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MAIN GARRISON CREEK STORM OVERFLOW SEWER AND EXTENSIONS, TORONTO

A REVIEW OF THE CONSTRUCTION OF THE NEW GARRISON CREEK SEWER AND EXTENSIONS THERETO, WITH PARTICULAR REFERENCE TO SECTION NO 4, RECENTLY COMPLETED.

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WHILE the city of Toronto was developing in virtue of its increasing size and population into Greater Toronto, the district bounded by Dupont Street, Lansdowne Avenue, Avenue Road and College Street, an area of approximately eight square miles, was increasing very rapidly in population, new streets were being opened up, permanent roadways placed, manufacturing plants established and many residences built. The district became settled very quickly on account of easy access to and from the more central part of the city. The Works Department, therefore, found that a new and much larger sewer had to be built to relieve the Garrison Creek sewer which had been in commission for over 25 years, and which had become very inadequate to handle the large increase in storm water and sewage. So, when in 1912 a by-law for storm sewers had been sanctioned by the ratepayers, a portion of the money was allotted for the main Garrison Creek and its extensions.

Much time and deliberation was spent on preparing the plans.* Numerous surveys were made to ascertain the best and most economical route, and it was finally decided to parallel the old Garrison Creek sewer as much as possible. For one reason, where the route of the sewer was off the city streets it ran through city property, thereby dispensing with the necessity of acquiring costly easements. Another reason was that over a half a mile of the old sewer runs through ravines and the work could be carried on in open cut, which is less expensive than tunnel work. The third and probably the most important reason was that junctions were to be made at several points for the relief of Garrison Creek sewer, as it was intended to use the latter entirely as a storm sewer.

Work was commenced in the spring of 1912, and the last section of the main Garrison Creek was completed in September, 1915, at a total cost of about $1,200,000, a saving of several hundred thousand dollars over the estimated cost.

The first section to be let was No. 1, which has its outlet for storm water in Lake Ontario at the foot of Strachan Avenue. This outlet is shown in Fig. 7. From this point it proceeds north along Strachan Avenue to Defoe Street, where it turns west and Section No. 2 commences. This was the next section to be tendered for. It runs along Defoe Street to Crawford Street and north to Lobb Street. Section No. 3 starts here and runs west on Lobb Street, north on Shaw Street and crosses Arthur Street to a point 300 ft. north of Arthur Street on Roxton Road, where it intersects the old Garrison Creek sewers, a 5-ft. 6-in. running north, a 4-ft. 6-in. sewer running west. A very large chamber (Fig. 6) was built here for relief of the Garrison Creek south of this point. After this stage had been reached the engineering department decided to construct some of the more urgent extensions, the work on which had already started on Barton Avenue, Section No. 1. By making an outlet for Section No. 1 extension in the old Garrison Creek sewer just south of Bloor Street, it proceeds north through Willowvale Park to Barton Avenue, where it branches, one branch running north to Pendrith Street, west to Shaw Street, north, then west on Manchester Avenue and north on Ossington Avenue. At Ossington Avenue and Hallam Street there is a junction chamber with a section that runs west on Hallam Street. The other branch of the main extension runs east on Barton Avenue to Christie Street, where it branches, one running north on Christie Street to the C.P.R. tracks, the other continuing along Barton Avenue to Brunswick Avenue, south to Lowther Avenue, thence east to Avenue Road.

After these sections had been completed Section No. 4 of the main sewer was commenced, it running north from junction chamber on Roxton Road through Prettie's Ravine to Sully Crescent, east on Sully Crescent to Montrose Avenue, north across College Street and up Beatrice Street to Bickford Ravine, where it intersects the old sewer again. Here another chamber was constructed, and Section No. 5, which was the last section to be let, commences and runs north to the junction chamber just south of Bloor Street.

The chief branch of the main Garrison Creek is Argyle Street storm overflow sewer, a section of which is under construction. This sewer joins the main sewer at Argyle and Shaw Streets, running west to Gladstone Avenue, north on Gladstone Avenue and west to Brock Avenue by way of Trafalgar Avenue, Dufferin Street, Gordon Avenue and Middleton Avenue. It then goes north on Brock Avenue to McConnel Street, west to St. Clarens Avenue, north to College Street and west to St. Helen's Avenue by way of College Street, Lansdowne Avenue and Lum-

*An illustrated article describing the design of the main Garrison Creek storm overflow sewer, sections 1, 2, and 3, showing cross-sections, wier chambers, junction chambers, etc., was published in *The Canadian Engineer* for March 20th, 1913, the author being Mr. R. R. Knight, now City Engineer of Fort William, Ont.

bervale Avenue. Another branch which the city contemplates building is on College Street running east and west from Montrose Avenue.

In the main Garrison Creek sewer, sections 1, 2 and 3 were entirely constructed in tunnel, with the exception of a few hundred feet in section No. 1, shafts being sunk at intervals, usually where the manholes are located, and headings driven each way from each. The excavation was brought to the surface by means of buckets or cars that were run on rails in the drifts. After a section of about 8 or 10 ft. had been excavated for walls and arch, forms were placed and concrete run in through a hole that had been previously bored from the street, a workman being stationed to spade the concrete and to see that it was properly placed. The excavation was carried on in the day time and concreting at night. After the allotted time for leaving forms in place (which was 48 hours at least) the forms were removed and 6-in. x 6-in. timbers were placed to protect the concrete from ground pressure until the invert was built. Ground pressure was very considerable in these sections as the material through which these sewers run is, in most places, a soft blue clay.

When the concreting of walls and arch had been completed between two shafts, the invert was concreted and brickwork laid, the 6-in. x 6-in. braces being removed as the work progressed.

It might be stated that the contractor on section No. 1 did not think it necessary at first to take any precaution against the ground pressure after he removed the forms, so he had a section to reconstruct as the walls "kicked in" to a considerable extent.

The design of sewer for these three sections (1, 2 and 3) was a culvert shape, with 18-in. class B concrete (1 : 3 : 5) in walls and arch, the invert being 14 in. of class B concrete and finished with paving brick to stand the wear of the water.

In section No. 1 there are four sizes, 10 ft. 8 in. x 10 ft. 8 in., 8 ft. 5 in. x 10 ft. 8 in. (reinforced under G.T.R. and C.P.R. tracks), 10 ft. 3 in. x 10 ft. 3 in., and 9 ft. 6 in. x 9 ft. 6 in. In section No. 2 there are two sizes, 9 ft. 3 in. x 9 ft. 3 in. and 8 ft. x 10 ft. The latter has a small oval sewer 1 ft. 9 in. x 3 ft. 0 in., alongside it to take care of the dry-weather flow from the Argyle Street section of the storm overflow sewer and convert it into the Queen Street sewer and thence into high level interceptor, through which it finds its way to disposal plant. Section No. 3 is constructed in two sizes, 10 ft. x 10 ft. and 9 ft. 6 in. x 8 ft. 4 in.

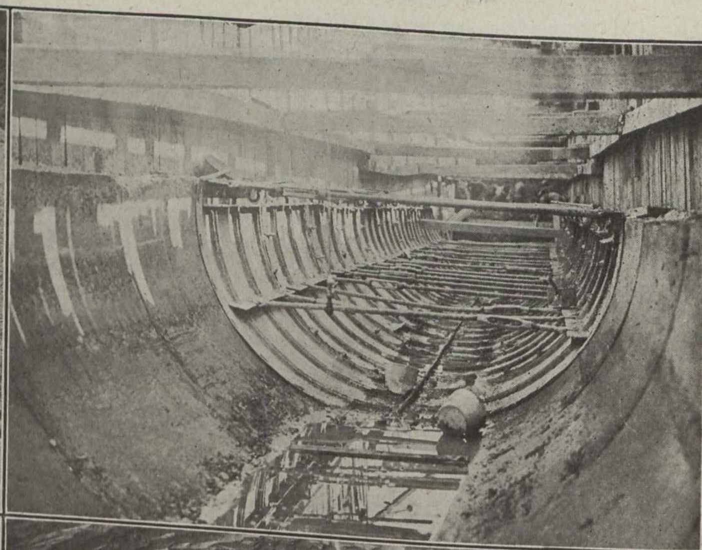

Fig. 1.—Open-cut Portion of Section No. 4, Showing Method of Mixing and Transporting Concrete.
Fig. 3.—Placing One Ring of Red Shale Brick in Invert After the Arch Had Been Completed. Section No. 4.

Fig. 2.—Main Garrison Creek Storm Overflow Sewer, Showing the Use of Steel Forms for the Invert.
Fig. 4.—Showing Method of Excavating in Tunnel, also Steel Circular Ribs and Lagging in Place. Section No. 4.

Section No. 4, which is dealt with in detail in a later portion of this article, was constructed partly in open cut and partly in tunnel, as part of it was in very shallow ground. There are three sizes, 8 ft. 0 in., 9 ft. 6 in. and 9 ft. 3 in. circular with 18 in. of class B concrete and with brick invert.

As section No. 5 was in Bickford Ravine the plans called for open-cut work, but a short section ran through a knoll of very hard clay. This portion was tunnelled, 18-in. brickwork being used in construction.

Owing to the unsatisfactory condition of the old Garrison Creek sewer through Bickford Ravine, it having cracked open on several occasions when under a heavy internal pressure, it was decided to abandon its use altogether and to use section No. 5 for a combined sewer. A junction chamber was placed at the entrance to section No. 4 with a weir which diverts the sanitary flow into the old Garrison Creek sewer and allows the storm water to go on down section No. 4.

In the Argyle Street storm overflow sewer, section No. 1 was 6 ft. 0 in. circular and of 18-in. brickwork. It was intended by the engineering department to construct this of concrete, but after a shaft had been sunk and tunnel work started, it was found on removing the braces from the concrete forms that the 18-in. concrete wall would not withstand the pressure of the soft blue clay through which the sewer was to run. The design was, therefore, changed from concrete to brickwork, which was placed satisfactorily.

Section No. 2 is constructed in two sizes, 5 ft. 6 in. and 5 ft. 3 in., with 14 in. of brickwork. In this section a much harder blue clay was encountered and the work was completed very rapidly.

Section No. 3, which is now under construction, is of uniform size of 4 ft., some sections having 9 in. of brickwork and others 14 in., the latter thickness being used where there is a heavy ground pressure.

All the extensions decrease in their sizes as they recede from the outlet.

The following table relates to the size and shape of each of the various sections, together with material of construction and nature of excavation work:—

Sewer.	Size.	Shape.	Material.	Excavation.
Barton Ave., Sec. No. 1..	4′ 6″ x 6′ 6″	Culvert	Concrete	616′ Open Cut
	4′ 6″ x 5′ 9″	"	"	Tunnel
	4′ 6″ x 4′ 11″	"	"	"
Barton Ave., Sec. No. 2..	4′ 6″ x 4′ 11″	"	"	"
	3′ 0″ x 4′ 9″	"	"	"
	3′ 0″ x 4′ 6″	Egg-shaped	Brick	"
	2′ 4″ x 3′ 6″	" "	"	Open Cut
	2′ 2″ x 3′ 3″	" "	"	" "
Extension No. 1.	8′ 3″ x 7′ 6″	Culvert	Concrete	Tunnel
	7′ 3″ x 7′ 6″	"	"	"
	8′ 0″ x 6′ 6″	"	"	Open Cut
	4′ 9″ x 6′ 0″	"	"	Tunnel
	4′ 9″ x 5′ 7″	"	"	"
Extension No. 2	4′ 9″ x 5′ 7″	"	"	"
	4′ 9″ x 5′ ½″	"	"	"
	6′ 0″	Circular	Brick	"
	3′ 0″	"	"	"
Christie St.	4′ 0″	"	"	"

Main Garrison Creek Storm Overflow Sewer, Section No. 4.

	Lin. ft.
Length of sewer constructed	3,425
Length of sewer in open cut	1,635
Length of sewer in tunnel	1,790

	Lin. ft.
Length of 8′-0″ circular sewer	1,341
Length of 9′-6″ circular sewer	774
Length of 9′-3″ circular sewer	1,310

Material used in construction—

Arch—Concrete, in proportion of 1 part cement, 3 sand and 5 of broken-stone or gravel; 18″ in thickness.

Invert—Concrete, same proportions, 13½″ in thickness, and one ring (4½″) of hard red shale bricks.

Location.—Starting at the junction chamber of the old Garrison Creek sewers and section No. 3, main Garrison Creek storm overflow sewers on Roxton Road, 150 ft. south of Harrison Street, it runs north on a 500-ft. curve for 400 ft., then straight northeast to Sully Crescent, through Prettie's Ravine. Passing under Shaw Street bridge, it goes east on Sully Crescent to Montrose Avenue, north to College Street, turning east on College Street to Beatrice Street and north on Beatrice Street to Bickford Ravine, where it joins section No. 5 of main Garrison Creek sewer.

Design.—Owing to the decided difference between the elevation at the outlet and the elevation that was to be used at Sully Crescent, it was possible to design an 8-ft. circular sewer with a fall of 1 ft. in 108 ft., that was large enough to take care of the volume of water that the following sewers, 9 ft. 6 in. and 9 ft. 3 in. with a fall of 1 ft. in 300 ft., were capable of carrying. If a sewer of uniform size and with a constant grade had been chosen from the inlet to the outlet its depth at College Street would have been much greater than the one constructed, thereby increasing the cost of construction, as the sewer was constructed just at the bottom of a clay strata with wet sand below. Had it been lower, the sand would have given far more trouble.

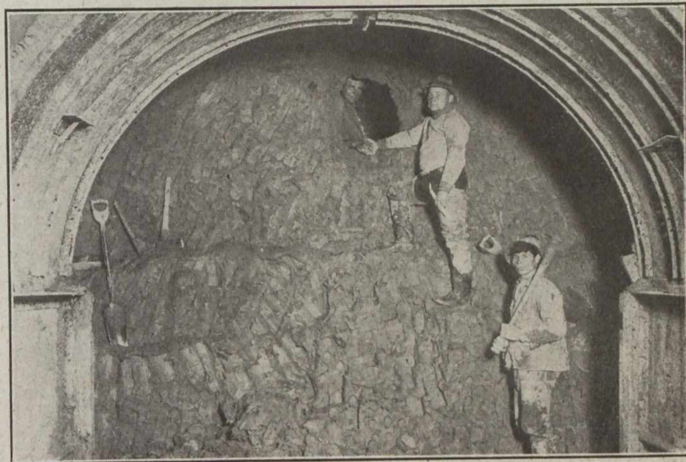

Fig. 5.—Meeting of Two Headings, Main Garrison Creek Storm Overflow Sewer, Section No. 1.

Borings, which had been taken to ascertain the nature of the materials through which the sewer was to pass, showed a layer of wet sand just above subgrade in some places and at spring line in others. It was therefore decided that owing to the presence of the sand every precaution possible was to be taken against settlement, and the sewer in the open cut was designed with a square concrete base. In the tunnel section 1,090 lin. ft. were constructed with a circular base owing to the absence of the sand, but in the last 700 lin. ft. the layer of wet sand came into prominence again, and on account of the method of construction which will be described later, this portion was constructed with square base. The sides were excavated straight and planks placed to keep sand from running in and thereby forming a cavity back of the arch which would allow it to spread, and also to keep sand from mixing with the invert concrete as it was being poured.

Under the Shaw Street bridge a short section (72 lin. ft.) of sewer was constructed with a square concrete top, the invert, walls and arch being reinforced with .50 mesh, 1.83 lbs. per sq. ft. This design was used here because a number of the bents of the bridge were being carried by the walls of the sewer.

Open Cut Section.—Work was started on the open cut section by sinking a shaft at Sta. 16+35, which was at the end of the open cut and the commencing point of tunnel work. Contrary to expectations, the ground turned out to be a very hard clay in this portion of open cut, right down to sub-grade. This shaft was used afterwards for a working head in tunnel work. The excavation in the open cut proceeded from this point to Sta. 0+00, a stop being made for two months at Sta. 12+35 when the cold weather set in. The excavation was done by an Ohn bucket on a travelling derrick, which proved to be much more economical than hand work, the excavation being removed for 62 cents a cu. yd. throughout the open cut.

Before closing down for cold weather 400 ft. of sewer was constructed, wooden forms being used for the concrete work. The concrete in the invert and arch was first run, after which the brick invert was laid.

When the worst of the cold weather was over, operations were resumed on this portion of the work (the tunnel work having gone on without interruption).

work to be placed in the invert. After the invert forms were set the concrete was placed and after this had set sufficiently the turnbuckles were released and the 60 ft. of forms were drawn ahead by the engine of the excavating machine. The brick invert was next laid. Then, 6-in. x 6-in. timbers were placed on the brickwork just high enough to allow a 2-in. plank to be placed, to run the arch forms on when released, the arch forms being blocked to proper elevation off the 6-in. x 6-in. timbers. When the concrete had been poured and had set 48 hours the forms were released and drawn ahead as in the invert. These steel forms were certainly a big improvement on wooden forms as they could be set up in much less time and gave a much more superior finish, requiring very little, if any, pointing up.

The concrete in the first section of sewer completed was all mixed at Sta. 16+35, where a steam plant was installed to heat the material and run the mixer. The aggregate was placed on a knoll just above the mixer and the concrete dumped into cars below, which conveyed it

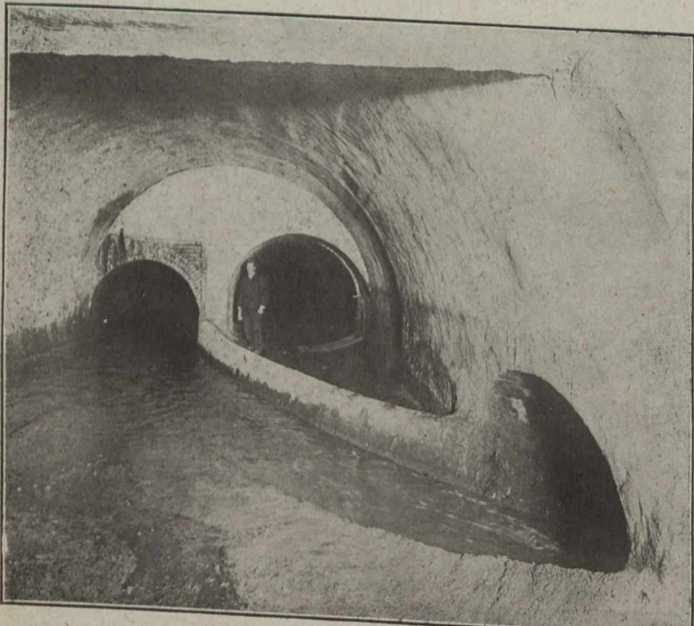

Fig. 6.—Junction Chamber, Viewed from Bellmouth of Section 4, Showing Section 3, Old 6 ft. 6 in. and Old 4 ft. 6 in. Garrison Creek Sewers on the Left and Right Respectively.

Fig. 7.—Outlet of Main Garrison Creek Storm Overflow Sewer at the Foot of Strachan Avenue.

In the balance of the open cut, 700 lin. ft. of it was in the ravine where the excavation was very shallow and the work went on very rapidly. Steel forms were used in place of the wooden ones and by so doing 240 ft. of invert and 180 ft. of arch could be finished in six days. These steel forms were manufactured by the Blaw Steel Form Co. They were made in 5-ft. sections and 12 complete sections (60 lin. ft.) were used. Each section was made in four pieces, two for arch and two for invert, the arch pieces being bolted together at the centre and separated by tie rods, which were operated with a turnbuckle, at spring line and half-way between spring line and centre of arch. The different sections were held together by U-s in one section passing through holes of the next and held flush with small oak wedges. Each section had four castors riveted to the angle plates at the spring line, to be used in pulling the forms ahead without being taken apart. The invert forms are practically the same, only they did not have the castors, and were 9 in. wider in diameter to allow for the one ring of brick-

along the line of work on tracks situated at the side of the trench. In the last section, two similar points were picked out for the mixer, but electricity was used for the motive power, proving much cheaper than either gasoline or coal.

The surplus excavation in the section from Sta. 16+35 to 12+35 was hauled to a nearby dump so the backfilling material for this section was obtained from the tunnel. This was brought to the surface on the elevator at the shaft, dumped into the concrete cars, and carried along to where it was needed. In the section between Sta. 12+35 and Sta. 5+00 there was no backfilling done as the arch of the sewer was above the ground elevation (Fig. 1) and as the city is filling in this ravine with ashes. But between Sta. 5+00 and 0+00 the excavation was piled up alongside the trench and after the sewer was completed it was replaced in the trench by the excavating machine.

Tunnel Section.—This is the portion of the contract where the contractors anticipated trouble owing to the borings showing a layer of wet sand. Most of the contractors who placed a tender for this work calculated on having to install a compressed air plant to facilitate in the excavation work. This was the reason for vast differences in prices submitted, the successful bidder being nearly $20,000 less than the second one.

The work in the tunnel was carried on from four shafts, which were situated at locations for manholes. Steam hoists were used to operate elevators, which brought the excavation from the tunnel to the surface in cars, where it was dumped into wagons, taken to Bickford Ravine and used for filling-in purposes.

The method of excavating was rather unique, having never been tried in Canada before. Contrary to the usual custom, which is to excavate the full size of bore at once, only the upper half was removed, the lower half or bench being left in place until all the excavating and concreting of the arch had been completed in that heading. Tracks

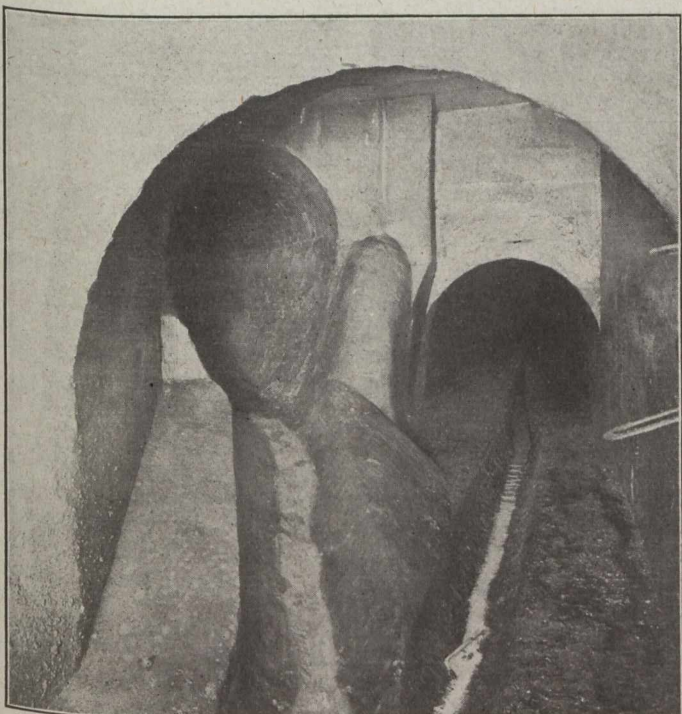

Fig. 8.—Junction Chamber at Lappin Avenue, Section 2.

were laid on this bench and the excavated material carried to the shaft in cars. This bench was also useful as a foundation for the concrete forms (Fig. 4). Lengths of 12 to 15 ft. were excavated at a time, and after each had been concreted another length was taken out, and so on until the entire drift was finished in the arch. Then the excavating of the invert commenced, this being taken out in alternate lengths of 12 to 15 ft. Trestlework was placed under the tracks as the excavation was removed. Forms were then set and filled to within 1 ft. of the arch concrete, this space being underpinned with brickwork after the concrete had set for at least 48 hours to allow for any shrinkage. When these alternate lengths were finished throughout the drift the intervening portions were treated in the same way. By this method of placing the invert the arch was never without support for any greater length than 15 ft., for when the alternate sections were being taken out the intervening sections carried the arch, and when the intervening sections were removed the invert had the load.

In concreting the arch, steel circular ribs of 4-in. channel iron, with 2-in. wooden lagging, dressed on three sides, were used for the form work. These steel ribs did not require any bracing (Fig. 4) and thereby allowed the cars to be taken right up to the face of the work. In the invert, wooden ribs with 1-in. sheeting were used for form work, allowance being made in placing them for the one ring of brick that was to be laid. When all the concreting

Fig. 9.—Showing Method of Excavating and Nature of Material, Section 2.

had been completed the trestlework and tracks were removed, all the surplus concrete was trimmed off and the brick invert laid. The concrete in the arch was mixed rather wet until the centre of the arch was nearly reached, when it was stiffened up and rammed back on the forms with hoes. In the invert the concrete was made as wet as possible to assure that no voids would be left, as it was being poured in a rather awkward place and tamping was almost impossible.

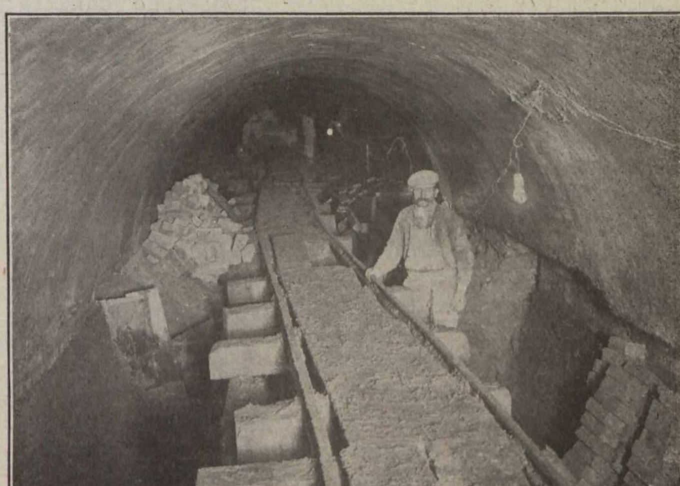

Fig. 10.—Tunnel Part of Section 4, Showing Method of Excavating and Underpinning.

As in the open cut, electric motors were used to drive the mixers, which were situated in a hole excavated alongside the shaft, large enough for mixer and motor. The concrete was deposited through a chute in the shaft to cars below, which conveyed it to the forms.

This method of construction proved very satisfactory, for, had the whole bore of sewer, which was 12 ft. 6 in. in size, been removed at once, sheeting in all probability would have been required to protect the arch excavation, owing to the wet sand in the invert; whereas, the excavation in the entire length of tunnel, with the exception of 50 ft. where a dry sand pocket in the arch was encountered, was carried on without the aid of timbering, which is a very heavy item of expense in tunnel construction, especially of this size. By not removing this bench it provided a working place both for mining and placing concrete in the arch. Such a bench would have had to be constructed had the whole size of sewer been removed.

Another innovation contrary to usual method of sewer construction was that the excavation was carried on at night and concrete and brickwork were placed in the day time. This proved much more satisfactory for the engineer and inspector, as it was possible to see that the materials were properly prepared before going into place.

The following figures are from cost data kept by the writer, who was resident engineer on this section.

Labor.

	Cu. yds.	Cost per cu. yd.	Remarks.
Excavation ..	11,332	$ 0.62	Done with clam, including placing sheeting, pumping, etc.
Backfilling ..	3,960	0.15	Done with clam, including pulling sheeting.
Surplus	.....	Nil	Just placed along line of sewer.
Forms	.....	.....	Wooden forms, 3c. to place and 6c. for material. Steel forms, $900 rental for 60 lin. ft. of 8 in. dia.
Concrete—Open cut...	3,352	1.10	Including placing forms, heating material and finishing, not including cost of material, as same forms are used over again.
Tunnel—Arch	1,731	1.75	Including placing forms, heating material and finishing, not including cost of material, as same forms are used over again.
Invert	1,762	2.25	Including placing forms, heating material and finishing, not including cost of material, as same forms are used over again, and form-work in four manholes.
Brickwork—Invert	691	6.15	Including trimming off concrete, etc.
Underpinning	200	2.99	Average of 3 cu. ft. per lin. ft. of 1,790 ft. sewer.
Tunnelling—Arch	4,435	1.60	Including sinking three shafts, hauling to and handling at dump.
Invert	4,610	1.40	Including sinking three shafts, hauling to and handling at dump.

Material.

Concrete—			
Stone	6,500	$ 1.50 cu. yd.	Stone and gravel used.
Sand	3,900	1.00 cu. yd.	
Cement	33,200	0.40 bag.	
Brick Invert—			
Brick	305,400	9.00 per M.	
Sand	380	1.00 cu. yd.	
Cement	3,845	0.40 bag.	
Underpinning—			
Brick	61,400	9.00 per M.	
Sand	70	1.00 cu. yd.	
Cement	695	0.40 bag.	
Lumber	41,600	22.00 per M.	Left in trench and tunnel.
"	23,000	15.00 per M.	
Reinforcing .	4,100	0.04 lb.	Used in Sec. B and in manholes and junction chamber.

These figures do not include any overhead expenses or any allowance for depreciation of plant.

Work commenced November 20th, 1914, and was completed September 30th, 1915.

	Lin. ft.
Length of sewer in contract.....................	3,405
*Length of sewer constructed	3,425
Length of sewer in open cut.....................	1,635
Length of sewer in tunnel	1,790

* Twenty lin. ft. of extra sewer.

	Lin. ft.
Length of 8′ 0″ square base and circular top......	1,269
8′ 0″ square base and top.............	72
9′ 6″ square base and circular top......	295
9′ 6″ circular base and top	479
9′ 3″ circular base and top	610
9′ 3″ square base and circular top......	700

Material used in construction—
Arch —18 in. class "B" concrete.
Invert—14 in. class "B" concrete and one ring of hard shale brick.

This work was carried out under the direction of Mr. R. C. Harris, Commissioner of Works, and Mr. Geo. G. Powell, deputy city engineer. Mr. W. R. Worthington is assistant engineer in charge of the sewer section, Department of Works, and Mr. W. G. Cameron was division engineer supervising the work.

POWER ENTERPRISES AT EDMONTON.

During the year it is the intention of the Edmonton Power Co., a corporation with headquarters at Montreal, to construct a dam across the Saskatchewan River at Rocky Rapids, about 75 miles west of Edmonton. The dam will be about 1,000 ft. with a head of 80 ft. Power will be transmitted to Edmonton and the city has entered into a contract with the power company to pay for the power delivered at the city limits. A railway will be built from the city to the dam, this wall will be about 80 miles, equipped for electric power. The firm of Fairchild, Jones and Taylor, consulting engineers, Edmonton, will do the engineering on the railway, according to a recent announcement. Total cost of undertaking including dam, railway and transmission line will be about $6,000,000. Edmonton has given a franchise to the Northern Alberta Gas Co. to sell natural gas in the city at 25 cents per 1,000 and this company will build a pipe line and distribution system. The line will be about 90 miles long and will supply small towns between the gas field and the city. The gas field is on the Battle River Anticline southeast of the city. The same firm will do the engineering. The cost of the work is estimated at about $4,000,000.

SOIL-TESTING AND EXCAVATION FOR FOUNDATIONS.

SOME general notes on foundation work were presented to our readers in *The Canadian Engineer* for December 9, 1915 (p. 671) in which a brief reference was made to the method by which soils are tested as to their suitability for foundations. The method, that of making wash borings, receives more detailed consideration in the following abstracts from Mr. Chas. T. Main's paper as read before the December meeting of the American Society of Mechanical Engineers. The writer takes up also the subjects of excavation, cofferdamming, piling and other phases of general foundation work, and his comments concerning them are also summarized.

Wash Borings.—These are made with the aid of a tripod, iron or steel casing, drill-rod, hose, force-pump, bucket, etc. The tripod used to support the casing and drill-rod usually stands 12 to 15 ft. high. The casing is usually made of heavy pipe, 2 to 2½ in. internal diameter, and inside it works a heavy, hollow drill tube or rod, 1½ to 1¾ in. outside diameter. This drill-rod is fitted at the bottom with a chopping bit having openings in it for the water jet, while the top is connected with a water hose and force-pump, the latter usually double-acting. In action, the water is forced down through the drill-rod, jetting through the holes at the chopping bit and carrying up the loosened material in the annular space between the rod and case.

The method of forcing the casing and rod down depends on the character and density of the material encountered. In soft material very little effort is required to work the rod down, while in hard material more or less lifting and dropping or churning will be required.

In order to record changes of strata and take samples of the soil, it is necessary to know the level of the bottom of the drill at all times and to watch the overflow for the color and character of the soil. In taking samples the overflow is caught in a bucket and allowed to settle. The samples are taken and placed in glass bottles carefully marked with the boring number, sample number, character and thickness of the stratum which the sample represents. To be complete the records should also include the level of the ground water and the elevation of the surface of the ground at the boring referenced to some datum.

Wash boring samples do not always represent closely the true character of the soil, as the water jet and chopping bit change it radically by breaking it up and separating the fine from the coarse material; the coarse parts are mostly pushed aside while the fine parts are taken to the surface by the water flow. The presence of clay in sand may be easily overlooked, while a hard clay suitable for supporting a structure may be reported as a soft one and unsuitable.

More reliable samples may be obtained by withdrawing the drill-rod and forcing a pipe into the soft soil, then bringing the pipe to the surface, thus obtaining a dry sample in nearly its natural state. In hard soils, such as very hard clay, soft slate or shale, the pipe for taking samples may have its lower edge sawtoothed, and the most satisfactory samples may be obtained by working this without the water jet.

Test-Pits and Rods.—Test-pits furnish the opportunity of observing the character of soil, its degree of compactness, amount of moisture, etc., but to be of full value they should be carried well below the level of the bottom of the foundations. In cases where the strata change with the depth, a test-pit gives no sure indication of the soil below the foundations unless carried deeper than the level of the footings.

Testing soil with a rod is an unsatisfactory method and cannot be relied upon to give accurate information except in a limited number of cases. In a homogeneous material, not too hard, the method is valuable in determining the constancy or varying density and resistance. In a heterogeneous soil, the sinking of a rod may be stopped by a layer of hard gravel, a rock or log, and would not furnish reliable or complete information.

Excavation.—Work on foundations consists of excavation of earth or rock, including shoring, sheet piling, or cofferdams, and a structure of stone, concrete, brick or timber at the bottom of the excavation, including bearing piles. In nearly all cases the expense of excavation will increase with the hardness of soil and inconvenience for working; but if the excavation is in sand or soft earth, with considerable water to contend with, the cost is largely increased by the necessary structures for enclosing the excavations and sustaining the banks.

Earth is hard in proportion to the amount of cementing material which it contains, and its temporary stability also depends on the amount of this material, while its permanent stability depends upon the friction of the particles on each other. The disadvantage of hardness for excavation is offset in many cases by the advantage of the self-sustaining power of the vertical cut for a time sufficient for the work on the foundation to be completed. If a vertical cut is exposed for a long time to the weather, it may become dangerous. The effect of an excess of moisture, freezing and thawing, or drying out is to crack off the bank and gradually to approach the natural slope of permanent stability. If the time required to lay the foundation be very long, or the weather unfavorable, it may become necessary to shore up, even in firm earths, but in a much less expensive manner than in material which has a tendency to flow.

Usually, in working in clean sand or gravel below a depth of 5 to 6 ft., shoring may be done by laying in planks horizontally along the sides of the banks, putting in vertical timbers or planks at short intervals and opposite each other, and bracing between them. Even with this sort of shoring, it is well to make it secure, so that no braces or other pieces may drop out and injure any person, or perhaps cause a slide.

When sand containing water, or soft clay with running water is encountered, the saving of soft excavation is entirely absorbed by the expense incurred in sustaining the banks and preventing damage to any adjacent buildings. Sheet piling must be used here, which consists of planks or timbers driven closely together and of a thickness varying from 2-in. plank to large timbers, according to the depth, pressure, and soil. Four-in. plank is about the thickest used in ordinary work. Three to 6-in. plank should be grooved on edges, the grooves to be filled with splines.

The usual way for driving sheet piling is to lay out the line for the sheet and on it drive some guide piles, the excavation being carried down as far as possible before commencing to drive. To the guide piles, inside and outside, are bolted or spiked stringers or rangers, which serve as guides for the piles at the top; a second ranger on the inside serves as a guide while the soil presses the pile from the outside. The bottoms of the piles are tapered off, and also cut slanting, so that there will be a tendency to crowd against the next one already driven. To prevent splitting while driving, the tops should be protected with an iron ring; the piles are driven far enough below the grade of the bottom of foundation so that no outward pressure can break them below the bottom ranger. As the excavation is carried down, these rangers are put in at a distance of 5 or 6 ft. apart and the bracing from side to side done on them. Although this is only a temporary structure, all the piles should be new and sound, as they are subjected to severe strain while being driven. New piles can be used again elsewhere if extracted, while shaky timber would cause trouble and perhaps cripple the sheeting, besides being useless after extraction.

Where any large amount of sheet piling is done, the steam hammer is the best driver to use, or if this type is not available, the ordinary pile-driver with falling weight can be used to advantage. The hammer should be lighter than that for driving bearing piles. Where the work is not very large, the piles may be driven with heavy beetles or mauls, but this method is extremely slow for thick sheeting. When driving by steam, a good many light blows of the hammer is better than a few heavy ones and the practice is not so apt to cripple the planks.

In commencing construction of a building it is customary to cut the trench around for the outside walls, leaving the earth which comes inside the building for the support of the sheeting until the walls are built and set enough to receive the outside pressure.

Cofferdams.—These are built for the exclusion of water while work is being done. The kind employed depends upon the nature and extent of the work, and the strength should be somewhat in proportion to the amount of damage or delay from failure. As the space and amount of puddling material are usually limited, the best and usual form will be a bank of puddle enclosed and supported by a row of sheet piling on each side. Experience has shown that 4 to 6 ft. is sufficient for the puddle to exclude the water; but unless the dam is supported independently, its width must be in proportion to the depth of water, so that it will not be overturned. Good timber should be used here as in ordinary sheet piling and for the same reasons. Where there is room, a bank of sand against the inside sheeting will assist in supporting the dam.

Single-sheeted dams are sometimes used successfully. They are made from planks, tongued and grooved, or carefully caulked, but they can only be used successfully where the soil is not of a flowing nature; otherwise, when the pressure is relieved from the inside, the flow will start under the bottoms of the sheeting and render the dam useless. This sort of dam should never be trusted where its failure would cause much damage or expensive delay. A double dam will, in nearly all cases, pay for itself.

Bag Dams.—Where the depth of water is not great, bag dams can be used to advantage. They can be cheaply and quickly constructed, and in some cases are almost indispensable. They can be used for shear dams for turning water away from foundations, especially where sheet piling cannot be driven, for repairing breaks in banks and for many other purposes. They are made from strong empty cement bags or gunny sacks filled with sand or other suitable material and securely tied and deposited in the place where they are to be used.

Disposal of materials of excavation should be made in the cheapest and quickest manner. If by carts, and the inclination is not too great, a run should be made from the surface to the bottom of the excavation, and the carts backed down and filled. If by wheelbarrows, the run should be the same. If loaded into cars on a side track, the material may, on any sizable job, be hoisted by derricks operated by steam power, in scales, and dumped into the cars. If it is impossible to load carts in the excavation itself, they may be loaded in the same manner as the cars. In excavating the trenches in soft material the hoisting method must be used. Where the amount of excavation is large, steam shovels can be used to advantage.

Material to be used again for backfilling should be put in a convenient place, and backfilling should be begun as soon as possible, to protect the foundation from the weather and for convenience in working.

Piling.—Where the depth of good bottom is too great to be reached economically by the foundations, approximately 10 ft. or more, it becomes necessary to use piles. The determination of the type of piles depends upon local conditions. If it is necessary to spread the load over as much area of the underlying land stratum as possible, wood piles should probably be used. If it is not necessary to spread the load, a fewer number of concrete piles with higher bearing value can be used. If the ground water is comparatively low down, it may be much more economical to use concrete piles and carry the foundations down to the ground water level than to use wood piles.

The kind of wood to use for piles is governed by the kinds which are obtainable at the location under consideration and the character of the soil through which it is to be driven. Soft wood, like spruce and white pine, can be driven into soft soils safely, but in hard soils there is danger of brooming the points or crippling the pile, and oak, southern pine or some hard wood should be used. As stated above, an exploration of the site should be made by borings in order to design properly the pile work.

The driving is done by either a drop hammer or a steam hammer. In sandy soils and soils containing gravel the driving can be assisted by the use of a water jet. The final blows to test the rate of penetration should be made after the water is shut off. Indication of overdriving is shown by the bouncing of the hammer and by bending and kicking. The length and size of the piles and character of the soil determine the weight and drop of the hammer.

John Millen & Son, Limited, of Montreal, have sold stock, assets and goodwill of their railway and supply department as a going concern to Frank D. Lyman, who has been manager of the department for the past nine years. Mr. Lyman will carry on the business under the firm name of Lyman & Lyman, Limited, with offices at Montreal and Toronto.

The Dominion Chain Company, with Dominion charter, has increased its capital stock from $50,000 to $500,000; the North American Chemical Company, Limited, with Dominion charter, from $30,000 to $100,000; Ford Motor Company, Limited, with Dominion charter, from $1,000,000 to $10,000,000; Soulanges Rural Telephone Company, with Quebec charter, from $5,000 to $10,000.

British Columbia has produced $73,269,603 of placer gold, $81,595,516 of lode gold, $37,709,282 of silver, $31,468,462 of lead, $86,939,370 of copper, and $149,814,462 of coal and coke; $26,026,050 other metals and building-stone, etc., a total production of $486,822,745. The mineral production for 1914 was $26,388,825. Lode mining has only been in progress for about 22 years, and not 30 per cent. of the mineral land has been even prospected; 250,000 square miles of unexplored, mineral-bearing land are open for prospecting.

FACTORS AFFECTING THE LIFE OF CONCRETE STRUCTURES.

NO structure is permanent, in the strict sense of the term, no matter what the constituent material or materials may be. The degree of durability is accordingly an item of great importance in the consideration of all materials of construction. In the majority of cases the most used have achieved their rank by virtue of their resistent qualities, and their general use has resulted from carefully gleaned knowledge and proven skill on the part of engineers of experience.

In this respect the acceptance of concrete, since the time when Portland cement came to be regarded as one of the principal construction materials, was viewed with distrust by many a doubting Thomas. It cannot be denied that the doubts concerning its permanence and reliability were justified, so many early failures occurred, due to crude preparation of cement, rule-of-thumb methods, and inadequate knowledge of the cementing qualities of the constituents of the resulting mixture. Each failure added weight to criticism and incentive to critics.

But concrete has survived; there are surely few engineers who do not rank it among the most resistent structural materials known. It is needless here to review the preponderous investigation and study through which only it gained its worthy classification.

The probable life of concrete structures is a subject having to do with the possible causes of their destruction, and a consideration of the latter serves well as a basis for an estimation of the former. Mr. Bertram Blount, of London, Eng., addressed the International Engineering Congress, in September last, upon the probable and presumptive life of concrete structures made from modern cements, outlining in the case of both plain and reinforced concrete the chief causes which determine their life. In the majority of cases what affects plain concrete affects reinforced concrete and vice versâ; but the probable life of reinforced concrete involves a consideration of the steel severally and jointly, in addition to that of the concrete.

The possible causes of destruction of ordinary concrete as distinguished from reinforced concrete are listed by Mr. Blount as follows: Bad cement, bad aggregate, bad proportions, bad mixing, bad workmanship, bad design, external violence, fair wear and tear, action of saline solutions, action of acids, electrolysis; and all the foregoing causes of destruction are operative towards reinforced concrete as well as plain concrete. In addition there are: (1) corrosion of reinforcement direct or by electrolysis. (2) cracking due to monolithic character or possibly to stresses between the concrete and the reinforcement.

With these causes Mr. Blount's paper deals in part as follows:—

The best modern cement made of suitable raw materials, intimately mixed, thoroughly burnt and finely ground, is as dependable a material as can be prepared until the time comes when all cement is made by fusing the constituents in a sort of super-blast-furnace, a method tried some years ago, and one which is regarded by many as an advance on the present rotatory process. But these conditions of excellence are not always fulfilled. Chiefly because of the endeavor to obtain large outputs of cement per unit of plant the control of proportions is sometimes inaccurate, the burning not uniform and the grinding not only coarser than is desirable but "gritty." Such cement fails in respect of the first quality, absolutely essential to the stability of any structure of which it forms part—it is not sound. Quite useless is it to say that such unsound cement has been used and the structures made with it are standing; the point of interest is how many have fallen down. Further, there is the pregnant question whether a buyer will not insist on a material which is certain to be free from vice, or whether for the convenience of the seller he will trust to luck. Generally, the man who pays can and will get what he wants. It may be confidently said that, given careful manufacture, rigid inspection and thorough testing to a searching specification, modern cement can be obtained free from all inherent vice, and that structures of which it forms part will not be brought to a premature end by internal treachery.

Bad aggregate is a fruitful source of trouble, and, simple as it is in a specification to say that the aggregate shall be "suitable, clean, sharp, well washed," and so on, it is not always easy to get such an aggregate at a reasonable price. Local material must almost always be used, and it may be of the most diverse description. The one property, which is indispensable, is that it must be chemically stable under the conditions in which it is to be used. It does not follow absolutely that the aggregate shall be stable *per se*, though it is much better that it should be; there are materials which oxidize, or which weather, that may on occasion act as a serviceable aggregate, but only urgent necessity will sanction their use. Thus, in general, rocks containing pyrites should be avoided, but it would be pedantic to reject a granite or a hard limestone on the sole ground that specks of pyrites are present. Not merely the amount and size of the enclosed pyrites should be considered; naturally a rock containing marcasite is *ipso facto* suspect. In such cases, petrological methods of examination should be used. Similarly, slags, such as copper slag containing much ferrous silicate, may well be used if their silica content is high enough; generally, such slags lie in dumps, and have so lain for years, and their behavior during exposure to weather is a great guide. The same remark applies to blast furnace slag. Analysis is very helpful if the results are carefully interpreted, but the behavior of the material on the dump is even better. Speaking generally, substances containing sulphates or sulphides, capable of oxidation under working conditions, are so dangerous that their use should not be tolerated, and the need of this restriction can be the better realized when it is remembered that 1% of SO_3, calculated on the aggregate, may mean 5% or more on the cement. Perhaps, of all the materials used as aggregate, the most dangerous is coke breeze. The danger lies in the fact that some samples contain an abundance of sulphates, and, on account of the porous nature of the breeze, these are readily extracted, and do their deadly work on the cement. No sample of breeze should be used as an aggregate unless it has been analyzed and tested. Aggregate may be mechanically as well as chemically bad, but exactly how to define that badness is not easy. Such obvious defects as softness, cracks or excessive smoothness need no more than mention, but how far a "dirty" aggregate carries its own condemnation, is a more difficult matter to decide. It may safely be said that clayey matter round the coarser lumps will prevent a proper bond, but the effect of a moderate amount of clayey matter in the sand is not necessarily harmful. Like most practical things, it is eminently a matter to be settled by trial, and test cubes of the proposed aggregate compared with similar cubes of some aggregate recognized as a standard, such as granite chips and clean sand, will decide the point. Four other causes of short life for a concrete structure, *viz.*, bad proportions, bad mixing, bad workmanship and bad design, call for little comment except this, that evil as are all these for ordinary concrete, they are ten times worse for reinforced concrete, because, while ordinary concrete is generally used in considerable masses, a structure of reinforced concrete is a more delicate affair in which all four sources of mischief have a greater say. Particularly is this the case in respect of bad proportions and bad workmanship. All reinforced concrete should be as nearly impervious as can be contrived, as it is of the utmost importance to protect the reinforcement; and although it is true that iron is protected in an alkaline medium, yet reliance should not be placed on that alone; it is far sounder practice to make concrete of all kinds, and especially reinforced concrete, as nearly watertight as is practically possible.

The life of concrete structures may be shortened by causes which are external to itself. The violence of wind, wave and earthquake, the effect of the subsidence of the soil, etc., will destroy any structure however well made. But, in practical affairs, one does not legislate for the infinite, and is content to make structures so good that ordinary natural violence will have little effect. The simplest and most important case is that of making harbors which must resist all these natural forces. Thanks to our harbor engineers, a fair degree of success has been attained, largely empirically. Putting aside for the moment the question of the quality of the cement, over which they had little control, they understood in some degree that the concrete must be strong and dense, and, by proportioning the aggregate, obtained a material which complied fairly with these requirements. But accurate measurement of voids and the knowledge that ordinary good concrete of about 1:6 may, and often does, contain 30% of voids, have not been so generally utilized as to prevent failures which are traceable to erosion and corrosion by the sea. It is not enough that a block of concrete should be strong; it must be as nearly as possible impervious and impenetrable. The need for these qualities in reinforced concrete is vastly more urgent; reinforced concrete has a vulnerable skeleton, and its exoskeleton must be perfect. Fair wear and tear is only a mild case of external mechanical violence, and need not be further considered.

A particular form of external violence is the action of fire in any serious conflagration. It has been frequently stated that concrete structures are substantially fireproof, and, as far as inflammability is concerned, this is true, but it must be remembered that set cement is a substance containing combined water and carbonic acid, and that these are expelled at a comparatively moderate temperature. It might be naturally supposed that a structure exposed to fire would be seriously weakened by the decomposition of the essential cementitious constituents, and this surmise is, of course, correct. But, for all that, the amount of deterioration is less than one would think likely, and the appended table shows the results of a few experiments made on a cement mortar in the usual proportions of 3 to 1 by weight.

Test pieces* were heated for 1 hour at the following temperatures:—

Temperature Cent.	% Loss calculated on cement.	
100	5.32	No appreciable effect.
200	14.12	No appreciable effect.
300	16.68	No appreciable effect.
400	16.56	No appreciable effect.
500	17.96	No appreciable effect.
600	21.92	Sound—weak at edges.
700	22.24	Sound—friable.
800	25.68	Sound—distinctly friable.
900	25.08	Sound—distinctly friable.
1,000	24.36	Sound—very weak.
1,100	25.40	Sound—very weak.

*Composition of test pieces, 3 standard sand to 1 Portland cement by weight. Age 3 months.

In no case, even at the highest temperature, were there any signs of disintegration or flying, and no mechanical loss occurred during the test.

It will be seen that up to a temperature of 500° C. there is no appreciable alteration, and even beyond that the test pieces show considerable stability, a circumstance which is reassuring from the point of view of that most important question of fireproof construction. Before accepting such a conclusion unreservedly, however, it must be remembered that the tenderest members of reinforced concrete are the steel reinforcements, and that if the heat penetrates the envelope of concrete sufficiently to soften the steel, the destruction of the building will occur exactly as in the case of an ordinary steel frame building.

Shortening of the life of concrete by chemical action of external origin, which for the purpose of a list have been put under three headings, may be conveniently considered under one. A great number of investigators have applied themselves to determine what is the probable or presumptive life of concrete, and, on account of the practical importance of the problem, have chiefly concerned themselves with the action of one saline solution. The destruction of concrete by seawater has always been, since the days when Portland cement first began to be used, a matter of much concern to engineers engaged in maritime works, and, even as lately as 30 years ago, much confusion of mind existed. Thus, because magnesia was found to be a predominant constituent of various incrustations and exudations on sea work, the erroneous conclusion was drawn that it was derived from the cement, and anxiety was felt concerning what could be considered the permissible limit for magnesia in cement. Of course, it is now common knowledge that the magnesia found has been formed from the seawater by the action on it of the lime of the cement, and that the small quantities of magnesia normally present in Portland cement of good quality are without influence in these cases of injury.

It may be accepted that the heaviest and most important work is block work, and in this case the cement has ample time to harden before it is exposed to the sea. From consideration of expense, it is sometimes desired to use a comparatively poor mixture, but the saving is sometimes dearly bought. In fact, the one indispensable condition for a long life for work exposed to the sea is the denseness and imperviousness of the concrete, and this is difficult to secure unless the cement is used liberally. It is impossible to fix a proportion, as that will depend on the aggregate. Every case must be judged for itself, the voids determined experimentally and enough cement used to fill them. Whenever any good form of puzzolanic material, such as trass and the like, is available it should certainly replace a part of the sand, for its use in forming a calcium silicate with the lime, normally set free during the setting of Portland cement, is undoubtedly of value, much conducing to the obtainment of that imperviousness which is a necessary condition for sound and lasting work. It should not be overlooked that any puzzolanic material can fulfil two functions. If coarsely ground, it acts partly as an aggregate like sand, and it is only when ground as finely as the cement itself that its full activity as a cementitious material comes into play. There is no objection to the use of coarse puzzolana if the supply is abundant and local, but, if it has to be brought from a distant place, it is evidently uneconomical to use part of it for a purpose equally well fulfilled by an inert material like sand. In some cases, it might be desirable to grind the puzzolana and cement together to an equal fineness. This plan has been objected to by many engineers as being equivalent to an adultration of the cement, but this view is mistaken if the mixture is sold under its old name, and the proportions of the two materials are stated. Many laudable attempts have been made to obtain imperviousness by the addition of the most various materials, such as barium salts, soap and fatty or mineral oils, but, though some of these are of value under special circumstances, they have not as yet shown themselves suitable for the heavy sea-work now being dealt with; at present there is nothing better than ordinary concrete made with most carefully chosen and graded aggregate, with the addition of trass if local conditions allow, and an ample proportion of cement. Concrete made thus can only be attacked on the surface, and its destruction by percolation is well-nigh impossible. To state its probable length of life would be a rash attempt; it should last indefinitely, in fact, until the harbor or other marine work had become obsolete.

When concrete has to be cast *in situ* opportunity for setting undisturbed is sometimes but poor, as compared with that of blockwork, but the same principles hold good, with the one addition that the setting time should be the minimum which will allow the material being got into position without disturbing or working it after setting has begun. Seawater is by far the most abundant saline solution, and contains those salts, magnesium salts and sulphates, which are most harmful to cement. What has been said of it applies to most other saline solutions which are likely to be harmful, and the precautions already mentioned apply in such cases. Of course, there are special instances of injury by such salts as sulphate of iron or the mixed metallic sulphates found in mine waters, but the nature of their attack is similar, and they are of too special a character to warrant more than mention in a paper dealing with the life of concrete structures in general. There is a common belief that salts in the act of crystallizing may expand and thus injure a structure of which they occupy the interstices. The amount of expansion of three typical, easily soluble salts have been determined as follows: (1) Supersaturated solution of sodium sulphate—Expansion on crystallizing, 1.45% by volume. (2) Saturated solution of magnesium sulphate—Contraction on crystallizing, 0.14% by volume. (3) Supersaturated solution of sodium thiosulphate—Contraction on crystallizing, 0.37% by volume.

Mr. Blount is of the opinion that much importance need be attached to the view that concrete is injured materially by the crystallization of salts in its crevices, for the crystals—even when they do connote an increase of volume—are mechanically weak, and can exercise but little disruptive effect. It is the chemical action of saline solutions which is to be feared and guarded against.

Destruction of concrete by acids, and by this term acid salts are included, stands on a different footing. Obviously, strong acids turned to waste from a chemical works will destroy so calcareous a material as cement, and if the acid is sulphuric acid, destruction will proceed after the acid has been neutralized. But there are less obvious, though very real, causes of destruction. Many putrescent matters, such as sewage, will give off gases containing sulphur, and these, under suitable conditions, will oxidize and produce sulphurous acid, and, ultimately, sulphuric acid; or, alternately, will form sulphides, such as calcium sulphide or ferrous sulphide, which in due course, oxidize to the corresponding sulphates and injure or destroy any cement with which they may come in contact. It has been observed that with sewage of this kind flowing through concrete pipes the invert may be unaffected, while the arch is seriously attacked. The explanation generally accepted is that hydrogen sulphide, or some gaseous organic sulphide, is generated from the liquid, and coming in contact with the upper part of the pipe forms sulphides, which are oxidized to sulphates by the air above the level of the liquid. As the source of the sulphides, and therefore of the sulphates, is continuous, attack by the latter proceeds, with the result that the part of the pipe which is not immersed may suffer severe corrosion. It is impracticable to prevent access of air and to turn the whole sewer into a septic tank, and the only reasonable course is to use some other kind of pipe where the conditions mentioned are known or suspected, or to face the expense and trouble of occasional repairs.

Closely connected with corrosion of concrete by acids, actual or potential, is attack by electrolysis. All cement contains a small quantity of alkali, and this is an excellent electrolyte and will serve to convey such a current as may be straying from a lighting or power circuit. Instances have been recorded of destruction of concrete by such stray currents, and in this case, again, prediction of a probable life of the structure is clearly impossible. But stray currents are not in the same category as wind and wave and earthquake and their divagations should be prevented by proper insulation. To regard them as inevitable, like the rain, is not the attitude of mind of the electrical engineer, and it is to him that we must look for prevention. Suggestions to make the concrete waterproof, where there is a possibility of electrical leakage, are, however, well worth consideration, and in such cases, which should be rare, a sheath of some asphaltic material, such as is used for damp-proof courses, would be serviceable. But it cannot be too clearly said that this is the wrong principle to go on; it should not be necessary to protect concrete from stray currents, because those errant currents should be kept in their narrow channel.

The quality of cement for reinforced concrete must be at least as good as that for ordinary concrete, and, if possible, should be better. This is not because the latter should not be as near perfection as the maker can achieve, but because Portland cement for reinforced concrete is, as it were, a pioneer of progress, and what is a special brand for such purposes to-day will be the ordinary commercial article to-morrow. Turning to steel, one may say that no better example of the advantage of that scientific direction which is now applied to Portland cement could be found than in the case of the steel, and it is significant that the metal, the more difficult of the two to manufacture, was being made of good and uniform quality before chemical principles were recognized and acted on in the manufacture of Portland cement. Thanks to the fact that for some forty years the regulation of the composition has been in the hands of the chemist, little is left to be desired in the modern commercial product. Of course, cases have occurred, and will occur, of careless manufacture and inspection where brittle and inferior material has found its way into the work, but they are not numerous and only rank with such failures as arise in all structures. Good as modern mild steel is, it may be properly asked whether, in some cases at least, steel of a higher grade and greater tensile strength may be advantageously used. This applies to ordinary structures and is, of course, obligatory for such buildings as safe deposits where the metal must not only have a good tensile strength, but be so hard as to be practically undrillable.

Turning now to reinforced concrete one may say that all the causes of attack, and consequently shortened life, which have been discussed under the heading of ordinary concrete, are valid equally with reinforced concrete, and, in addition, there are some other causes peculiar to reinforced concrete. In practice, the reinforcement consists of steel in some form, and is subject to the same corrosion as steel in other structures. By a very fortunate circumstance, cement is an alkaline substance and the metal, iron, in an alkaline medium does not rust. These comforting facts do not warrant the deduction that the steel reinforcement is immune from corrosion. That is true only if it is completely enclosed with concrete which is fully in contact with it and is free from fissures, a cogent reason for the use of concrete, for reinforced work, of a higher grade than that generally necessary. It is highly desirable that the concrete should not only be without fissures, but should be impervious. The advantages in preventing the percolation of any saline or corrosive substance are so great that the extra trouble and cost are well repaid.

Regarding the conditions which influence the stability of reinforced concrete, it is highly desirable that a full set of tests should be made to obtain reliable data on two points, *viz.*, rate of percolation and alteration of strength of reinforced concrete; and, in both cases, the test pieces must be prepared by an operative accustomed to such work, and carrying it out as it would be carried out in practice under proper supervision. No reliable data obtained by experiment, as distinct from observation, are extant, showing whether reinforcing steel will corrode; and here again, a full set of tests should be made. Casual observations of the condition of the metal in reinforced concrete which has been exposed to severe natural conditions are of the utmost value, but we want something more than that. We want definite facts which will tell us what is the prospect of life of reinforced concrete properly and carefully, but not meticulously, made, when it is exposed to the most drastic conditions which it will be called upon to endure in practice; and one of the governing factors is the non-rusting of the steel. In matters of this material importance, it is not sufficient to come to a conclusion on general principles alone, but these must be used in conjunction with experimental data as accurately obtained and obtained over as long a period as practical requirements allow. It is true that long-time tests may be useless and obsolete before their term is out, 20 years, 50 years it may be, not much in the life of a structure, but the trouble and cost of making them is trifling, and sometimes their results are priceless. Let us build for posterity in this matter; it is easy for them to discard our juvenile ideas, but now and then they may find something good. With the knowledge of this date, it seems fairly certain that little fear need be felt of steel reinforcement rusting when well embedded in good non-pervious concrete of adequate thickness, even when the structure is exposed to seawater or other saline solutions, but the case is altered when the concrete is exposed to electrolysis. As has been mentioned above, cases have been observed of the destruction of ordinary concrete by electrolysis, and the risk of injury to that is small compared with the likelihood of destruction of reinforced concrete by the same cause. The advantage of an alkaline medium may disappear, and the steel reinforcement serving as a positive electrode may be attacked by all the negative ions of the electrolyte. Corrosion will be rapid, and the stresses exerted by iron rusting are known to be large, though they have never been computed. It must be remembered that it is not necessary for there to be a direct electrical leak from the inside to the outside of the concrete. Wherever the current flows there must be a drop of potential, and as the joints between the metallic members are electrically poor, it is certain that at all those points corrosion must occur. In a modern structure honeycombed by electric leads, most serious results may occur from such unsuspected cause, and the mischief may be wrought secretly and effectively, quite nullifying any reasonable presumption of the life of the structure.

There is another fact which tends to limit the life of a structure made of reinforced concrete. One of the great advantages of this material is its homogeneity. A properly designed and made structure is as much of a piece as if it were a casting, and, like a casting, experiences internal stresses. These can be minimized or provided for by careful design, but there is no process equivalent to annealing by which they can be removed. Instances are on record where cracking has happened in long continuous lengths or in large thin walls or panels, which, assuming material and work to be free from fault, must have been caused by internal stresses. There is always some stress, and the amount may be increased by part of the structure being wet and another part dry, and it is just on this point that very little exact information is available. Because, by a happy accident, the co-efficients of expansion of steel and concrete are nearly identical, it has been too hastily assumed that stresses between the two are negligible, the fact being overlooked that wetting steel has no effect on its size, and wetting concrete has a well-marked effect. Thorough investigation, using large test pieces over a long period and under perfectly determinate conditions, would be of the utmost value, and would afford us data superseding the somewhat casual observations on which too much reliance has hitherto been placed.

That this knowledge is of much more than academic importance will be admitted when the construction of dams in reinforced concrete is considered. In a dam, every element of destruction of the kind which has been discussed must be studied and prevented. The concrete must be watertight, for any percolation through pores or cracks will be much more injurious than a similar leakage through an ordinary concrete or masonry dam. The very core of the structure will be attacked, and its ruin is only a question of time. The fact that a dam is a monolith, and may be a huge one, with a crest which is slim and delicate compared with the base, and that it lies, as it were, between wind and water, wet on one side, dry on the other, with a fluctuating height of wetness and a varying load, enforces the absolute necessity of knowing precisely what internal stresses must be met.

Of all the causes of destruction, by far the most important is corrosion by saline solutions, and it is the most insidious, as the structure exposed to the action of the solution—whether a harbor or a sewer—may be covered by the attacking liquid, and difficult to examine. For such structures, impermeability is imperative. Reliance on any form of silting up, taking up, covering by organic growths, is mere lazy folly. The material must be free from interspaces which are not microscopic and disconnected. Anything approaching a channel is undoubtedly mischievous, and may be fatal. This axiom has been arrived at painfully and with heavy cost in the hard school of experience before reinforced concrete was thought of, and is doubly axiomatic—if one may be pardoned the term —when the concrete has in its heart a more sensitive core, protected, it may be, by a layer only two or three inches in thickness. The permanence of concrete depends on its imperviousness, and that any condition which limits this limits its life almost *pari passu.*

All other causes which tend towards destruction sink into insignificance beside this, but for all that they must not be ignored. The next worst, closely approaching the severity of attack of saline solutions, is the injury caused by aggregates of the class of coke breeze, containing sulphates of potential sulphates. From the very nature of the material, and from the use to which it is put, namely, to make light floors, ceilings and partition walls, it is clear that it cannot be impervious, and it follows that whatever water reaches one of its surfaces will speedily make its way to the interior. Where water can go, air can follow, and the assumption that sulphides are fairly harmless falls to the ground, because they are in the most favorable condition to become sulphates, and the fate of the structure is then settled.

Next in order of sinister magnitude is the injury caused by electrolysis. It is true that the cases recorded are at present few, but it must be remembered that the transmission of large currents at high pressures is a comparatively modern thing, that large structures of reinforced concrete are comparatively modern things, and the most progressive spirits cannot hope to see buildings only five years old fall like the walls of Jericho. It may soothe their natural impatience to reflect that although the structures and the electrical power are fairly new, yet human blundering is fairly ancient and to be relied on, and on that ground alone, it is reasonable to suppose that failures induced or exaggerated by electrolytic action will become fairly common, particularly when there is a steel core to attack and an electrolyte additional to those alkali salts which naturally occur in any normal cement.

It has been necessary to indicate all those causes of injury for destruction which are to be reckoned with as affecting the life of concrete structures made with modern cement, and the impression conveyed may be that all such structures are so liable to decay as to be almost ephemeral. The conclusions to be drawn, however, are these: First, that there exist causes of destruction, internal and external, which, if uncontrolled, will certainly destroy any structure, even when its design is impeccable, and that its life is at the mercy of these causes, and though its death may be lingering, it is certain. Second, that all such causes, except extreme external violence, can be controlled, and their effect nullified by knowledge, care, and skill exercised in the directions mentioned and discussed above; and, as a necessary result, by the practical elimination of nearly all these attacking forces, security and something like permanence will be attained.

GRADATION OF ROAD TRAFFIC.

THE report presented at the annual meeting of the Canadian Society of Civil Engineers last week by the standing committee on roads and pavements, contains an appendix relating to traffic gradation, that is as follows:—

Traffic is not only to be regarded from the standpoint of total tonnage, per foot of width of pavement or roadway; but also from the standpoint of predominating class of vehicle, speed, and maximum weight of vehicle, etc. An analysis of the various forms of traffic may be made as follows:—

Horse-drawn steel tires.	Pleasure vehicles.	Single horse. double or pair.
	Farm or commercial vehicles.	Single { Loaded. / Not loaded. Double { Loaded. / Not loaded.
	Extraordinary.	Quarry, brickyard or other regular and destructive traffic.
Self-propelled rubber tires.	Pleasure vehicles.	Less than 7-seat motor. Seven-seat or over.
	Commercial trucks.	Loaded. Not loaded.
	Extraordinary.	Motor bus or other special traffic.
Self-propelled steel tires.	Steam lorries and tractors, with trailers, etc.	

The conclusions from a traffic census as to unit weight and other details can be only approximate. Refinement in traffic census might be difficult for many town or city engineers to obtain, and might defeat the aims of the committee. A general and simplified classification is therefore under consideration, which may be briefly expressed, for which purpose the following is suggested:—

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

In the description of traffic, the various factors of the foregoing schedule may be indicated by letter and number thus: A (3) + B (2) + C (2) would mean "Light vehicles, heavy traffic + heavy vehicles, medium traffic + passenger automobiles, medium traffic."

The method of using this notation is indicated by its application to treatment of various road surfaces for dust prevention. In the following schedule, Column (1) shows the surface material considered; Column (2) shows the maximum traffic for which such surface would be applicable; and Column (3) shows a suitable treatment for dust prevention in each case. (It is to be understood that this schedule has not been finally adopted by the committee as a standard for dust prevention, but is submitted for explanatory purposes in connection with the proposed notation for traffic gradation.)

(1) Surface material.	(2) Maximum traffic on which it can be considered.	(3) Treatment for dust.
1. Sand	A1 + B1 + C1	Asphaltic oil, hot application. Calcium chloride.
2. Gravel	A2 + B2 + C3 + E1	Asphaltic oil, cold application.
3. Gravel	A2 + B2 + C3 + D1 + E1	Bituminous penetration or mix.
4. Broken stone, soft, water-bound	A2 + B2 + C2 + D1 + E1	Oil, paraffin base.
5. Broken stone, soft, water-bound	A2 + B2 + C2 + D1 + E1	Asphaltic base, cold.
6. Broken stone, soft, water-bound	A2 + B2 + C3 + D1 + E1	Asphaltic base, hot.
7. Broken stone, soft, water-bound	A2 + B2 + C3 + D1 + E1	Tar, cold.
8. Broken stone, hard, water-bound	A3 + B2 + C3 + D2 + E1	Bituminous.
9. Broken stone, hard, water-bound	A3 + B3 + C3 + D2 + E2	Bituminous concrete or penetration.
10. Concrete	A2 + B2 + C3 + D2	....
11. Vitrified brick stone setts and wood block	A3 + B3 + C3 + D3 + E3	....

MASONRY DAMS.*

By Arthur P. Davis and D. C. Henny.

THE remarkable progress of the last few years in the application of science to the uses of man has extended to the design and construction of dams. The wide range of experience covered by recent practice in this branch of engineering affords an extensive field of study and an inexhaustible mine of information. The progress of sanitary science, demanding better and more generous water supplies for rapidly growing urban population; the wonderful growth of water power development; and the demands of irrigation and flood control have all performed their parts in stimulating the construction of dams of all classes; and the large number of such structures recently build have led to the evolution of ideas and theories that inevitably accompanies important experience.

The two great classes of dams are those of masonry and of earth, which, though fulfilling identical functions, are so different in character and construction as to require widely different treatment both in theory and practice. Between these two distinct classes, the rock-fill and the combination of earth and rock-fill constitute a third class partaking more or less of the characteristics of both the main classes.

For a logical treatment of the subject, it seems best to ignore the purpose of the structures. While this may at times exert some influence on design its effect is generally not of a material character. The more natural division already mentioned refers to the material of construction, generally dictated by considerations of foundation and materials available.

Up to 30 years ago, only one general type of masonry design had been carried out in America, namely, mass masonry, depending for stability against water pressure on weight of material.

The most favorable disposition of material was determined upon the assumption that tension in masonry should be avoided, leading to the requirement that at any horizontal plane the resultant of all forces should fall within the middle third. The theoretical section, considering water pressure alone, thus became a rectangular triangle, with its apex at maximum high-water level, a vertical water face and a downstream slope of approximately 2 to 3, dependent on the specific gravity of the masonry. This theoretical section was then adjusted to the constructural necessity of providing top width and the limitations assumed for permissible compression stresses in the dam itself and on the foundation. In some cases, ice thrust was assumed in addition to water pressure. Examples of this type of dam are the old and new Croton Dams and the Ashokan Dam of the New York Water Department, the Wachusetts Dam for the supply of the Metropolitan District, including Boston, the Elephant Butte Dam of the United States Reclamation Service near El Paso, and numerous others. These dams are all intended for water storage and are not subject to overflow, independent spillways being provided to pass flood waters.

The same type, with the addition of an apron, is very commonly used in diversion dams, as in the case of the Granite Reef Dam, near Phœnix, Ariz., the Bull Sluice Dam near Atlanta, Georgia, and especially the Le Grange Dam, near Modesto, Cal., the latter having a height of 100 feet. The Boonton Dam, near Jersey City, is an example of a dam which for part of its length acts as a spillway.

Mr. John D. Van Buren, in 1895, pointed out the danger of sliding to which dams of this type are subject, if approximately horizontal cleavage planes exist in the masonry itself, or in the foundation. The upward pressures in such planes tend to reduce the pressure of superstructures upon foundation, upon which resistance to sliding is largely dependent. The failure of the dams at Austin, Texas, and at Austin, Penn., illustrates this danger. An increase of section and weight was therefore proposed to meet this danger, the extent of which can be only surmised, as it is dependent on factors difficult or impossible to determine. The San Mateo Dam, near San Francisco, was designed to resist uplift under its entire base, equal to the hydrostatic head, reservoir full.

This involves the assumption that cleavage planes can exist in which there is no point of contact between the over and underlying strata, and yet these bodies are so close together as to confine the leakage and produce full uplift. This condition is, of course, impossible and can hardly be approached in practice. Various compromises have been proposed, all either involving some diminution of pressures near the downstream slope, or making reduction for areas in contact. The Olive Bridge and Kensico Dams of New York City Water Supply were designed on the theory that upward pressures would occur equal to full head of full reservoir on the upstream side, and full head of ground water on the downstream side, the head varying uniformly between these limits.

Natural conditions vary widely, but it is not safe to assume any foundation to be entirely impervious. The determination of the perviousness of natural formations is one of the most difficult things in nature. Any examination of such formations which disturbs them, changes the conditions which it is desired to ascertain; for this and other reasons, it is necessary to allow a large factor of safety in any estimates which involve this factor.

In general, it may be said that water will more readily follow seams or bedding planes than devious paths through the material of the rock. It follows that it will pass more readily and in larger volume in the direction of stratification than in a direction normal thereto. Similarly, stratified rock will permit percolation more easily and in greater volume than good massive rock, such as granite.

Granular rock, such as sandstone, is likely to transmit more water through the rock itself than one of denser or finer grain, such as limestone or shale, but no exact rule of this nature can be laid down, because there are many varieties of each kind of rock with various percolating capacities. In general, however, the following rules may be taken as a rough guide:—

1. Massive or crystalline rocks, such as granite, gneiss and schists, will transmit water less freely than those of sedimentary origin.

2. Stratified rocks will transmit water much more readily in the direction of stratification than transversely thereto.

3. In the direction normal to stratification, sandstone will generally transmit water more readily than limestone, and the latter more readily than shale.

4. Stratification on a plane approximately horizontal is the worst possible condition for introducing upward pressures beneath a dam. Conversely, the most favorable position in this respect for stratified rock is in vertical beds.

Avoidance of tensile stresses in the water face of a dam is clearly of the utmost importance in connection with uplift pressures, since cleavage planes might otherwise be formed at the point of greatest danger. Some interesting experiments with small models of dams made of flexible

* From a paper on "Dams," presented at the International Engineering Congress in San Francisco.

material indicate that even with the resultant falling within the middle third, tensile stresses are liable to exist at the heel of the dam. The existence has also been alleged of severe shear stresses, such as would materially reduce or neutralize supposed factors of safety.

The success, however, of so many of the dams of ordinary gravity type where no distinct cleavage planes exist in the foundation material, makes any large addition to the triangular section seem unwarranted. Moreover, other and more economical means suggest themselves for overcoming danger of sliding, the foremost of which has been the adoption of a plan for the dam curved upstream instead of straight. Each portion of the dam remains self-supporting by its own weight as to horizontal water pressures, while arch or wedge effect will develop in case of tendency to slide. Its application generally involves but a moderate additional mass, where the dam is relatively short. The Furens Dam in France, the Cheesman Dam in Colorado, the Roosevelt Dam in Arizona, the East Park Dam in California, and the Arrowrock Dam in Idaho, illustrate this principle. The Sweetwater Dam in California, as originally completed in 1895, is an example of a dam in which, considered as a gravity dam, the resultant with reservoir full strikes outside the middle third, and in which the arch effect due to its curved plan is depended upon to prevent tension near the water face. It was, however, enlarged in 1911, as a gravity structure.

Uplift pressures being due to penetration of water can be reduced or prevented by increasing the density of the masonry near the water face, by surface treatment of this face, and by deep cut-off and drainage. All these means are now being employed, as, for instance, in the case of the Elephant Butte Dam, New Mexico. The concrete masonry, for a depth of 10 feet from the water face, is extra rich in cement, the face is given a one-inch mortar coat with a cement gun, the cut-off wall at the heel has been carried to a great depth (Max. 100 feet below river water), and the method of grouting under pressure is employed to 50 feet greater depth. Downstream from the plane of closure, drainage wells have been provided in the masonry and drilled in the foundation to dissipate pressure of seepage water. Similar precautions have been taken at the Arrowrock Dam, Idaho, which, moreover, is built on a curved plan.

Another method for reducing uplift pressure is used in the case of low diversion dams built on water-bearing material, as, for instance, the Grand River Diversion Dam, Colorado. This consists of a concrete blanket or apron extending upstream from the heel of the dam, with cut-off wall at upstream edge. The effect of such apron is to lengthen the path of percolating water, thereby reducing the upward pressures under the dam, which, moreover, is given added weight to resist the estimated remaining uplift. The same effect has been aimed at in puddle-fill on the water side, which method appears to have been more common in Europe than in the United States.

It is apparent that the natural process of silting, where water carries silt, will aid in reducing upward pressures, the artificial means, in case of silt-bearing water, being especially intended to obviate danger during the earlier years.

In low dams constructed of wood, it has for a long time been customary to provide a water face with a rather flat slope, resulting in a vertical water load on the foundation which would tend to resist sliding. This type of dam has been copied in reinforced concrete for structures of considerable height. Near Douglas, Wyoming, a reinforced concrete dam of this type has been built for storage purposes, having a total height of 130 feet. A portion of this dam is adapted to overflow as a spillway. A notable overflow dam of this type is the Clackamas Dam, 70 feet high, recently built near Portland, Oregon.

The water slab is supported by buttress walls, which afford a relatively long base up and downstream, imparting great safety against tensile stresses (except in the reinforced slabs themselves), and also rendering it economically practicable to reduce foundation loads either by spreading of the bases of buttress piers or by placing them on a continuous concrete floor. It is essential that such floor be provided with weep holes to eliminate upward pressures.

The low foundation pressures which can thus be economically secured render this kind of dam practicable on gravel foundations, provided a deep cut-off connects with the water face slab or the latter be extended upstream in the nature of an apron. Dams of this type have also been built on clay foundation, slight settlement being immaterial in view of possibility of sliding adjustment between abutments and water face slabs.

The facility with which construction of this kind of dam will permit handling of flood flow during construction is obvious and valuable.

This type of dam has also been executed in steel, as in the cases of the Ash Fork Dam in Arizona, and the Hauser Lake Dam, Montana. The latter dam failed, but its destruction is believed to have been due to insufficient cut-off and piping, part of it having been founded on gravel, and is in no way to be attributed to the substitution of steel for reinforced concrete.

Dams to be constructed in relatively narrow canyons invite consideration of the use of the arch principle, not merely as a safeguard against sliding, but as the chief means of resisting horizontal pressure. The famous old Bear Valley Dam, California, now made useless by the construction of an arched gravity dam a short distance downstream, furnishes the boldest example of this type, in which arch pressures may have existed of over 70 tons per square foot. More recent instances are the Pathfinder Dam, Wyoming, and the Shoshone Dam, Wyoming, of the United States Reclamation Service, the dam near Ithaca, New York, and a number in Australia. The safety of these dams depends upon unyielding abutments and limitation of arch pressures. These pressures generally range between 15 and 30 tons per square foot. Danger from sliding due to upward pressures is absent. The division of load between the arch and the cantilever introduces secondary stresses the nature of which is as yet not thoroughly understood.

Dams of this type are usually protected from overflow by independent spillways. The Huacal Dam, in Mexico, has but a partial spillway protection and may at times be overtopped, for which reason an auxiliary low dam was built downstream to form a water cushion and protect the foundation.

All the above dams are arched to a radius, which remains constant from foundation to top. Considerations of economy have led to a design with a variable radius and as near as feasible constant circumscribed angles. The principle has been developed by L. R. Jorgensen, Mem. Am.Soc.C.E., who shows that a considerable saving of masonry may, under favorable circumstances, be effected, and has been applied in the Salmon Creek Dam, Alaska, and the Lake Spalding Dam, California, and on a smaller scale in the Clear Creek Dam, Washington, which latter is also an overflow dam. It may be stated as a matter of historical interest that the original Bear Valley Dam was built with a shorter radius in the lower part than in the upper.

A series of vertical arches supported by buttress walls was used as a low spillway dam in connection with the

East Park Reservoir, California, for purposes of economy and lengthened spillway crest.

The principle of the inclined face dam with buttresses has been successfully used recently by substituting arches for flat slabs, resulting in the multiple arch type. This permits avoidance of beam tension in the closing curtain and obviates the necessity of dependence upon concrete embedded steel, the life of which, in saturated concrete, is as yet a matter of uncertainty. A diversion dam of this type was built on the Umatilla River in Oregon, and a storage dam with a maximum height of 61 feet at Hume Lake, California. A singular example of this type of dam occurs on Lost River near Klamath Falls, Oregon, where a plan in the shape of an elongated horseshoe was adopted to give the desired length of overflow so as to avoid submergence of valuable land in times of freshet, and to provide a basin for receiving the overflow water.

Contraction Joints.—The reinforced and multiple arched types naturally contain numerous contraction joints. Such joints were introduced in the Ashokan, East Park, Arrowrock, Elephant Butte, and other gravity dams. Dams of the pure arch type have, however, been generally of monolithic construction, the need of contraction joints being less marked by reason of greater flexibility of the general body. No cracks have been so far observed in the Pathfinder Dam. The Shoshone Dam shows a very slight crack near the top at each abutment.

Contraction cracks being objectionable from the standpoint of ultimate life, as well as appearance, many dams are now provided with contraction joints for a part of their height. These are placed from 100 ft. to 50 ft. apart, and near the top sometimes closer. They are provided with one or more keys and at times with a metal water stop, and usually with a drain back of the closure. These joints permit shrinkage due to setting, as well as to temperature effect, and tend to reduce secondary stresses. They do not seem objectionable in any way, except in requiring more form work. The work can be laid out so as to construct the alternate sections, at least near the top, at a time when contraction is at a maximum.

Material.—The material used in masonry dams has been coursed masonry throughout, rubble masonry faced with coursed masonry, using ordinary mortar or concrete mortar in connection with very wide joints, coursed masonry faced with concrete interior, and all concrete with or without plumstones. The use of concrete has been growing in favor. It can be laid mainly by machinery, and is economical in many locations where good rock is not available. The economy of its use has recently become more marked through improved processes of mixing and depositing. It requires, however, more cement than rubble masonry, which, where distance of cement haul is an important factor, may render the latter at times the cheaper.

The New York Board of Water Supply has built two dams of concrete, faced on both sides with concrete blocks laid in mortar. These block faces serve instead of forms, and as they can be cast while foundations are in preparation and in all kinds of weather, they tend to expedite construction. Their chief virtue, however, is their appearance.

Portland cement is now universally used in mortar and concrete and is shipped from commercial mills. The mass concrete is generally proportioned 1:3:6, the aggregates being crushed rock or gravel tested for minimum voids. In some cases Portland cement has been ground locally with sand (sand cement) in proportions varying from 40% to 50% of the mixture. This material was largely employed on the Arrowrock and Elephant Butte Dams, in order to reduce the proportionate cost of cement. It sets more slowly, however, and forms are therefore more costly per cubic yard, as they cannot be removed as soon as with normal cement concrete. This tends to reduce the saving due to reduction in pure cement. A like result follows from the tendency to increase the proportion of sand cement, as compared with normal Portland cement used in the mixture. There has also been observed greater liability of damage to surfaces from frost, probably due to slow hardening. The tests with concrete blocks show a slightly reduced strength, but indicate no reduction of strength with age and a strength ultimately equal to that of straight Portland cement. It is only on work of great magnitude, where freight items are large, that any saving can result from the use of this material.

The concrete with either Portland or sand cement is usually mixed sloppy, water being carefully limited, however, so as to avoid excess. This consistency permits distribution from towers and through pipes. It is worked by shovelling and man-kneading so as to make it as homogeneous as feasible and to release contained air. Spades are used next to the forms to insure sound and tight surfaces. The tendency to the formation of smooth surfaces between old and new work is counteracted by wire brushing and by imbedding plumstones.

Cement Made Locally.—It is the universal custom to transport Portland cement to the locality. An interesting exception is the case of the Roosevelt Dam, in Arizona, where the distance from the nearest railroad point was 60 miles, with mountain roads intervening. Suitable materials for manufacturing cement were found near the site and local manufacture caused a saving estimated at over $1,000,000 in the construction of 360,000 cubic yards of masonry.

Movable Dams.—The use of movable dams has been steadily increasing to meet conditions under which it is necessary to maintain a relatively constant water level under fluctuation, flood or changeable uses of water. Devices for such use are very numerous. The various forms of wickets and shutters have been long in use in Europe and America with a fair degree of success. The more recent bear trap, to be operated by water pressure, has had several modifications and has been frequently employed.

The Stoney sluice gate, gliding on movable rollers to reduce friction, which is employed extensively in the great Assuan Dam of Egypt, has been adopted, with some modification, for the spillway of the Gatun Dam at Panama. It has also been employed in many other cases.

For cases in which long span is essential, the roller dam patented and employed in Europe for some years, has recently been introduced into the United States, the first installation being a small one upon the Boise River in Idaho, and several larger installations are now in progress on the Spokane River, in Washington, and the Grand River in Colorado. This, in addition to the practicability of very long span, has the advantage of simplicity, certainty of action, and a good degree of watertightness.

To accomplish the same purpose by another method, the siphon spillway has recently been introduced to this country from Europe, and used in several cases with success. Having no moving parts, it is well adapted to certain locations where there are no complications from drift, and where the volume of the fluctuation is moderate. It has the further advantage of being adapted to construction of concrete, and is, therefore, more permanent than steel or wooden structures. By various simple adjustments, a series of such spillways can be so arranged as to prime themselves automatically at different levels and thus secure any desired gradation in rate of discharge.

FIELD WATER PURIFICATION PLANT.

When the Ontario troops went into camp early last summer at Niagara-on-the-Lake, Ont., many complaints were made regarding the town's supply of water. The town of Niagara-on-the-Lake has been desirous for several years of having a mechanical filter plant, because the water which they pump from the Niagara River is greatly polluted. As a considerable amount of water is used each year, however, by the militia camp, the town believes that the government should aid financially in the construction of the filter plant, and, as arrangements along this line have never been made satisfactorily to both parties, the town is still using water which must be very heavily chlorinated.

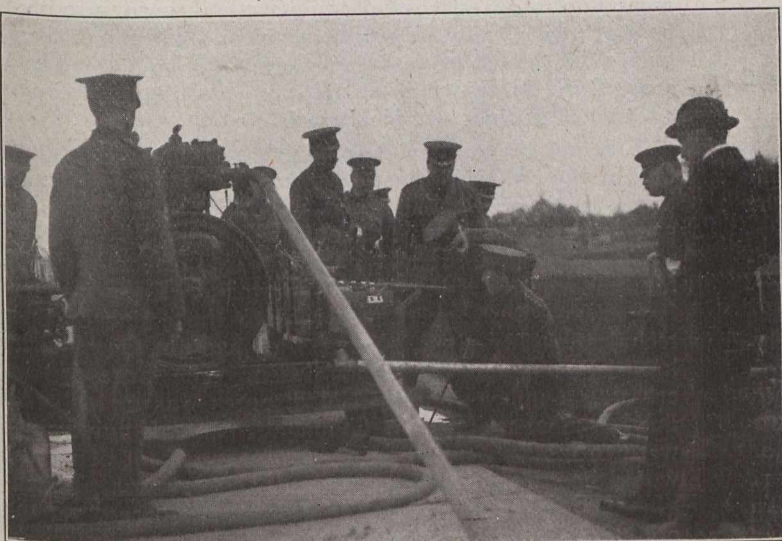

Fig. 1.—Side View of Sterilizing Outfit.

To provide a better supply for the troops, a portable ultra-violet ray sterilization plant was designed and installed by Capt. F. A. Dallyn, C.E., engineer for the Provincial Board of Health of Ontario.*

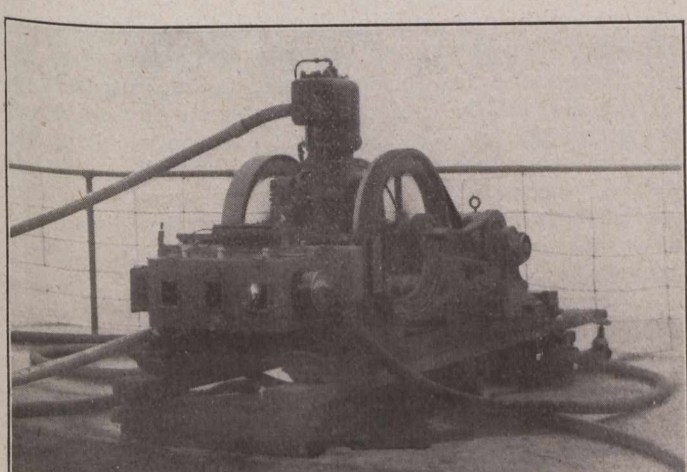

Fig. 2.—Front View of Sterilizing Outfit.

The lay-out of this plant is unique, and patents have been granted to Capt. Dallyn in regard to same, under the title of "Power Army Water Supply Outfit," and the apparatus seems to be quite adaptable for use at the front, although it is not known to what extent, if any, it is so being used.

The capacity of the plant is three thousand gallons per hour, but at Niagara it was operated at twelve hundred gallons per hour. The difference in elevation between the plant and the river level was 19 feet, and the pump overcome a total suction lift of 25 feet. The water was pumped directly from the Niagara River, a short distance above the town pumping station, the town's supply not being used at all for drinking purposes, although it was used by the soldiers for washing, etc.

The water was first passed through a mechanical filter (illustrated in Fig. 3) of the ordinary reverse flow type with high velocity wash. The water then passed through a special casting into which there were inserted three quartz tubes. An ultra-violet ray lamp was attached to each of these tubes, and the violet ray emanations reached the water through the quartz, the casting being made watertight around the quartz tubes by means of rubber gaskets.

The quartz tubes are 1½ inches in diameter, 4 inches long. One of them is shown, together with its lamp, in Fig. 5. A closer view of the part of the casting in which one of the quartz tubes is inserted, is shown in Fig. 4. A side view of the outfit is shown in Fig. 1. This photograph was taken during a trial run at Exhibition Camp, Toronto, before the equipment was shipped to Niagara. The Duke of Connaught can be seen bending over the operator's shoulder. Fig. 2 is a front view of the sterilizing outfit. Three windows will be noted in front of the casting, through which the operator can watch the operation of the lamps, the openings for the insertion of the quartz tubes being just below the windows.

The sterilizing outfit consists of the special casting and lamps previously mentioned, and of a generator, engine and pump. The current for the lamps is supplied by a 2½-kw., 220-volt, direct-current generator. The pump is a 2½-inch Albany water-sealed rotary pump, with a capacity of three thousand gallons at 250 r.p.m. The motor is belt-driven, the pump chain-driven, and both motor and pump are driven by a 9-h.p. vertical gas engine, fitted with automatic pump lubrication, enabling it to run between 200 and 250 hours without refilling the lubricating oil chamber. The cylinder is water-cooled with connection to the discharge of the pump and overflow to waste. The

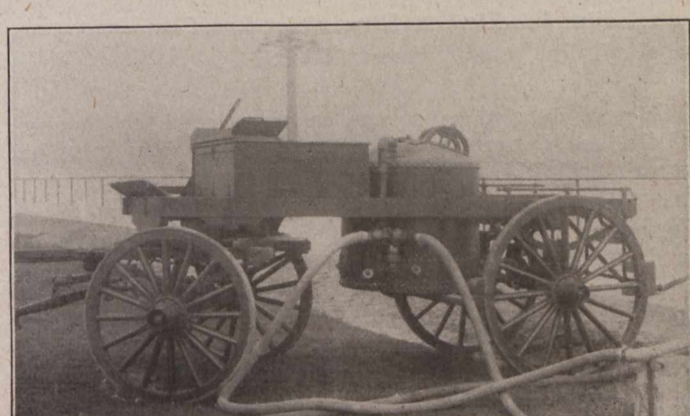

Fig. 3.—View of Portable Pre-filter.

*The reader is referred to the article in *The Canadian Engineer* for December 16th, 1915, relating to the Provincial Board of Health investigations into ultra-violet ray sterilization of water.

engine has a throttle governor, phosphor bronze bearings and pump-fed carburettor. The governing of the engine is such as to give practically constant speed at all loads within its capacity.

The engine was supplied by R. A. Lister & Company, Toronto, and was built at their works in England. The generator was supplied by the Canadian Westinghouse Company, Hamilton, and the pump by the Albany Pump Company, Toronto. The lamps, quartz tubes and special casting were furnished by the R. U. V. Company, New York City. The prefilter was built by the Thor Iron Works, Toronto, in accordance with specifications furnished by Capt. Dallyn.

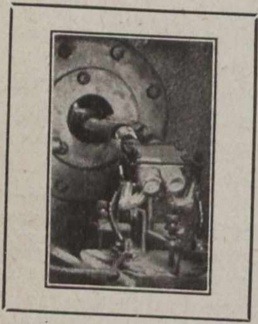

Fig. 4.—Closer View of Portion of Special Casting in which the quartz tube is Inserted.

The plant was purchased by the government upon recommendation of Lieut.-Col. Marlow, assistant director of medical service, and was operated under the supervision of Capt. A. V. Delaporte, B.A.Sc., of the Canadian Army Hydrological Corps, with the assistance of M. F. Hasbrouck, of the R. U. V. Company.

An efficiency of from 99.75 per cent. to 100 per cent. was obtained during operation, as the normal count in the raw water was four thousand bacteria per c.c., and

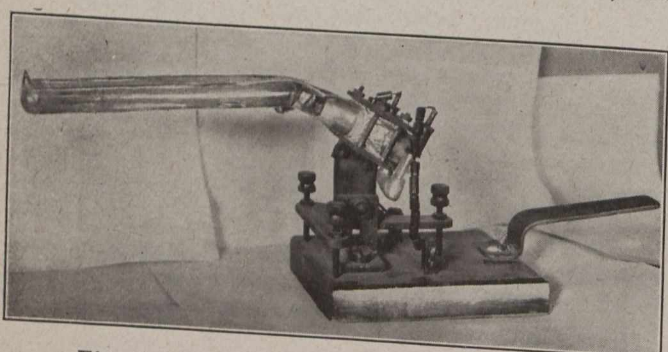

Fig. 5.—View of Ultra-violet Ray Lamp and Quartz Tube.

this was reduced to counts ranging from ten to zero. Colon bacilli were commonly present in 0.01 c.c., but after sterilization were normally absent in 50 c.c.

The Canadian Engineer is indebted for the above information and accompanying illustrations to Capt. Dallyn and to Mr. W. J. Ellis, of the R. A. Lister & Company.

A United States consular report notes the recent completion of the large tunnel on the Bagdad railway piercing the Amanus mountains, on the border between Asia Minor and Syria. It is known as the Baghtché tunnel, taking its name from the station of Baghtché, at its northern entrance, about 75 miles east of the city of Adana and some 60 miles northwest of Aleppo. It has a length of 16,028 ft.

Preliminary organization has been effected of an organization called the Cement Products Association of Canada. The temporary chairman is W. Dillane, of Kemptville, Ont. The temporary secretary is W. A. Toohey, Herald Bldg., Montreal. The membership of the association will be composed at first of concrete pipe manufacturers. Standard specifications will be adopted, and all who wish to join the association will be required to live up to these specifications in the manufacture of their pipe.

THE BUSINESS SIDE OF ENGINEERING.

A weak point in the engineers' professional armor was mentioned by Mr. A. E. A. Edwards recently in his presidential address to the Birmingham Association of Mechanical Engineers.

Three features of an engineer's training, he said, did not usually receive sufficient attention—the commercial side of the business, the control of men, and the power of speech. There were doubtless others, but there they had three features which were essential to turn a sound technical man into a successful engineer, and there were numbers of men absolutely sound technically who would be at or around the top of the tree if these three points had been more fully developed in them, even at the expense of a great deal of their technical work.

To put the matter in a nutshell, an engineer is usually taught the profession instead of the business of engineering. In his opinion, if a firm undertook to teach an apprentice engineering they should be expected to give him some knowledge of the commercial side of the business, for that was the side of first importance. Comparatively few engineering apprentices rose to the eminence their technical skill merited, because they had not the requisite knowledge of how to manage men. The large and increasing number of industrial disputes was undoubtedly due to the want of tact in the management. If universities were to institute a course on the management of men it would be to the lasting benefit of the country. An engineer had no training in the power of speech, yet the power of the trained speaker was apparent everywhere.

The inability of clever technical men to write decent English has frequently been commented upon. It must be admitted, too, that the engineer, like the artist, is sometimes a poor business man. We suppose the reason is to be found in specialization. There is nothing in business which the engineer could not manage perfectly well, but he finds the theoretical and practical problems of engineering too absorbing to admit of time being appropriated for the minutiæ of commerce. Even the manufacturing side of engineering seems repugnant to some engineers. It is in the exploitation of patents, however, that we get the most striking illustration of the divergence between technical skill and business adroitness.

The conclusion is borne in upon us that in these days of specialization the engineer who interests himself to any extent on the business side must pass on much of the technical work to others. It seems to be well established that a successful engineering concern must have able specialists in both departments, and that this division of work must inevitably be more pronounced as the business expands.

In many small concerns both technical and commercial duties may be performed by the same person, but if the business grows a division on the usual lines is inevitable, and the head will have to ask himself whether his primary object in life is to revel in engineering details or to make money.

The Canadian Forestry Association, Commission of Conservation, Canadian Timbermen's Association, and the Canadian Society of Forest Engineers, all held annual meetings in Ottawa, January 17th, 18th and 19th.

Liquid chlorine has replaced hypochlorite of lime in the disinfection of water supply in Minneapolis. A contract has been let to Wallace & Tiernan, New York City, for the installation of three liquid-chlorine outfits with a capacity to treat 60,000,000 gallons a day each. The contract price was $2,000. The apparatus is of the solution-feed manual-control type, described in *The Canadian Engineer* for August 19th, 1915, page 276.

Editorial

ONTARIO'S PROGRESS IN HIGHWAY ORGANIZATION.

The Ontario Government has created a Department of Highways in connection with the existing Department of Public Works. Hon. Finlay McDiarmid has assumed the title of Minister of Public Works and Highways. Mr. W. A. McLean, C.E., M.Can.Soc.C.E., whose connection with road improvement in the province is prominent and of long standing, has been appointed Deputy Minister of Highways.

This is an appointment the announcement of which will be read with pleasure by engineers and road men in Canada and the United States, Mr. McLean being widely recognized as an eminent road authority. The Ontario Office of Public Roads has, under his direction, done a great deal to assist in the problems of rural transportation in Ontario. The work of the Public Roads and Highways Commission in 1913-14, presented in its 1914 report, evidenced the thoroughness with which the survey of Ontario conditions was entered into. The investigations and conclusions of the Commission were and are of great importance to the Province. The Highway Improvement Act of 1915, which went into force last week, and by which the Government pays 40 per cent. instead of 30 per cent. of the cost of construction of county roads by counties meeting the requirements of the department, and 20 per cent. of the cost of maintenance, has been a further step of great magnitude towards better highways in the province. The second instruction conference on highway work which will be held next month, being a series of lectures on road construction, given by the engineers of Mr. McLean's department for the benefit of county engineers and superintendents, marks the continuation of a most useful procedure, established last year.

These and other indications of the progressive steps towards cheaper transportation in the province are indicative of the extensive policy and indispensable organization which Mr. McLean has formulated. Undoubtedly his service to the province will be considerably increased by the added scope and powers which his new appointment as Deputy Minister confer upon him.

ZINC, COPPER AND NICKEL REFINING IN CANADA.

Very worthy of note among the industrial activities, the establishment of which in Canada is due in large measure to the necessities of the war, is the rapid advancement that is being made in the refining of metals. By virtue of the unusual demand for zinc, copper and nickel in the manufacture of munitions and armaments, at home and in allied and neutral countries, the progress made recently is most promising. Zinc, for instance, is now being refined electrolytically in Canada by three new plants, all using different processes. The Standard Silver Lead Mining Co., of Silverton, B.C., is producing electrolytic zinc by a process originated by French, using manganese in the electrolysis of zinc sulphate solutions, the manganese being recoverable, as it is deposited as manganese dioxide on the anode, and may be redissolved in sulphuric acid for future use. The Weedon Mining Co., with lead-zinc mines in Quebec, is using the Watts process in its refinery at Welland, Ont. By this method zinc is deposited from a zinc sulphate electrolyte, the quantity of sulphuric acid being kept down by the use of zinc oxide or some similar compound. At Trail, B.C., the Consolidated Mining and Smelting Company of Canada is using an older process, in use at Anaconda, Mont., and other plants, a process in which the electrolytic liquor containing sulphuric acid is used for bleaching the ore, just enough of the acid being used to form zinc sulphate for electrolysis, the idea being to keep the solution low in other constituents of the ore. At present the Trail plant is being greatly increased in capacity, to produce, it is stated, between 35 and 50 tons of metallic zinc per day. This indicates the success of the investigations carried on at the experimental plant there in 1915, the output averaging from 1,000 lbs. to 2,000 lbs. of spelter per day.

The zinc produced from the ores hitherto exported from British Columbia for want of a plant to treat them there has reached about 9,000,000 lbs. a year. Now the production of the province itself will aggregate from 25,000,000 to 30,000,000 lbs. It is interesting to know that development work done on the Sullivan mine by the company has proved it to be one of the largest and most valuable deposits of zinc ore on the continent. The company is driving a low-level tunnel two miles in length to provide for the economical mining and shipment of the ore from this mine, which will form the principal source of supply for the new zinc refinery at Trail.

Turning now to the enormous production of nickel in Ontario, last year's exports of which totalled nearly $7,000,000, and concerning which there was much controversy in the early stages of the war, it was recently announced in Ottawa that the nickel matte, in which form the metal has been exported for refining, may shortly, by Government requirement, be refined in Canada. This measure would mean the establishment of a very important industry in the Dominion, designed as it is to keep control of the export of a commodity that figures very prominently at present in armament manufacture.

MEASUREMENT OF RAINFALL.

The importance of knowing exactly the quantity of rainfall in hydrographic basins is evident. Besides the great scientific interest from the point of view of solution of numerous problems of terrestrial physics, there is the urgent and practical need associated with all hydrological subjects; utilization of water power, correction of streams, irrigation, agriculture, etc. In experiments described in Il Politecnico for June 30, 1915, a field rain gauge and a totallizer pluviometer were utilized, the latter indicating 9 per cent. less than the other. The most serious difficulty met with was to place the instruments in positions where they could not be tampered with. This difficulty was solved in a satisfactory way by putting them on the top of large masonry pillars. The mouths of the instruments measured 1 sq. dm., and the diameter of the cylindric part of the receptacle was 32 cm., the height 32 cm. Thus the capacity was about 28 litres, sufficient generally for a year's rain. The observations were made every month.

The Engineer's Library

Any book reviewed in these columns may be obtained through the Book Department of The Canadian Engineer, 62 Church Street, Toronto.

CONTENTS.

Books Reviews:

BOOK REVIEWS.

Elements of Mechanics of Materials. By C. E. Houghton, B.A., M.E., Associate Professor of Mechanical Engineering, New York University. Published by the D. Van Nostrand Co., New York. Second edition, 1915. 213 pages; 94 illustrations; cloth. Price, $2.00 net. (Reviewed by Eric P. Muntz, B.A.Sc., New Welland Ship Canal.)

For the purpose for which this book is intended—an elementary text book in conjunction with the usual engineering courses in colleges and universities—it covers the necessary ground in a clear-cut and concise manner, which should appeal to the average college student and to anyone endeavoring to master the elementary principles of design.

In the opening chapter the different stresses are explained, together with the meaning of unit deformation, coefficient of elasticity, elastic limit, resilience, etc., working stresses and factors of safety. This is followed by the application of these terms and stresses to bars of uniform strength, thin pipes, cylinders and thick pipes with a discussion of riveted joints and stresses due to temperature.

Chapter 3 deals with the "bar" of Chapters 1 and 2 in a horizontal position supporting loads perpendicular to its axis; *i.e.*, as a beam. The various bending moments and shearing forces are explained as well as section modulus, moment of inertia, etc., with their application to standard sections. Shear and moment diagrams and the effect of moving loads are explained.

Derivation of formulæ for tension is taken up in Chapter 4. Twist, relative strength and horse-power of shafts and shaft couplings are covered.

The equation to the elastic curve is derived, also formulæ for the deflection of beams, and the effect of restraining or fixing the ends of beams. Long columns are taken up with a review of Rankine's, Ritter's, the parabolic and straight-line formulas.

Combined stresses are covered in Chapter 7, and Chapter 8 takes up compound bars and beams, which is followed by the final chapter touching on reinforced concrete. Beams of rectangular and T-beam section are taken up. Their shearing and bond stresses are gone into. Web reinforcement necessitated by diagonal stress is also brought in, which revives the much-discussed question of the utility of *vertical* stirrups as web reinforcement. Their spacing, at all events, should be less than the distance from the centre of gravity of the steel to the neutral axis and not so great as ¾ d. as allowed in the book.

A very useful feature of the book is the large number of problems presented at the close of each chapter, occupying altogether fifty pages.

Altitudes in Canada. By Messrs. James White, Assistant to Chairman and Deputy Head, Commission of Conservation, Canada, and George H. Ferguson, Assistant Engineer. Published by the Commission. 603 pages, 8 maps and profiles, 6 x 9 ins., cloth.

The first edition of this work was published in 1901 when Mr. White was Chief Geographer, Department of the Interior. The present is the second edition, in which the information has been brought up to date and considerably enlarged upon. It is a very comprehensive compilation of altitudes and will be found exceedingly useful as the best possible interpretation of the conflicting evidence available respecting the elevation of many points in the Dominion. Its value as a work of reference in relation to climate, health, railway location, atmospheric pressures in machine design and construction, irrigation and pipe-line construction, etc., is self-evident in addition to the necessity of such information in geological and geographical problems.

Pocket Diary and Year Book, 1916. Published by Emmott & Company, Limited, Manchester and London. 428 pages, 4 x 6 ins., illustrated, cloth. Price 25 cents.

The 29th annual publication of the "Mechanical World" series, contains a collection of useful engineering notes, rules, tables and data. Many parts of the volume have been re-written and much additional information introduced.

Concrete Silos. By E. S. Hanson. Published by the Cement Era Publishing Co., Chicago. First edition, 1915. 174 pages, illustrated, 5 x 7 ins., cloth. Price, $1.00.

This is a very complete little treatise on concrete silo construction dealing first with the nature of the material, its suitability, and with instructions as to how to build according to the various systems in use. These systems of construction are many, and those which have been proven thoroughly reliable and practical are described in detail.

The book has eighteen chapters and a catalogue section. It is illustrated by numerous half-tones and line drawings.

Water Supply for Country Houses. By Dr. W. P. Gerhard, C.E. Published by Review of Reviews Company, 1914. 51 pages, illustrated, 6 x 9 ins., paper binding. Price, 40 cents.

The writer first deals with points to be borne in mind for the search for an adequate and suitable supply of water for domestic use. He treats of volume necessary, pressure required, etc., and deals with the various sources as rainfall, lakes, rivers, springs, etc. In Chapter 2 he refers to appliances for distributing water, power for machinery required, and lays out as an ideal system a compressed air pumping station.

First Course in Engineering Science. By P. J. Haler, B.Sc., and A. H. Stuart, B.Sc. Published by the University Tutorial Press, Limited, New Oxford Street, W. C., London, First edition, 1915. 191 pages, 159 illustrations, 5 x 7 ins., cloth. Price, 40 cents.

This book treats of the material laid down for certain technical school requirements in England. It describes experiments that may be performed on ordinary apparatus, the great difficulty in many institutions being the lack of suitable laboratory equipment for carrying out prescribed work.

The book has two parts, the first dealing with stresses, strains, moments, parallel forces, work, energy, power, velocity, acceleration, etc. The second deals with fluid pressures, heat, specific heat, conductivity, radiation, etc. It also treats in general way of the simple steam engine and boiler.

Examples in Magnetism. By Prof. F. E. Austin, B.S., E.E. Published by the author. First edition, 1915. 90 pages, 27 illustrations, 5 x 7 ins., flexible binding. Price, $1.10.

This book should be a favorable guide for students in elementary electrical engineering. As the author states, it is not a book of problems, but a carefully compiled volume of information dealing with physical laws underlying various problems, with the systematic tabulation of data relating thereto, with the process of solution and finally, in every case, with a problem properly worked out. The book does not enter into the analytical derivation of equations. These are taken for granted and the mathematical processes involved in their application to problems are dealt with.

Land and Marine Diesel Engines. By Giorgio Supino. Translated by A. G. Bremner and James Richardson. Published by Charles Griffin & Co., London. 309 pages, 380 illustrations, 19 plates, 6 x 9 ins., cloth. Price, $3.50 net.

This is an acceptable translation of the work of an Italian engineer of high repute. It deals with the development of the oil engine on the continent of Europe where the practice is considerably in advance of that of the United Kingdom and America. Part 1 involves six chapters relating to Diesel engines of both stationary and marine type; to fuels, thermodynamic cycles, efficiencies and the calculation of cylinder dimensions. Part 2 deals with engine design to which is devoted five chapters, and in addition there are supplementary chapters upon engine room accessories, fuel regulation, marine installations, tests, etc.

While calculations in the original work were based upon the metric system, the translators have added the British units where they tend to a readier understanding of the text. Calculations themselves are left in the metric system, and a convertion table is added.

The book has a very comprehensive index, list of illustrations, tables, etc.

Water Power Engineering. By Daniel W. Mead, Professor of hydraulic and sanitary engineering, University of Wisconsin, Consulting Engineer. Published by McGraw-Hill Book Co., New York. Second edition. 843 pages, 430 illustrations, 6 x 9¼, cloth. Price, $5.00 net. (Reviewed by T. H. Hogg, C.E., assistant hydraulic engineer, Hydro-Electric Power Commission of Ontario.)

The first edition of this treatise appeared in 1908, and in the past eight years has come to be recognized as a standard authority on hydraulic engineering, the advances in the art of which have been very great during this time. The new edition is therefore amply justified.

Chapter 1 gives a concise resumé of the history of water power engineering covering the improvement in design of water-wheels, both reaction and impulse, together with a short discussion on conservation and its effect on water power development.

Chapter 2 discusses the different losses in any plant, unavoidable and otherwise, and gives a list of units used in the analysis of conversion of energy.

Chapter 3, entitled "The Load," deals with load factor and the load curve and their significance as related to the efficiency and general design of waterpower plants. The chapters on "Rainfall," "Run-off" and "Stream Flow" of the first edition have been omitted, as not sufficiently complete.

Chapters 4 and 5 deal with the flow of streams and the measurement of stream flow. In these chapters are discussed the various formulæ for the losses in channels and conduits, and the various conditions influencing the flow of streams, together with a description of the standard methods of measurement of stream flow.

Chapters 6, 7 and 8 fall into a group dealing with the hydrograph in its relation to power plant design, the effects of pondage and storage, and the study of the power of a stream as affected by head. The author's use of the hydrograph is particularly to be commended. As he states, the graphical method is of great service in attacking many phases of the problem.

Chapters 9 to 13 deal with turbines, details and appurtenances, hydraulics of the turbine, testing and analysis and selection of turbines. This section, which is perhaps the most valuable of the treatise, has been re-written and a uniform nomenclature is used throughout. The treatment of turbine analyses is most concise and discusses the subject in the clearest possible way.

Chapters 14 to 18 take up speed regulation of turbine water-wheels, the governor, arrangement of reaction wheels, selection of machinery and design of plant; also examples of water power plants. The discussion of speed regulation is good. It is to be regretted, however, that more space is not given to the discussion of water, hammer, or pressure change. Joukowsky's analysis is given, but no mention is made of the more recent work of Allievi, and of Warren. Joukowsky's formula gives results which may be far from the truth when the time of the governor is taken into account.

The surge tank is treated in rather a perfunctory manner, the simple tank formulæ only being given, while inaccurate statements regarding the differential surge tank are made. A number of these tanks are in commercial operation, and the criticism that the sudden drop in the riser is opposed to good speed regulation is proved to be wrong. These tanks show remarkable results under operating conditions, and it is therefore unfortunate that the theory is not presented.

Chapters 19 to 21 deal with the relation of dam and power station, the principles of their construction and appendages of dams.

The cost of power plants and of power, the financial and commercial aspects of power development, and the analysis of water power projects are discussed in Chapters 22, 23 and 24. This section gives a much-needed warning against the financing of undesirable developments, and forms a valuable commentary on the economics of hydro-electric developments.

A criticism that may occur to the engineer after going over this book carefully is that perhaps too little attention has been given to recent modern developments using the single runner vertical type unit with scroll case and concrete draft tube, and to the various appurtenances such as trash racks and rock cleaning devices, flashboards, etc., and too much attention has been devoted to the old type multiple runner horizontal setting.

The treatment of the flow of water in pipes may appear to some to be inadequate. The economics of steel pipe line follows present-day practice, but leaves much to be desired. The method of balancing lost power through friction and cost to secure the most economical development might profitably be discussed with reference to such hydraulic elements as the canal or feeder pipe, the forebay and rocks and penstock.

While the value of the new edition might have been enhanced by the elimination of the defects above specified, it more than maintains the standing of the first edition as probably the most useful hydraulic treatise extant in the English language.

The Elasticity and Resistance of the Materials of Engineering. By Prof. Wm. H. Burr. Published by Messrs. John Wiley & Sons, New York; Canadian selling agents, Renouf Publishing Co., Montreal. Seventh edition, revised, 1915. 927 pages, 173 text figures and 3 plates, size, 6 x 9 ins., cloth. Price, $5.50. (Reviewed by David A. Molitor, C.E., Designing Engineer, Toronto Harbor Commission.)

This work, which appeared in its first edition in 1883, is the most important and best known volume from the pen of Prof. Burr, for which reason no very lengthy review is considered necessary.

The book consists of two main parts and three appendices.

Part I., analytical, contains six chapters with the following chapter headings: 1, Elementary theory of elasticity in amorphous solid bodies; 2, Flexure; 3, Torsion; 4, Hollow cylinders and spheres; 5, Resilience; 6, Combined stress conditions.

Part II., technical, contains twelve additional chapters as follows: 7, Tension; 8, Compression; 9, Riveted joints and pin connections; 10, Long columns; 11, Shearing and Torsion; 12, Bending or Flexure; 13, Concrete steel members; 14, Rolled and cast-flanged beams; 15, Plate girders; 16, Miscellaneous subjects, curved beams, springs, flat plates, rollers, etc.; 17, The fatigue of metals; 18, The flow of solids.

Appendix I. treats of "Elements of Theory of Elasticity in Amorphous Solid Bodies" in three chapters, as follows: 1, General Equations; 2, Thick, Hollow Cylinders and Spheres, and Torsion; 3, Theory of Flexure.

Appendix II. devotes three pages to "Clavarino's Formula for Thick Cylinders."

Appendix III. gives four pages on "Resisting Capacity of Natural and Artificial Ice."

The present edition has received a very general revision with the aim of supplying new material to meet the advancing requirements of the profession. The empirical data has been materially enhanced, by the inclusion of results from more recent experimental investigations. The limitations set by a single volume preclude the possibility of exhausting this wide field of research which has received so much attention during the past decade.

The book might have been improved in its general arrangement by eliminating some of the approximate derivations which consume considerable space. These might have been given as approximations following the more exact demonstrations. Thus, arts. 24 to 33, covering 58 pages, deal with the theorem of three moments and beams involving redundancy, which problems can be more comprehensively solved by the use of the one general work equation which affords solutions to all redundancy problems with any degree of accuracy or approximation desired.

Other instances of this kind are noticeable, and space being a consideration in such a voluminous work, greater economy in this direction might have been practised without detriment to the book.

The author's treatment of reinforced concrete beams is commendable in this respect. The T-beam, being the more general case, is treated first, and the formulæ for plain rectangular beams are obtained by appropriate simplifications.

It is regrettable, however, that the high unit working stresses proposed in "the report of the Committee on Concrete and Reinforced Concrete" of the American Society of Testing Materials should find such a warm reception in the present treatise. If it is prudent to employ a factor of safety of about four for a material like steel, it is obviously unwise to allow a safety of only three for concrete on the basis of 28-day tests.

The calculus is freely employed, but this cannot be regarded as objectionable when dealing with intricate matters. The nomenclature is not generally uniform with American practice, so that a tabulated summary would have been a very useful addition.

On the whole, this volume contains much valuable information both for use as a text and reference book. In style, it corresponds to the uniform excellence of the Wiley publications.

Rivington's Notes on Building Construction. Edited by W. N. Twelvetrees, M.I.Mech.E. Published by Longmans, Green & Co., London. Part I., 306 pages; 484 illustrations. Part II., 332 pages; 395 illustrations; 6 x 9 ins.; cloth. Price, $2.25 each.

When to the title of this work we add the words "as practiced in England," and give a list of twenty-one names of contributing authors (including the names of some of the best-known architects and engineers in England), and mention at the same time that the present edition is the last revision of a book that has been a standard text for forty years, its character is well displayed.

It is intended as an authoritative text and hand book for students and architects, and certainly the comprehensive character of its subject matter, the concise yet clear treatment that prevails, and the prestige of the authors would indicate that its object is fulfilled.

Unfortunately, there exists so marked a difference in building methods and devices in England and on this continent that the Canadian reader will find the work of secondary value only. The architect or engineer fully conversant with American practice can use it with profit as a fertile source of suggestion, but not so the student if he hopes to put his reading into practice.

Unlike many books on building, Rivington's Notes does not indulge in pages of futile description in cases where one clear drawing will suffice. In consequence, it is a very easy book of reference, and most valuable where working drawings can be used. Each term peculiar to any branch of building is usually defined at the first of the chapter dealing with that branch, and the text then proceeds with description and illustration of the best methods in vogue. Very little information is included concerning the properties of building materials, and some of what is given is not true of the materials on this market. Where so many writers have had a finger in the pie one would expect to find repetition and contradiction, and that this is so in a very minor degree speaks well for the book and its editor. On the whole, it is a very excellent work, containing such a fund of building fact that it can not fail to be of value to any one occupied with building.

PUBLICATIONS RECEIVED.

American Society for Testing Materials.—Proceedings of 18th annual meeting.

Upper White District, Yukon.—By D. D. Cairnes. Report to the Department of Mines, Canada.

Department of Naval Service.—Report of the Deputy Minister for fiscal year ending March 31st, 1915.

Arisaig-Antigonish District, Nova Scotia.—By M. Y. Williams. Report to the Department of Mines, Canada.

Department of Public Works, Canada.—Report of the Minister for the fiscal year ending March 31st, 1915.

U.S. Bureau of Mines.—Fifth annual report of the director to the Secretary of the Interior of the United States.

The Oil and Gas Fields of Ontario and Quebec.—By Wyatt Malcolm. Report to the Department of Mines, Canada.

Department of Marine and Fisheries of Canada.—Forty-eighth annual report, covering the fiscal year 1914-15.

Canadian Production of Coal and Coke.—Annual report for the year 1914, as prepared by Mines Branch, Department of Mines, Canada.

Canada and the British West Indies.—By Watson Griffin. Published by authority of Sir George E. Foster, Minister of Trade and Commerce.

Relining Old Brick and Ashlar Sewers.—Bulletin on use of the cement-gun in this work. Published by the Cement-Gun Co., Inc., New York City.

Trenching Machinery.—U.S. Department of Agriculture, Bulletin No. 98, concerning trenching machinery used for the construction of trenches for tile drains.

Asphalt Primer and Colloidal Catechism.—A 20-page publication of the Barber Asphalt Paving Company, Philadelphia, explaining the principles of colloidal chemistry as applied to the paving industry.

Duty of Water Experiments.—Bulletin No. 4 of the Irrigation Branch, Department of the Interior, Canada, relating to experiments conducted at various points in the Canadian West. 62 pages, 6 x 9 inches, illustrated.

British Columbia Hydrographic Survey.—Water Resources Paper No. 14, Water Power Branch, Department of the Interior, Canada. Report for 1914, prepared by R. G. Swan, Chief Engineer; 534 pages, illustrated.

CATALOGUES RECEIVED.

Wells Light for Contractors, Etc.—Catalogue regarding portable night light burning kerosene oil. Published by the Alexander Milburn Co., Baltimore, Md.

COAST TO COAST

Calgary, Alta.—The Ogden bridge has reached such a stage of construction that street railway traffic is now passing over it.

Mimico, Ont.—The construction of the joint sewerage system of New Toronto and Mimico is proceeding with few interruptions owing to severe weather.

Winnipeg, Man.—The Arlington Street bridge has been practically completed and arrangements are being made for the routing of street car traffic over it.

Hamilton, Ont.—H. M. Marsh, Industrial Commissioner, in his annual report, stated that during the past year eight new industries had located in Hamilton.

Edmonton, Alta.—The total mileage of water mains in Edmonton at the present time is 162.23, with the number of services 10,495, or an average of 64.6 to the mile.

Munro Township, Ont.—An important platinum find is reported in Munro Township, ten miles east of Matheson, Northern Ontario. It is stated that assays, of which five were made, run from $180 to $1,800 a ton.

Montreal, Que.—An announcement has been made that the Canadian Car and Foundry Company has obtained a loan of $1,500,000 from the Russian government, and it is understood that more funds will be available from the same source as needed.

Winnipeg, Man.—The Greater Winnipeg Water District Commission states that there will be no delay, owing to the financial condition, in the completion of the Shoal Lake aqueduct. Arrangements have all been made regarding money matters.

North Vancouver, B.C.—According to the annual report of Mr. A. B. Clucas, acting city engineer, during 1914 there were constructed in the municipality 1.5 miles of sidewalk, 1.7 miles of road graded, 3.9 miles of roads cleared, .17 mile of water mains laid, three hydrants and 28 gate valves installed.

Vancouver, B.C.—A decision favoring McIllwee and Sons in their suit for a quarter million dollars damages against Foley, Welch and Stewart over boring the C.P.R. tunnel at Roger's Pass has been handed down by the Privy Council, which dismissed with costs the appeal of Foley, Welch and Stewart from a judgment of the British Columbia Court of Appeals, awarding McIllwee and Sons the full amount of their claim. The plaintiffs claimed damages for a cancelled contract.

Toronto, Ont.—It is reported that legislation will be introduced at the coming session of the Legislature to provide for about $300,000 more for the Toronto-Hamilton highway. This road will cost when completed about $850,000 or $900,000, whereas the money provided under the original estimate by debentures was only $600,000. The increase in cost has been partly occasioned by the decision of the commission to increase the width of the road from 16 feet to 18 feet. This caused an additional cost of one-eighth, or $75,000. Other items in increasing the cost were: The extra cost of carrying on operations in the cold weather; the effort to supply employment, $50,000; old concrete culverts which were undermined and had to be replaced, $100,000; washouts occasioned by a great midsummer rainstorm, $50,000.

PERSONAL.

C. D. CAMPBELL, city engineer of Galt, Ontario, has resigned.

J. S. LAING, B.A.Sc., formerly assistant engineer of Galt, Ont., has been appointed town engineer of Barrie, Ont.

H. L. VERCOE has been appointed special engineer of the Canadian Northern Railway for lines west of Port Arthur, Ont.

J. C. BRECKON, formerly waterworks engineer for the city of Vancouver, B.C., is now associated with the engineering firm of Du Cane, Dutcher & Co., Vancouver.

N. W. EMMENS has severed his connection with the Great Western Mines Development Co., Limited, and has opened an office in the Credit Foncier building, Vancouver, B.C., as consulting mining engineer.

Captain PAUL F. SISE, B.Sc., has been appointed adjutant of the 148th Battalion, Montreal, and has volunteered for overseas service. Captain Sise is vice-president and general manager of the Northern Electric Company. He was born November 10th, 1879, and was educated at Bishops College School, Lennoxville, Que., and at McGill University. He was one of the organizers of of the University Club, Montreal.

Capt. Paul F. Sise.

Lieut. W. H. MUNRO, manager of the Peterborough Radial Railway, has been promoted to a captaincy. He is in the mechanical transport branch of the Canadian Army Service Corps and went to England last July.

MANFRED FREEMAN, who has been elected public utilities commissioner for Lethbridge, Alta., to succeed Mr. Reid, has been connected with the Lethbridge Waterworks and Electric Light Company as chief engineer, manager and secretary.

W. N. JOHNSTON, B.Sc., has received the appointment of costs engineer on a new piece of construction for the Canadian Copper Co. at Copper Cliff, Ont. For the past two years Mr. Johnston has filled the position of resident engineer on sewer construction for the city of Toronto.

W. A. McLEAN, C.E., M.Can.Soc.C.E., has been appointed Deputy Minister of Highways for the Province of Ontario. The appointment is the result of the establishment of a new Department of Highways by the Government. Mr. McLean has been connected with the Department of Public Works since 1896, prior to which he was for three years engaged in municipal engineering at St. Thomas, Ont. His appointment to the position of Provincial Engineer of Highways, several years ago, was a very popular and well earned promotion. He has since acted as secretary of the Ontario Public Roads and Highways Commission. Last year he was president of the Canadian International Good Roads Convention, and in 1914 acted in a similar capacity for the American Road Builders' Association. He is a member of the Canadian Society of Civil Engineers, and is chairman of its standing committee on roads and pavements. He is a member also of the Association of Ontario Land Surveyors.

OBITUARY.

The death has been announced of Mr. Griffith D. Walters, who died in Calgary, Alberta, January 14, 1916, after a brief illness following an operation for appendicitis. Mr. Walters was born in Wales in 1884. He received the degree of B.S. in civil and irrigation engineering in the Colorado Agricultural College in 1911 and during the following year was assistant in irrigation investigations there under V. M. Cone. In 1913 he was engaged to take charge of the duty of water investigations for the Canadian Government under F. H. Peters, M.Am.Soc.C.E., M.Can.Soc.C.E., Commissioner of Irrigation, and was at the time of his death chief agricultural engineer, Irrigation Branch, Department of the Interior.

OTTAWA BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

On January 21st, Mr. G. R. G. Conway, M.Can.Soc. C.E., consulting engineer, Toronto, addressed the members of the Ottawa Branch of the Canadian Society of Civil Engineers. Mr. Conway chose as his subject "The Engineer and Standards of Beauty," in which he urged a freer co-operation between engineers and architects in the design of engineering structures, particularly in great public works such as bridges, railway terminals, dams, aqueducts, power houses, public highways, etc. The paper was fully illustrated with lantern slides giving examples of engineering structures where this co-operation had been attempted, and in some cases successfully carried out.

The branch has recently made arrangements with the officers of No. 3 Field Company, Canadian Engineers, for members of the branch to attend the lectures and drills. Three classes of participation in the military work have been arranged for: (1) drill and lectures with a view to taking examination for officer's certificate; (2) drill and lectures, but no examinations; (3) lectures only. Members in classes 1 and 2 will be attached as civilians to No. 3 Company.

The first lecture, January 28th, will relate to the "Royal Engineer and Signal Unit with an Army in the Field." Lectures will follow weekly.

Examinations will be held in April on the following subjects: Infantry training, military engineering, interior economy, organization and equipment, military map reading and sketching.

A special committee on military engineering has been appointed by the managing committee of the branch, consisting of the following: W. S. Lawson, chairman; R. de B. Corriveau, G. G. Gale, Alex. Gray, J. B. Challies.

COMING MEETINGS.

CANADIAN RAILWAY CLUB.—Fourteenth annual dinner to be held at 8 p.m. January 29th, 1916, in the Green Room of the Windsor Hotel, Montreal. Tickets may be obtained from Jas. Powell, secretary, P.O. Box 7, St. Lambert, P.Q.

AMERICAN ELECTRIC RAILWAY ASSOCIATION.—To be held in Chicago, Ill., February 4th, 1916. Joint dinner that evening with American Electric Railway Manufacturers' Association.

NINTH CHICAGO CEMENT SHOW.—At Chicago, Ill., February 12th to 19th. R. F. Hall secretary, 208 South La Salle Street, Chicago, Ill.