should work out. Three factors form the basis upon which this work is conducted:—

1. Operation Records, relating to the physical facts connected with waterworks operation.

2. Financial Accounts, relating, of course, to the finances.

3. Technical Skill, which is required in obtaining and interpreting the operation records and financial accounts in such a way that all of the needs of the waterworks plant are fully revealed.

It will be of advantage to inquire a little more fully into these three items and consider them separately.

Operation Records.—Records may be subdivided into several groups as follows: Those relating to source of supply, purification works, pumping station, and line distribution system.

(*a*) *Records Relating to Source of Supply.*—Records relating to the source of supply comprise measurements of the quantity of water available, sources of possible pollution and analyses of the water.

The measurement of the quantity of water available may be made in a variety of ways, some simple, some elaborate, depending upon the character of the source of supply. At any rate, such records are exceedingly valuable in forecasting the adequacy of the source of supply for future requirements. In the southern part of Illinois are two communities, each of which obtain their water supply from an impounding reservoir. During the past summer both of these reservoirs went practically dry, and remained so for some months. In one case no emergency supply could be secured, the community suffered for want of water for ordinary domestic purposes and was left helpless against a conflagration.

In the case of surface-water supplies, the records relating to the condition of the watershed, particularly if the water is used in an unpurified condition, are exceedingly important. Inspections of the watershed, when intelligently made, are much more reliable than analyses in showing dangers to health. It is merely necessary to mention the Plymouth , Pennsylvania, epidemic of typhoid fever in 1885 to demonstrate the futility of analyses in detecting intermittent pollution, such as was responsible for that disastrous outbreak.

Analyses, however, should not be ignored, especially when it is possible to secure a long series of analyses, as they then become a measure of the pollution and give a record of the physical and mineral characteristics of the water. Where purification of the water is employed, such analyses are well-nigh indispensable, as will be discussed later.

It is much easier to give examples of the evil results of failure to maintain proper records regarding the source of supply than to give examples of water famines and other disasters that have been averted by the maintenance of such records. The latter instances are ordinarily not recorded and the danger is never realized by the general public.

(*b*) *Records Relating to Purification Works.*—A volume might be written upon this subject alone. Experiences with small filter plants are most disheartening. Practically all of the small filter plants in Illinois, numbering half a dozen or more, are being ineffectively operated. The same is true in Ohio and Kentucky, and, no doubt, in other States. Some of the difficulty is due to bad design. Very small filter plants are apt to embody bad design, whereas the conditions under which they are operated are such that they should embody the very best design.

Expert supervision over mechanical filter plants (those most generally used in the middle west) does not necessarily result in reduced cost because of the prevalent reprehensible custom of omitting the use of coagulant when the raw water is moderately clear, but within the limits of efficient purification the cost can undoubtedly be reduced. The average small purification works is placed in charge of a pumpman or fireman, having many other duties to attend to, and it is but natural that this, combined with his lack of knowledge of water purification, results in almost total neglect. In many instances such men, through ignorance of the danger of impure water to public health, have no hesitancy in by-passing the raw water into the mains when it becomes convenient to do so.

Records necessary for maintaining proper supervision over mechanical filter plants include analyses of the raw and filtered water, the quantity of water treated, quantity of chemicals used, the frequency of washing the filters, the quantity of wash water used, and numerous other details. For obtaining analytical data there should be established, in connection with every filter plant, however small, a modestly-equipped laboratory. It is an easy matter to train any ordinary waterworks employee of normal intelligence how to make simple analytical determinations which will not only furnish the desired records, but will guide the filter attendant in his daily operation of the plant. If the expert has laboratories at his command, additional analytical control may be maintained on a somewhat more elaborate scale.

(*c*) *Records Relating to Pumping Station.*—A small waterworks pumping station, for which complete records are maintained, is a great rarity. Often it is impossible to get even an approximation of the quantity of water pumped, and generally the only records are from pump revolution counters without any allowance for slippage. It is a comparatively simple matter to weigh the coal and ash, to maintain pumping records both from revolution counters on the pumps and from a meter placed upon the main discharge from the station, and records of the discharge pressure, suction lift, quantity of boiler water used, etc. With such items as these it is possible to always know the condition of the pumps, figure accurately the station duty, and otherwise reveal opportunities for improvement and cutting down the demands on the coal pile. The expert can also arrange, where conditions warrant, for purchasing fuel and possibly other supplies on an analytical basis.

(*d*) *Records Relating to Distribution System.*—Most deplorable of all are the records ordinarily maintained in connection with the distribution system. The location of mains, valves, and service connections is generally stored in the memory of ex-waterworks employees and local plumbers, who regard these facts more or less as stock-in-trade, and would consider it business suicide to record them. In many towns there is no vestige of a map of the distribution system to be found, and where such maps do exist it is only occasionally that they show mains laid since the original waterworks installation. It is not strange, therefore, that extensions to the distribution system are generally unwisely made, that fire pressure is often lowest where most needed, and that there are many undetected leaks and thefts of water. In the hands of an expert all of these difficulties may be easily overcome simply by the maintenance of complete maps and plans, by periodic inspections, and by occasional tests for pressure, leakage, and waste.

Financial Accounts. — Waterworks accounting, especially in municipally-owned establishments, is usually in a chaotic state. About all that is ordinarily recorded are the gross receipts and gross expenditures, roughly itemized. Capital accounts are almost unheard of, and it is often impossible to get even approximately the cost of the plant. In many municipal plants large donations from public funds are calmly included as earnings. Such items as depreciation, allowances for taxes, interest on investment, sinking fund, rent, etc., are altogether ignored. If the gross receipts, no matter from what source exceed the gross expenditures, no matter for what purpose, a profit is proudly proclaimed. In some instances, on the other hand, large numbers of free service connections make a waterworks appear as a losing proposition, whereas suitable compensation for such services would place the plant upon a sound financial basis.

Correctly-maintained accounts should display fully itemized capital accounts, maintenance accounts, repair accounts, replacement accounts, sinking fund accounts, depreciation accounts, interest accounts, and, in fact, every item that enters into waterworks construction, operation, and maintenance should be carefully recorded in its proper place. In addition, there should be maintained accounts showing unit costs for operation and construction. These latter are very valuable in making comparisons with other plants and with the same plant in other years. Accurately-maintained accounts are particularly serviceable in the adjustment of water rates. The establishment of water rates is, at the present time, on a most unscientific basis, and it is common practice for small communities to adopt, parrot fashion, the rates established in some other community, regardless of the manner in which the water is obtained and the cost of delivering it to consumers.

Technical Skill.—But little can be said with respect to technical skill. It is primarily a matter of natural aptitude and experience, and it is needless to say that no one should presume to enter this field of consulting practice unless his natural aptitude and experience have rendered him fitted therefor. Aside from the maintenance of records and financial accounts it is necessary for the consulting expert to thoroughly instruct the men locally employed in their respective duties, and this necessitates, of course, skill and a thorough knowledge of such duties on the part of the expert. The analytical mind of the expert also enables him to discover opportunities for modifying methods of operation which the more or less untrained man would fail to see.

To summarize: The employment of consulting experts to supervise the operation of public water supplies and other public utilities in the small communities, constitutes a simple and the only practicable method whereby the operation of such utilities may be rendered efficient, whereby the design may be improved, and whereby there will accrue a distinct professional and financial advantage to the experts. Once this system is fairly tried it is hard to believe that it will not gain general favor.

BUCKET ELEVATORS.

By Reginald Trautschold, M.E.

ALL the material handling equipment so far considered in this series of articles has one and the same drawback—so serious that in some installations use of such apparatus is impossible or inadvisable—and that is its limitations in elevating operations. Flight conveyers, belt conveyers and to some extent even screw conveyers are used to raise material from one elevation to a higher one, but such operation necessitates the load being carried up a comparatively gradual incline so that considerable space for equipment is necessary before any relatively great lift is possible; even when the elevating system consists of a system of several inclined conveyers that deliver their load from one to the other and are arranged as compactly as possible, such as systems of criss-cross conveyers. The logical procedure is to place the load in a bucket and raise it in a vertical or nearly vertical plane—that is, when space is not available for the more cumbersome arrangement of elevating in slightly inclined planes. By substituting a succession of relatively small buckets, attached to an endless chain or belt running over suitable sprockets or pulleys, so that they may be raised continuously, the material may be elevated in small individual loads so that at the higher elevation it is practically delivered in a steady and uniform stream, thus greatly increasing capacity of elevating apparatus and supplying the material in quantities that can be easily and rapidly handled from that point, when further conveyance is necessary, by other conveying machinery, or can be efficiently disposed of by chutes, etc. Such a system for elevating materials comprises what is known as a "bucket elevator."

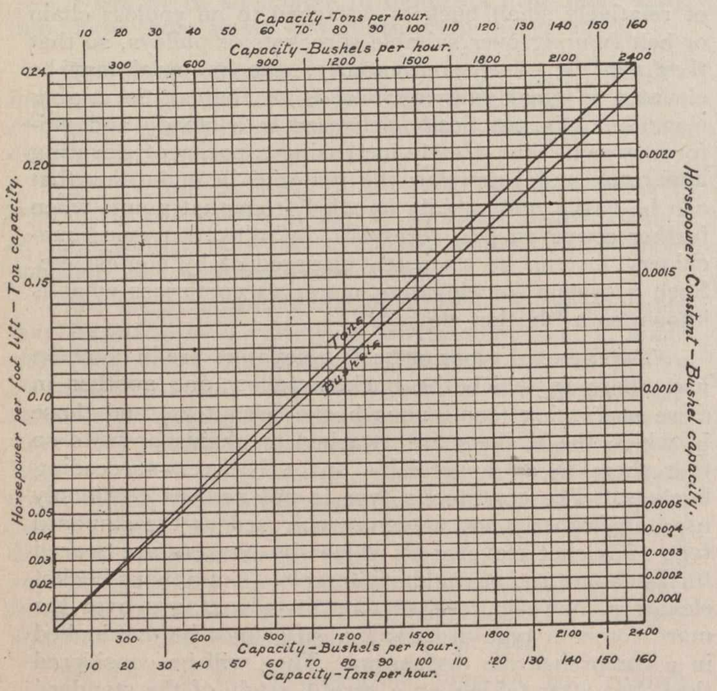
Two general types of bucket elevators are in common use, those in which the buckets follow one another in close succession (continuous bucket elevators) and those in which the buckets are attached to chains or belts so that there is an appreciable space between succeeding buckets. The continuous type is not now as commonly used as formerly nor as commonly used as the standard type of bucket elevator in which the buckets are spaced further apart and at regular intervals. Continuous bucket elevators, however, possess certain advantages over the more common type of elevator, so cannot be overlooked in a comprehensive discussion. They will be considered then, but after taking up a careful study of the standard bucket elevator.

Bucket elevators in which the buckets do not follow one another in close succession may be of three general classes: 1st, those in which the buckets are attached to a single endless chain; 2nd, those in which the buckets are attached to two matched strands of endless chain; and 3rd, elevators in which the buckets are attached to an endless belt. Bucket elevators in which only a single chain is employed on which to carry the buckets are nearly always installed at an inclination with the vertical in order that the load may be properly discharged from the buckets as they pass around the head elevator sprocket, for a vertical elevator of this kind would spill a large portion of its load between the two runs of buckets, or, if run at such a speed as to assure proper discharge of load as the buckets passed the top of the head elevator sprocket it would be impossible properly to fill the buckets, to say nothing of the difficulty of properly handling the load discharged at the necessarily high speed. Equipment employing two chains for carrying the buckets may be similarly inclined or may be run vertically if choke sprockets are employed to deflect the return (downward) run of conveyer close to the head elevator sprockets, or if the rising buckets are carried over a short more or less horizontal path before they descend to the elevator boot to be refilled—i.e., causing the path of the buckets to follow the outline of a right-angle triangle, the loaded buckets ascending the vertical stretch, then being carried and unloaded over a horizontal section of elevator and the empty buckets returned to the elevator boot in an inclined plane. The belt type of bucket elevator, not permitting the use of deflecting pulleys, must also be run in a plane inclined to the vertical, for, though the spill of load between the rising and descending stretches of elevator would not be as great as in the case of the single chain elevator, still much of the load would

BUCKET ELEVATORS.

Horsepower required for Elevators continuously and uniformly loaded.

Notes:- To ascertain total horsepower required; when the ton is the measure of capacity, multiply the "Horsepower" reading of Chart by the distance in feet between the end Elevator wheels (sprockets or pulleys); when the bushel is the measure of capacity, multiply the "Horsepower-Constant" reading of Chart by the product of the distance in feet between the end Elevator wheels by the weight of the load in pounds per cubic foot or by four-fifths of the weight of one bushel of load in pounds.



HORSEPOWER CHART.

fail to reach the discharge chute of the elevator and material would fall against the descending belt and be carried about the boot (lower elevator) pulley, causing disastrous wear to the belt, possible wreckage of elevator, etc.

Standard bucket elevators, of any of the three classes, are nearly invariably similar so far as their drives and loading equipment are concerned. They are driven, through a train of reducing gears ordinarily, by their head sprockets or pulleys and are loaded from an elevator boot which ordinarily contains adjustable take-up bearings for the boot sprocket or pulley by which the tension in the return run of buckets may be regulated—the excess slack taken up. Frequently the elevator is enclosed in a casing, from the elevator boot up, with suitable outlet for the discharge, which serves to protect the equipment from injury and to return any spill of the load to the elevator boot for re-handling. Modifications of these general types of elevators naturally exist, excluding special elevators for handling materials in barrels, boxes, bales, etc., etc., such as elevators in which the lower end consists of a more or less horizontal stretch over which the load is scraped or dragged, as in the case of a flight conveyer, before the buckets start their operation of elevating or where the upper end of the elevator is carried over a similar stretch before entirely discharging its load, but such modifications so closely resemble "bucket carriers" that they will be overlooked at present and referred to again when discussing the more complicated combined bucket elevator and conveyer, the bucket carrier. Limiting this discussion to the ordinary type of standard bucket elevator, therefore, further description is unnecessary owing to the extreme simplicity of the equipment.

Table VIII.—Capacity of Bucket Elevators (Standard Buckets)—Tons Per Hour. Material Weighing 100 Pounds Per Cubic Foot. Elevator Speed, 100 Feet Per Minute.

Size of Buckets	Buckets spaced 12 in.	15 in.	18 in.
5 in. x 4 in.	6.50	5.35	4.25
6 in. x 4 in.	7.75	6.00	5.00
8 in. x 5 in.	19.00	15.00	12.50
9 in. x 5 in.	21.25	17.00	14.00
10 in. x 6 in.	34.50	26.75	23.00
11 in. x 6 in.	37.75	30.00	25.00
12 in. x 6 in.	41.25	33.00	27.25
14 in. x 6 in.	48.00	38.50	32.00
16 in. x 6 in.	55.00	44.00	36.50
18 in. x 6 in.	61.75	49.25	41.00
20 in. x 6 in.	69.00	55.00	46.00
14 in. x 8 in.	78.50	62.75	52.25
16 in. x 8 in.	90.00	72.00	60.00
18 in. x 8 in.	100.00	80.00	66.00
20 in. x 8 in.	112.00	90.00	74.00
24 in. x 8 in.	128.50	104.00	86.00

The capacity of bucket elevators depends, of course, upon the size of the buckets, their number and the speed at which the elevator is run. The size of bucket also depends somewhat on the character of the material to be handled for bulky materials naturally require larger buckets than those which might be entirely suitable for the handling of fine material. However, the average class of materials usually handled in bulk by bucket elevators does not vary so much as to prevent a fair average carrying capacity being fixed for a bucket of specified size. The shape of the bucket also effects the question of its carrying capacity, but here standardization of equipment has devised a shape of bucket that is almost universally employed or when modified for special installations, such as those in which the inclination of the elevator from the vertical is great, has a carrying capacity about the same as the standard bucket, which is fairly constant for any particular size (size expressed as length x width of bucket) so that, for all practical purposes, the length and width of the bucket determines its carrying capacity. The number of buckets, as they are invariably attached to the chain or belt at regular intervals, depends upon the spacing; while the capacity of any elevator buckets and their spacing being the same, depends directly upon the speed at which the elevator is run, i.e., speed of elevator chain or belt. Table VIII. gives the best ordinary capacity, in terms of tons per hour, of standard bucket elevators, equipped with various common sizes of standard elevator buckets at ordinary standard spacings, when the elevator is continuously and uniformly loaded with material weighing 100 pounds per cubic foot and an elevator speed of 100 feet per minute. For elevators handling material of other weight or at other speeds, capacity varies directly with the weight of the material per cubic foot and with the speed at which the buckets are run. Table IX. gives similar data expressed as the number of bushels of material that can be handled by such elevators in an hour. The question of most efficient speed at which to run a bucket elevator, the condition upon which the capacity of the apparatus directly depends, is one concerning which there is a great diversity of opinion. It is generally admitted, however, that the most efficient speed for a standard bucket elevator is about the same as that for a flight conveyer handling similar material. Such practice is usually pretty correct and Table X., giving the average actual speed at which a number of very successful and efficient bucket elevator installations are run, confirms the rule.

Table IX.—Capacity of Bucket Elevators (Standard Buckets)—Bushels Per Hour. Elevator Speed, 100 Feet Per Minute.

Size of Buckets	Buckets spaced 12 in.	15 in.	18 in.
5 in. x 4 in.	114	91	76
6 in. x 4 in.	137	110	91
8 in. x 5 in.	335	268	223
9 in. x 5 in.	377	301	251
10 in. x 6 in.	610	487	406
11 in. x 6 in.	671	536	448
12 in. x 6 in.	732	586	488
14 in. x 6 in.	854	684	568
16 in. x 6 in.	976	781	651
18 in. x 6 in.	1098	879	733
20 in. x 6 in.	1220	976	813
14 in. x 8 in.	1393	1104	929
16 in. x 8 in.	1592	1274	1062
18 in. x 8 in.	1791	1433	1194
20 in. x 8 in.	1990	1592	1327
24 in. x 8 in.	2388	1912	1592

In the consumption of power, bucket elevators are not particularly economical or efficient, for not only does the force of gravity act directly against the lift of the load but several other operations consume considerable power. For instance, there is the loss due to the inefficiency of the driving mechanism, comparatively heavy friction losses considering the fact that the number of bearings is quite small in any elevator, owing, in a chain elevator, to the individual friction in each link joint of chain which resists carrying the chain about the end sprockets, etc., and, in the belt elevator, to the unavoidable slippage between the elevator belt and the elevator pulleys, the resistance of the material in the elevator boot to the passage of the buckets through the boot as they pick up their load, etc., etc. There is also, in an inclined elevator, a certain slight consumption of energy in carrying the load from the vertical loading plane to the vertical discharging plane, but this latter requirement of power is actually so slight, as elevators are ordinarily installed, that it can be disregarded. The exact value of these inefficiencies and operations consuming power that is not instrumental in raising the load is difficult to ascertain, and no fixed law for arriving at the correct proportion to allow for such losses of power can be advanced. Manufacturers of bucket elevator equipment usually allow a margin of 50 per cent. to cover all requirements for power other than the theoretical amount that would be actually required to elevate the given load from the point at which it is received (in the elevator boot) to that at which it is discharged (over the head of the elevator). Numerous tests of various installations in actual operation tend to confirm this practice and though the percentages of power losses in various operations do vary considerably their sum is more constant and does actually amount to close to 50 per cent. In the derivation of Formulæ XVII., XVIII-a and b average losses and inefficiencies have been allowed for and the results obtained from the use of any of these formulæ will be found to agree very closely with the actual requirements of the average well-installed and properly cared for standard bucket elevator. Chart IV. presents the same data as the horsepower formulæ in a

Table X.—Efficient Speeds for Bucket Elevators Handling Various Materials.

Material	Advisable Speed
Coke	100 feet per minute
Broken Stone (coarse); Lump Coal—R/M	125 " "
Ashes, Lime and Cement	150 " "
Ore, Crushed Stone, Sand and Gravel	175 " "
Fine Coal	200 " "

convenient graphical form that enables the ascertaining of the power requirements of any ordinary installation to be made rapidly and with sufficient accuracy for practical purposes.

Horsepower:

H = distance through which load is elevated—height of elevator—in feet.
W = Weight of load elevated in tons per hour (capacity).
B = Bushels of load elevated per hour (capacity).
w' = Weight of 1 cubic foot of load in pounds.
b' = Weight of 1 bushel of load in pounds.

$$\frac{W \times 2000 \times H}{60 \times 33000} = \text{horsepower required to elevate load} = \frac{WH}{1000}$$

$$\frac{B \times 1.25\, w' \times H}{60 \times 33000} = \text{" " " "} = \frac{63\, Bw'H}{100{,}000{,}000}$$

$$\frac{B \times b' \times H}{60 \times 33000} = \text{" " " "} = \frac{50\, Bb'H}{100{,}000{,}000}$$

Power loss consumed in running apparatus	about 17½%
Power loss due to dragging buckets through charged boot	25
Other unavoidable losses	12½

Then,

HORSEPOWER REQUIRED TO OPERATE BUCKET ELEVATOR:—

$$HP = \frac{15\, WH}{10{,}000} \qquad \text{Formula XVII.}$$

$$HP = \frac{95\, Bw'H}{100{,}000{,}000} \qquad \text{Formula XVIII-a.}$$

$$HP = \frac{75\, Bb'H}{100{,}000{,}000} \qquad \text{Formula XVIII b.}$$

Standardization of bucket elevator apparatus facilitates arriving at the cost of the average complete equipment, but the multiplicity of standard types of buckets, chains, etc., varies to a considerable extent the initial cost of even an ordinary installation, necessitating a formula for approximating the cost of equipment a number of constants that differ for the standard component parts of the elevator. However, as this discussion must necessarily be limited to a consideration of general practice and the class of bucket elevator usually found in installations of such character, it is possible to group the apparatus into classes in which exists an approximately constant relationship as to cost. For instance, the chains customarily employed for bucket elevators may be grouped into two classes: one represented by the ordinary detachable link chain, commonly known as the "engineering chain," and the other by the more costly "combination chain," a chain with malleable iron links and steel pins, or by the relatively expensive all-steel link chains, etc. The cost of the chains of both these groups varies closely with their strength or weight, which in turn varies with the load that the elevator is to handle—one group to a greater extent than the other. Practice has also pretty well standardized the spacing of the buckets for any particular size of elevator (size measured by length x width of bucket) so that the load on an elevator can be expressed in terms of size of bucket, height of elevator and weight of the material handled. A similar relationship exists for elevators employing belts instead of chains upon which to carry the buckets. The elevator buckets are usually of steel or of malleable iron, the latter type of bucket being employed when the load to be handled possesses certain chemical properties or is of a temperature that would be injurious to steel elevator buckets. The weight of the bucket, governed by the thickness of its walls, depends nearly entirely upon the weight of the material to be elevated. These definite relationships, and the fact that the capacity of a standard proportioned elevator varies with the size of the buckets employed, permit the expression of the cost of the necessary elevator buckets at so much per foot of elevator, depending upon their size, the weight of material handled and whether of steel or malleable iron construction. The balance of the necessary equipment, consisting of elevator boot, drive, sprockets or pulleys, shafting, bearings, etc., does not vary so much in cost with the load carried as with the size of the buckets—at least, in the ordinary installation. In fact, grouping must again be resorted to, for the cost of these parts does not vary to any great extent for elevators of about the same size—that is, the cost of these parts for 8″ x 5″ elevator would not differ much from the cost of similar parts for a 10″ x 6″ elevator. The average carrying capacity of these two sizes of elevators, however, would vary by nearly 100 per cent. All these relationships and conditions are taken into consideration in the derivation of Formula XIX. and a certain allowance is also made for the cost of the elevator discharge chute, so that the costs obtained through the use of this equation will be found to be approximately accurate in the majority of simple bucket elevator installations. It must be remembered, however, that no allowance is made for an elevator casing and, if such is required, it should be figured upon as an extra item—an item of convenience or safety that does not necessarily affect the economic value of the installation.

Initial Cost:

C = Cost of complete bucket elevator equipment in dollars
H = Height of elevator in feet—distance load is raised.
wl = Size of elevator (buckets) = width x length in inches.
S = Spacing of buckets in inches.
w′ = Weight of material elevated (load) in pounds per cu. ft.

Cost of elevator chains (engineering chain) $= \dfrac{0.00656 \text{ wlH}}{S} \times w'$

(combination chain) $= \dfrac{0.01312 \text{ wlH}}{S} \times w'$

Cost of elevator belts (high grade rubber) $= \dfrac{0.00437 \text{ wlH}}{S} \times w'$

Cost of standard steel elevator buckets $= \dfrac{0.02592 \text{ wlH}}{S} \times w'$

Cost of malleable iron elevator buckets $= \dfrac{0.04493 \text{ wlH}}{S} \times w'$

Cost of boot, drive, pulleys, etc. (D = constant) = Dwl.

Then :—

$$C = \frac{(A + B)\text{wl} \times H \times w'}{S} + \text{Dwl} \qquad \text{Formula XIX.}$$

Where :—
A = Constant = 0.00656—standard detachable chain.
= 0.01312—combination chain.
= 0.00437—high grade rubber belt.
B = Constant = 0.02592—standard steel elevator buckets.
= 0.04493—malleable iron elevator buckets.

SINGLE CHAIN ELEVATORS.

D = Constant = 1.56 when wl does not exceed 24 square inches
= 1.09 when wl exceeds 24 square inches

DOUBLE CHAIN AND BELT ELEVATORS.

D = Constant = 2.01 when wl does not exceed 24 square inches
= 1.40 when wl equals from 30 to 66 square inches
= 1.18 when wl equals from 72 to 96 square inches
= 1.11 when wl exceeds 100 square inches

Assuming that an ordinary installation of bucket is properly cared for and that it is subjected only to the service for which it was designed, Formula XIX. may be greatly simplified and a close approximation of the initial cost of equipment expressed in terms of average tonnage capacity and height of elevator. Such a general equation would not be as accurate for purposes of forming an estimate of the cost of an installation, but is quite accurate enough for purposes of arriving at the probable net operating cost, where the fixed burden of interest on investment, taxes and insurance represents but a comparatively small percentage of the initial cost of equipment. Calculations of depreciation, etc., may be made on such a general equation, for, though depreciation is not constant for elevators subject to all kinds of service or even to average service, the error or increase in depreciation for an elevator handling heavy material would be in large part compensated for by the excess fixed burden charge that would arise from the error in the initial cost, as obtained from the use of such general formula, such initial cost being in excess of the real cost. The expense for power, supplies, etc., being nearly directly proportional to the load handled and height of the elevator and, being a considerable expense in "net operating cost," can be pretty accurately figured and has a marked effect upon the accuracy of Formula XX., by the use of which a conservative and fairly reliable opinion can be formed of the probable net operating cost of any ordinary installation of bucket elevator, knowing the actual cost of power.

Net operating cost (N.O.C.):—
H = Height (distance) through which load is elevated in feet.
= Height of elevator.
W = Weight of load elevated in tons per hour (capacity).
Average cost of equipment :—
= 0.000328 WH + 0.003484 W.
Fixed charges :—

Interest - 6% total cost	}	= 0.000027 WH + 0.000296 W
Insurance - 1%	}	
Taxes - 2%—¾ cost	}	

Depreciation, renewals, etc. :—

On elevator buckets	=	0.000090 WH	
elevator chain or belt	=	0.000012 WH	
balance of equipment	=		0.000523 W
Depreciation account	=	0.000010 WH +	0.000052 W
Total depreciation, etc.	=	0.000112 WH +	0.000575 W

Yearly burden :—
= 0.00014 WH + 0.00087 W
Horsepower, attendance, supplies, etc.:—
P_c = Price (cost) of a horsepower per hour.
N = Number of hours (total) elevator is in use per year.

Cost of power	=	0.0015 $WHNP^c$
attendance, etc.	=	0.000075 WHN
supplies, etc.	=	0.000055 WHN

Burden depending on use of elevator = 0 0015 $WHNP_c$ + 0.00013 WHN

Then :—

Net operating cost (N.O.C.) per ton :—

$$\text{N.O.C.} = \frac{112\,H + 575 + (130\,H + 1500\,HP_c)\,N}{1{,}000{,}000\,N} \qquad \text{Formula XX.}$$

Examples:

1. Conditions :—

Material elevated	50′ 0″	= H
Service	2400 hours per year	= N
Cost of power ..	$0.02 per horsepower per hour	= P_c

$$\text{N.O.C.} = \frac{5600 + 575 + 19200000}{2{,}400{,}000{,}600} = \$0.0080025 \text{ per ton elevated.}$$

2. Conditions :—
The same as in the preceding example except that service is but 1200 hours per year.

$$\text{N.O.C.} = \frac{5600 + 575 + 9600000}{1{,}200{,}000{,}000} = \$0.0080051 \text{ per ton elevated.}$$

Assuming conditions that are common in practice and which may therefore be taken as representative, it will be noted that there is really very little difference in the average net cost of handling material by a bucket elevator whether the installation is in operation a good share of the year or only made use of for half that time. This is due, of course, to the fact that the item of power, etc., which is dependent upon the actual hours of service, plays an important part in the question of cost of operation. This is a decided advantage in dredging and excavating operations, etc., in which modifications of the standard type of bucket elevators are very frequently and extensively employed, as such operations are of necessity intermittent and, though not as conducive to economy as if the apparatus was more mechanically efficient, does enable accurate preliminary estimates of cost to be arrived at, etc., etc.

The continuous bucket type of elevator differs from the standard bucket elevator principally in design, consisting of a close succession of V-shaped buckets, having their sides projecting past the back of the bucket so as to form a kind of chute over which—on commencement of the downward travel of the buckets—the succeeding buckets discharge their load as they pass over the head elevator wheel or sprocket, and in the common omission of loading elevator boot. The elevator may be vertical or lie in a plane somewhat inclined to the vertical. In the former arrangement, take-up bearings must be provided for the tail elevator wheel to permit the maintaining of the proper tension in the elevator chain in order that the return (downward) run of buckets may not oscillate and interfere with the rising and loaded buckets. Inclined continuous bucket elevators, on the other hand, are seldom provided with take-up bearings, the tension in the chain of the rising run of buckets provided by the elevator drive, which for all types of bucket elevators is invariably located at the head of the elevator, keeping the loaded side of the elevator taut while the return run of empty buckets is allowed to descend in the path of a parabola—the exact curvature depending upon the slack in the chain. As appreciable time is required to fill each succeeding bucket of a continuous bucket elevator, and thus realize the full capacity of the apparatus, it must necessarily be run at a comparatively slow speed. It is in this exaction for efficiency that the main advantage of this type of elevator construction lies, and for this reason the continuous bucket elevator is not entirely replaced by the higher speed and cheaper elevator of standard bucket elevator construction. The slow speed of the buckets enables them to be filled directly—that is, the elevator load is usually delivered directly to the buckets, not to an intermediate receptacle from which the load is picked up by the moving buckets, as is the practice for the standard bucket elevator. The slow movement also permits the discharge of load in a comparatively slow-moving stream. Thus, breakage of material by the moving buckets at moment of loading the elevator is minimized, as is also the breakage on discharge.

The carrying capacity of each individual V-shaped bucket of the continuous elevator does not vary greatly from that of the individual bucket of the standard type of bucket elevator, so that the table of capacity of standard bucket elevators can be made applicable to the continuous bucket type of elevator by correcting for the speed of the elevator and the spacing of the buckets; which, in the case of the continuous bucket elevator, is approximately equal to the depth of the V-shaped buckets. The power required to operate a bucket elevator of either the standard or continuous bucket type is the same—elevators of the same carrying capacity—as the descending empty buckets compensate for the power required to raise the buckets themselves on the carrying stretch, so that the formula for horsepower required is the same for either type of bucket elevator. The formula for ascertaining the net operating cost of a standard bucket elevator (the measure of true economic value of the system) is also approximately correct for a continuous bucket elevator, for though the latter type is more expensive in first cost, its depreciation charge, etc., is not apt to be as high. The two inaccuracies tend to counteract each other, besides which any error is discounted by the fact that the major expenses, those for power, attendance, supplies, etc., are about the same under similar conditions of service.

Other modifications of bucket elevators are in common use for handling barrels, boxes, heavy bales of goods and for many other special purposes, but a detailed consideration of such is quite impossible in a limited discussion of this nature. However, the horsepower formulæ will be found to be of considerable value in considering the economic advantages of even such special types of apparatus, as but minor alterations in such formulæ need be made to suit any conceivable system. Net operating costs will vary in each special installation, however, and cannot readily be arrived at without careful consideration of all the particular conditions and requirements. Without such data, an opinion of the economic value of any such apparatus must be based largely upon the convenience that such an installation would promise, but it is usually safe to assume that in addition to convenience a considerable monetary saving would ensue from the installation of almost any kind of apparatus for mechanically elevating materials confined in boxes, barrels, or in other ways—a saving usually approaching that which is possible in the handling of materials in bulk.

DESTRUCTION OF GARBAGE BY INCINERATION.

By H. C. Andrews.

ACCORDINGLY as the population of this country increases so must the representatives of communities and officials in charge of public works give this important matter their more careful consideration, more especially in the large cities and thickly populated areas.

The health of the community is reflected in its commercial prosperity; and, unquestionably the sanitary arrangements of a town go very far towards promoting and maintaining the health and energy of its inhabitants. In this age of the application of science to all questions of sanitation, it is universally recognized that cleanliness (by which is meant the entire absence of filth) is not only "next to Godliness," but is absolutely essential for the prevention of such diseases as smallpox, typhoid fever, and consumption. Students of public health are agreed that such diseases have, in the past, been very largely caused by deposits of refuse providing the breeding ground for the multiplication of the most deadly of the known bacilli; and, as a consequence, the method of dealing with the refuse accumulating daily in a town of any size becomes a vital question.

In Canada, with its hot summer, collections of dumped garbage should be an unknown quantity, and it is surprising that the Department of Public Health should have allowed to exist so long as it has the large and offensive garbage tips one frequently sees, and upon which dwellings are subsequently erected, the occupants of which are likely to suffer from the exhalations that must necessarily arise in such cases.

It has been for some years past an acknowledged fact that the worst of our summer pests, commonly called the house fly, and the blue bottle, thrive and multiply in millions on these heaps, which are in various stages of putrefaction and decomposition; also that these flies are responsible for a large proportion of infantile mortality and other sickness during the summer months.

City authorities preach to the householder to "swat the fly," but if they themselves collected the garbage more frequently and totally destroyed it when collected, they would strike right at the root of the evil, do more to abate the fly nuisance, and incidentally improve the health statistics.

The above is a résumé of what has been preached by the medical health officers in Great Britain, Germany and France for some years past, with the result that the authorities of nearly every densely populated area have at the present time an efficient, and what is really more important, an hygienic method of dealing with the garbage.

Incineration has been nearly universally adopted for this purpose, although in a few cases reducing plants have been utilized. The practice of incineration, the first to be used, is gaining in favor, because it fulfils more closely the combined necessities, efficiency and hygiene, than does disintegration.

The latter may or may not be a paying proposition, as is claimed for it, but the fact remains that the public and expert opinion in the older countries are almost unanimous in deciding in favor of destruction by fire, and obtain thereby a clean innocuous clinker residue, rather than risk the adoption of a plant which in abating one nuisance is likely to create another; and this is the case with any scheme which does not destroy immediately and totally all garbage deposited.

Having thus far proved that incineration is at least the most hygienic method of dealing with garbage, the process of incineration can next be examined.

In the early days of incinerators, many difficulties were encountered which earned for them a none too savory reputation, partly because the plants were too small for dealing with the quantity of material to be consumed.

The heat obtained in the furnaces was not sufficient to destroy everything, and at times the fires were nearly put out, this resulted in ashes rather than clinker being raked out when the fires were cleaned, causing quantities of dust to be always flying about. Unconsumed gases escaped up the chimney causing smoke and evil odors.

All these difficulties have now been overcome and the modern incinerator, as a natural consequence of years of experience and use, is positively without nuisance, and can be worked in close proximity to a residential district, without causing offence.

The work of the employee is not unpleasant, and there should be no dust or overpowering odors within the building itself.

Design of Incinerator Plants.—In designing a modern plant it is the universal practice of engineers to consider the following details:—

1. The furnaces should be able to deal efficiently and easily with the maximum supply of garbage; no storage should be allowed for longer than a few hours.

2. There should be stand-by furnaces or cells so that in case of repairs the capacity of the plant is not impaired.

3. The arrangements for feeding the cells should be such that the garbage may be dumped from the carts, and these released at once with as little delay as possible. On this detail will weigh to a great extent running expenses, but a mechanical feeding device may be adopted to overcome this vital point.

4. The construction of the furnaces must be of suitable design, strong and well reinforced to prevent bulging or collapsing of the arches. The heat of the fires must be intense. The continuous grate is now the only accepted form of fire grate; the cells may be arranged in units, with a combustion or carcase chamber and boiler.

5. There are various types of doors for clinkering the fires and also various methods of clinkering, but a truck running on tracks in front of the furnaces, into which the clinker is raked direct from the fires, is used in most cases, as the truck, when full, can be pushed outside and dumped at anv convenient spot outside the building.

6. Forced draft can be obtained by electric or steam-driven fans, the air being drawn by pipes from any desired part of the building. By this means no foul air or dust has a chance to collect within the building itself.

7. If power is required boilers can be introduced and the steam generated entirely by the heat obtained from the incinerator furnaces.

8. The flues should be arranged so as to make it absolutely impossible for unconsumed paper and dust to escape up the chimney.

9. The chimney should be of strong construction and lined, and of ample area to allow for possible additions of extra furnaces.

10. The buildings should be built so as not to be an eyesore to the neighborhood, and provision be made for the attendants' wants, i.e., proper washing accommodation, etc.

Generally speaking, there is always a good outlet for the clinker obtained and it is often turned into a revenue-earning item.

From high-temperature furnaces the clinker obtained is hard and perfectly innocuous and may be used for a variety of purposes. For road beds, for concrete, ground for mortar, for concrete paving blocks, for ordinary filling purposes and several other every-day requirements.

The choosing of a site for an incinerator is often the stumbling block over which all sorts of trouble is encountered, but this should not be the case, as providing the contractor for the plant will guarantee no nuisance, and there are several well-known contractors who would take the onus of such guarantee, the modern incinerator should be no more offensive and certainly less unsightly than many factories.

There are cases known of city councils having been compelled by public sentiment to go to the expense of building far away from habitation and in a few years finding their incinerators completely built around by a very fair class of property-holders.

TRUCKS AND ECONOMY.

A Montreal contracting firm recently undertook to test the practical possibilities of trucks with trailers in work in that city, using one or two trailers, these being animal wagons that had been adapted for the service and which were constructed to be discharged quickly. The trains are made up with two trailers, carrying nine tons, 2.5 tons on the truck and 3.25 tons on each wagon, and it was found that the truck could haul the trailers over comparatively rough ground and in soft roads at a satisfactory speed—at least, fast enough to be very economical. The cost of moving excavated material was, with the loads described, reduced from $1.50 to 95 cents, the comparison, of course, being made with horse haulage. So satisfactory was the trial that the company bought seven four and five-ton trucks and will use them with trailers in excavation work whenever possible, and in other haulage wherever practical.

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

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CONTENTS OF THIS ISSUE.

CHEMISTRY IN ENGINEERING.

The field of the chemist is many times the magnitude it possessed a few years ago, and it is rapidly co-mingling with many of the branches of the engineering profession. With the exception of mathematics, and perhaps of physics, the science of chemistry stands closest, and as the manufacture of the materials used in engineering approaches perfection, the more pronounced is the handiwork of the chemist.

The production of iron, steel, and the alloys, for varied and special purposes, are examples. The constituents of each are selected in proper percentage by the chemist, and the rules-of-thumb are no more. The chemist furnishes the data whereby the engineer varies the chemical content of his materials to obtain the particular physical characteristics desired. The manufacture of cement is another striking example.

Equally important are the relations of the chemist and the engineer in the matter of water supply and the treatment of sewage. It is what the former finds in the nature and extent of impurities that determines the policy of the engineer in the treatment of the water supply. The utilization of nitrogen, of ozone, or of the much-indulged-in hypochlorite of lime or soda, to destroy bacteria; the introduction of copper sulphate (1 part to one million parts of water) to dispose of algae; the use of alum to precipitate suspended organic matter, without appreciable trace in any instance of the remedial substance in the clarified water—these are notable instances of the work of the engineer wherein he is dependent upon the chemist.

In the growing science of road engineering, with its many complexities; the selection and composition of the materials of construction; problems of water purification, and of the disposal of waste—a knowledge of chemistry is essential to the engineer in many phases of his work, and his engineering skill, supplemented by the expert assistance of the professional chemist, leads one to believe that the advancement of industry would be relieved of a considerable amount of its hazard if there was more of an outward acknowledgment of the interdependence of these two applications of science.

ONTARIO'S TEN-MILLION-DOLLAR ROADS.

Ontario is willing to spend ten million dollars during the next few years on road construction. But it wants one hundred cents' value for every dollar expended. The Commission which was appointed by the Government—Messrs. Magrath, Rankin and MacLean—are therefore going to more trouble in gathering information on roads than did any similar commission ever appointed. They are expected to devise a model system for Ontario—avoiding all the errors made by the State Highway Commissioners in the United States, dodging political "pull," keeping the lid tight on the "pork-barrel," and reducing maintenance costs to the lowest limit consistent with reasonable first cost.

The problems that are being considered by the Commission are included in three general classes—men, methods and materials. More specifically, they come under the headings of legislation, administration, finance, expenditure, construction and maintenance.

The most important part of the legislation is to keep the roads out of politics. To this end the Ontario Commission is studying the Highway Acts of twenty-seven States, noting their weak points and their good points. The Highway Commissioner of each of these States is being consulted as to the success or failure attending the road laws enacted by his State, the changes that have been recommended in the laws and the reasons therefor, and above all, the changes that each Commissioner would like to see made to obtain his ideal, but which he perhaps dares not make on account of politics, public sentiment, poverty of the State coffers, or other reasons. The amount of money placed by the Provincial Parliament at the disposal of its road-building organization must also be carefully considered. Were too much money voted at one time, it is feared that it would tax the contracting capacity of the Province too greatly. It is thought desirable to have only thoroughly reliable contractors build the roads, and to let to each contractor only enough work to ensure his being able to handle it with the most careful attention. The letting of too much work in any one season might result in higher prices and inferior work, it is said.

The selection of the administrative and constructive staffs is most important. Mr. Campbell, the Deputy Minister of Railways and Canals (and why not of Highways also?) said at the banquet of the American Road Congress at Detroit, that proper drainage was the most essential item in road building. The Mayor of Detroit replied that "drainage" is not so important as "foundation"—the foundation of good men to administer the enterprise. It is recognized by the Ontario Commission that it will take some time to build up the personnel of the various highway departments. Men with the proper qualifications must be picked or trained. The administrative policy must be carefully decided; whether it would be better to have division engineers each in charge of certain limited territory, or to have strongly centralized control. Under the heading of administration come also the problems of cost-keeping, purchasing departments, etc.

The financing of good roads may prove troublesome in Ontario. The large mileage compared to population makes financing more difficult than in densely populated States. Various methods of raising revenue are being considered—bond issues, automobile fees, corporation taxes, assessments on railways that would benefit by better roads, etc. The substitution of a money tax instead of the work done on the roads by the farmers is being considered. The wisdom of using convict labor will also be decided.

Provision will be made for the systematic inspection of the expenditure of moneys. Uniform accounting systems must be provided and such statistics kept of all payments that accurate data can be placed before Parliament at all times.

The actual construction and maintenance of the roads causes, perhaps, the most travel by the Commissioners. They will visit ten or eleven States and obtain accurate data regarding costs, lifetime, popularity, etc., of the various types of roads. Hundreds of miles of roads will be inspected.

In order to meet and obtain the good-will of the numerous State Highway Commissioners to whom they will later apply for information and assistance, the Ontario Commissioners gave a luncheon at the American Road Congress and invited all of the State Commissioners. The ice was thus broken, and the interest of each commissioner awakened in Ontario's problems. These State Commissioners are now furnishing the Ontario officials with data concerning dimensions, first cost, wear, maintenance charges, what types are being abolished as unsatisfactory, what types are being substituted as more satisfactory, etc. The relative merits of concrete, brick, bituminous macadam, asphalt block and chemically bound macadams are being investigated; the methods of construction and suitability of gravel, sand-clay and earth roads are being studied.

The Commission is being aided in this work by J. E. Pennybacker, whom they have appointed as a consulting expert, as previously mentioned in these columns.

CANADIAN PUBLIC HEALTH ASSOCIATION. CONVENTION AT REGINA, SEPTEMBER 18, 19 AND 20.

[This article, dealing with that part of the proceedings of the Canadian Public Health Congress at Regina that is of interest to *The Canadian Engineer* readers, was unavoidably precluded from our issue of October 9th; hence its appearance at this late date.—Ed.]

THE Third Annual Congress of the Canadian Public Health Association was held in Regina, Sask., Sept. 18th, 19th and 20th. Upwards of two hundred delegates registered. As indicated in the programme appearing in a previous issue, the work of the convention was divided into eight sections, additional to the general sessions. To each of them the papers presented were of such a nature as to open up a volume of keen and vivid discussion upon all phases of the work which the association has set itself about to do.

The congress had its various sessions well interspersed with social functions of one kind and another, and the city of Regina displayed such an excellent type of hospitality to the visitors as earned for it a highly commendable resolution on the minutes of the association.

There were several papers read at the general session that would have interested a large number of the engineers of Canada, apart from Section VI., which was devoted entirely to engineering subjects, and Section V., which was closely related covering the various phases of sanitary inspection and promotion.

Of the ten papers presented at the Engineers' Section, two, viz., "Mechanical Gravity Filtration at Saskatoon," by George T. Clark, city engineer, Saskatoon; and "The Chemical and Biological Effects of Water Filtration," by H. W. Cowan, chief engineer, Bell Filtration Company, Toronto, appeared in October 2nd issue, and other important papers will be published in due course in these columns.

Among the papers read at the general sessions the presidential address by Dr. J. W. S. McCullough, Provincial Health Officer for Ontario, related a few of the experiences of the speaker in his recent visit to Europe. His address was, in part, as follows:—

"In the province of Ontario, from the fact that the rivers and lakes must become the great sources of water supply, it has become apparent that to preserve these supplies in a pure state, it is necessary to take prompt action to prevent their pollution with sewage. With this end in view the legislature of last year and this year gave very extensive powers to the Provincial Board of Health in this regard, requiring that all plants for waterworks and sewage disposal must have the approval of the Board before any money can be raised for these purposes. In addition, a further enactment gives the Board power to compel the construction of such works, when, in the Board's opinion, they are required by an urban municipality; and such approval being made, no vote for the electors is required to raise money on debentures for this purpose."

During the present season the Board has been engaged in making a careful examination of the rivers and lakes separating Ontario from the United States, beginning at Fort Francis and ending at the eastern boundary of the province, with a view of discovering the causes and extent of what sewage pollution may exist. Following this, the speaker was instructed by the Government of the province to take up the study of sewage questions in Great Britain and other parts of Europe.

"Of the many extensive works for the disposal of sewage in Great Britain, perhaps the most important are those of Birmingham, Manchester and Glasgow. Many large cities such as Liverpool and Edinburgh have an easy problem—that of letting the sewage go out to sea with a rapid ocean tide. Others, like London, Belfast and Glasgow, send the sludge or solids out to deep sea by vessels, but the hundreds of inland towns and cities must otherwise dispose of it. Since the great water supplies of Great Britain are taken from upland watersheds, it is not, generally speaking, so necessary to have as good an effluent as conditions in most of Canada require.

"The problem of dealing with sewage embraces the disposal of sludge or solids, of the liquid portion of the sewage, and of storm water. Each of these is a problem of importance and difficulty. It is apparent that the sludge problem is the most difficult one, while that of the liquid portion from a sanitary point of view is perhaps the most important."

The major portion of Dr. McCullough's address comprised a description in detail of typical British and German disposal plants with an outline of the methods employed.

Dr. M. M. Seymour, Commissioner of Public Health for Saskatchewan, in his paper dealing with the work which was being done in that province, detailed the methods employed by the Government toward the prevention of disease and the prevention of the pollution of rivers and streams.

Dr. R. E. Wodehouse, a district Health Officer in Ontario, in his paper concerning the field work of an officer in his position, referred to Dr. McCullough's division of the province into seven districts, eventually to be increased to ten, for the administration of public health work.

The first duties of the office pertained to making a careful sanitary survey of each organized municipality in the several districts. These surveys called for a report of the activity of the Board of Health and its officers, the keeping of the vital statistics, the condition of public buildings, the source, nature and management of water supplies, private and public; the sewerage undertakings, both to have maps in detail, in duplicate, one to be retained by the district office and the other to be sent with the report to Toronto office. The schools, ice supply, garbage collection and treatment, hotels, restaurants, railway stations, lanes, nuisance grounds, stagnant water and all things pertaining to public health to be investigated. The epidemiological history of the community, both as to man and animal, were to be reported upon.

The results of the work have been fairly satisfactory. Actual improvements in the state of the provinces' status of health will probably be more grossly evident at the end of three years. Speaking of District No. 7, the one to which the writer is attached, during the past six months five municipal water chlorination plants have been installed upon order, three municipalities have regulated, changed location of or abandoned nuisance grounds. Railways have cleansed the lights of boarding camps and cars, have established sewage treatment plants at their terminal or divisional points, and are reporting surveys of the water supplies used for their dining cars, day coaches and the engines, as this is used by the rolling stock men.

"Standards With Reference to Sewage Treatment" was the subject taken by Mr. T. Aird Murray, consulting engineer, Toronto. The paper dealt exhaustively with the different systems of the treatment of sewage before allowing it to flow into the streams and lakes from which the water supply of towns and cities is taken.

Mr. Murray summarized his paper by stating that in his opinion, based on much observation, there was no standard of treatment which could be generally applied to sewage, but that some system which would do away with internal germs in the sewage should be generally adopted. Such care to some extent must be treated separately according to the local requirements.

The dilution method of treatment as advocated by many engineers because it is the most economical method from a financial point of view was pointed out as a makeshift, which did not protect future water supplies. The different systms of dilution and purification by chlorinization were fully discussed.

With the sewage treatment subject, one of the most important points touched upon by the author was that of the pollution of water supplied. Water supplies, he stated, should be doubly protected by the disinfection of sewage flowing into them and the filtration and disinfection of the water drawn from them which is about to be used. He called attention to the fact that there are many uncontrollable sources of pollution with which it is hard to deal, but ventured the opinion that legislation would be able to control much of the apparently uncontrollable sources of pollution. He pleaded for legislation in Canada before the waterways become hopelessly polluted as they are in the United States and in England.

Section V. brought out several papers of particular value to those who have to do largely with the maintenance of proper sanitary conditions in congested or outlying sections of cities. Mr. E. W. J. Hague, Assistant Chief Sanitary Inspector, Winnipeg, furnished a lengthy paper on the housing problem, recommending a number of remedies to counteract over-crowding, inadequate building laws, etc. Mr. F. Cartlidge presented a paper entitled "City Waste Disposal by Incineration. He briefly reviewed the history of city waste disposal, from the old method of the nuisance grounds, with its unsightliness and the comparatively large area of land laid waste for this purpose, through the different stages in the development of a satisfactory incineration plant down to the present, where it was possible by incineration, to convert the putrescent matter in city refuse into harmless products, by means of combustion.

"The process of incineration," he said, "has made much headway with the introduction of high temperature furnaces of 2,000 Fahr. and upwards by means of forced draught, induced either by powerful fans or steam blast. The heat obtained in these furnaces is sufficient to consume anything put into them.

"In the older types of independent cells the introduction of a fresh charge of refuse resulted in the lowering of the temperature with imperfect combustion of the gases, a condition which is obviated by increasing the number of cells, and by charging them in turn so that some are at their greatest heat while others are being charged.

"With present improved methods of construction such high temperatures are often obtained that no inconsiderate amount of waste heat is available, and steam boilers are generally made a part of the equipment. This will provide steam for the blast or to drive the fan, and by absorbing heat from the waste gases will reduce the cost of repairs to flues and a less expensive and lighter firebrick in the chimney will suffice.

"Naturally, in these notes a description of the incinerator at Moose Jaw, and the methods for operating same may be much in evidence, as it is operated under similar conditions and with the same class of refuse that will be met with elsewhere throughout Western Canada.

"In the collection of our refuse all house and trade refuse are collected and dumped together at the incinerator, where it becomes automatically mixed with a larger quantity of stable manure, as both are being delivered in the course of the day.

"To obtain the best results and complete combustion, the conditions necessary are:—

"A sufficient air supply brought into intimate contact with all parts of the fuel and the maintenance of the temperature up to ignition point until the whole is consumed.

"All modern high temperature incinerators will have the following features: Forced draught, either steam blast or air; a drying hearth above the grate; a combustion chamber where the gases are mixed and raised to incandescence; a steam boiler for utilization of waste heat; an economizer to heat the feed water, and a regenerator for the air blast. Other things of equal importance are some arrangement to discharge direct into the combustion chamber from above, carcases of horses, mattresses, wet damaged fruit and certain other things that cannot be consumed during the burning of a single fire on the grates, and which would come out with the ashes only partly burned and require to be thrown in again. A storage floor to hold 24 hours' accumulation of refuse, and tipping platform of such size and arrangement that the ordinary box wagon can safely be brought to the tipping sill.

"The incinerator at Moose Jaw is a Heenan and Froude high temperature, with three cells in one continuous chamber. Fires are fed from the top, where the refuse is shovelled into hoppers, the top of which are with the floors of the tipping and storage platform. The blast is air, supplied by fan and drawn from above storage floor. A pressure of from 3 to 4 inches is given, with temperature around 2,000 Fahr. The fan for the blast is driven by an enclosed steam engine which, with the feed pump, absorbs approximately 15 per cent. of the power generated by the waste heat.

"Under ordinary working conditions an average of two tons of refuse per hour is consumed, and the fires are cleaned about every two hours. The operating costs average a little over **$1.00 per ton.**

"Until quite recently no serious effort was made to utilize the power in the steam generated by waste heat. Observations have been made several times under ordinary working conditions which indicated that after allowing for use on the plant itself there was at least 100 h.p. available for other purposes. This is now to be used for the purpose of pumping sewage at the disposal works, which are situated conveniently near, the steam being piped across the short distance in 4-inch insulated pipes.

"Without going outside the scope of the Health Department there are many uses to which this waste steam might be put and so reduce the cost of disposal of refuse, for instance: The establishment of baths and washrooms; steam disinfecting station; electric lighting of depot and works; or even to generate current for ordinary purposes.

"Of other residuals very little has been made so far. The clinker is made small in size, and when free from dust is a suitable material for bacteria beds, some having already been used for that purpose. The dust from the combustion chamber can be used as a body for disinfecting powder and in a small way this has been experimented with."

Business Session.—The Association elected the following members to form the executive committee for the ensuing year: President, Dr. M. M. Seymour; general secretary, Major Lorne Drum; treasurer, Dr. George D. Porter, and Dr. C. J. Hastings, M.H.O., of Toronto, Dr. C. A. Hodgetts, of Ottawa, and Dr. Duncan Anderson, of Toronto. Dr. Adam H. Wright, chairman of the Provincial Board of Health of Ontario, was elected honorary president of the association for the ensuing year.

The next annual congress will be held at Fort William and Dr. Woodhouse, the district sanitary officer of that city, has been appointed the convener of the local arrangements committee.

Among the resolutions adopted was one authorizing the appointment of a committee to assist in the formation and operation of a proposed Federal Health Department. Another read: "That in the opinion of this association it is a matter of great importance that the Dominion Government do take steps to create a Department of Public Health in order that all federal branches dealing with health work may be coördinated under one administration."

Another fixed the membership fee of the association at $3.00 per annum.

Mr. J. T. Vallance, of Lethbridge, Alberta, read a very interesting paper on "Public Abattoirs," going fully into the questions of cost, methods of operation, sanitation and other details, expressing himself of the firm belief that civic abattoirs will prove themselves not only self-supporting, but profitable. He spoke of the manner in which the institution of civic abattoirs in England and Germany had reduced materially the cost of living.

"Leaves From An Inspector's Note Book" was the subject of a paper by Mr. H. D. Mathias, of the Health Department of Regina. The paper dealt largely with the training of a man for sanitary inspection, and with the essential recognition of the provision of a pure and ample supply of air and water as an assurance of safety and health.

Mr. Thomas Watson, of Regina, dwelt upon the legal aspect of the sanitary inspectors' work. In the course of his discourse, Mr. Watson mentioned the unanimity of the various health acts of the Dominion in placing under the control and jurisdiction of the Boards of Health all that properly belongs to sanitary and health matters; but added that in spite of this there is a tendency among municipal authorities to deprive sanitary inspectors of a good deal of authority they should possess with respect to certain elementary fundamentals under their supervision.

OTTAWA WATER SUPPLY PROJECT.

FOR years the supply of water for domestic use in Ottawa has been unsuitable. The summer of 1912 was marked by the visitation of a serious outbreak of typhoid, which brought the problem into prominence, and called for a rapid and permanent solution. The result has been that in the past year the civic authorities have kept the matter constantly under probe, until the present time finds them furnished with numerous reports covering all feasible sources of supply.

There are five possible sources, viz., Ottawa River, Madawaska River, Lake Deschenes, McGregor Lake, and Pemichangaw Lake.

The Ottawa River, the present source, has been reported upon as being unfit for use without mechanical filtration and chemical treatment. In February, 1913, Sir Alex. Binnie and Dr. A. C. Houston advised the city to abandon the Ottawa River as a source of supply. Then, in April the Ontario Provincial Board of Health advised the city that the use of the Ottawa River without mechanical filtration would not be permitted. The decision was backed by the fact that Ottawa had had 3,000 cases of typhoid within 18 months from using this water. The filtration scheme has not met with favor at the hands of the ratepayers, generally, when advanced for their consideration. The proposal submitted last year did not provide for future growth, sentiment was against chemical treatment, and the risk of contamination from the unsanitary waters of Nepean Bay, under which the supply had to be conveyed, was important and against the adoption of the scheme.

Lake Deschenes.—On October 3rd, 1913, City Engineer Currie submitted a report in answer to the following Council inquiry:—

"If the city of Ottawa continues to use the Ottawa River water in its natural condition as a permanent source of supply, what would be the best point from which the water should be taken, and what works would be required to be constructed, with an estimate of the expense of such works?"

His report stated that in his opinion the most suitable point from which to take the water was a little west of Ennis Point, in Lake Deschenes, and opposite Aylmer Island. This is over 14 miles from the pumping station. Mr. Currie found that the gradients were such that the water could not be carried by gravity to the pumping plant, and that, therefore, another pumping plant would need to be installed and operated at Lake Deschenes. As no hydraulic power could be secured there, this plant would require to be operated by electric power.

The city engineer proposed that a small low-level service reservoir to hold ten million gallons be constructed just inside the city limits to provide a reservoir of water in case of fire, and to enable the water to flow by gravity from the reservoir to the present pumping station. He also proposed to have two 48-inch pipes from the intake at Lake Deschenes to the service reservoir, and two 42-inch pipes from the reservoir to the pumping station. The estimated cost of this project was estimated at $2,900,000.

A later issue will contain a more detailed report of Mr. Currie's investigation.

McGregor Lake Supply.—This includes a large number of lakes at distances varying from 15 to 30 miles to the north of Ottawa. The engineering features connected with this source of supply for the city will appear in a later issue. It is generally conceded that filtration would be necesary. An estimate of the cost of the necessary works is placed at $7,054,000.

Madawaska River.—Owing to the necessary length of pipe-line from this source to the city, the variations of level along it, and the low total elevation above Ottawa, this project has not met with favor. It is also objected to because of its questionable quality, and the uncertainty of continued safety of river water generally, which feature applies forcibly to the proposition.

With this brief summary of the situation, attention is directed to a report, submitted last week. It has already been mentioned that in February Sir Alex. Binnie and Dr. A. C. Houston visited Ottawa, studied its water supply, advised the abandonment of the Ottawa River as the source, and recommended an uncontaminated source, such as is afforded by the lakes lying between the Gatineau and Lievre Rivers. The city was also advised to undertake a careful survey of the district. Consequently, arrangements were made with the Dominion Government, whereby contour maps and other necessarv information have been obtained.

On May 5th, the City Council requested Sir Alex. Binnie to make a detailed report, and the result has been a thorough investigation by his staff of all the sources of water supply, including a detailed examination of the proposed routes for the aqueducts, service reservoir, etc.

In the report the city is recommended to use every effort to bring down the rate of water consumption, which at the present time averages 170 gallons per capita per day. Contrasting this consumption with that of other Canadian cities, according to the report of the Commission of Conservation, 1912, the report deems it feasible to reduce the water supply per capita to 100 gallons per day. It is on this assumption that the capability of the various sources of supply to provide for 250,000 persons with a possible future population of 750,000, has been considered.

The report divides itself into a consideration of two schemes: (1) Supply from Thirty-One Mile and Pemichangaw Lakes. (2) Supply from McGregor series of lakes. These sources are shown in Fig. 1. The following is extracted from the portion of the report dealing with the former:—

Thirty-One Mile and Pemichangaw Lake Scheme.—These two lakes are situated on the east bank of the Gatineau River at a distance of about 40 miles to the northward, measured in a straight line from Parliament Hill to the south end of Pemichangaw. The surrounding area of land which drains to these lakes is dotted with numerous other smaller lakes, but the above are the only lakes of any importance and extent.

As to the quantity of water that may be obtained from this source, the three important factors upon which the service from any drainage area depends, respond to investigation in the following way:—

(1) The extent of the drainage area is approximately 150 sq. miles.

(2) The quantity of rain or snow annually precipitated on this area averages 37 inches.

(3) The run-off is conservatively placed at 13.6 inches.

Taking 13.6 inches of run-off from a catchment area of 150 sq. miles, the average yield approximates 81,000,000 gallons per day, ample to meet the requirements of a population of 750,000.

The drainage area has been found free from peat or other surface deposits liable to discolor the supply. The water is bright and clear and of exceptionable purity, and if steps are taken by the city to prevent future contamination, the report forecasts not the slightest neces-

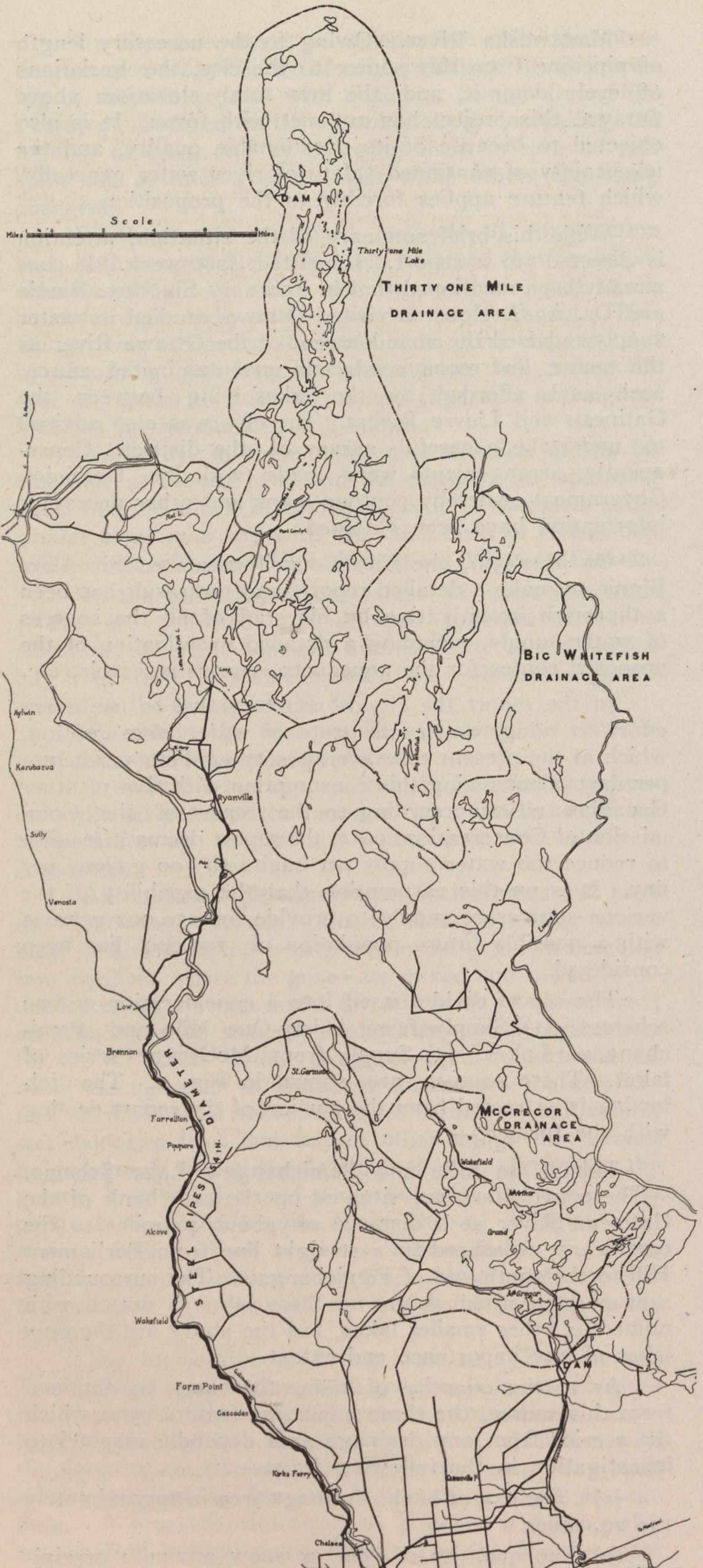

Fig. 1.—General Plan of Storage Area.

sity for filtering this water at any time. It pronounces this source as one of the finest supplies in the world.

The method of collecting and storing the water is as follows, according to the report. Fig. 2 illustrates the plan herewith described:—

There are four lakes which form a chain stretching approximately north and south. Commencing at the north is Mitchell Lake, a small lake which discharges through a narrow gorge at its outlet into a channel which finds its way into the Gatineau. This lake has a surface area of 0.7 square miles, and the water level in Sept. was 523 feet above datum. It receives the entire discharge of Thirty-One Mile and Pemichangaw, and a narrow rocky gorge, already referred to, forms an admirable site for a dam.

The next in the chain towards Ottawa is Thirty-One Mile Lake, which is about 18 miles in length, with a water area of 18 square miles, the water level this summer being about 530 feet above datum. Immediately to the south, and separated by a narrow neck of land, lies Pemichangaw, with a water area of 6 square miles and a length of about 5 miles, the water level this summer being about 552 feet above datum. Crossing the height of land to the south-west of Pemichangaw we come to Long Lake, having a length of about 1¼ miles, and a water area of about one-quarter of a square mile. The distance between Pemichangaw and Long Lake is about 3,000 feet, and the water surface of Long Lake is 561 feet above datum.

It is proposed to tunnel through the ridge between Pemichangaw and Long Lake, and by means of the dam at the outlet of Mitchell Lake to bring all the lakes to one level, namely, 570 feet above datum, and to start the aqueduct to Ottawa from the south end of Long Lake. This would mean raising Mitchell Lake 47 feet, Thirty-One Mile Lake 40 feet, and Pemichangaw Lake 18 feet.

The contour surveys to determine the top water area at this level are not yet completed, but the total when brought to this uniform level of 570 feet above datum will increase to about 35 square miles in area. One foot difference in level of a water surface having an area of 35 square miles represents about six thousand one hundred million gallons, and 18 inches would give a year's storage of a daily flow of 25,000,000 gallon, 3 feet would give sufficient storage for 50,000,000 gallons per diem, and 4 feet 6 inches sufficient for 75,000,000 gallons per diem. The maximum variation in water level would, therefore, be small.

The dam at Mitchell's Lake would be designed so as to overflow at a height of 570 feet, the total content of masonry to this level being estimated at about 9,100 cubic yards.

It has already been stated that the dam would be constructed so as to raise the level of the lake to 570 feet above datum, which means that Thirty-One Mile Lake would have to rise 40 feet, and Pemichangaw 18 feet. Owing to the enormous area of Thirty-One Mile Lake it would take five or six years before this lake would rise even to the level of Pemichangaw, that is 22 feet, and ten or twelve years before it reached the final level of 570 above datum. It is obvious that the scheme should be so laid out as to enable water to be brought forward to Ottawa as soon as the aqueduct and service reservoir can be completed, which can be effected in the following manner:—

Pemichangaw and Long Lake have a total drainage area of about 41½ square miles, and would yield on the basis of a runoff of 13.6 inches about 22½ million gallons per diem, or sufficient for the needs of the city for many years. The level of Pemichangaw Lake varies between about 554 and 552 feet above datum, and the lake is separated by a narrow neck of land known as Point Comfort from Thirty-One Mile Lake, which is about 30 feet lower in level. This neck of land acts as a natural barrier, which retains water at the higher level in Pemichangaw, and is traversed by a narrow gorge, through which the water is discharged into Thirty-One Mile Lake. This gorge is blocked by a wooden dam provided with sluices, and the fall of water from one lake to the other is utilized for a saw-mill. Water also finds its way into Thirty-One Mile Lake from Pemichangaw through debris overlying the rock, filling the bottom of what no doubt was at one time a valley of discharge from one lake to the other. There are underground fissures connecting the two lakes, and the measurements which have been taken this summer show that when the water level in Pemichangaw stood at 554 feet above datum the amount of water which got through this debris or surface fissures in the rock amounted to approximately 8,000,000 gallons per diem; but when the water level in the lake had fallen to 552 feet above datum the discharge was very small, indeed, showing that the water was really finding its way from one lake to the other through a comparatively shallow channel. It is proposed to open a trench first of all across the old channel, and fill with concrete so as to cut off the supply that would leak away when the water level is raised to 554. This would enable the water to be retained in Pemichangaw Lake, upon which the city could draw as soon as the aqueduct is completed. The present water area of Pemichangaw is about 6 square miles, and 5 feet in depth on that area would represent the total storage required for the first instalment of 25,000,000 gallons per diem. Assuming that the minimum draw-off level was to be 549 feet above datum, or 3 feet below the present level, the maximum level at which the water would overflow would be 554 feet above datum.

The dam at the outlet of Mitchell's Lake should be proceeded with as soon as the necessary arrangements could be made, so that Thirty-One Mile Lake can be gradually raised to such a level as to flow towards Ottawa by means of the aqueduct. The report includes in the estimate for the supply of 25,000,000 gallons the cost of the dam at Mitchell's Lake, and also the necessary clearing to bring Thirty-One Mile Lake and Pemichangaw Lake to the level of 570 feet above datum, when storage will be provided for the full yield of the drainage area, or 81,000,000 gallons a day.

Tunnel between Pemichangaw and Long Lakes.—To bring the water of Pemichangaw into Long Lake, from which lake the aqueduct would start, will necessitate constructing a tunnel through the height of land between the two lakes, a distance of about 3,000 feet. This tunnel should be made about 7 feet internal diameter so as to permit of the whole available yield, namely, 81,000,000 gallons per diem, being passed through into Long Lake without appreciable loss of head.

The best location for the invert of the tunnel would be about 6 feet below the present level of Pemichangaw, or at about 546 feet above datum, 24 feet below top water level when brought up to 570 feet above datum.

This tunnel would terminate at each end in covered shafts, the water entering and leaving the shaft well below the water level of the respective lakes, to remove all danger of freezing.

Works at Long Lake.—Long Lake varies in depth from about 20 feet to 50 feet, being shallow towards the north end and deep towards the south. This lake, like Pemichangaw, is formed by a natural barrier, and the water issuing from it passes over this barrier by means of a series of small falls and cascades to the valley below, dropping 50 or 60 feet in a short distance. A short cutting through this barrier will, therefore, enable the water to be drawn down 20 or 30 feet without any difficulty.

The shores of the lake are steep and rocky, but at times during and after windy weather the sediment in the bottom is stirred up by wave action. This action does not extend to any great depth, probably not much below 10 feet. It is, therefore, proposed to remove the sediment, logs, etc., when the lake is drawn down so as to prevent similar action taking place in the future.

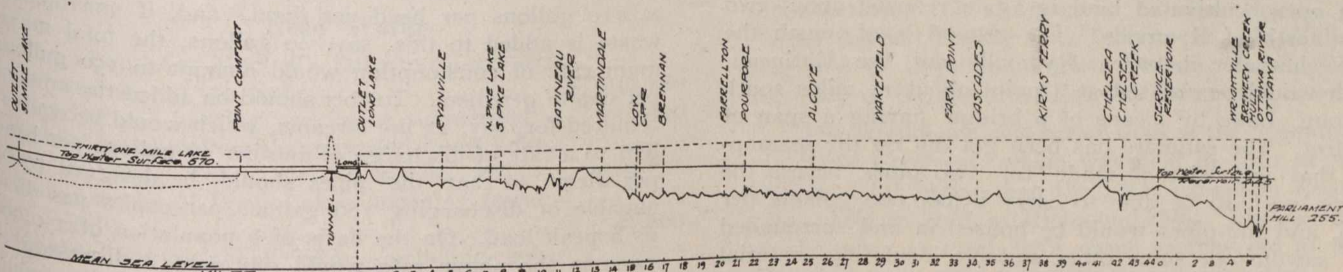

Fig. 2.—Profile of Lakes and Pipe Line.

The outlet works would consist of a straining tower about 50 feet high, covered at the top, and provided with copper gauze screens; the water entering the tower at a depth of 7 or 8 feet below the minimum water level of the lake and after passing through the screens leaving by means of a culvert through the natural barrier already referred to, to the commencement of the pipe. It is proposed to install a small water-driven turbine so as to work a pump for supplying high-pressure water for washing the screens. The power for this turbine would be supplied by allowing water to pass from the lake to the valley below, the turbine being situated at the foot of the fall, which has already been referred to. The screens would be made so that they can be lifted in rotation for cleaning purposes without interfering with the flow of water, and the dirty water, after cleaning, would be discharged into the valley below the straining tower.

Description of Pipe Line.—The top water level of the service reservoir would be 445 feet above datum. The distance between the outlet and the service reservoir is about 235,000 feet, and allowing for losses of head at the reservoir, the hydraulic gradient would be approximately 1 in 1960, and with this gradient a welded or lock-bar steel pipe, 54 inches in diameter, would deliver 25,000,000 gallons a day, allowing for future encrustation. If rivetted steel pipes were used the internal friction is slightly greater on account of the rivet heads and the diameter of the pipe would be slightly larger to discharge the same quantity of water. The estimate has been based on approximate quotations received for 54-inch welded steel pipe, 7-16ths of an inch in thickness. With soft water considerable encrustation may be anticipated; but seeing that the Thirty-One Mile Lake water contains about four and a half grains of lime per gallon it is probable that this may not take place to any appreciable extent. The Ottawa River water contains about two and a half grains per gallon, and appears to have had very little effect on steel pipes which were laid many years ago without any protection by means of coating. It has been found that steel pipes are also liable to corrode from the outside if laid in saline or marshy ground unless special precautions are taken. The best protection in such cases is to surround the pipe with tarried hessian or jute, and provision has been made in the estimate for this precaution where the pipes would be located in swampy ground. To prevent freezing in winter the pipes should be laid so that the bottom would come a minimum of 8 or 9 feet below the surface of the ground, and the estimate has been got out on this assumption.

After leaving Long Lake the pipe would pass southward gently undulating cultivated land for a distance of about one mile until a cedar swamp is reached, which would have to be traversed for a distance of another mile, when open, cultivated land is again reached about two miles north of Ryanville. The ground is of much the same character between Ryanville and the Gatineau, which would be crossed at a point about 11 miles south of Long Lake by means of a bridge having a span of 150 feet. The estimate has been got out on the assumption that provision is made for two pipes across the bridge, each to be able to carry 25,000,000 gallons per diem, and the pipes would be housed in and surrounded with sawdust or some other suitable insulating material to prevent freezing in winter where they are brought over the bridge. After crossing the Gatineau the pipe would proceed in a south-westerly direction, joining the C.P.R. about half a mile south of Low Station, passing through cultivated land and another cedar swamp between the river and this point, the total length of the pipe from Long Lake to the C.P.R. being about 16 miles. From Low as far as Chelsea, a distance of about 24 miles, the pipe track would be in close proximity to the C.P.R., and this portion of the route would not be so easy from the point of view of pipe-laying, a good number of minor work, such as bridges, stream crossing and culverts being required. At Chelsea the pipe would leave the C.P.R. and proceed nearly due south, passing close to Old Chelsea to the service reservoir, a distance of about four and a half miles. The service reservoir is located in the hills, about two and a half miles south of Old Chelsea and four miles north-west of Hull. The portion of the track between the C.P.R. and the service reservoir would be through cultivated land.

Service Reservoir.—The function of this reservoir is two-fold:—

1. To provide against a water famine in the town should the water have to be cut off in the aqueduct to allow of repairs being executed.

2. To meet the daily fluctuations in demand, as the water supplied to a town varies throughout the day, the maximum draught or peak load being nearly twice the average. A reserve must also be available in case of fire.

It is far more economical to lay out a gravity scheme of this nature so as to include a service reservoir of ample size than to lay a duplicate main when the aqueduct is long and a good site can be found for the reservoir at a suitable level. Fortunately, a good site at a suitable level has been found where the water would be stored in a basin having a flat bottom and surrounded by hills. The bottom of the reservoir varies from about 410 to 416 feet above datum, and by means of three small dams the water would be held up to a level of 545 feet above datum. The water area would be about 54 acres, and one foot in depth would represent approximately 15,000,000 gallons. The probable variation in water level to meet the daily fluctuation in demand would, therefore, be less than one foot. The contents of the reservoir between the level of 420 and 445 feet above datum would amount to about 295,000,000 gallons, and represents a reserve of about 12 days' supply, which is very ample when compared with what is allowed by other cities. The static pressure given by this reservoir would represent 118 pounds at the pumping station, or 81 pounds at Parliament Hill, and is about the maximum pressure that the house fittings would stand in the lower parts of the city.

Pipes from the Service Reservoir to the City.—These pipes should be designed so as to be able to discharge for short periods during the day a much larger quantity than the pipes from the source to the service reservoir. The maximum rate of consumption is taken at 110 gallons per head per diem, and, if unavoidable waste is added to this, say, 40 gallons, the total maximum rate of consumption would amount to 150 gallons per capita per diem. To this should be added the amount required for, say, 25 fire streams, which would be equivalent to a rate of discharge of another 36 gallons per head per diem; so that the pipes should be designed to be capable of discharging 186 gallons per capita per diem as a peak load. On the basis of a population of 250,000 persons the above rate would represent a discharge of 46½ million gallons per diem. Two 51-inch pipes would deal with this peak load, so that when the population increased to 250,000 persons the pressure would not fall below 110 pounds at the existing pumping station, even should a serious fire occur during the period when the maximum demand was being made for water for domestic purposes.

After leaving the service reservoir the pipes would be laid through cultivated land to the west side of Hull Station so as to cross under the proposed Georgian Bay Canal below the level of the bottom of that channel. If the canal is constructed culverts should be provided by the Canal Company at some future date to surround the pipe under the bed of the canal and allow them to be always visible for inspection. The pipes would then cross Brewery Creek about the site of the existing bridge at the end of Wright Street, and would pass through Hull till the bank of the Ottawa River is reached at a point about 1,400 feet east of the Union Bridge.

It is emphatically recommended in the report that the pipes should be carried over the Ottawa River rather than under it, so as to facilitate easy inspection and maintenance in good condition at all times. A tunnel is not recommended, owing to the peculiar rock formation, which, being full of joints and crevices, would have occasioned considerable difficulty in driving.

There are four channels which would necessitate: a bridge about 300 feet long on the Hull side of the river, a bridge 500 feet long over the main channel of the river, two short spans, one of 80 and one of 120 feet, the latter crossing the tail-race canal from the present pumping station. For the longest spans 500 feet and 300 feet in length, it is proposed to carry the pipes on suspension bridges, which can be made light and elegant in design at a smaller cost than any other form of bridge for these spans. Changes of temperature cause the decking of such bridges to rise and fall considerably at the centre of the span, and allowance for this will, of course, have to be made by the employment of a special form of joint to prevent racking of the pipes. In order to prevent the freezing of the water in the pipes where they would be exposed to the air, there is the alternative of insulating them with a sufficient thickness of material and of carrying them within a light timber structure or shed, special provision being made to warm the air inside the shed in winter. The latter alternative permits of a lighter and cheaper bridge for the long spans, and the estimate is based on this assumption. Where the pipes cross the two narrow channels the box girder form of bridge would be suitable, the pipes being laid in the interior of the box girder, the bridges being designed so as to interfere as little as possible with the existing surface of the ground and of sufficient strength to carry four 51-inch diameter pipes, which would give a maximum discharge at the rate of 93,000,000 gallons per diem without material loss of head between the service reservoir and the city.

The following estimate is based upon the proposals mentioned in the report:—

Head Works.	
Dam at outlet of Mitchell's Lake to raise water surface to 570 feet	$ 130,180
Clearing and burning area to be submerged	128,000
Tunnel between Pemichangaw and Long Lake, including shafts, etc.—3,000 lin. ft.	119,630
Outlet works at Long Lake—straining tower, etc.	43,660
Smaller works about lakes, including subsidiary dams at depressions in height of land, temporary works at Pemichangaw, dowering and clearing Long Lake, etc.	72,000
Aqueduct to Service Reservoir.	
54-in. steel main, 7-16-in. thick, between outlet tower and service reservoir—235,000 lin. ft.	4,314,080
Bridge on Gatineau River	30,000
Various smaller stream crossings and culverts	110,000
Service Reservoir.	
Dams	212,150
Clearing and stripping site	21,460
Inlet and outlet works	26,600
Aqueduct Service Reservoir to City.	
51-in. steel main, 7-16-in. thick between service reservoir and city—two lines of pipe, each 32,000 lin. ft.	1,101,120
Various smaller stream crossings, culverts, etc.	20,000
Bridge across the Ottawa River	180,000
Total for works	$6,508,880
Add 10 p.c. for engineering and contingencies	976,320
	$7,485,200
Land, lakes, compensation, etc.	500,000
Total	$7,985,200

If the scheme is proceeded with immediately, the system may be in use in 1917.

The City Council will have the proposal under consideration at its meeting to-morrow (October 17th, 1913).

OVER FIFTEEN HUNDRED AT ROAD CONGRESS

Over fifteen hundred delegates attended the American Road Congress held at Detroit the first week of this month. About sixty Canadians attended the meetings, including A. W. Campbell, Deputy Minister of Railways and Canals; Honorable Dr. Reaume, Minister of Public Works of Ontario; Honorable J. E. Carron, Minister of Agriculture and Roads of Quebec Province; the members of the Ontario Highway Commission; the city engineers and some of the assistant city engineers of London, Hamilton, Toronto, Ottawa, Oshawa, Port Arthur, Orillia, St. Catharines, Windsor and Walkerville; M. D. Hallman, County Roads Superintendent, Berlin; E. A. James, engineer of the York County Highway Commission, Toronto; C. H. Keefer, C.E., Ottawa; A. T. Laing, Department of Highway Engineering, University of Toronto; A. J. MacPherson, Chairman of the Provincial Highway Commission, Regina; W. G. MacKendrick, of the Warren Bituminous Paving Co., Toronto; Controller J. W. Nelson, Ottawa; the Mayors of Port Arthur and Hamilton; Victor Pigeon, Chairman of the Road Commission of Longueuil, Que.; J. O. Sharkey, President of the Central Steel and Wire Co., Toronto; B. E. Smith, of the Barrett Manufacturing Co., Toronto; Gordon Smith, of the Barber Asphalt Paving Co., Toronto; F. M. Williamson, Engineer of Dominion Parks, Ottawa; D. P. Wagner, secretary of the Ontario Highway Commission, etc.

The attendance was better than at the Second American Road Congress, which was held in 1912 at Atlantic City, and far better than the First American Road Congress, held in 1911 at Richmond, Va. The exhibits occupied twice as much floor space as they did at Atlantic City, and were most interesting and instructive.

The asphalt interests were represented by the exhibits of the Barber Asphalt Paving Co., A. B. Chamberlain, Standard Oil Co., The Texas Co., U.S. Asphalt Refining Co., and the Warner-Quinlan Co.

The brick interests were represented by the National Paving Brick Manufacturers' Association and its constituent companies.

A number of cement companies exhibited, including the Canada Cement Co., which was the only Canadian firm having a booth, with the exception of *The Canadian Engineer.*

Several firms exhibited expansion joints or reinforcements for concrete pavements, including the American Steel and Wire Co., R. D. Baker & Co., Thomas Steel Reinforcement Co., and the Trussed Concrete Steel Co. A felt expansion joint filler was exhibited by Philip Carey Co.

Among the companies exhibiting other types of pavements or paving materials were the Asphalt Block Pavement Co., Barrett Manufacturing Co., Rudolf S. Blome Co., Dolarway Paving Co., Jennison-Wright Co. (wood block), Robeson Process Co. (Glutrin), and Warren Brothers Co.

Rock crushers, graders, rollers and other road machinery were shown by the Acme Road Machinery Co., J. D. Adams & Co., American Road Machinery Co., Austin Western Co., Climax Road Machine Co., Galion Iron Works Co., Good Roads Machinery Co., Charles Hvass & Co., Port Huron Engine and Thresher Co., Rumely Products Co., Wheeling Mold and Foundry Co., etc.

Buffalo Pitts, Holt and Wallis traction engines were at the show. Buffalo Pitts and Troy dump wagons were exhibited, a Packard motor dump wagon also being shown.

The increasing use of concrete for road construction, whether for foundations or surfaces, was indicated by the number of different makes of concrete mixers exhibited, which included the Austin, Big-an-Little, Coltrin, Eureka, Hartwick, Kent, Koehring, Lansing, Milwaukee, Rapid-Heated, VanDuzen and other makes.

Various methods of building culverts were exhibited, the cast iron pipe interests being represented by the American Car and Foundry Co. and the United States Cast Iron Pipe and Foundry Co., while corrugated metal culverts were shown by the Shannon Self-Locking Metal Culvert Co., the Portsmouth Culvert Co., the American Rolling Mills and the Galion Iron Works. Collapsible forms for concrete culverts were shown by the Concrete Form and Engine Co.

Engineering instruments were shown by the Bausch and Lomb Optical Co., and Keuffel and Esser.

Laboratories were represented by Robert W. Hunt & Co.

Gasoline engines and pumping outfits were exhibited by the New Way Motor Co., Novo Engine Co., Original Gas Engine Co., and the Whitman Agricultural Co.

Orenstein-Arthur-Koppel Co. showed models of dump cars. Steam shovels were represented by the Marion Steam Shovel Co.

The Steel Protected Concrete Co. showed the Wainwright Corner Bar, and distributed literature of the new Guelich asphalt plant. The Tarrant Manufacturing Co. exhibited various tools and other appliances for paving work, as did the Iroquois Iron Works and the Anderson Tool and Supply Co.

The exhibit of miniature models by the Office of Public Roads of the United States deserves special mention. Models of roads from the early Roman roads to the present modern types were shown. There were also models of bridges, culverts and drainage structures, rollers, crushers, etc. The New York State Highway Commission chemists were present with considerable laboratory equipment, and gave out much useful information. The United States technical papers were well represented, eleven of them having booths.

The exhibition of machinery and materials formed only one part of the work of the Congress of course, great interest being shown in the large number of valuable papers read at the meetings. Some of these papers appeared in full in last week's issue and in this issue of *The Canadian Engineer*, and others may be printed during the next few weeks; but it is understood that a complete report of the proceedings of the Congress, together with all speeches in full, will be procurable within a few weeks, for a small fee, from the secretary of the American Highway Association, J. E. Pennybacker, Colorado Bldg., Washington, D.C.

The Fourth American Road Congress will likely be held at Atlanta, Ga. The executive committee are considering the advisability of holding the Congress about January, 1915, instead of late in the fall of 1914. Many road contractors and engineers are too busy in the fall to attend the Congress, and it is also thought that possibly the lessons learned would be better remembered if the Congress were held nearer the opening of the following construction season.

ESSENTIAL FEATURES IN GOOD BRICK ROAD CONSTRUCTION.

In the course of the paper which he read before the American Highway Association at Detroit (American Road Congress), Mr. Jas. M. McCleary, road engineer of Cuyahoga County, Ohio, refers in an interesting manner to the various events in the process of evolution which road engineering has gone through in that county from the initial stages of highway improvement to the conditions which at present mark its roads as being worthy of praise. The paper deals largely with mistakes of early brick construction, and the methods whereby they were, and may be elsewhere, overcome. Cuyahoga County possesses no peculiarities of topography or soil that are not ordinarily found in other districts and countries, and for this reason the following points as disclosed by Mr. McCleary's paper are applicable, with almost equal weight, in Canada:

In the western part of Cuyahoga County the land is so level that drainage is a difficult problem and must be given much consideration. In the southern and eastern parts, the land is so broken that to secure a feasible grade without undue expense for excavation becomes the chief difficulty. The soil varies from a sticky yellow clay in the southern and eastern sections to a sandy loam at the west. The development of the brick road, therefore, was obstructed by all the probable problems to be found elsewhere: natural and artificial soil, grades, climatic influences and the opinion of the abutting property owner.

The first brick road in the county was started in 1893 and completed in 1895. It was located on what is known as the Wooster Pike, in the southwest portion of the county. The wearing surface was of standard size brick, eight feet in width, tar filled, placed between stone curbs, 3″ x 15″, and resting upon a six-inch broken stone base. The pavement was placed upon one side of the roadway with a graded earth drive occupying the balance of the width. No drainage was provided and really nothing of detail was taken into consideration. No requirement in the specifications dealt with the quality of the stone, and the result was that field stone was used for base, and of such consistency that, when the roller had done its work, one might think that sand ballast had been used. Upon this the cushion was placed without compression and then the brick. As to the filler, no one could have told its composition at the end of six years, so little of it could be found.

The pavement being but eight feet in width, all the traffic came in one place. Lack of bond and absence of uniform support caused a depression to appear. In the wet season this rut or groove filled with water which soaked through the base, creating a worse condition from day to day during the damp seasons. The colder weather brought upheavals and such havoc that many sections of the so-called improvement were a hindrance rather than an aid to the traffic.

These defects were not repaired, owing to the fact that the law under which these improvements were made permitted no expenditure for maintenance. In 1898 this legislative flaw was remedied, but for five years there was no chance to palliate the badness of our methods nor to interfere with the increasing delapidation which constituted the chief value of this road—the value of a horrible example.

The next road laid was South Woodland. This is in the eastern section of the country. Again the wearing surface was eight feet in width, tar filled, and placed between flush stone curbs on a six-inch broken stone base. We had learned, in a small way, from our first mistakes and placed a six-inch drainage tile beneath the centre of the roadway. But on account of the soft filler and imperfect preparation for carrying off the water, but little improvement in the result was realized. An uneven settlement of the base soon resulted in roughness.

Lorain Road, our next installation, was built sixteen feet wide, tar filled, and resting upon a crushed stone and slag base between flush curbs, with drain tile beneath each curb. Subjected to an unusually heavy traffic, the almost inevitable result of such construction must be extensive repairs, amounting almost to reconstruction.

Our next great forward step occurred when the tar filler gave way to a grout filler composed of one part sand and one part cement. This plan was followed until 1905 with success, at least in comparison with previous experiences. The cement filler alone could not cure all of the defects due to inferior drainage and frost action. Another step was therefore decided upon—the inclusion in the specifications of a requirement for a 4-inch concrete foundation which, of course, increased the price. The increased cost brought immediate opposition, resulting in a temporary return to broken stone or slag base until 1908, when concrete was again adopted as a foundation and continued up to the present time.

Since 1908 it has been the policy not merely to conform to the chief essentials of brick paving, which are: (1) properly prepared subfoundation, (2) smoothly finished concrete base, (3) compressed sand cushion, (4) laying of good brick, (5) application of the cement filler to the joints; but to attach importance to minor details of approved manner and method of construction. Doubtless we have not even yet given weight to certain details advocated by some of the more painstaking students of brick road construction in the country.

A satisfactory plan for an average rural pavement may include a paved portion anywhere from 9 to 16 feet in width, the width being controlled by the amount of traffic to which the road is subjected. A dirt or gravel macadam should occupy the balance or unpaved portion of width. Whatever dimensions are adopted, the surface drainage should be over the pavement toward a ditch on the side of the road closest to the pavement, eliminating a crown from the paved portion. The unpaved portion should be drained in the opposite direction.

Immediately you ask: "Why a dirt road?" The best answer is, "Ask the farmer," and he will tell you to ask the horse.

The engineer will save himself much trouble if he holds to such a grade line as will entail minimum depths of fill. This is not always possible and it is the larger fills that call for the most extreme care. It behooves the engineer to see that his specifications contain a clause calling for the fill to be put in layers of not more than 6-inch thickness and each layer compacted with a roller not exceeding 10 tons in weight. This clause must be enforced with rigidity.

Puddling is the one method that can be followed successfully in the treatment of old fills. The surface of the road should be broken and dirt removed from the centre to the sides. At right angles to this trench, shorter trenches should be dug at intervals of 25 feet, forming a rectangular vat. Pump water into these compartments and allow it to stand until it has leaked its way into the fill. This will disclose the weak spots and the engineer can take care of them as he thinks best.

The drainage of the graded portion of the road is of first necessity. Whatever plan is adopted, the one that will most nearly maintain the sub-structure free from moisture below the frost line is the ideal condition to be sought. This means that you must not merely drain the road bed, but adequate side ditches must be provided to carry off promptly the accumulated water. In the preparation of a sub-base the only debatable proposition is the purpose of rolling. Common practice, including the use of a very heavy roller, has been founded upon the theory of compacting the soil to as great a depth as possible. This can do no harm, but the writer believes that the chief purpose of rolling is accomplished when the weak or spouty places in the soil are revealed so that the engineer can treat them as he sees fit. For this purpose, a roller weighing from 8 to 10 tons answers every requirement.

Preceding the final preparation of the sub-base the curbs must be placed. In case of most of our rural work, curbs are placed flush with the surface of the completed pavement.

With curb set and base prepared, the next step is the placement of the concrete base, which with our roads has been 4 inches in depth. In specifying the proportions, a mixture of 1:3:5 with a permissible variation according to the size of the aggregates which will most nearly fill the voids, meets every necessity. To meet this variableness, which obtains with almost every job, it is necessary to specify the size of the coarse aggregate, but not the amount, requiring only so much of the coarse aggregate to be used as shall leave the concrete most nearly free from voids. This, instead of an inflexible rule of proportions, will assure a condition of concrete whereby a smooth surface is easily attained. A smooth surface must be had, for upon that much of efficiency and durableness of the wearing surface depends. It assures in the next step a requirement of equal importance, that of placing the sand cushion of uniform fill and of uniform density.

While it is possible that often too much importance is placed upon the ability of the sand cushion to afford a resiliency or absorb shock, it is unquestionably a necessity for the purpose of bringing the wearing surface of the brick to a perfect plane, by neutralizing the unevenness and lack of uniformity of the brick. No one will question but that the support of the wearing surface provided for by this sand cushion must be uniform. It is therefore necessary to compress and bring to a like density every part of this cushion. Dropping the sand cushion on to the base from dump wagons and leaving the bottom portion of the load untouched before striking off with a template is objectionable, as it renders the hand rolling difficult by having a dense pile and a loose pile to contend with, the roller spanning the looser portion. It is better to spread the sand entirely by shovels, then by rolling and striking off and re-rolling, even a third time. This brings the cushion to a condition of compactness and even density that will not only furnish an even support to the entire pavement, but will prevent the sand from flowing up into the joints of the brick when the brick surface is rolled. While it is not necessary for this cushion sand to be entirely free from soil and vegetable matter, it should be nearly so, otherwise its density cannot be maintained.

Respecting the laying of the brick, the following points are noted by Mr. McCleary as important:—

(1) See that the lugs are turned one way.

(2) Make certain that the joints are broken so that one-third or more of the brick of one course overlaps the brick of the next course.

(3) Be sure that every fourth course is driven up to a straight line.

(4) For the sake of appearance, keep the line of the brick at right angles with the curb.

Next in order is culling. Care should be taken to see that all soft brick or brick that are burned too hard are removed. Those so heavily kiln-marked that they will cause unevenness in the pavement should be turned. Caution should be exercised in this, for many a kiln-marked brick is thrown out which, if allowed to remain would have been of more value to the pavement than others that are retained.

After the brick are thus placed in the street, their slight unevenness should be ironed out by the use of a roller not exceeding 5 tons in weight. If a horse roller is used at all, it should have a diameter of at least 5 feet. Rolling should begin on one side and pursue a course parallel to the curb. The roller should return over the same course. The next trip should lap the first, the roller again returning over the same course. This should continue until the centre of the pavement has been reached when the roller should be moved to the opposite curb and continue as before until the centre is reached from the other side.

The roller should then start at one side and work diagonally across the pavement. This diagonal rolling will have a tendency to bed the brick in such a manner as to avoid "rocker." The pavement should then be culled again for broken brick, after which it should be hand-rammed with a paver rammer weighing not less than 50 pounds. Interpose a plank not less than 6 feet long, 10 inches wide and 2 inches thick, between the surface of the pavement and the rammer. The plank should be laid parallel to the curb.

For filling joints, the next process in order, use a grout filler composed of equal parts of sand and cement. It seems hardly necessary to state that the cement should meet the standard specifications for Portland cement as adopted by the American Society for Testing Materials. The sand with which we have had much success has been taken from the lake and, although not very sharp, is nevertheless fine and clean and has given good results. In any event the sand to be used should be free from sewage, acid or soil, and should be sharp and fine.

A watertight box, standing on uneven legs so as to afford a "lower corner," should be used as a receptacle for the grout. In it place one cubic foot of sand and one bag of cement, mixing the mass until it assumes a uniform color. Add water and stir the mixture until it assumes the consistency of thin cream. The mixture should then be applied to the pavement by means of scoop shovels and thoroughly swept into the joints. After this has had sufficient time for setting a second coat, slightly thicker, should be applied and later a third coat, which will assure filled joints. This last coat should be worked either with a specially prepared broom or a rubber squeegee, and swept across the joints at an angle of 45 degrees.

After the initial set has taken place, the pavement should be covered with a half inch or more of sand and this kept saturated with water for at least 5 days. The pavement should not be opened to traffic for at least 10 days.

We have not undertaken any special provision against possible thermal effect, such as contraction and expansion due to low and high temperatures, but have relied mainly upon the condition of our structure by avoiding moisture underneath the roadway and by an endeavor to have our cement-filler of the greatest possible strength. These provisions, together with a rigid curb, enables us to hold in compression, the expansion occurring in our narrow roadways. In this respect, we have not been entirely successful. A few cracks in the pavement have appeared, but so far, they have not ravelled out so as to injure the traffic worth of the road, and have not been thought of sufficient importance to require repairs.

COAST TO COAST.

Montreal, Que.—The fourth and last 270-foot span of the C.P.R. Lachine bridge has been placed in position.

Toronto, Ont.—The Hon. Robert Rogers, when inspecting the city harbor, made the statement that it is planned to have the Great Lakes watercourse for ocean freighters completed in 1918.

Regina, Sask.—The sewer work contracted for by the Regina City Council early in the year is nearly all completed, and already the city engineer and his staff are busily engaged on planning the extensions for next year.

Vancouver, B.C.—The contractors have announced that within 30 days, work will commence on the erection of the Dominion Government dock in East Vancouver, which has let at an estimate of three-quarters of a million dollars.

Edmonton, Alta.—The city council has instructed the city commissioners to apply to the Dominion Government to have lands reserved for the source of the city's gas supply in the gas district at Vegreville. A pipe line of 90 miles, the cost of which would be $946,500, would be necessary to carry the supply to Edmonton.

Saskatoon, Sask.—At the recent convention of Canadian municipalities held at Saskatoon, a movement was set on foot to urge the establishment of a local government board, whose particular function will be to keep in constant touch with the finances of each city and municipality within its jurisdiction on lines similar to the system in vogue in England.

Montreal, Que.—The first C.N.R. train to make the through trip from Toronto to Quebec, covered the road early in October, bearing the president and Lady Mackenzie to the "Royal Edward" steamship. The track is pronounced in first-class condition, though regular passenger service will not commence until the ballasting is fully completed.

Ottawa, Ont.—The Conservation Commission will support the recommendation of the Ontario Municipal Electric Association that the water powers along the rivers and canals of Ontario be handed over to the Ontario Hydro-Electric Commission. It has been urging this policy for some time, though it is not particular whether the development is carried out by the federal or by the provincial government.

Edmonton, Alta.—A deputation of 70 farmers called upon Premier Sifton to ask that he urge upon the government the necessity of considering the question of assisting in the building of light railways to connect with settled districts removed from main lines of railway. The deputation was particularly concerned with the construction of a railway in Blindman Valley in the Lacombe and Ponoka districts.

Montreal, Que.—Mr. T. S. Darling has stated that between the 20th and 30th of December, the completion of the tunnel through the mountain will be announced. Two thousand feet of distance remain to be cut, but there has been little trouble so far and none anticipated until the work is finished. No difficulty with respect to air pressure has been experienced, since the tunnel does not lie under a river.

Victoria, B.C.—An important operation was achieved in connection with the improvement work in the Inner Harbor, when 700 tons of rock were displaced at a single charge. This was accomplished at the Soughees rock where drilling and blasting operations are being carried on at present. The elimination of several of the dangerous rocks has removed the menace to shipping, which has prevented large vessels from entering the Inner Harbor.

Montreal, Que.—At the annual meeting of the Grand Trunk Pacific Railway Company, report on the construction of the main line to the Pacific coast showed that the work has reached mile 1,204 west of Winnipeg, and mile 305 east from Prince Rupert. This leaves a section of only 236 miles in British Columbia on which the grade is to be completed and the track laid. It is hoped to complete the connection of steel to the Pacific Ocean within the next nine months.

Coquitlam, B.C.—After four years of labor, the great dam at Coquitlam has reached completion. Its construction necessitated the tearing down of hills and the displacement of vast quantities of earth, the boring of two tunnels through solid granite and the erection of two towers. Work has ceased on all portions of the construction, the final piece of labor being the spillway, a trench 250 feet in width and 15 feet in depth, which was driven through solid rock.

Victoria, B,C,—The announcement has been made that the middle of next summer will see a new channel for the use of steamers entering and leaving Victoria's inner harbor. This channel will be one quarter of a mile wide and 20 feet deep at low water. Several patches of mud must still be cleared away, and a couple of pinnacles of rocks broken up and removed. A shorter run into the harbor will be gained by the new channel, eliminating the turns which cause considerable trouble to certain boats.

Toronto, Ont.—The acceptance of the 86-foot road standard by the Ontario Railway Board assures for Greater Toronto one of the finest road systems on the Continent. St. Clair Avenue has a width of 100 feet, and will serve as a plan for future boulevard constructions. Only at street intersections can vehicles cross from one side of the street to the other, thus obviating the difficulties to street car traffic caused by vehicular traffic in older sections of the city. Here, also, the track area has been covered by broken granite for the purpose of deadening sound.

Vancouver, B.C.—Another bridge, the largest of its type on the mountain section of the C.N.R., has been completed. It stretches for 760 feet over Stoyama Creek, and consists of seven steel spans resting on six concrete pedestals. Surmounting the pedestals are six towers, each 40 feet in width. Track is now being laid over the bridge and beyond it westwards until Nine Mile Creek is reached, where another steel viaduct, 300 feet long, having three towers and two spans, will be constructed. Still further west, between Nine Mile Creek and Cisco, smaller steel bridges will be erected over obstructing creeks and gullies.

Regina, Sask.—City Engineer McArthur has decided on a novel plan to keep the roadways of Regina in proper condition. The assistance of the boy scouts has been enrolled Boy scouts patrol different sections of the city at stated times and report where improvement is needed in the roads. These reports are handed over to what is now called the "road repair gang." This gang of men is employed for the specific purposes of making repairs, and is kept busily engaged fixing up the bad spots reported by the boy scouts. It is expected that by this system the roads throughout the entire city will be in good repair by freeze-up.

Vancouver, B.C.—The opening of Kingsway, the newly-paved 12-mile highway connecting Vancouver with New Westminster and the municipalities of South Vancouver and Burnaby, was celebrated recently by a program of ceremonies comprising an imposing procession of city and municipal officials carried by 563 automobiles bountifully decorated with flags as far as the corner of Kingsway and Boundary Road, where speeches were given by the Mayor, Reeves and the Hon. Thos. Taylor. He formally declared the highway open to traffic, congratulated the cities and municipalities upon the highway construction, and outlined the possibility of a circular road paved from Vancouver to New Westminster, via Kingsway, returning by the river road. Amidst the enthusiastic cheering of the great crowd assembled, the procession re-formed and continued along the highway to the Royal city.

Medicine Hat, Alta.—The Southern Alberta Land Company has been carrying out an irrigation project that will water the greater part of 400,000 acres of excellent land in Southern Alberta. They have engaged in the work Mr. David W. Hays as chief engineer with a force of about 500 men. One of the greatest feats in connection with the scheme will be the construction of one of the longest tunnels for carrying water in Western Canada, as well as one of the largest in diameter, its cross-section being 100 feet. The tunnel will commence at a point three miles south of Lake McGregor, and extend about two miles along the lower end of the Snake Valley. It will cut off five miles along the main ditch from the lake, which is the main source of supply. When completed it is estimated that it will carry 1,300 second feet, or 1,300 cubic feet will pass a given point every second.

Edmonton, Alta.—Much discussion is being given to the deficits which appear every month in the earnings of the city's street railway department. Among other recommendations, Cost Engineer Bowness has suggested that an immediate investigation of power rates be made to settle the basis of rate and the method of measuring power delivered, which is now indefinite and unsatisfactory. The rates charged by the power department are admitted to be excessive. To reduce the power charges so as to supply direct current to the street railway company at the exact cost of production would alter the monthly report of Mr. Woodroofe, superintendent of the street railway department, and deficits would be eliminated. The power department would show a smaller surplus with the carrying out of the recommendation, but a report showing a balance on the right side in both departments would make more pleasant reading for the citizens, the owners of these concerns.

PERSONAL.

W. G. CHACE, B.A.Sc., of the firm of Kerry and Chace, Limited (until recently, Smith, Kerry and Chace), has been appointed chief engineer of the entire construction of the Greater Winnipeg water system.

W. S. HARVEY, mentioned in our personal column on August 21st, as acting city engineer of Lethbridge, Alta., succeeding A. C. D. Blanchard, resigned, has just been appointed to the position of city engineer.

ERNST POENSGEN, manager of the Tube Department of the Phœnix Steel Works of Dusseldorf, Germany, returned home last week. He spent some time at Montreal with his firm's Canadian agents, Gerald Lomer, Limited.

DR. CARL IMHOFF, eminent in the design of system and apparatus for scientific sewage disposal was a visitor in Toronto last week, and made a careful tour of inspection over the sewage disposal plant at Morley Avenue.

J. H. FUERTES, civil and sanitary engineer of New York, and a member of the board of experts, who reported recently on the Shoal Lake Water Supply scheme for Winnipeg (See *The Canadian Engineer*, September 11th, 1913), has been appointed consulting engineer for the work.

C. R. KRUMBIEGEL has been appointed Chief Engineer for Canada for Deutsche Maschinenfabrik, A.G., Duisburg, Germany. Mr. Krumbiegel has been on the engineering staff of this firm for a number of years and has had experience, not only in Germany, but in the United States as well. He will be permanently located in the office of the firm's Canadian agents, Gerald Lomer, Limited, Fraser Building, Montreal.

R. H. REYNOLDS, was last week appointed a commissioner to act in connection with the Shoal Lake water supply system for Winnipeg, upon which construction work will begin immediately. It is stated that the other commissioners will not be appointed for some little time. Mr. Reynolds was for some years assistant city engineer under City Engineer Ruttan, and when he left in 1907 was succeeded by R. D. Wilson, who still holds that position. For a number of years he was engaged in mining pursuits, and is at present a resident of Victoria, B.C.

J. E. PENNYBACKER, secretary of the American Highway Association, was in Toronto this week making preparations for his new work as consulting expert to the Ontario Highway Commission. Mr. Pennybacker was educated at West Virginia University and the University of Georgetown, graduating in law in 1900. After four years' practice with a railroad corporation, he was appointed chief clerk of the United States Office of Public Roads. Some particularly able work that he did in gathering economic data regarding roads, attracted the attention of the Cabinet, and he was appointed Chief of Road Management. When the American Highway Association was formed about two years ago, Mr. Pennybacker resigned his government position to become its permanent secretary. On the recommendation of Director Page of the United States Office of Public Roads, Mr. Pennybacker was also appointed as consulting expert to the Joint Congressional Committee on Road Legislation. Mr. Pennybacker gave valuable assistance to the Committee which reached the notice of the chairman of the Ontario Highway Commission. At the request of the Ontario Government, the American Highway Association permitted Mr. Pennybacker to act as consultant to Ontario Highway Commission. The vast amount of data that he has gathered during the past ten years on every phase of road legislation and road construction, will undoubtedly help the Ontario Commissioners in framing a model Highway Bill and in organizing an ideal Highway Department.

OBITUARY.

GEO. G. ROSE, C.E., a member of the engineering staff of the Cornwall Canal, and a native of Morrisburg, Ont., died last week at Cornwall. Mr. Rose was a graduate of the Royal Military College, Kingston, and was connected with the Marine Department, Ottawa. Fifteen years ago he was in charge of the construction of a part of the Rapide du Plat Canal. He was 63 years of age.

JAMES HARRISON, a member of the engineering staff of the York County Road Commission, died suddenly in Woodbridge, Ont., last week. Deceased was overcome by a paralytic stroke, and a record run to a city hospital proved in vain. Although not a graduate, Mr. Harrison was a member of the 1887 class in Civil Engineering at the School of Practical Science, Toronto

EXTENSIONS TO ELECTRICAL FIRM.

Contracts have just been placed by the Eugene Phillips Electrical Works of Montreal for a large amount of new machinery with which to equip the new quarter of a million dollar extension to their Montreal plant. There has already been installed in this extension all of the machinery that had been previously used by the Stromberg-Carlson Telephone Manufacturing Company of Rochester, New York, in their telephone-cable making branch. This branch of the Stromberg-Carlson business was purchased outright by the Montreal firm, which is now in a position to bid on very large contracts for telephone cable. The capacity for making other cable will also be greatly increased, and the contracts recently let for machinery will widen the field of the company's activities.

COAL TESTING.

At the October meeting of the Cleveland Engineering Society, held on 14th inst., Dr. W. G. Wilcox, of the Cleveland Research and Testing Laboratories, presented an illustrated paper on "Coal Testing." Another meeting is being held on October 21st, when Mr. Jos. R. Poe, Structural Engineer, the Wellman, Seaver, Morgan Company, will give a paper on "The Practical Side of Steel Structures."

OTTAWA BRANCH—CANADIAN SOCIETY OF CIVIL ENGINEERS.

At the annual meeting on October 2nd, of the Ottawa Branch of the Canadian Society of Civil Engineers, Mr. Geo. A. Mountain was appointed chairman of the branch. Meetings for the presentation and discussion of papers will be held on the first and third Thursdays of the fall and winter months, the other Thursday evenings to be devoted to informal or business meetings. Mr. R. F. Uniacke is the retiring chairman.

COMING MEETINGS.

CANADIAN SOCIETY OF CIVIL ENGINEERS.—The first monthly meeting of the Society for the winter session will be held on Thursday, the 16th inst., at 8.15 p.m. An illustrated address on Elevator Construction will be delivered by Mr. Jas Spelman, M.Can.Soc. C.E.

NATIONAL SOCIETY FOR PROMOTION OF INDUSTRIAL EDUCATION.—Annual convention to be held at Grand Rapids, Mich., October 19th to 25th. Secretary, C. A. Prosser, 105 E. 22nd Street, New York City.

AMERICAN MINING CONGRESS.—Annual convention will be held at Philadelphia, Pa., October 20th to 25th. Secretary, J. Callbreath, Majestic Building, Denver, Colo.

AMERICAN RAILWAY BRIDGE AND BUILDING ASSOCIATION.—Annual convention will be held at Montreal, Que., October 21st to 23rd. Secretary, C. A. Lichty, 319 N. Waller Avenue, Chicago, Ill.

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

NATIONAL MUNICIPAL LEAGUE.—Annual meeting will be held in Toronto, November 12-15. Secretary, C. R. Woodruff, 705 North American Building, Philadelphia, Pa.

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

ORDERS OF THE RAILWAY COMMISSIONERS OF CANADA

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

20447—September 30—Authorizing C.P.R. to open for traffic that portion of its Swift Current North-West Branch from Cabri, mileage 34.8, to Westerham, near mileage 94.0, a distance of 59.2 miles. And relieving company of speed limitation of fifteen miles an hour between mileages 34.8 and 33.0, imposed under Order No. 16869, dated June 25th, 1912.

20448—September 29—Authorizing Lachine, Jacques Cartier, and Maisonneuve Ry. Co., to take certain lands in city of Montreal, P.Q., required for diversion of Harbor Street: said lands being required to give effect to Order No. 16181, dated March 28, 1912, authorizing the crossing of certain streets in Montreal, including diversion of Harbor Street.

20449—September 29—Directing that crossing of Wallace Ave., Toronto, by G.T.R., be protected by gates operated by day and night watchmen appointed by Ry. Co.; cost of installing and maintaining gates and wages of watchmen be borne and paid by city of Toronto; work to be completed within 60 days from date of this Order, and rescinding Order No. 9247, dated January 12th, 1910; such revision to take effect upon installation of gates herein required to be provided.

20450—September 26—Authorizing G.T.R. to construct siding, and spur therefrom, into premises of Ogilvie Flour Mills Co., Limited, west of Mill Street, Montreal, Que., subject to and upon certain conditions.

20451—September 27—Authorizing G.T.R. to construct additional track, or siding, commencing at a point on its railway west of Gore Street, Stratford, Ont., thence extending easterly across Gore Street. Siding to be completed within three months from date of this Order.

20452—September 29—Extending, for a period of three months from date of this Order, time within which G.T.R. construct branch lines of railway and additional tracks in the village of Port Colborne, Ont., authorized under Order No. 19535, dated June 4th, 1913.

20453—September 29—Authorizing C.N.O.R. to construct, subject to conditions contained in consent of Montreal Tramways Company, dated August 26th, 1913, proposed temporary grade on its Montreal-Hawkesbury Line from mileage 46.69 to 48.62, to be used for construction purposes only for a period of one year; and to cross on said temporary grade for said period, the Monkland Boulevard, Bois Franc Road, Montreal Park and Island Ry., and St. Laurent Road.

20454—September 30—Authorizing C.N.R. to construct across twenty-two (22) highways on its Goose Isle Branch, Manitoba.

20455—September 30—Authorizing C.L.O. & W. Ry. (C.P.R.) to construct, at grade, across side road in Lot 14, Con. 3, Tp. of Bathurst, Ont.; and to construct temporary diversion of said railway at mileage 2.1.

20456—September 30—Authorizing C.L.O. & W. Ry. to construct ballast pit spur line, by means of grade crossing, across road allowance between Lots 10 and 11, Con. 1, Tp. Murray, Co. Northumberland, Ont., at mileage 0.09 on ballast pit spur.

20457—September 30—Approving, subject to provisions of sub-section 2 of Sec. 327, and sub-section 1 of Sec. 331, of Ry. Act, maximum tolls to be charged for passengers for all distances on C.P.R. lines in Canada now in operation or under construction, as specified in Co.'s Standard Passenger Tariff, C.R.C. No. 2279, dated at Montreal, Aug. 12th, 1913, to become effective Sept. 1st, 1913, namely: three cents (3c.) per mile east of and including company's railway between Macleod, Calgary, and Edmonton, Alta., and four cents (4c.) per mile west of and including Macleod and Calgary, said tariff being a consolidation of company's approved Standard Passenger Tariffs, C.R.C. Nos. W. 38, and E. 664.

20458—September 30—Directing C.N.O.R. to provide and construct suitable farm-crossing and cattle-pass where it crosses lands of William and Robert Wilson, in Lot 26, Con. B, Tp. Westmeath, Co. Renfrew, Ont., subject to and upon certain conditions.

20459—September 11—Authorizing C.P.R. to construct spur for Northern Elevator Co., Limited, Winnipeg, Man., from a point on existing spur on Sutherland Ave., subject to and upon certain conditions.

20460—September 30—Authorizing G.T.P. Ry. to construct wye track at mileage 29 west of Yellowhead Pass, Cariboo District, B.C.; and rescinding Order No. 17618, dated September 25th, 1912, made herein.

20461—September 30—Extending, for a period of thirty days from date of this Order, time within which G.T.R. complete culvert under its tracks, Tp. Tecumseh, Ont., authorized by Order No. 19988, dated Aug. 5th, 1913.

20462—October 2—Declaring that joint tariff of Alta. Ry. and Irrigation Co., C.R.C. No. 165 is lawfully in effect; and that Supplement No. 16 thereto, published and filed by C.P.R. to take effect August 18th, 1913, is disallowed. Board will be prepared to consider an application for annulment of said C.R.C., No. 165 on publication and filing by C.P.R. of local and joint tariffs of rates from Lethbridge, and from points on line of Alta. Ry. and Irrigation Co., via Lethbridge, which shall not be greater than those shown in said C.R.C., No. 165, via Coutts, to points in B.C., on G.N.R. and C.P.R., to which the rates of said C.R.C., No. 165 are now lower than via C.P.R. from Lethbridge, having regard to provisions of Ry. Act.

20463—September 30—Establishing collection and delivery limits of the Dominion Express Co., in town of Swift Current, Sask.

20464—October 1—Authorizing Edmonton, Dunvegan and B.C. Ry., to construct across two highways—namely, 1. between N.E. ¼ Sec. 13-74-16, W. 5 M., and N.W. ¼ 18-74-15, W. 5 M.; 2. N.E. ¼ Sec. 13-74-16, W. 5 M., Province of Alberta.

20465—October 1—Extending, for a period of 60 days from date of this order, time within which G.T.R. install electric bell at crossing of Mill Street, Milverton, Ont., required under Order No. 19893, dated July 24th, 1913.

20466—October 1—Authorizing G.T.R. to construct siding into premises of the Ham and Nott Co., Limited, on Block "C," north of Bruce Street, city of Brantford, Ontario.

20467—September 30—Authorizing G.T.P. Ry. to construct spur for the Park Lumber and Planing Mills, Limited, in Block 10, Cromdale Subdivision of River Lot 24, Edmonton, Alta.

20468—October 2—Approving location C.P.R. stations on Port McNicoll Subdivision, Ont. Div.—namely, 1, Lot 28, Con. 3, Tp. Ops, Co. Victoria, Ont., at Cambray, mileage 22.78, and 2, at Franklin, mileage 6.3, Lot 22, Con. 12, Tp. Manvers, Co. Durham, Ontario.

20469—October 1—Authorizing C.P.R. to construct spur into premises of G. F. Stephens and Co., Limited, on Lot 64, parish of St. Boniface, Winnipeg, Man., subject to and upon certain conditions.

20470—October 1—Authorizing C.P.R. to construct, subject to terms of consents of town of Swift Current, dated May 23rd and September 9th, 1913, spur for Swift Current Grocery Co., Limited, and Winnipeg Paint and Glass Co., Limited, Swift Current, Saskatchewan.

20471—October 1—Approving location C.P.R. station at Musquash, parish of Musquash, Co. St. John, N.B., at mileage 66.41 on Co.'s Shore Line Subdivision, Atlantic Div. Dist. No. 1.

20472—September 30—Authorizing C.P.R. to construct Weyburn-Stirling Branch Line across twenty-nine (29) highways between mileage 37.94 and 65.20 (zero of said mileage being at Stirling).

20473—October 1—Authorizing C.P.R. to construct sidings for Messrs. McGregor and McIntyre, Toronto, Ont.

20474—October 2—Authorizing Commissioners of Transcontinental Ry., to make, subject to terms of consent of C.P.R., siding connection with C.P.R. tracks to shop site of applicants, in Lot Cadastral, No. 2345, parish of St. Sauveur, Co. Quebec, Que.

20475—October 2—Authorizing G.T.R. to use and operate Bridge over Richelieu River, at Mile Post 8.73 on Thirtieth Dist., near Lacolle Junction, authorized to be reconstructed under Order No. 15863, dated February 2nd, 1912.

20476—October 2—Authorizing C.N.O.R. to construct spur from its Rly. at Richmond Hill to property of J. H. Dunlop, Lot 24, Con. 1, Tp. Markham, Ontario.

20477—October 2—Authorizing C.P.R. to construct tracks of extension to town siding, at grade, across public road between Lots 12 and 13, Con. 3, Tp. Hagar, Dist. Sudbury, Ont.

20478—October 3—Amending Order No. 20226, by striking out figure "2" after word "Lot," wherever same appears in said Order, and inserting in its place figure "4," so as to make the Order read, "situated in Subdivision, Lot 27, Lot 4, Con. 11, Tp. Tillsonburg.

20479—October 2—Authorizing C.P.R. to change present grade crossing, necessitated by additional track (double track); and to construct, by means of grade crossing, said additional track across road allowance between Cons. 2 and 3, Tp. Toronto, at mileage 18.61 on Co.'s main line, London Subdivision.

20480—October 3—Amending Order No. 16874, dated June 26th, 1913, by striking out figures "35.5" in first line under heading Mountain Subdivision, and substituting figures "35."

20481—October 2—Directing that C.N.R. install caretaker at Sandy Lake, Man., who shall, amongst other things, keep waiting room clean and heated for arrival of passenger trains; meet passenger trains on their arrival and assist in putting on or taking off any baggage; meet local freight trains and see that package freight is properly housed; keep freight shed locked, with key at a convenient point; and deliver freight to consignees between hours of 8 a.m. and 6 p.m. Caretaker be installed not later than October 5th, 1913.

20482—October 3—Authorizing C.N.O.R. to construct bridge to carry its railway across Kiosh-Koqui Lake, Tp. Pentland, Dist. Nipissing, Ont., at mileage 186.6 from Ottawa.

20483—October 3—Directing that the sum of $4,700, deposited in a chartered bank in City of Fort William, Ont., under Order No. 18908, dated March 20th, 1913, be paid upon request of C.P.R.; and that production of a certified copy of this Order be authority to bank for such payment.

20484—October 3—Approving C.P.R. plans dated Winnipeg, May 30th, 1912, and September 10th, 1913, showing proposed location of stairway from Arlington Street Bridge to engine house at Winnipeg, Man.; and rescinding Order No. 16860, dated June 22nd, 1912.

20485—October 3—Authorizing C.P.R. to construct additional track (second track or siding) across road allowance on East Boundary of Sec. 5-9-21, W. 4 M., Alberta.

20486—October 3—Relieving G.T.R. from providing further protection at second highway crossing north of Corbeyville, Belleville and Peterboro Division, Ontario.

20487—October 4—Authorizing C.P.R. to construct, by means of a bridge, additional track of its main line, Sask. Div., Moose Jaw Subdivision, over and across road allowance between Secs. 21 and 22, Tp. 18, R. 13, W. 2 M., at mileage 52.65 on said main line, Province of Saskatchewan.

20488—October 3—Requiring C.N.R. to erect a third-class station building at St. Gregor, Sask.; work to be completed with not later than July 31st, 1914.

20489—October 2—Amending Order No. 20009, dated August 11th, 1913, by adding following clauses:—"3. That Government road allowance over C.P.R. between Sec. 1-17-27, and Sec. 6-17-26, W. 2 M., be closed subject to and upon condition that C.P.R. (Applicant Co.), provide and construct subway 40 feet wide, in the clear, just south of and adjoining its right of way, in accordance with plans submitted by Applicant Co., and approved by the city of Moose Jaw. 4. That contribution of $2,000 herein required to be paid by C.P.R. shall not become due or payable until on or after completion of subway authorized and required to be constructed under this Order."

20490—October 4—Authorizing C.P.R. to construct spur for Manitoba Cold Storage Co., Limited, city of Winnipeg, Man., subject to and upon certain conditions.

20491—October 4—Authorizing C.P.R. to use and operate, subject to condition that men be kept off sides and tops of cars when using the crossing, undercrossing shown in red on plan, during construction of Heffernan Street Bridge, Guelph, Ont. And approving and authorizing clearances as shown on plan of false work to be used at Heffernan Street Viaduct, Guelph, Ont.

20492—October 4—Authorizing city of Edmonton, Alta., to open up Spadina Avenue, across C.N.R. at rail level, within limits of city; expense of constructing and maintaining crossing to be borne and paid by applicant.

20493—October 3—Granting leave to B.C. Telephone Co., Limited, to erect its lines across G.N. Ry., on Oscar Street Abbotsford, B.C.

20494—October 1—Authorizing C.N.O.R. to construct spur to mills of Laberge and Sons, in town of Sudbury, from station 41.58.7 on connecting track between its line and Algoma Eastern Ry., and across Wilma Street.

20495—October 4—Authorizing C.P.R. to construct, at grade, spur for Tillsonburg Electric Car Co., Limited, Tillsonburg, Ont., across King Street and Sixth Street, at mileage 15.4, Port Burwell Subdivision.

20496—October 4—Approving Michigan Central R.R. plan showing bridge to be constructed under M.C.R tracks at mileage 32.98, Little Creek Drain, Tp. Tilbury West.

20497—October 4—Authorizing G.T.P. Ry. to construct spur and sidings, for Pembina Coal Co., Limited, in Secs. 19 and 30-53-7, W. 5 M., Alta.

20498—October 6—Extending collection and delivery area, in the city of Ottawa, Ont., prescribed by Order No. 16147, dated March 18th, 1913, by inserting words "including the Isolation Hospital" after words "Somerset Street," in said Order.

20499—October 6—Authorizing C.N.O.R. to construct bridge to carry its railway across Ottawa River at Fitzroy Harbor, Tp. Fitzroy and Onslow, Cos. Carleton and Pontiac, Provinces of Ontario and Quebec, at mileage 37.32 west of Ottawa, subject to terms and conditions contained in Order in Council.

20500—October 1—Authorizing C.N.O.R. to cross, at grade, Metcalfe, John, Harvey, Bourke, Jane, Durrill, Copeland, Bell, William, McIntyre, Timmons, and Nipissing streets, town of North Bay; and certain streets and avenues by means of subways. 2. construct across and divert Marion Street. 3. Closing of Cedar Street be conditional upon Co.'s extending McLaren Street, from Klock Avenue, to Home Avenue. 4. Closing of Fraser Street, be conditional upon Co.'s constructing subway 10 feet in clear width and 8 feet in height through station and under its tracks; station to be located in centre of Fraser Street to be as good, if not better, and of similar design, as Co.'s station at Belleville, Ont. 5. Co. be responsible for any damages property owners affected may be legally entitled to recover. And 6. All subways be satisfactorily drained by Applicant Co.

20501—October 6—Extending, until December 31st, 1913, time within which C.P.R. was required to construct and complete subway at Dundas Street, Woodstock, Ontario.

20502—October 6—Approving revised location C.P.R. main line, double trackage, Moose Jaw Subdivision, Sask., from a point in Sec. 27, in S.W. direction to a point in Sec. 21-18-14, W. 2 M., being from mileage 59.6 to 60.45. 2. Authorizing C.P.R. to construct road diversion across Blocks 147, 148, 149 and 150, Sec. 21, Blocks 143 and 144, Sec. 28, and across Sec. 27-18-15, W. 2 M., and to construct, by means of grade crossings main line across said diversion and across town crossing.

20503—October 6—Authorizing Government of Saskatchewan, at its own expense, to construct highway north of Sec. 28-16-15, W. 3 M., Sask., across C.P.R. Swift Current Northwesterly Branch.

20504—October 7—Amending Order No. 20190, dated August 26th, 1913, by striking out words "Suffield to Blackie" where same occur in said Order, and substituting therefor words "Weyburn-Stirling."