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Index to Volume 37

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Telephone Main 7404, Branch Exchange connecting all Departments
Cable Address: "Engineer, Toronto"
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The Canadian Engineer

A Weekly Paper for Civil Engineers and Contractors

Light Railway Engineering in Modern Warfare

Principles of Construction, Maintenance and Operation — Movement of Supplies, Ammunition and Troops — Different Types of Light Railways Built by French and British Armies — Their Use in Gas Attacks — Inner Rail of Turnouts Slightly Raised

By LIEUT. C. H. R. FULLER
Formerly Assistant Engineer, Toronto-Hamilton Highway Commission

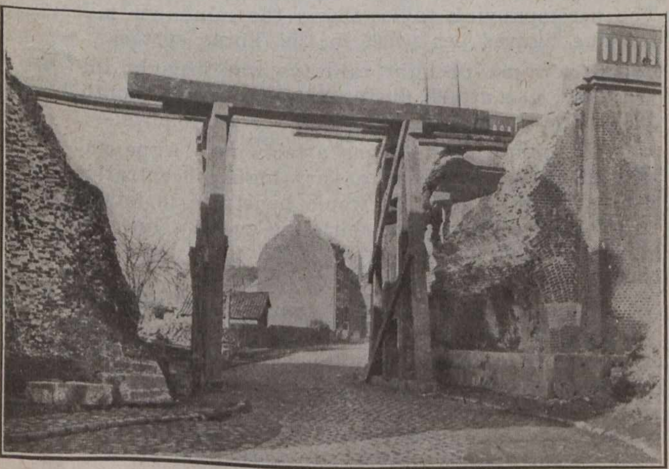
IN the construction of standard gauge railways, highways and canals in Canada and the United States, light railways, in the last few years previous to the war, assumed a prominent part. The wise and energetic contractor or engineer found it cheaper to grade or haul material for his work, directly to the spot required, by light railway than by the old method of teams.

The nearest standard gauge railway siding is sought for, and the light railway laid from this to the work in question. Material is then transhipped and hauled to the work by flat cars or other types adjusted to the light rail.

In grading, the light railway may be laid parallel to the highway proposed or railway, as the case may be, and earth moved from cuts to fills by trains of dump-cars, thus reducing the cost to a great extent. As the work advances, the light railway rails are pulled up and moved ahead, the weight of the rails lending itself to this.

Value Not Realized at First

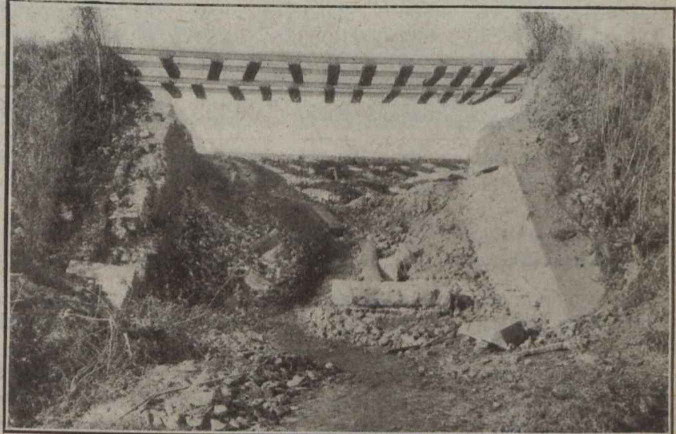
During the first year of the war the value of light railways was not realized; in fact, the British army, outside the building of a few trench tramways, had practically none at all; however, towards the end of the first year a few light railways were constructed on the Somme by Canadians and Royal Engineers. These lines were mainly lines connecting broad-gauge railways to R.E. dumps for carrying materials.



Standard Type of Bridge Erected by the Canadian Railway Troops

The value of light railways used in the little work they performed during the first year was soon realized. An increase in the number of technical units on construction and operation of this type of railway immediately took place, most of the construction being handled by Canadian railway engineers and operation by Royal Engineers and Australians. Light railways then came into operation on all fronts, and an organization to handle this branch became imperative. A director of light railways for the British army was created; under him, for each army, were assistant directors. Each A.D.L.R. had his own organization for each armmy, which subsequently became as follows:—

A Light Railway Chief Engineer, in charge of construction, etc.; a Superintendent of Operation; an Army Locomotive Superintendent; and an officer in charge of telephones and signals.



Brick Arch Near Courtrai Blown Out by Huns, Tracks Curiously Remaining Intact

When a construction unit comes into an army area, they automatically come under the A.D.L.R. for that army, and, consequently, the Army Chief Engineer. An operating company is controlled by the Superintendent of that army.

This organization was brought into a state of greater efficiency by opening up minor appointments in different parts of the work where needed.

Canadian Railway Units were in a corps composed of themselves alone for administration, discipline, etc., under a brigadier-general, but were distributed all along the front under different army A.D's.L.P. for their technical work.

Principles of Supply in an Army

The service of supplies in an army is assured by means of: (a) Supply depots on lines of communication; (b) railway trains; (c) mechanical transport supply columns; (d) trains; (e) supplies carried by transport units and the individual.

Supply depots may be base depots, main supply depots, or field depots. A base supply depot is located at the base of operations to receive supplies from overseas. Main supply depots are placed along the lines of railways or at an advanced base. Field depots are small, temporary depots in the immediate neighborhood of troops.

Troops are supplied with supplies by rail and fast-moving mechanical transport, delivering daily to trains, and thence to troops from railheads. At railheads the supplies are received by the supply columns and conveyed to rendezvous and refilling points. A rendezvous is a spot where representatives of the H.Q. concerned, order the supply columns to refilling points situated in the locality concerned. These are usually fixed at the actual refilling point.

Ammunition differs somewhat from the system of supplies on account of the fact that the replenishment of am-

ANALYSIS Traffic Dead Weight Tonnage Standard Weights	SECTION Ouderzeele Tons	Watou Tons	Vox Vrie Tons	Weston Hoek Tons	Total Tons
Personnel	90	1,851	2,322	3,027	7,290
Ammunition	420	1,338	2,342	440	4,540
R.E. stores	1,403	192	814	814	3,233
Timber	36	60	.....	.....	96
Ordnance Stores:					
Guns					
Supplies	91	70	20	192	373
Coal and coke ...	5	581	105	...	691
Roadstone	.	72	...	...	72
Empty cases ...	.	30	10	103	143
Salvage	.	..	1,350	1,344	2,694
Miscellaneous ..	54	152	180	46	432
Total army traffic	2,099	4,346	7,143	5,966	19,554
Ballast	3,320	2,626	880	163	6,989
Railway material	899	1,003	1,284	600	3,786
Miscellaneous ..	891	342	486	219	1,938
Total traffic	7,847	8,317	9,793	6,948	32,267
Total ton miles..	48,695	58,061	52,840	54,065	*213,661

*Includes 32,267 tons in French System.

munition is more or less spasmodic, and neither the precise quantities nor the times they will be wanted can be exactly foreseen.

The reserves of ammunition are divided as follows: (1) Regimental reserves; (2) artillery brigade ammunition column reserves; (3) divisional ammunition column reserves.

Parks are placed within easy reach of ammunition columns, who carry the ammunition forward. Refilling points may be placed at various distances from the parks to suit the situation.

"Personnel" includes the movement of troops, which is usually carried out by means of standard gauge trains and marches. Motor buses and lorries are also used for quick movements.

Wounded are brought to field ambulance units by ambulances or stretchers from advanced dressing stations and taken to clearing hospitals in ambulances.

Light Railways Supersede Older Methods

Light railways have superseded the supply column to a great extent. All kinds of supplies, such as trench material, steel, sandbags and cement, are carried from the supply depots to the most advanced dumps directly by light railway. Approximately 400 tons of R.E. material may be hauled in twenty-four hours on an army front under ordinary conditions of trench warfare, besides other supplies.

Under ordinary conditions of warfare, contours of country, etc., most ammunition is hauled from refilling points in the back areas to forward area dumps, or else direct to the batteries concerned. For heavy batteries ammunition is often transhipped directly from a railhead to light railways, and hence direct to batteries. These conditions illustrate the amount of labor and handling of ammunition which is done away with by making use of light railways. Many batteries are so situated that it would be impossible to get ammunition into them efficiently by any other way except by a light railway. Main lines are constructed through a battery area, with spurs running into each battery to be supplied. These main lines are connected in the rear by lateral lines and various other back area lines, enabling dumps to be placed out of reach of forward area shelling, although they may be subject to some long range shelling and bombing.

Another advantage of using light railways is the fact that they may be built through the front between roads. Ammunition carried along roads is subject to far heavier shelling owing to the fact that they are usually well marked by enemy batteries. A light railway is hard to range on, and when it is broken, is it very quickly repaired, causing practically no delay.

Within 500 Yards of the Trenches

Two thousand tons per twenty-four hours of delivered ammunition is an average carried by light railways under ordinary conditions. If abnormal battle conditions exist, as much as 5,000 tons may be carried forward.

Light railways are usually built up to within 500 yards of the trenches in the forward area. This enables them to be used also for the transport of infantry, working parties, etc. An infantry battalion going into rest, or a battalion going up to the front, may be brought directly back to approximately the location of their rest billets or taken up to within a short distance from their location in the trenches. This has a great advantage over the long marches "up the line" over roads constantly under shell-fire. Wounded cases are brought back directly to clearing hospitals from advanced dressing stations, which advantage is obvious.

The amount of personnel handled in twenty-four hours by light railways, of course, depends on the character of the front. If an offensive is in operation on one part of the front, more personnel will be carried than on a comparatively quiet front, although it is impossible to carry all the troops in the area and other supplies as well. On the Ypres front in May, 1918, approximately one complete division was carried forward to relieve another division which was carried out of the line back to rest stations, besides carrying on the supply of ammunition and material at the same time. The accompanying table shows the minimum mileage and tonnage figures per week in the Ypres system.

A new use of light railways was brought into use by the cloud gas attack during the end of the month of May, 1918. The method of operation was as follows:—

The object of this gas attack near Ague and Tmulet was to discharge gas at a very high concentration to produce a cloud of gas that would penetrate in lethal strength to a considerable depth behind the enemy's lines. The cloud was estimated to be highly lethal to a depth of 9,000 to 10,000 yards from the point of discharge.

The gas was discharged from trains of special trucks, containing cylinders fitted with an electrical device for opening all cylinders simultaneously. These trucks were conveyed from railway bases to power heads by tractors on the light railway. Forward of power heads, infantry pushing parties, consisting of fifteen parties of twenty men each, pushed the trucks ahead. Each light railway forward line was allotted seventy-five trucks, each containing twenty-one cylinders. The number of cylinders amounted to about 4,725 in all.

The seventy-five trucks were sent up along each line in seven trains of ten trucks and one train of five trucks. The pushing parties, after pushing to the discharge points, were withdrawn to a trench system in the vicinity, where they awaited the completion of the attack. After completion, the pushing parties organized as before, hauled the empty trucks back to power heads by means of 40-foot ropes, which were used to keep the men away from residual gas. On reaching the power heads the trucks were made up into trains as before and conveyed by tractors back to the railway bases.

Royal Engineers load cylinders into the trucks and provide a sapper to accompany each truck. Maintenance of track was carried on during the attack by Canadian Railway Engineers, who ensured that the track stood the loads required. An adequate supply of material and tools were kept ready to fix breaks due to shell-fire. The importance of this is shown by the fact that due to breakage of tracks by enemy shell-fire the attack was delayed one hour and three quarters, although the track was immediately repaired.

A pilot engine was used to travel in front of each group to avoid every chance of delay by collisions and breaks in track, etc.

In order to carry out this attack, the Light Railways on the day previous had to be closed to ammunition and food supply from 12 o'clock noon onwards. It was arranged that two days' supply would be taken up on a previous day, thus allowing for one day's supply to be used following the night of the gas attack.

Construction of Light Railways

The following types of light railways existed in France during 1918:—

(a) Metre gauge railways.—Weight of steel 451 lbs. per yard.

(b) Light railways, 2 ft. gauge.—Weight of steel 20 lbs. per yard.

(c) French light railways, 60 c.m. gauge.—Weight of steel 9.5 kilos per yard.

(d) Artillery decauville, 60 c.m. gauge.—Weight of steel 9 kilos per yard.

Metre gauge railways were in use in France and Belgium long before the war. The rolling stock is limited and is seldom used except by French and the civic governments. Latterly they were used more extensively.

Light railways are the railways most used in the British army, which we are considering in this article. The gauge is 2 ft. and weight of steel 20 lbs. per yard. In back areas and rear forward areas wooden ties are used. In front areas sectional steel, assembled on steel ties with clip bolts, are used to ensure greater speed in maintenance.

The French light railway has slightly less weight than the English light railway, due to the fact that the French system of standard weights includes the ties, fastenings and both rails.

Artillery decauville is assembled steel on steel ties. It is primarily used for pushing small flat cars about in a battery position and also used for trench tramways in the extreme forward line. Locomotives are not used on it. It is valuable in serving as the connection between the light railway spur and the actual guns.

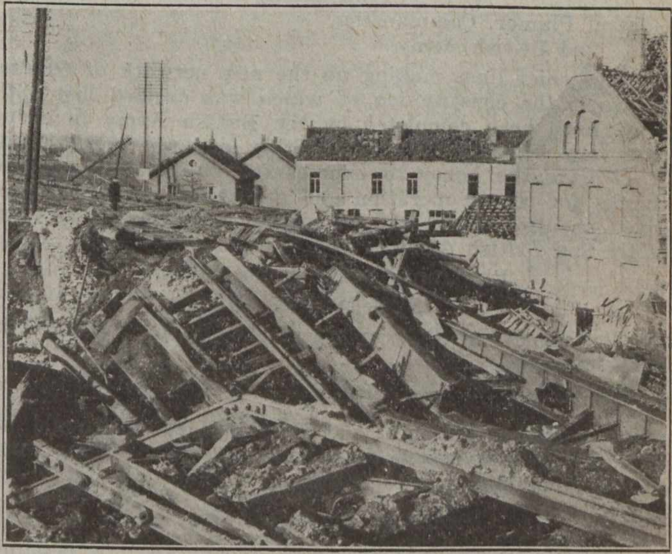
On Fronts After Advance

On the ordinary stationary front caused by the continual trench warfare, with little variance in the trench line of either side, a system of light railways is quickly built and reaches a point where maintenance and a few extra spurs here and there is the only work carried on; however, an advance by our forces quickly throws the construction machinery into action. Gun spurs, spurs into ammunition dumps, R. E. dumps, etc., then become useless due to the forward movement of batteries, dumps, dressing stations, etc. The main lines must quickly be extended to the forward batteries and spurs built into new positions. New switch lines must be constructed so that no delay occurs in the forward movement. New locomotive and storage yards also must be built forward of their former locations.

After an Enemy Advance

If the advance by the enemy is over considerable territory, necessitating a retirement (for strategical reasons) of the whole army affected, the network of light railways becomes nonexistent and must be relayed farther back to conform to the new front. This was especially the case after the German advance on the Ypres front extending to south of Armentieres in 1918. Every one knows the old military principle that a line of communication must run at right angles to the front line. After the enemy's advance a decided salient was created, causing the line of communication to swing around to the northwest to conform, thus causing the necessity of a large increase in new light railways to be built rapidly to serve new ammunition depots, new refilling points, new R. E. dumps, new workshops, new clearing hospitals, etc.

This causes a feverish activity on the part of railway engineers, who work day and night building up a new system. The light railway line which exists farthest from the front line should be extended to enable all rolling stock, etc., to be evacuated quickly in case of a further advance by the enemy. Lines are constructed running parallel to the new front line caused by the salient. Every consideration is given to running lines to meet standard gauge railways for transhipment purposes. Spurs are constructed to serve ammunition depots, and in the case of the Ypres area it was



Bridge Between Lille and Brussels Destroyed During Hun Retreat—Rebuilt by Canadian Railway Troops

decided to built light railways in the French army area due to the close co-operation of the two armies at this stage.

When the above work is completed it is thought advisable to construct cross lines to serve reserve battery positions which are constructed in case of another advance by the enemy. Also in the new forward area all locomotive yards and storage yards are dismantled, leaving only the running tracks over the main lines. Any lines which are double tracked and are in the new forward area are also torn up, leaving only a single track. It was at this stage that the French army realized the full importance which was attached to the light railways and many appreciative remarks were made regarding this work. A letter from the general commanding the French army of the north appears on the next page.

On New Fronts

On new fronts devoid of light railways, an entirely new system, both in forward and back areas, must be built up. This will happen in an area taken from a force of different nationality than our own. A system of forward lines to feed batteries and dumps is first considered but not constructed. There may be three to six forward main lines decided on. Then a main back area line is located and built to serve the forward main lines which are then constructed in turn. As the track advances, forward locomotive and storage yards are constructed, spurs built into forward standard gauge lines for transhipment and the usual spurs to serve batteries.

Before an Advance

This is a case of advancing light railways as far as possible towards the trenches and constructing a few new spurs into advanced dumps established preparatory to the advances.

It was shown in 1918 that light railways could be maintained and constructed ahead of the H.Q. of the infantry battalion in the line. This enables the advance of our forces to be closely followed up by a network of steel and thus assisting their progress by bringing up supporting troops quickly from back areas to the line and delivering rations and ammunition.

In order to carry this out, a railway map of the existing light railway lines in the front under consideration should be consulted. The lines which could be used as main lines and those which could be used as cut-off lines or avoiding lines should be picked out and placed under increased maintenance so that these may be in the best running condition possible at the moment of the advance. As soon as the advance, progresses, if it is successful for any reasonable distance, the lines decided on should be immediately constructed on ahead with the avoiding lines so that ammunition, rations, etc., will follow without delay.

(Translation)

General Plumer, Commanding,
2nd British Army.

The chief lines making up the new network of 60 c.m. railways, the construction of which was decided last 12th May, have been completed by the British Army in every case very satisfactorily, very quickly, and well constructed.

I have the honor to express to you my very sincere thanks for the co-operation and the valuable aid which is given us also by the 60 c.m. railway construction services of the 2nd British Army.

Remaining yours respectfully,
(Signed) H. de Mitry,
Commander of Detachment of the Army of the North, French Forces.

Before an Enemy Advance

The knowledge that an attack on any front is pending is usually gained by information received from prisoners, aerial observation and from our own spies; preparations should then be made in case it is necessary to retire for a short distance as after an enemy advance.

The strictest attention should be directed to light railway bridges the size of which would be sufficient to warrant demolition to cause delay to the enemy advance. These should be mined by means of gun cotton and fuses and sentries posted ready to demolish on receipt of orders from the proper authority.

Surveys, Construction and Maintenance

The principles of surveying and locating standard gauge railways in any country should be made to apply in light railway work. In some armies light railways are not surveyed but constructed only on information gained by a preliminary reconnaissance. This is poor practice and at the present time experience has shown that instrumental surveys and proper preparation of plans and profiles will give better results.

The first step in connection with any proposed light railway line should be to obtain the best available maps of the country in question. Sheets on a scale of 1/20,000 are very useful. On such maps routes may be sketched and a very good idea of the maximum grades of the railway obtained. Routes which are obviously unsatisfactory are eliminated from further consideration. Those that look favorable should be examined by travelling over them. This method minimizes the actual amount of field examination. Grades, curvature, length of time, earthwork and character of soil, bridging and general drainage should be taken into consideration.

Of course, in all consideration of these matters, the serving of R.E. dumps, ammunition dumps, gun positions, A.R.P.'s, etc., should not be lost sight of. The traffic to be accommodated by the proposed light railway may be heavy in one direction and light in the other, in which case a grade of 1 per cent. may not be as serious in one direction as a grade of 0.5 per cent. will be in the opposite direction.

An approximate route having been decided on, a preliminary survey is run, composed of a transit party, level party and an officer in charge. A profile of the preliminary line should be kept up to date during the progress of the survey to give aid in judging whether to push ahead or back up and run the line over different ground. On completion of the preliminary survey the final grade line is decided on and placed on the profile, due regard being given to keeping total quantities of excavations and embankments to a minimum. Long cuttings should be avoided, especially in the forward area. Vertical curves are not used, but short breaks in grade may be decided on to ease, for instance, a level grade connecting a 1 per cent. grade.

Lines should not be located across in front of artillery positions but always in rear when possible. Broad gauge crossings should be 90 degs., 75 degs., 60 degs., or 45 degs. Metre gauge crossings should be made to conform with above angles as nearly as possible. Main lines should not parallel roads closer than 200 yards distance and should be located to serve groups of batteries and not single units.

Plans of proposed lines are plotted on a scale of 200 ft. to 1 in. They should show nature of ground, buildings, roads and other railway lines, streams, the kind of crop and measurements of trees, etc., which may be destroyed. Profiles are plotted on scales of 200 ft. to 1 in. horizontally and 10 ft. to 1 in. vertically. A route map on standard square system must always be prepared to accompany plan and profile. Yard and station plans are plotted on a scale of 40 ft. to 1 in.

Construction by Railway Engineers

Grading.—On authority being received to commence construction, various units should be attached to railway engineers for unskilled labor. Each railway battalion is equipped with a complete set of slush escapers hauled by mule teams, which are used to grade the heavier portions of the line. A level party must lay out the work by means of slope stakes before grading. Quantities must not exceed 3,000 yards a mile. The general principles of standard gauge railway practice should be made to apply to light railways. A sufficient berm must be left between borrow pits and the toe of the embankment. All culverts should be properly bedded to take care of the drainage. Culverts should always be laid at right angles to the line diverting drainage courses where necessary. Concrete 8 ins. and 12 ins., and corrugated pipe 18 ins. and 24 ins. diameter are used.

Bridges.—Where a single span only is required, wood stringers 9 ins. by 18 ins., or 8 ins. by 16 ins., should be used. Wherever the soil is unsuitable, in case of wide spans, pile foundations will be driven by a track driver. A record of driving must be kept, giving penetration measurements.

Bridges should be avoided, if possible, in the forward areas, owing to their vulnerability. Another important point to note is that shore bents are not placed on sills but pile driven invariably.

Track.—Rails of 20 lbs. per yard are used on all lines. Track is laid with staggered or broken joints with nine ties per five metre rail length. If the formation is very soft, this number may be increased by two. Joints are supported and not suspended. In the case of soft formations, 5-in. by 2-in. slabs are laid under the ends of the ties, particularly inside of curves.

Assembled track is laid with even joints and 2,929 steel sleepers per mile. When metre gauge ties are used ,the spacing is 2 ft. 6 ins. centre to centre of the ties. Gauging should be most accurate, especially on curves. Tie plates shall be used, two per tie, on all curves of a lesser radius than 100 metres. Guide rails may be placed where necessary on inner rails.

All turnouts are of 30-metre radius. Where the turnouts are riveted through steel ties, the two rivets tying the check rails to the two centre ties are cut out. The centre block is removed and check rail jim-crowed, so that the clearance between it and running rail is 1¼ ins. The bolt, if present, is replaced and tightened and the block of wood wedged in between the check rail and the throat of the frog.

In case of unriveted turnouts, the gauge at the nose is exactly 2 ft. and a block of wood inserted between the middle of the check rail and the throat. The gauge throughout the curved part should be ⅜-in. slack, easing off to the heel of the switch in a length of about 4 ft.

In order to facilitate the passage of Baldwin and petrol electric locomotives, a slight raise of the inner rail on turnouts has been found most satisfactory. This is an important point to remember in light railway practice.

The gauge of all curves should be ⅜-in. slack, except where rails are riveted to steel ties, which, of course, cannot be altered.

Four spikes should be used on each tie, two inside, opposite one another, and two outside. On curves, eight spikes per tie should be used.

One-eighth-inch expansion should be left at the joint in each five metre rail length. Experience has shown that no elevation should be put on the outer rail of 50 metre curves. On 30 metre curves a slight super-elevation should be placed on the inner rail. This is done on account of the passage of very slow-moving trains hauled by Baldwin locomotives. One-half inch elevation on outer rail should be applied to curves of 100-metre radius.

Ballast.—Every attempt should be made to obtain ballast locally, particularly from ruined brick buildings. Ballast is also brought in by train. It may be sand or mine earth.

The minimum allowance of ballast per running yard of track is 0.2 cubic yards. The width of ballast should be 6 ins. beyond the end of the tie. The average lift is 6 ins. under the tie, made in two lifts of 3 ins. each, well tamped, two men working diagonally packing under the rail. Earth on no account should be packed on the ballast shoulder, as this stops drainage. A light earth skimming may be thrown on top of light sand ballast to prevent loss through wind storms.

Road and farm crossings should be built as required. Mine earth approaches and an inner platform of four rails inside the running rails and outer guard rails, filled with mine earth well packed, make good crossings.

Reports.—These should be turned in by company commanders to their chief engineer daily and weekly on a standardized form.

Daily reports should indicate the area in charge of the company, number of officers and other ranks employed on the work, including attached labor, also the number employed on each class of work. Work is usually classified as follows: Grading, tracklaying and ballasting, in yards lineal; unloading B.G. cars and distributing L.R. cars, number of cars; dismantling of track, number of rails, ties, etc.; salvage of mine earth, number of cars of light railway.

A separate daily report should show the number of breaks in last 24 hours, on account of shell fire, with time and main locations. Also another daily report should indicate the detail of work by power allotted to the construction unit. Weekly reports should show total grading, ballast, tracklaying, tons of ballast in dumps, amount of track salvaged during week, etc.

Maintenance

Forward Area.—Maintenance in the forward area is probably the most important part of light railway work, where the highest technical skill is required.

It is most essential that forward area lines be intact and in fine working order at all times. Patrols of all lines in charge of an officer of technical knowledge should be placed day and night. The patrol should be able to tell quickly what part of the lines require repair and to be placed under increased maintenance.

Assembled steel is usually used to repair shelled out track quickly. As many as 50 breaks may occur on a line in 24 hours. This will make it difficult for any but highly skilled railway construction men to keep the lines open for operation. Care should be taken that too much attention is not paid to any one section of line when other sections are in need of ballasting and lifting. Gauge of track should be checked continually. A sufficient supply of reserve material should be kept to repair blown-out track.

Forty miles of forward area maintenance may be handled by one company of railway engineers. Five or six petrol tractors should be allotted to each company and about twelve box cars. The line is patrolled by four or five patrols, each travelling by means of a train, made up of a tractor, one box car carrying the personnel, one box car of ballast and one box carrying steel rails, ties, tools, etc. Each patrol has a certain area to keep up. The strength of each patrol depends on the condition of the track in its area and the amount of shell fire and blown-out track.

It is found that the light railway lines lying between the trenches and the battery area require very little maintenance, while the track running through the battery areas requires the most maintenance. Consequently, parts of battery areas should be allotted to all patrols. It is found that spurs to batteries and tracks running along sides of roads are shelled out more than other parts of the lines. Hence, all such track should be carefully examined by patrols.

Back Areas.—The maintenance work in back areas is much different from forward maintenance, since track is very rarely shelled out. The principle of patrols being placed on the lines still exists but not necessarily in the same strength. Ballasting and lining is the principle work carried on. Attention should be paid to spurs which are used continually. Unloading of standard gauge ballast trains should be done by the company in charge of back area maintenance.

Construction of new spurs required is also part of the work of back area maintenance. Civilian labor may sometimes be used as maintenance patrols under supervision of back area maintenance engineers.

Operation of Light Railways

The general organization for operation is a superintendent, a chief traffic officer, central control, district controls and controls in sections.

All traffic matters of operation will be dealt with by the traffic officer. He should be on two telephone systems, with direct telephone. The central control and, under his orders, the district controls, do the actual operation of the line. N.C.O. traffic inspectors are also appointed. These men and a district control officer are forward every night to check up the deliveries.

Traffic priority is usually as follows:—Personnel, rations, heavy ammunition, field ammunition, R. E. material, construction material, wounded and stretcher cases returning home from forward area, unless otherwise stated by control.

Ammunition (heavy) is loaded at the railhead as in field ammunition. This will be labelled "day" or "night" by the railhead ordnance officer, and a copy of this on paper, giving wagon number, number of battery, and light railway group station name is shown. Ammunition marked "day" goes forward by steam power as early as possible by a transfer engine to a selected point. It then goes forward to its destination by petrol power. Ammunition marked "night" goes forward by steam power to a selected point and leaves in convoy at dusk.

Field ammunition goes direct to batteries at night. These trains remain at a selected point during day and go forward by night, using petrol power, as points of delivery are, as a rule, well forward.

The normal train for light railway work at night should, if possible, be five wagons (59 tons), otherwise there is a loss of power. It is more satisfactory to send five wagons for three nights per week, than fifteen wagons one night, or two wagons six nights and three on a seventh.

All engines and tractors should be supplied with re-railing ramps. Maps showing light railways and names of stations should be supplied to all concerned.

The types of petrol locomotives used in the forward area, with their permissible loads, are as follows: Petrol electric, 45 tons; 40 h.p. tractor, 35 tons; 20 h.p. tractor, 16 tons.

Steam power should always be used in the back area, saving the petrol power for forward work. Several points in connection with conservation of power follow:—

(1) In 1918 the value of light railways was better realized than at any previous time. This caused a shortage of power and rolling stock and made necessary the greatest economy.

(2) About 15% of total power and stock available was allotted to construction units for hauling material. Power and wagons not actually required by these units should always be released to operation department.

(3) Locomotives and tractor parts were very scarce.

(4) Shop facilities for making repairs were entirely inadequate.

In view of the above, every care of power and rolling stock was enforced.

Varous operation rules follow here which also apply in forward area:—

(a) Trains should not run by a section control post without securing right of way by a green flag being shown.

(b) Trains should not be allowed to stop in between controls without notifying the control.

(c) Trains should not get right of way to one point and branch off to another.

(d) Loading or unloading on main line should not be permitted.

(e) No wagon bearing a repair label should be put into traffic.

(f) Engine fires should not be drawn in ammunition dumps. Cases of this have caused fires.

(g) Locomotives must not take water at odd places on the main line but at regular watering stations.

(h) Brigade reliefs should have priority over all other trains, personnel or otherwise.

The general analysis in back areas shows haulage of material, rations, etc., from railheads to ammunition refilling points, forward dumps, etc. This material is carried ahead from the forward dumps by other trains as required.

Military Importance of Light Railways

A railway system is a highly sensitive machine, easily dislocated by unskilled treatment. It is at the same time an organism most vital to the maintenance of the army. Subject to considerations of tactical security, the convenience of individual bodies of troops must be subordinated to the efficient working of the line as a whole.

BRITISH INDUSTRIES FAIR

THE British Industries Fair, to be held in 1920, will be limited to firms whose works and head offices are situated within the British Empire, and which are not controlled by foreign interests. In other words, as regards Canada, only such manufacturers as come within this definition will be eligible to exhibit. The fair will be held simultaneously in three different cities—London, Birmingham and Glasgow—representing three distinct sections, grouping various industries. Attention is drawn to the fact that these industrial fairs are not exhibits, but trade fairs, to which admittance is restricted to *bona-fide* buyers, seriously interested in the participating trades, and that admission is by invitation only, the general public being excluded. A preliminary event open this year for a period of eleven days drew an attendance of 17,600, and the authorities state that it resulted in the placing of orders amounting close on to $10,000,000, thus indicating the importance of the Trade Fair for which arrangements are now being made. Canadian manufacturers who are desirous of securing exhibit space or more complete particulars should communicate with the following British government trade commissioners:—G. T. Milne 367 Beaver Hall Square, Montreal; F. W. Field, 260 Confederation Life Bldg., Toronto; or L. B. Beale, 610 Electric Railway Chambers, Winnipeg.

MORE DISCUSSION ON LEGISLATION

WHEN is an engineer not an engineer? That seemed to be the main question at a special meeting of the Toronto branch of the Engineering Institute of Canada, held June 12th, at the Engineers' Club, Toronto. The answer, claimed the younger members of the branch, is, "When he is an assistant engineer."

The meeting was called by special request of the younger members of the branch, to continue the discussion on the draft of the proposed legislation which will be sought by the Engineering Institute in order to close or partially close the engineering profession.

Clause 7i, dealing with assistants working under professional engineers, was the one to which objection was taken by the younger members. J. C. Krumm thought that if the bill were passed in its present form it would mean that no engineers other than chiefs of departments would be considered as professional engineers.

H. A. Goldman strongly defended the professional standing of salaried engineers who report to superiors, and complained regarding the injustice the bill would do to the professional standing of these men.

Frank Barber thought that the bill in its present form does not exclude all salaried engineers from being considered as professional engineers.

Willis Chipman read several letters from other members of the legislation committee stating that undergraduates cannot expect to be considered as professional engineers immediately upon graduation. Among others who took part in the discussion were E. T. Wilkie, F. B. Goedike, C. S. Gzowski and Major H. N. Gzowski.

It was moved by J. C. Krumm and seconded by Frank Barber that a committee of five members be appointed to consider carefully the draft bill in detail and to submit recommendations to a general meeting to be called at a later date. This motion was carried and the following members were appointed to special committee:—

Willis Chipman (convenor), Prof. H. E. T. Haultain, Thomas Hogg, J. C. Krumm and H. A. Goldman. This committee will meet weekly until its work has been completed.

ACCELERATION OF CONCRETE HARDENING

AS the result of some experiments made by the U.S. Bureau of Standards to develop a method to accelerate the rate at which concrete increases in strength with age, it was found that the addition of small quantities of calcium chloride to the mixing water gave the most effective results. A comprehensive series of tests was inaugurated to determine further the amount of acceleration in the strength of concrete obtained in this manner, and to study the effect of such additions on the durability of concrete and the effect of the addition of this salt on the liability to corrosion of iron or steel embedded in mortar or concrete. The results to date indicate that in concrete at the age of two or three days the addition of calcium chloride up to 10 per cent. by weight of water to the mixing water results in an increase of strength over similar concrete gauged with plain water, of from 30 to 100 per cent., the best results being obtained when the gauging water contains from 4 to 6 per cent. of calcium chloride.

Compressive strength tests of concretes gauged with water containing up to 10 per cent. of calcium chloride, at the age of one year, give no indication that the addition of this salt has had deleterious effect on the durability of the concrete.

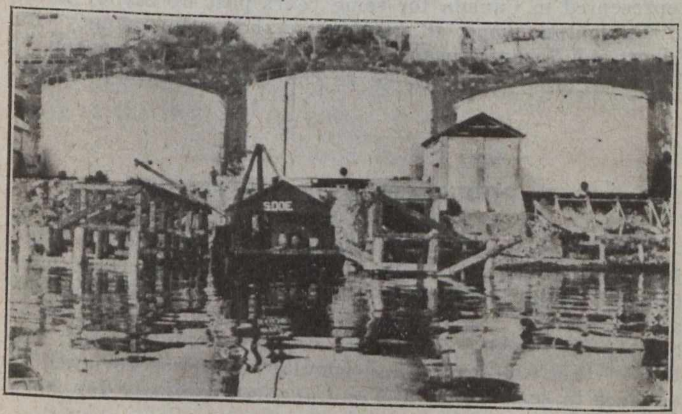
At a recent meeting of the Engineering Council of the United States, Chairman Loweth, of the Committee on International Affiliation of Engineers, presented a verbal report to the effect that a few weeks previously he had visited Vancouver and met five or six prominent engineers, who were receptive to proposals for activities that might be of common interest.

MOVING 60-FT. OIL STORAGE TANKS 150 MILES BY WATER

By A. J. T. Taylor
Manging-Director, Taylor Engineering Co., Ltd.

EARLY in 1918 the Powell River Co., operating a very large paper mill at Powell River, B.C., were faced with the necessity of immediately providing additional fuel oil storage capacity of 45,000 barrels to accommodate the last cargo of fuel oil that they expected to be able to obtain from the California fields during the duration of the war.

The matter of providing this storage was placed in the hands of the Taylor Engineering Co., Ltd., of Vancouver, who upon investigation found that not only was the price of steel tank plate very high, but it was impossible to obtain the necessary plates within the desired time.

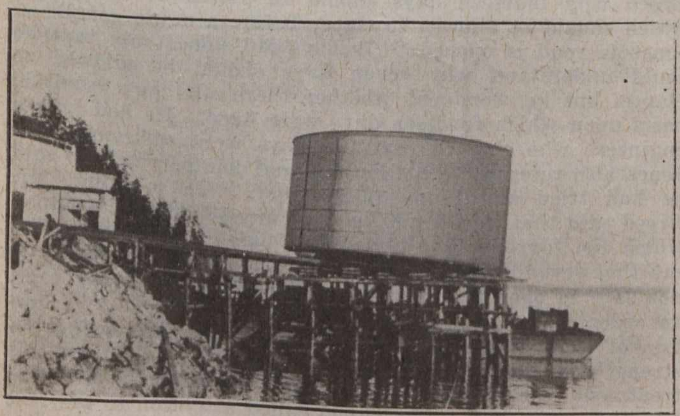


Tanks in Original Position at Bamberton

Concrete storage tanks were considered, and it was found that a tank of the capacity of 45,000 barrels would have cost in the neighborhood of $60,000.

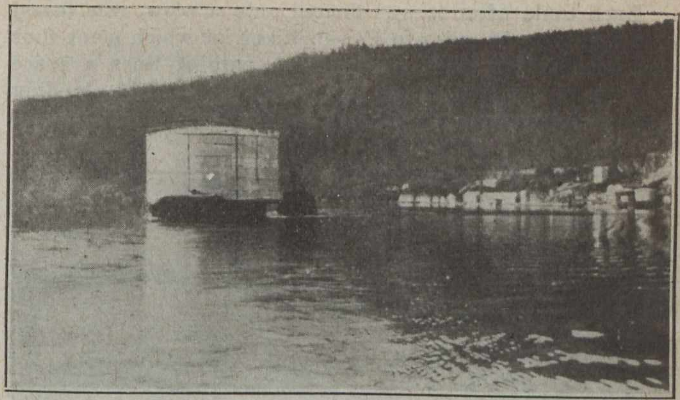
The situation appeared almost hopeless until it was discovered that the Associated Portland Cement Co., at Bamberton, B.C., had three 15,000 barrel storage tanks that they were not using, and were willing to sell. These were purchased on the foundations, as they stood at Bamberton, for approximately $24,000.

The question of transferring these tanks from Bamberton to Powell River was next tackled ,and it was at first thought that the only way of doing this would be the usual method of cutting the tanks down and re-erecting them. It was then found that, due to the large program of the Imperial Munitions Board for the construction of wooden and steel



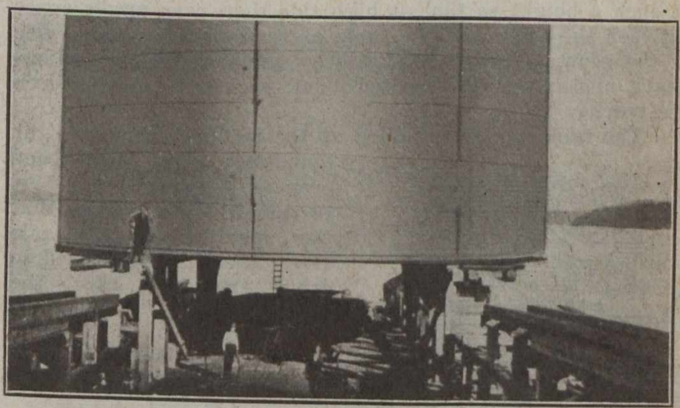
Scow Moving into Position Under Tank

vessels in the neighborhood of Vancouver, there were only three or four boiler makers available, and only one of these who had any experience in tank work. In other words, it was practically impossible to ge an adequate supply of labor to cut down and re-erect these tanks.



First Tank Loaded and Leaving Bamberton

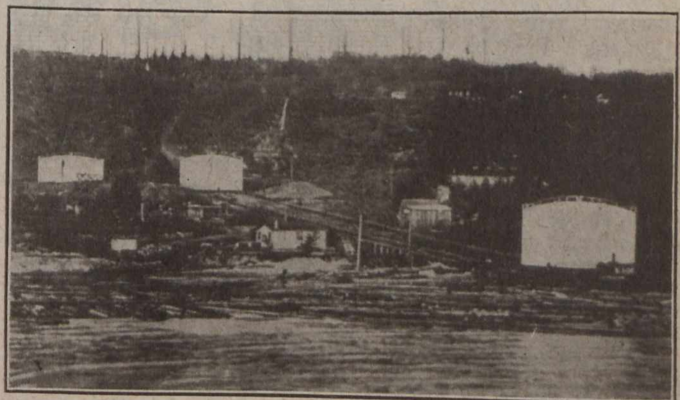
Therefore, it was determined to move the tanks in one piece after calculations had been made to determine the stability of each tank when mounted on a 30-ft. by 40-ft. scow. Two lines of piles were driven at Bamberton opposite the point at which the tanks were located. The tanks were lifted from their foundations by means of jacks, and set out over the water at a sufficient distance above the water so that the scow could be run in between the lines of piles at low tide, and after the tide came up, each tank would settle



Tank at Foot of Incline, Powell River

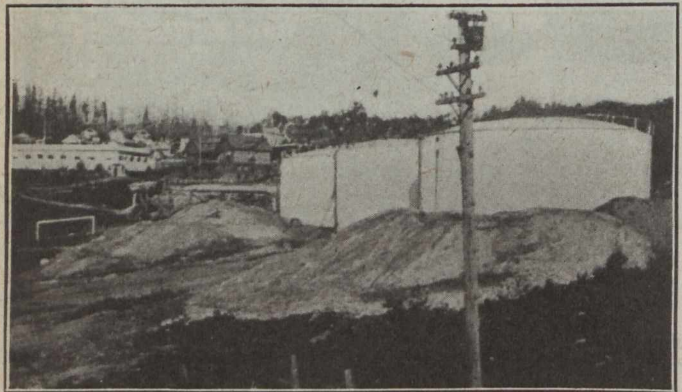
on the scow and the scow and tank be pulled free of the trestles.

It was thought desirable to brace the tanks internally to eliminate so far as possible the strain that they would be subjected to in their journey from Bamberton to Powell River, and the method finally adopted was to drill a 2-in. hole in the centre of the bottom of each tank, and in this hole mount a shackle from which was set up a series of turnbuckle guys from the top edge of the tank to the shackle, the structure of each tank being depended upon to prevent the sides being pulled in by the strain on the turnbuckles.



Ready to Haul up Incline at Powell River

Each tank, after it was floated onto a scow, was towed approximately 150 miles to Powell River, at which point four lines were driven, and between each pair of lines a space was left that would admit the scow. From the landing platform double tracks were extended up approximately 800

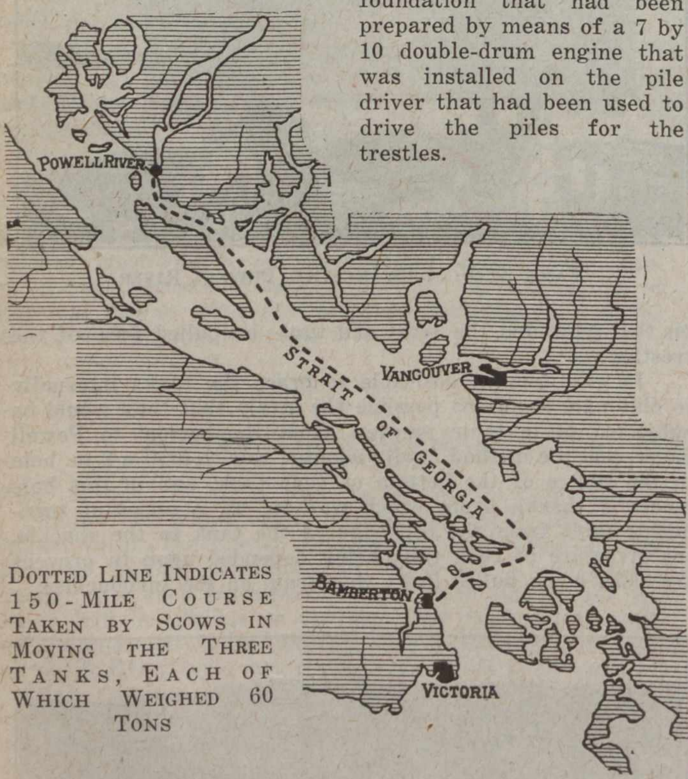


THE THREE TANKS IN FINAL POSITION AT POWELL RIVER

ft. to the final location for the tanks, these tracks being spaced so as to accommodate standard-gauge tracks.

The scow was floated between the trestles, which were at such a height so that at high tide there was ample space between the bottom of the tank, as it projected on each side of the scow, to enable the railway trucks to be run underneath, and as the tide lowered it left each tank supported on the trucks.

The tank was then hauled up the inclined runway to the foundation that had been prepared by means of a 7 by 10 double-drum engine that was installed on the pile driver that had been used to drive the piles for the trestles.



DOTTED LINE INDICATES 150-MILE COURSE TAKEN BY SCOWS IN MOVING THE THREE TANKS, EACH OF WHICH WEIGHED 60 TONS

The three tanks were unloaded and the job completed within thirty days at a total cost of $14,000, which was nearly $5,000 lower than the lowest tender had received from local iron works for cutting down and re-erecting the tanks. The total cost to the Powell River Co. of the three tanks complete was $38,650.

The tanks when loaded on their final foundations and tested, were found to be absolutely free from leaks,—evidence that they were not seriously strained in the moving operation.

AGENTS FOR ROBERTS FILTER MFG. CO.

ANNOUNCEMENT has been made of the appointment of E. J. Philip & Sons, Hamilton Trust Bldg., Toronto, as agents for Ontario for the Roberts Filter Mfg. Co., of Darby, Pa. Mr. Philip returned to Toronto last February after having spent two years in Porto Rico as resident engineer for the Roberts Filter Mfg. Co. on American government business in connection with emergency water supplies. Previous to his connection with the Roberts Co., Mr. Philip was manager at Brockville, Ont., of the gas, electric light and waterworks departments, and had previously held a similar position at Kitchener, Ont., where for seven and a half years he had been manager of the gas, electric light and street railway services. Prior to moving to Kitchener, he spent seven years as mechanical and electrical engineer for the T. Eaton Co., Ltd., Toronto. The Roberts Co. have been represented in Canada for some years past by Smiley Bros., of Edmonton, who will continue to have the agency for Albert and Saskatchewan, and by Arsenault & Plamondon, of Montreal, who will continue as the Quebec representatives.

PUBLICATIONS RECEIVED

TRAUTWINE, THE CIVIL ENGINEER'S POCKET BOOK.—First issue of the twentieth edition, published by the Trautwine Co., 257 South Fourth St., Philadelphia. Canadian selling agents, Renouf Publishing Co., Montreal. 1,528 pages, 4 by 6½ ins., flexible cover. Price, $5 net. This new edition of this well-known and popular work was reviewed in advance in some detail in *The Canadian Engineer* for April 10th, 1919.

The Dominion Tar and Chemical Co., Ltd., have moved their Toronto office from the Bank of Hamilton Building to larger premises at 400 McKinnon Building, Melinda St. Their new telephone number is Adelaide 3827.

At the good roads convention in Quebec, T. Harry Jones, city engineer of Brantford, Ont., discussed Mr. Breed's paper on the use of concrete in roads, bridges and culverts. Referring to the tests described by Mr. Breed (see *The Canadian Engineer* for May 29th, 1919), Mr. Jones said that they were most valuable in concrete road work from a pioneer standpoint, as the machine had the same effect on the pavement as the caulks of horses' shoes. If proper methods are used in their construction, said Mr. Jones, there is no doubt about the absolute satisfaction that will be given by concrete roads. He inquired from Mr. Breed why fourteen days should be stated as the period which should be allowed to elapse before a newly completed concrete road is opened to traffic. Mr. Jones said that he could understand why seven days should be allowed to elapse, but he wondered whether there was any scientific basis upon which fourteen days were fixed. He had known engineers who claimed that two days were sufficient. Mr. Jones also referred to the longitudinal joints, which he said he had tried and found satisfactory. In replying, Mr. Breed said that he did not know of any scientific data upon which the fourteen day period was based. Some engineers say that seven days are sufficient, while others say that it is not safe to open the road to traffic even in fourteen days. In order to harden the concrete more rapidly, a 4% solution of calcium chloride had been used, thus increasing the strength of the structure, and after seven days with this treatment, the increase in strength of the pavement was approximately 20%. Mr. Breed called attention to the fact that longitudinal joints should be continued up into the new material when resurfacing a road. In regard to transverse joints, he said that New York had spaced them at various intervals from 25 to 150 ft. and that no definite conclusions had yet been arrived at as to the best spacing, as the state had been experimenting along these lines only three or four years and it was impossible yet to arrive at any definite conclusion.

WATER WORKS SITUATION AT TORONTO

Consumption is Increasing and Additional Filtration and Pumping Capacity May Soon be Required—Works Commissioner Favors New Construction

DESPITE the new ver Mehr filtration plant, the city of Toronto is said to have insufficient filtration capacity for its present requirements. R. C. Harris, commissioner of works, has admitted that a certain amount of raw water had to be let through the mains recently because the combined capacity of the old slow sand filter plant and the new ver Mehr rapid sand plant was insufficient.

The slow sand plant is rated at 48-million gallons daily capacity and the ver Mehr plant at 60-million, so that on paper the city has 108-million gallons daily capacity, but it is only on paper, as the slow sand plant cannot filter with maximum efficiency more than 36-million gallons daily, as part of the plant is always "out" for cleaning, while the ver Mehr plant has had one or more units out of commission most of the time for one cause or another.

Difficulty with the Throats

The chief difficulty in connection with the ver Mehr plant has been the throats on the sand washers, which have been cut rapidly by the sand and water, and which have had to be constantly repaired and replaced. It is understood, however, that a heat treatment has been devised that is producing satisfactory results in these throats, and that the ones produced by this new process are lasting much longer. All of the units are now being equipped with these heat-treated throats.

Upon inspection of the plant a couple of weeks ago, *The Canadian Engineer* found that three of the ten units were out of commission. One was out on account of repairs to the throats, and another for other necessary repairs. In the third unit all of the sand had been removed and a layer of fine graded gravel, mixed 1 to 15 with portland cement, was being laid over the coarser gravel. It was stated that this was being done as an experiment to see whether it would hold down the coarser gravel, as trouble had been experienced during the back-washing with gravel being shot up into the sand.

Referring to the general situation, Works Commissioner Harris is reported to have said: "I can only say what I have said for years, and that is that the situation will never be satisfactory until we have a duplicate plant."

When he presented his plans in 1913, for a new filtration and pumping plant to be located at the east city limits (Victoria Park), the cost mentioned was $6,033,700, including nearly $2,400,000 for 32 miles of distribution mains. What the cost would be to-day is not known, but it would certainly be much higher. Some of the new mains have already been constructed, however.

In the two filter plants at the Island, Toronto has invested nearly $2,000,000.

Pumping Station Nearing Capacity

The main pumping plant is also nearing its capacity. The capacity of the steam pumps at the John St. station is 102-million gallons, daily, but on account of repairs, etc., the average pumping capacity is often not over 78-million gallons. There are electrically-driven standby pumps of 88-million gallons capacity. As the maximum consumption has reached the rate of 90-million gallons daily (for a portion of a day only), part of this must be supplied by the reservoir. The consumption during the recent very hot weather was at times 78-million gallons daily.

As all Toronto's water, whether filtered or raw, is effectively chlorinated, there is no danger of an epidemic, says the health department. In fact the department announces a new low record in typhoid mortality in Toronto, there having been only three deaths from that disease during the present calendar year, and two of those cases originated outside of the city. This is largely due to the fact that no expense is spared in treating the water whenever it is in a dangerous condition. When there is an east wind, endangering the supply on account of the sewage outfalls, three grains of alum per gallon of water are used at the new filtration plant, and the amount of chlorine fed at John St. is also increased.

The alum consumption for the month of May averaged over two grains per gallon. For a time chlorination was tried at the Island, ahead of filtration, as well as after filtration at John St., and it was thought that by chlorination ahead of filtration the amount of alum required would be reduced. Although this was found to be the case, the Health Department objected to the two chlorinating plants on account of division of responsibility, and the Island plant was recently removed and the chlorinating again centred entirely at John St.

The only chlorinating plant at Toronto Island now is a small unit for chlorinating the supply for the Island itself, and it is connected into the suction of the pump that supplies the services on the Island.

It is rumoured that before asking any further money for the extension of filter plants or the construction of new pumping stations, the Works Commissioner will eliminate all underground leaks by means of thorough pitometer surveys, and that he will also recommend the reduction of waste in houses and industrial establishments by the metering of all services, both domestic and industrial. It is well-known that nearly all of the city officials are keenly in favor of meters and also of constant surveys for underground and other leaks. A few years ago a very successful pitometer survey was conducted in Toronto, and this work is most likely to be taken up again in the near future, as the daily average consumption per capita is about 120 gallons and has at times probably exceeded 150 gallons.

PROGRESS BY ENGINEERING COUNCIL'S COMPENSATION COMMITTEE

REPORTING at the recent regular meeting of the United States Engineering Council, the committee on classification and compensation of engineers presented the following analysis of the situation:—

"In attempting to formulate standard rates of compensation for professional engineers, the first task is to find what rates are actually in force, especially in those fields where attempts at standardization have been made. The second task is to inquire what adjustment should be made to correspond to the great change which has taken place in the cost of living, or, in other words, in the value of the dollar. How great this change has been during the past 20 years is realized by few. Fortunately, an accurate determination is available in the statistical records of average prices which for many years have been gathered and published by leading commercial organizations.

"A record of average prices of the necessaries of life kept by R. G. Dun & Co., shows that prices have increased continuously for 22 years. A certain quantity of staple necessaries could have been purchased July 1st, 1897, for $72.45. By January 1st, 1905, the same quantity cost $100.32. On January 1st, 1914, before the outbreak of the war, the cost had risen to $124.53; May 1st, 1917, to $208.43, and October 1st, 1918, to the maximum of $233.23.

"This enormous increase in prices of the necessaries of life has been accompanied by an increase in wages, especially among workers organized in unions which had the power to compel attention to their demands. In the unskilled labor market the relations of supply and demand raised wages during the war to points in some cases exceeding the increase in the cost of living. No such increase has taken place in the compensation of salaried workers in the professions. It has been assumed that these workers, living in a different social environment, had a margin of compensation sufficient to enable them to meet the increased cost of living. This assumption is not justified by the facts. Where salaries have been increased during the past three years, there are few cases in which the increase has been at all commensurate with the increase in prices of the necessaries of life, which the salaried worker, like the wage worker, has to purchase. That this is a correct statement is amply proved by many direct comparisons which have been made of the wages of the workers in various skilled trades and the salaries of the rank and file of technical and professional workers.

"There is little doubt that an unprejudiced investigation would show that a large proportion of the salaried workers in professional occupations during the past three years have been unable to pay their living expenses from their earnings and have been obliged to rely on income from property owned or to use up savings of other years in order to maintain themselves.

Present Prices Here to Stay

"A serious question is whether the present scale of prices is here to stay. There has been a general belief that with the coming of peace and the resumption of productive industries a heavy fall would occur. It has been assumed that the salaried worker would have to wait for this so that he could again live within his income. It now appears, however, to be the opinion of many financiers and economists that the present high prices of necessaries are likely to continue for a long time, probably for several years. The salary of $2,000 a year which a man received from 1902 to 1905, will now buy less than $1,000 worth of necessaries. This has been the case for two years. If this is to continue for two, three or four years to come, then surely the salaried worker, in a professional or any other occupation, has an equitable claim to have his compensation brought back in purchasing power to where it was fifteen years ago.

A Gross Deception

"There is another aspect of the compensation of the professional worker which has been frequently misunderstood, but which, with present knowledge, ought no longer to deceive. The pay of professional engineers has for many years been influenced by the idea that a young man in the earlier years of his work should expect moderate compensation because of the future to which he might look forward. In Great Britain this idea found expression for many years in the custom of the young engineer paying a premium during a number of years' service in order to learn the business. There was justification for this idea during the period when the development of engineering was so rapid that a large proportion of the men who were turned out from the few engineering schools or the engineering workshops were able eventually to rise to positions of large responsibility and importance, commanding high salaries.

"That condition has been altered. Of the men who begin technical engineering work to-day, only a very few selected ones can rise to positions of responsibility commanding high salaries. The rank and file must inevitably be ten times as numerous as the captains and lieutenants, and a hundred times as many as the majors and generals.

"The man of exceptional ability, indeed, may find it worth his while to work for low compensation because of the future awaiting him. But to hold up to the rank and file of technical workers the idea that they can afford to work for insufficient salaries for the sake of some future high position, which they have not one chance in twenty or fifty of attaining, is a gross deception.

In Public Interest that Engineers be Well Paid

"The committee believes, therefore, that in adopting standards for the compensation of workers in all technical fields, due consideration must be given to the great increase in the cost of living which has taken place. The dollar of salary must be considered with regard to what it will purchase to-day and is likely to purchase next year, and not with regard to the value of the dollar ten or fifteen years ago.

"This increase in compensation is necessary, not merely as a matter of justice to the engineer, but in order that engineering work may be maintained on the plane that it must be to secure economical and efficient work. Not only the leaders but the rank and file of technical workers often have it in their power largely to affect the cost of the work in their charge by the quality of the effort they exert."

WATER EXPECTANCY IN TUNNELS, MINES AND DEEP WELLS IN HOMOGENEOUS ROCKS*

By Robert E. Horton

In planning deep subsurface structures such as tunnels and mines, it is desirable to form some idea in advance as to the amount of water which will probably be encountered and will require removal. Isolated test shafts are costly, and may not show average conditions. It is desirable to supplement such special data by considerations based on general experience as to the yield of underground water under similar conditions.

Data can generally be secured as to the yield of shallow or surface wells overlying the region where the underground structure is to be made. Such data have been published concerning many conditions and kinds of rock as to the average and usual range of yields of surface wells under different conditions.

It is the purpose here to present a method and formula by which data obtained from surface wells can be applied, under suitable conditions, to the estimation of the amount of water which it may reasonably be expected will be encountered in any deep excavation.

The method is limited to cases where the bed rock is somewhat uniform in character throughout all depths from the rock floor down to the bottom of the tunnel or other structure. For example, the method will apply to the estimation of probable water in a tunnel in granite, which extends to the surface, but will not apply to a tunnel in deep-seated granite overlain by thick beds of sedimentary rocks.

Without giving details it may be said that there are physical reasons, well confirmed by statistics and experience, showing that the frequency and water-carrying capacity of fissures, joint openings and solution channels in rocks decreases rapidly as the depth increases.

Assuming, for simplicity, and as fairly representing experience, that the water-yielding capacity of a given kind of rock varies inversely as the depth, and that q is the maximum yield per sq. ft. of surface at a depth 0 to 1 ft. below the water table. The quantity q corresponds to Slichter's "transmission constant" and its value can be determined from the measured yield of shallow wells in the given location and kind of rock. Then the yield per sq. ft. of surface at a depth h below the surface of the water table may be expressed by the equation

$$q_h = q/h \qquad (1)$$

The total yield from one side only of a vertical surface one foot wide intersecting the water bearing rock from a depth h_1 to a depth h_2 will be to

$$Q' = q_1 \int_{h_1}^{h_2} dh/h \qquad (2)$$

If p is the ratio of the perimeter of a tunnel to its height, or the ratio of the perimeter of a well to its diameter, then letting Q_1 equal PQ^1, where Q_1 is the total yield of a horizontal tunnel per ft. of length, or the total yield of a well between any chosen depths per ft. diameter, there follows by integrating

$$Q_1 = q_1 p\,(\log_e h_2 - \log_e h_1) \qquad (3)$$

If it is desired to determine the total yield of a well from surface to bottom, h_1 should be taken as unity to correspond to the conditions assumed in fixing the value of q_1.

As a practical example, statistics gathered by E. E. Ellis, M. L. Fuller and others show the average yield for numerous shallow wells, on steep, rocky areas, in granitic gneiss and schist of southeastern New York and Connecticut, to be about 4 gals. per min. for 6 in. wells with an average depth in rock below the water table of about 150 ft. The perimeter of a 6-in. well is 1.54 ft. and the corresponding rate of yield for a flat surface 1 ft. wide and 150 ft. deep would be 2.60 gals. per min. Solving (3) for q_1 under these conditions:—

$$q_1 = 2.6/\log_e 150 = 0.52 \text{ gals. per min.}$$

*From the Journal of the American Water Works Association.

It should be noted that only wells with little cover of sand or other unconsolidated material have been considered in selecting the value of Q_1 to determine q_1. Shallow wells in rock but with deep cover of loose material often receive much of their supply from above the rock, and may indicate water quantities in excess of the transmission capacity of the rock itself, even at the surface where it is most fissured.

Let it be required to determine the amount of water that will probably be encountered in a tunnel 15 ft. high and with 60 ft. perimeter, at an average bottom depth of 250 ft. below water table in granitic gneiss and schist, the length of the tunnel in rock being 11,000 ft. Using the value of q_1 above determined, and solving (3)

$$Q_1 = 0.52 \times 4\ (\log_e 250 - \log_e 235) =$$
0.135 gals. per min. per ft. of tunnel.

Let Q equal the total infiltration to the tunnel, the length being L. Then $Q = Q_1L = 1485$ gals. per min. This indicates that provision should be made to dispose of 1485 gals. per min., or something over 2,000,000 gals. per day.

Experience in constructing the tunnel for which data are above given showed an average yield for some time of 1,000,000 gals. per day, and larger yields at times, approaching the amount above calculated.

Like most hydrologic methods and formulas, this one is not infallible, and its application requires intelligent discrimination in selecting surface-well data to determine q_1. It is intended to apply to fissured rocks such as granites, trap, basalt, gneisses, schists, and sometimes limestones and dolomites. It is possible that a large water vein may be encountered which will greatly increase the yield, but the probability of this decreases with increased depth.

In the case of unconsolidated materials and sandstones, the water transmission capacity may decrease little or none with increased depth, and formula (3) does not apply. The quantity of water obtainable from such deposits by means of wells, tunnels and infiltration galleries can be calculated by existing formulas given in various books on water supply.

In the case of shales, experience shows that the water-bearing fissures decrease very rapidly with increased depth, in fact little or no water is generally obtained in dense shales at depths more than 50 to 100 ft. below the rock floor. Observations by the author in the case of many deep wells in Hudson River shale as to the relation of depth to yield is fairly represented by the formula

$$Q_1 = 2q_1p\,[(1/h_1) - (1/h_2)] \qquad (4)$$

This is derived on the assumption that both the number and size of connected fissures in shale decrease as the depth increases, or that the transmission capacity per unit of surface varies inversely as the square of the depth. For example, if a 6-in. well extending 20 ft. below water table in shale yields 6 gals. per min., then solving for q_1p in (4) by taking $h_1 = 1$ and $h_2 = 20$

$$q_1p = 6/2\ (1 - 1/20) = 3.15$$

To find how much the yield of this well will be increased by extending it to a depth of 100 ft., we have from (4)

$$Q_1 = 6.30 \times (1 - 1/100) = 6.24$$

The yield of the well would be increased ¼ gal. per min. by extending it from 20 to 100 ft. depth.

The formula indicates that half the water obtainable will be found in the first foot of depth in shale rocks.

This result is certainly of the right order, since experience shows that nearly all the water obtainable in Hudson River shale is often found within 5 ft. below rock surface. A number of wells to depths of over 1,000 feet in shale in the vicinity of Albany, N.Y., afford their entire yield very near the surface and refute the popular belief that water can always be found in abundance if only a well is drilled deep enough.

Formula (3) can be applied in a manner similar to (4) to determining the probable increase of yield with depth for wells in granite, etc., and indicates little expectancy of increased yield at depths exceeding a few hundred feet, which also is verified by experience.

Formulas (3) and (4) are intended more especially for application to tunnels and mines rather than to wells, since the surface area of ground water interception in the case of the former is much larger and will generally approximate average conditions more closely than for isolated wells.

EFFECT OF THE WAR UPON WATER WORKS' REVENUES AND EXPENSES*

By Leonard Metcalf
Consulting Engineer, Boston, Mass.

THE situation with regard to the water works of the United States is probably fairly shown by the accompanying comparative records of about 50 plants with aggregate annual revenue of about $35,000,000 and supplying a total population of upwards of 9,000,000 persons, or nearly 9% of the entire population of the United States. The data for 1914-17, were presented to the association a year ago by its committee on war burdens of water works. The 1918 figures have been collected and added by the writer. These records indicate that:—

1. The annual revenues with such increase in rate schedules as were granted by the regulatory authorities and put into effect by the plants, have increased at an average rate of approximately 7% per annum, slightly less than a normal amount.

TABLE I.—COMPARATIVE WATER WORKS REVENUE AND EXPENSE, 1914-1918, IN PERCENTAGES OF 1915

Group.	1914.	1915.	1916.	1917.	1918.
Percentage Gross Annual Revenue.					
Eastern	95.7	100	110.1	112.8	120.6
Central	98.3	100	109.1	111.4	126.4
Southern	97.7	100	107.5	120.3	126.3
Western	101.7	100	107.3	109.5	117.5
Average	98.3	100	108.5	113.5	122.7
Percentage Operating Expenses, Including Taxes.					
Eastern	99.7	100	121.9	141.1	149.7
Central	100.9	100	109.3	137.3	162.3
Southern	97.0	100	109.7	134.6	165.9
Western	98.6	100	109.9	117.4	128.0
Average	99.0	100	112.7	132.6	151.5
Net Revenue Applicable to Depreciation, Interest, Dividends and Surplus.					
Eastern	90.9	100	103.0	90.4	105.8
Central	97.3	100	110.0	98.5	106.5
Southern	97.9	100	96.3	104.0	89.1
Western	103.6	100	104.3	105.3	114.4
Average	97.4	100	103.4	99.6	104.0

2. The operating expenses, including taxes where taxes are paid, and excluding them where none is paid, have increased over the year 1915, abnormally, by 13% in the year 1916, 33% in the year 1917, and 52% in the year 1918.

3. The net (operating) revenues applicable to depreciation, interest, dividends and surplus, have substantially stood still since the year 1915.

The average increase in population in this country has been at the rate of approximately 1.9%, compounded annually, and of the cities supplied by these 50 typical water works, about 3.1%.

The net revenue of water works usually increases at the rate of from 4% to 5%, compounded annually. Yet the total increase in the three-year period from 1915 to 1918, is but 4%, against a normal amount of from 12% to 15%, in spite of increases granted by the commissions.

The records gathered indicate further that the increases in rates granted to water works by the commissions seem to have amounted on the average to about 10%, serving thus to decrease the loss in net revenue in the year 1918, from 20%, more or less, to 10% or thereabouts. If this inference is sound, the loss in operation was divided equally between the works and their consumers.

It is clear, however, that the burden of increased operating expenses, plus the interest upon the new investment put into these properties during the war period, has been *borne by their owners*, in larger measure than by the public, except in the case of publicly owned works.

Unskilled Labor Costs, in cents per hour (see Table II.) did not generally feel the influence of the war until the middle of the year 1916. As compared with pre-war conditions,

*Read last month at the Buffalo Convention of the American Water Works Association.

TABLE II.—INCREASE IN COST OF LABOR AND MATERIALS TO WATER WORKS IN THE UNITED STATES, AS REPORTED TO THE EXECUTIVE COMMITTEE OF THE AMERICAN WATER WORKS ASSOCIATION, MAY, 1918, AND REVISED, APRIL, 1919

Item.	Number of Records	Prices per Unit 1915	1916	1917	3 Mos. 1918	Per Cent. Increase over 1915 1916	1917	3 Mos. 1918	Year 1918 No. of Records	Unit Price	Per Cent. Increase Over 1915
Unskilled labor* in cents per hour:											
(a) Western Group	7	27.0c.	28.5c.	31.4c.	Still increasing in 40.6% of all groups	5.0	16.0	Still increasing in all groups	8	41.8c.	54.7
(b) Central Group	12	21.7	25.3	26.9		17.0	24.0		10	37.2	71.3
(c) Eastern Group	15	23.0	26.7	30.4		16.0	32.0		18	40.2	74.7
(d) Southern Group	10	17.9	20.6	24.5		15.0	37.0		12	34.3	91.6
(e) Average of Groups (4) ..	..	22.4	25.3	28.3		13.0	27.0		4	38.4	71.2
(f) Average of all	44	22.1	25.2	28.3	......	14.0	28.0	.....	48	38.4	73.2
Cast-iron pipe, per 2,000 lbs.	21	$24.23	$30.70	$51.60	......	26.7	112.9	.....	..	$67.74	179.0
6-inch valves	11	11.18	12.64	19.13	$23.20	13.1	71.1	107.6	23	19.13	71.0
12-inch valves	3	34.78	41.53	65.22	69.00	19.4	87.6	98.7	10	65.02	87.0
Two-way hydrants	6	26.69	32.04	43.13	53.90	20.1	61.6	102.0	38	5.80	94.0
Coal, per 2,000 lbs.:											
(a) Eastern Group	13	$2.98	$3.80	$5.96	$7.04	27.5	100.0	136.3	16	6.00	101.0
(b) Central Group	11	2.41	2.77	3.75	6.38	14.9	56.4	164.7	10	4.53	88.0
(c) Southern Group	12	1.92	2.01	3.03	4.02	4.7	57.8	109.4	10	3.89	102.0
(d) Western Group	5	3.97	4.37	6.31	7.89	10.1	58.9	98.7	6	7.92	99.0
(e) Average of Groups (4) ..	..	2.82	3.24	4.77	6.33	14.9	69.2	124.4	4	5.57	97.0
(f) Average of all	41	$2.62	$3.04	$4.52	$5.69	15.3	73.7	117.1	42	$5.42	107.0
Fuel oil, cents per gallon—South..	1	1.80c.	1.80c.	2.00c.	4.50c.	0.0	11.1	150.0	1	4.28	138.0
Fuel oil, cents per gallon—West..	1	1.38	1.50	2.57	3.55	8.7	86.2	157.3	4	4.05	193.0
Alum, cents per pound:—											
(a) Western Group	2	1.14c.	1.21c.	1.51c.	......	6.1	41.4	.....	3	1.53c.	34.0
(b) Central Group	5	0.91	0.91	1.25	......	0.0	37.0	.....	6	1.50	65.0
(c) Eastern Group	9	1.12	1.72	1.48	......	54.0	32.7	.....	8	1.45	29.0
(d) Southern Group	9	1.08	1.38	1.48	......	28.0	37.0	.....	9	1.78	65.0
(e) Average of Groups (4) ..	..	1.06	1.30	1.43	......	23.3	35.1	.....	4	1.56	47.0
(f) Average of all	25	1.07	1.40	1.44	......	30.6	34.4	.....	27	1.59	49.0
(g) New York market price†..	Average of Monthly Prices	2.08	4.63	3.57	5 Months 3.15	123.0	71.6	51.4	..	....	....

*Note. It was generally reported that there has been also a marked decrease in efficiency of labor since 1914, variously estimated at between 20% and 50%; and that the increase in wages paid to labor by water-works had not kept pace with contract prices, owing probably to the advantage of continuity of service.

†See "Journal of Industrial and Engineering Chemistry." Note that 1915 price was an advance of 34% over the 1914 average price before the advances listed went into effect.

reflected by the prices prevailing in 1915, they increased one-eighth in 1916, one-fourth in 1917, and nearly three-fourths in 1918. The increase was felt most markedly in the south and upon the eastern seaboard, being nearly doubled in the first, and increased by three-fourths in the latter district. The wages paid upon the Pacific coast before the war, which were much higher, have advanced relatively less than elsewhere, so that at the present time the eastern and western unskilled labor prices are about the same. Thus the average rate in the western group increased from 27c. per hour in 1915, to 42c. in 1918; while the southern rate increased from 18c. to 34c.; the central group from 22c. to 37c.; and the eastern group from 23c. to 40c.

In spite of the general business uncertainty and resulting depression, wages paid to unskilled labor, by water works in the vicinity of Boston, have advanced from approximately 41c. per hour, under date of September 14th, 1918, to approximately 46c. per hour in April, 1919, without allowance for the effect of vacations and holidays under pay, granted by some works. Present (June, 1919) conditions give little if any indication of reduction in prices this year, or hope for any marked reduction in the future.

Cast-iron pipe prices (Table II.) which had about trebled at their maximum point, have now receded to about twice pre-war figures. *Valves, hydrants and pumps*, which had more than doubled in price, are now to be had at an advance of something over seven-eighths of pre-war prices. *Coal and fuel oil prices*, which more than doubled, have receded somewhat. *Chemicals* used in the purification of water, which, by reason of outstanding contracts showed an average advance of but one-third, though the market price had increased approximately three-fourths, have decreased so that the present excess cost is about one-half over pre-war prices.

Future prices—Engineers prefer the role of interpreter of facts to that of prophet. It is desirable, however, to note here probable future price tendencies. First, with respect to unskilled labor, no marked change is to be looked for; and with respect to the rates paid to water works employees, it is believed that the prices now paid are likely to continue in most cases, and to increase rather than to decrease in the remaining cases. Unless Bolshevism runs its course in this country, or industrial depression should follow the war—neither of which seems likely—an active demand for labor is to be looked for in the near future. It is to be remembered that, despite the war, the population of this country has been increasing at a rapid rate. Immigration has been at a standstill, and in the light of home demand for labor abroad, does not seem likely to be active for some time to come. Many employers, contractors and labor leaders believe that in the not distant future this country is sure to feel the competition for available labor and that this will stimulate yet higher wage scales.

Necessary Improvements Should Go Forward

Second, with respect to materials of construction, there is greater hope for relief. Nevertheless, no substantial reduction in the price of cast-iron pipe, valves and hydrants seems likely for the present year, and but a gradual reduction is to be looked for in the future. In spite of the increased facilities for production, the labor, transportation and money conditions involved seem likely to make themselves adversely felt for some time, and the losses resulting from the war seem likely to be permanent.

Third, the materials of operation—coal, fuel oil, and chemicals—do not appear likely to decline markedly in cost, and such tendency toward decrease as there may be will probably cause the making of short-time, rather than long-time, contracts for such supplies.

The Future—The conclusion to be drawn from the present physical and financial condition of water works in the United States seems clearly to be that *necessary improvements should go forward as rapidly as possible.* It is desirable to restore public confidence and further the government's wise wish to give employment to idle labor. More important yet, *improvements are seriously needed to restore our normal high standard of water service, to safeguard adequately the public health.*

While city officials and water works men are hesitating, the large manufacturing interests, dominated by shrewd, farsighted business men, are going ahead with their construction work, with their plant extensions and housing projects, confident that postponement will at best offset increased cost in small measure; will probably involve loss in service or profit far exceeding any saving in construction cost; and at worst will involve yet higher costs, coupled with increasing difficulties due to a vanishing labor surplus.

The public is far more vitally interested in thoroughly good and adequate present service than in any probable saving to be effected by delaying construction to a later date, in anticipation of further, more or less problematical, decline in costs.

CEMENTS PRODUCING QUICK-HARDENING CONCRETE*

By P. H. Bates

IN the course of the investigations which the Pittsburgh Branch of the Bureau of Standards has been conducting dealing with the various problems relating to Portland cement, there have been made a number of cements which are characterized by a very high early strength. This is developed when the cements are used either as mortars or concretes. These cements have been made in a manner differing in no wise from that used in the manufacture of Portland cement. However, the composition of the materials entering into their manufacture was decidedly different, limestone and calcined alumina having been used in some of the raw mixes, and in others the alumina was replaced in part by kaolin or bauxite in order to determine the effect of impurities on their general properties. While such materials have been the subject of research by others, especially Spackman, their property of developing very high early strengths is not generally known. It is believed that the data presented in this paper, especially that dealing with the concrete, are the first of their kind ever presented.

The data dealing with the aluminates are augmented by some obtained in making concrete from "Sorel cement" which, as is generally known, is light calcined magnesite guaged with magnesium chloride. It has been unofficially reported that during the recent war the enemy used a concrete made of such a cement for "setting up" their large guns. As it obtains the greater part of its strength within 24 hours, and as this strength equals that obtained by a Portland cement at the end of two or three weeks, the possibility of using it becomes very attractive. The data herewith presented were obtained in making a limited number of concretes, but it is believed that such data, in so far as they relate to concretes, have never before been presented.

Concrete Made with Sorel Cement

It is not intended to go into any great detail in presenting these data. For this reason, the nature and general properties of this cement will be touched upon but briefly. The fact that magnesium oxide, when mixed with a solution of magnesium chloride, will harden was possibly first known by Sorel in 1853. From him it has at least taken its more common name. The physical character of the oxide and the permissible impurities, the concentration of the chloride and its permissible impurities, and the nature of the hardened material have all been the subject of extended investigations. Briefly, the results show that the purer the ingredients, both oxide and chloride, the better the resulting cement. The oxide must be produced by burning a carbonate to such a temperature only that a plastic mass results when it is gauged with water. Too high a temperature of calcination produces a very inferior oxide. The nature of the hardening has never been satisfactorily solved. For a late investigation and discussion of these points and a satisfactory bibliography, reference should be made to Bulletin No. 879 of the University of Wisconsin.

At the present time this cement is used in rather large quantities for making a resilient flooring which is usually referred to as "composition flooring." When so used the aggregate is composed of asbestos fibre, sawdust, inert finely ground filler as sand and coloring matter. This flooring is widely used in a monolithic form in office buildings, passenger and subway cars and interior ship decks. Recently a mortar very similar in nature to the above, excepting the omission of the fibrous material, has been rather successfully used as a stucco.

The magnesia used in the present investigation was made from magnesite mined in California. It was a mixture of two shipments from two manufacturers of flooring. Both had given satisfactory results when used in flooring mixes. No data are at hand which would enable one familiar with portland cement to form an idea of the relative strengths which these would develop in the usual small briquette or compression specimen. The small specimens made were of a flooring composition and as such were composed of 50% magnesia, 12% asbestos, 10% sawdust, 22% ground sand and 6% iron oxide, all by weight. This mixture when gauged with 52% of a solution of chloride having a gravity of 1.1885 (about 23° Baumé) gave the following strengths in pounds per square inch:—

Specimen.	24 Hours.	7 Days.	28 Days.	90 Days.
A				
Tension	531	841	1087	1034
Compression .	2240	3795	5300	4340
B				
Tension	576	900	935	1049
Compression .	2900	4240	5300	5370

The tension specimens were of the form specified in the A.S.T.M. Standard Specifications and Tests for Portland Cement. The compression specimens were 2 by 4-in. cylinders. All specimens were stored in air until broken.

The analyses of the mixed oxides and the chloride were as follows:—

	Oxide.	Chloride.
Silica	5.14 per cent.	....
Alumina	0.78 "	....
Iron oxide	0.57 "	....
Lime	5.69 "	0.20 per cent.
Magnesia	85.01 "	9.24 "
Ignition loss	2.86 "	....
Potassium oxide	.... "	0.17 "
Sodium oxide	.... "	0.70 "
Chlorine	.... "	16.54 "

In Table 1 is shown the strength of the concrete made from this mixed oxide and also the compressive strength developed by a Portland-cement concrete using the same proportions of the same aggregates. Notwithstanding the fact that the specific gravity of the magnesia is very close to that of Portland cement (3.08 for the magnesia and 3.12 for the cement), the volume occupied by the same weight of the two differs very materially. As the magnesia weighed but 51 lb. per cu. ft., the actual percentage by weight of the magnesia in any one concrete was decidedly less than the percentage of Portland cement. For this rea-

Table 1—Comparison of Compressive Strengths of Sorel and Portland-Cement Concretes

6 by 12-in. Cylinders. Strengths in pounds per square inch.

Proportions by Volume.	Percentage of Cement by Weight.		24 Hours.		48 Hours.		7 Days.		Per cent H_2O in Portland-Cement Concrete.	Per cent $MgCl_2$ in Sorel-Cement Concrete
	Portland.	MgO.	Portland.	MgO.	Portland.	MgO.	Portland.	MgO.		
Gravel Aggregate.										
1 : 0.5 : 1.5	33.3	20.3	...	1740	1570	3490	2965	2910	12.1	14.7
1 : 1.0 : 3.0	20.0	11.3	....	1705	1115	2260	2020	2850	7.8	9.5
1 : 1.5 : 4.5	14.3	7.8	....	1755	680	2145	1430	2240	7.9	9.8
*1 : 1.5 : 4.5	....	14.3	....	2880	....	3315	. .	2720	....	12.1
Limestone Aggregate.										
1 : ⅔ : 1⅓	35.2	21.8	....	2985	2260	3990	3930	4320	12.2	18.5
1 : 1⅓ : 2⅔	21.4	12.2	....	1940	1340	2805	2990	2970	9.9	13.7
1 : 2 : 4	15.4	8.5	...	1935	655	2330	1755	2480	9.5	12.8
*1 : 2 : 4	....	15.4	...	3270	....	4020	...	4320	....	13.7
Coarse Sand Aggregate.										
1 : 0.5 : 1.5	34.0	20.8	....	2060	1715	2570	3270	2735	13.2	20.0
1 : 1.0 : 3.0	20.6	11.6	....	1910	545	2225	1635	2430	11.4	16.0
1 : 1.5 : 4.5	11.7	8.0	....	935	325	1695	985	1870	11.4	14.7
*1 : 1.5 : 4.5	...	14.7	....	2355	.....	3260	...	3190		15.7

Note.—The percentage by weight of MgO in 1:0.5:1.5 and 1:⅔:1⅓ is but very little greater than the percentage by weight of Portland cement in 1: 1.0 : 3.0 and 1: 1⅓ : 2⅔, respectively.

* MgO proportioned by weight, making weight percentage of MgO equal weight percentage Portland cement in 1: 1.5 4.5 and 1: 2: 4

*Paper read at the annual meeting of the American Society for Testing Materials, June 24th to 27th, 1919.

son the 1: 6 concrete was proportioned both by weight and by volume, when the magnesia was used as the cementing material. All specimens were stored in the air until broken. The gravel used was obtained from the Allegheny River and was screened between a ⅛-in. and 1½-in. screen. It contained an excessive amount of the finer sizes. The lime stone was a rather soft stone screened between the ¼-in. and 1-in. screens. The "coarse sand" aggregate was sand from the Allegheny River screened between the ⅛-in. and ¼-in. screens.

As the information sought had to do alone with early strengths, specimens were made for breaking at 24 hours,

TABLE 2—COMPOSITION, CONSTITUTION AND TEMPERATURES OF BURNING OF CALCIUM-ALUMINATE CEMENTS

ALL COMPOSITIONS IN PER CENT.

Cement No.	1	2	3	4	5	6	7	8
SiO_2	0.44	0.76	9.41	10.48	17.23	17.38	11.33	0.68
Al_2O_3	62.31	61.25	55.09	46.71	39.96	30.52	47.66	74.11
Fe_2O_3	0.51	0.60	2.04	2.13	2.57	1.85	3.10	0.40
CaO	36.69	36.32	30.73	39.79	38.84	46.72	34.87	23.82
MgO	0.36	0.48	2.95	1.04	1.29	2.27	3.66	0.81
Ignition loss	0.07	0.50	0.08	0.32	0.14	0.78	0.17	0.38
	100.38	99.91	100.30	100.47	100.03	100 52	100.19	100 20
Temperature of Burning, deg. Cent.	1460	1480	1490	1380	1455	1360	1445	1500
Constituents[1]	3C 5A CA 2CS	CA 5C 3A 2CS	CA 3C 5A 2CAS	2CAS CA 2CS	2CAS CA 2CS	2CS 5C 3A CA	2CAS CA 2CS	CA 3C 5A 2CAS

[1] C = CaO; A = Al_2O_3; S = SiO_2.

48 hours and 7 days in the case of those made with magnesia and 48 hours and 7 days when Portland cement was used.

The results show that the Sorel-cement concretes, with but two exceptions, have a strength at 48 hours greater than that obtained by the use of Portland cement in 7 days. However, it is also seen that there is in general but little increase in the strength of the former between the 48-hour period and the 7-day period. The results obtained at all periods from the Sorel-cement concrete proportioned by weight are generally higher than those obtained when the proportioning was done by volume, regardless of what the proportions were. This clearly shows that for such a light material the proportions should be decidedly different from

TABLE 3—TIME OF SETTING AND FINENESS OF CALCIUM-ALUMINATE CEMENTS

Cement No.	Initial Set.				Final Set.				Per cent Passing 200-Mesh.
	Gillmore.		Vicat.		Gillmore.		Vicat.		
	hr.	min.	hr.	min.	hr.	min.	hr.	min.	
1	0	55	0	25	4	45	2	10	83.0
2	0	30	0	12	2	0	0	50	80.0
3	6	25	5	15			7	0	81.2
4	0	35	0	7	3	30	1	15	78 0
5	0	40	0	15	4	45	3	15	80.2
6	0	7	0	2	0	45	0	12	76 4
7	6	0	3	45	[a]		[a]		79.8
8	7	0	3	30	[a]		[a]		86 6

[a] Final Set between 8 and 16 hours.

those generally used with Portland cement. It would seem as if too much magnesia was used in the rich concretes and too little in the lean ones when the proportioning was carried out by volume.

Attention should be called to the difference in the manner in which the hardening of the two concretes takes place. In a Portland-cement concrete, the cement hardens by the action of the added water. During the process of hardening it is immersed in an atmosphere containing in a greater or less degree one of the essential elements of the process, that is, water, either as a liquid or vapor. On the other hand, in the Sorel-cement concrete the hardening takes place as a result of the action of the chloride on the oxide. The chloride is always essential, but any deficiency, as for instance the use of a too dilute solution, or any marked excess, is injurious. Therefore, not only the ratios between the aggregate and the magnesia must be studied, but also the ratio between the chloride and the magnesia.

While the results do show the lack of proper proportioning of both the magnesia and the chloride, yet these poorly proportioned concretes show in 24 hours as high strengths as the more properly proportioned Portland-cement concretes show in seven days. Another point should be remembered in regard to these Sorel-cement concretes, that is, they cannot be frozen. Temperatures below freezing will retard the hardening to a degree, but the freezing point of the solution is so low that no care need to taken to prevent damage from low temperatures.

Concrete Made with Calcium-Aluminate Cements

The calcium aluminates were all made in the experimental rotary kiln of the bureau. The composition of these, the constitution arranged in order of the amounts present, and the temperatures of burning are given in Table 2. The fineness and the time of setting* are given in Table 3.

With the exception of cement No. 6, no particular difficulty was encountered in burning. On account of the composition of this cement, its position in the ternary system CaO-Al_2O_3—SiO_2 was such that it was located in a field having both a low burning temperature and also one in which the orthosilicate predominate. This combination

TABLE 4—COMPRESSIVE STRENGTH OF 1: 3 STANDARD SAND MORTARS, FROM CALCIUM-ALUMINATE CEMENTS

ALL VALUES IN POUNDS PER SQUARE INCH.

Tested at	24 Hours.	7 Days.	28 Days.	28 Days.	90 Days.	26 Weeks.		1 Year.
Stored in	Water.			C. S.	Water.	Water.	C. S.	Water.
Cement No. 1	3570	5945	3765	6815	3945	5330	6015	3045
2	4260	4760	3945	7625	4735	4570	5290	4430
3	2240	4940	6475	8000	7180	7760	11 050	5315
4	4410	4880	5285	6400	4565	3470	3480	3200
5	1035	1400	1820	2875	2070	2900	3845	2410
6	1340	1260	1425	3130	1680	1895	4345	2310
7	2165	5140	3930	7085	5205	3605	6090	5225
8	2860	8610	7845	10 690	8260	6380	8045	8945

C. S.=Stored for one quarter of period in water and the remainder in the air of the laboratory.

always produces a material which fluxes at such a temperature that the silicate on cooling reverts to the γ form from the β form of the silicate. This reversion is manifested by the "dusting" of the clinker. It was possible to produce this particular cement only either in a decidedly underburned condition, or overburned to such a degree that it fell from the kiln in large, soft balls, which dusted on cooling unless quickly water quenched. The latter procedure of burning, without quenching, was used. Cement No. 4 was made from a very hard clinker but the latter did not show any tendency toward dusting. The clinker of the other cements was of the porous character of normal Portland clinker. Those low in iron oxide were white to yellowish in color; none of them had the glistening black appearance of Portland clinker, the darkest being a dark reddish brown. The raw materials used were calcined alumina and limestone for cements Nos. 1, 2 and 8; in Nos. 3, 4 and 5 the same materials were used but part of the alumina was replaced by a kaolin, thus reducing the alumina content of the mix but increasing the silica con-

*In carrying out the investigation presented here, no addition of SO_3 in any form was made to the cements. Work carried on at the same time as this presented here showed that such additions accelerated the time of set and caused a reduction in both the tensile and compressive strength.

tent. In No. 6 it was necessary to add some very finely ground flint, in order to secure the desired silica content, in addition to the kaolin, alumina and limestone, and iron oxide. In No. 7 bauxite, limestone and iron oxide were the raw materials.

Reference should be made to the work of Rankin, "The Ternary System CaO-Al_2O_3-SiO_2," and the author, "The Hydraulic Properties of the Calcium Aluminates," for further information in regard to the general properties of the constituents of these cements. For this present paper dealing more particularly with concrete made from them, it is not desirable to give more in regard to their properties than their reaction with water. Those aluminates indicated in Table 2, as being present in these cements, all react with water to form the hydrated form of $3CaO \cdot Al_2O_3$.* Such a reaction requires the formation of hydrated alumina. The amount of the latter will depend upon the amount of the alumina in the cement, consequently the $3CaO \cdot 5Al_2O_3$ will give the most and the $5CaO \cdot 3Al_2O_3$ the least. This hydrated alumina is, as is well known, a colloid and, when formed under the conditions indicated above, constitutes the greater part of the cementitious material of these compounds.

The higher the alumina content in any of the aluminates, the slower will be the reaction with water and consequently the slower will be the time of setting. This is shown in Table 3, but not very clearly unless studied in connection with the relative amounts of the constituents shown in Table 2. The former table shows that cement No. 3 has a slower setting time than cements Nos. 1 or 2, and also a lesser alumina content. The latter table, however, shows the presence of a large amount of silica and therefore the presence of a quantity of silicate which reduces the amount of alumina in the former cement and also retards the setting time. The two silicates present in these cements react very slowly with water, in fact the ternary compound $2\ CaO,Al_2O_3.SiO_2$ reacts so slowly that it will not form a cementing material, while the orthosilicate, $2\ CaO.SiO_2$, at the end of a year shows but little more than 5% water of hydration but a very satisfactory strength. Also a comparison of cement No. 8 with cements Nos. 1 and 2, or cement No. 7 with Nos. 5 and 6 will confirm the statement that increasing alumina content gives a slower setting cement. This has been more strikingly shown in other work carried on with the pure compounds when it was found that the tricalcium aluminate—the aluminate lowest in alumina—always gives a flash set.

With the exceptions of cements Nos. 2, 3 and 8, the burning temperatures used were either those generally used in burning Portland cement or a little lower. The temperatures used in these three exceptions were not much in excess of that infrequently used in making the latter cement and can be comparatively easily reached in a rotary kiln. One point in particular should be noted: it is impossible to produce an unsound cement unless a temperature far below that used in Portland cement practice were attempted. Slight underburning or burning at a temperature of 100° lower than that given would have produced an aluminate lower in alumina and free alumina.

*The amount of water of hydration has never been very closely determined. Some water is lost at such low temperatures, that adhering water or moisture cannot be removed without removing some combined water.

TABLE 5—COMPRESSIVE STRENGTH OF 1:6 AND 1:12 GRAVEL CONCRETE, FROM CALCIUM-ALUMINATE CEMENTS

ALL VALUES IN POUNDS PER SQUARE INCH.

Tested	24 Hours.		7 Days.		28 Days.		90 Days.		26 Weeks.		1 Year.			
Proportions[b]	1:6	1:12	1:6	1:12	1:6	1:12	1:6	1:12	1:6	1:12	1:6	1:6[a]	1:12	1:12[a]
Cement No.														
1	2825	....	3270	....	3310	..	4150	...	4180	...	3310	5590		
2	3000	....	4150	....	4740	....	2480	....	1760	.	1760	2360	...	....
3	Soft	....	2175	....	3680	....	3900	....	4525	...	4135	5660	...	....
4	3145	880	3570	1005	3370	1000	2930	875	2565	800	2965	3280	960	1275
5	310	Soft	885	225	1250	365	1050	390	1270	550	1460	2110	570	870
6	840	275	765	275	990	305	1260	400	1515	470	1440	2035	470	810
7	1475	455	4135	1405	4625	1500	4640	1600	4450	1580	4650	5300	1350	1815
8	2930	890	6010	2270	7060	3415	7050	3980	7610	3910	6720	8220	3930	4445

[a] All specimens in these columns were stored for the first 4 months in the damp closet and for the remainder of the period in the air of the laboratory. All other specimens were stored in the damp closet for the entire period aged.
[b] Contained 3 per cent plaster.

Table 5 shows the strengths produced by the cements when tested in the form of a 6 by 12-in. cylinder as a 1:1½:4½ gravel concrete. In order that some idea may be obtained in a comparative way of their deportment as a mortar, the compressive strengths of some 1:3 standard sand 2-in. cubes are given in Table 4. Previous work showed that, on account of the large amounts of colloidal material formed in the process of hardening, retrogression is likely to be shown by any specimens stored continuously in water or the damp closet. At certain periods, therefore, some of the specimens were removed from the water or damp closet and placed in the air of the laboratory until broken.

These two latter tables very clearly show the high 24-hour strengths. Special mention should surely be made of strengths of 2,800 to 3,100 lb. per sq. in. for a 1:6 concrete at the end of 24 hours. The strengths of some of the 1:3 mortars at the end of the same time is just as unusually high. The gain in strength with aging is also quite large, although maximum strength is reached at a comparatively early period. Consequently some very phenomenal strengths for either kind of a specimen are developed. A compressive strength of 8,610 lbs. per sq. in. at seven days for 1:3 mortar or 6,010 lbs. at the same period for 1:6 concrete are surely striking. While these results represent some of the maximum ones obtained, there are many other very exceptional high strengths shown in the tables, when these are compared with the results generally obtained with Portland cement.

An examination of the tables shows that the maximum strength for the water or damp closet stored specimens was attained at some period previous to one year. As stated before, the quick hardening is due to a great amount of hydrated material rapidly formed. This is also in the colloidal form and will, therefore, in the presence of excess water, take up in a comparatively short time such an excess of the latter that there is a reduction in strength. It will not take up enough from air of the usual humidity to materially affect the strength. It does, however, lose water to the latter to a certain extent. It is this latter loss of water with consequent drying out of the colloid which causes the increase in strength of the water-air or damp closet-air storage over the storage in the water or damp closet alone.

It is interesting to note that in the case of the mortar specimens, cements Nos. 3, 5 and 6 developed the highest strengths by the combined method of storage at the end of the 26-week period, while the other cements developed their maximum strength by this method of storage at 28 days. Apparently, therefore, the latter were much quicker hardening than the former. Concrete specimens aged by the combined method were broken only at the one-year period. At this period, by this method of storage, maximum strength was developed by all the cements except Nos. 4 and 2. These latter developed maximum strength by damp closet storage at 7 and 28 days respectively. The continued storage of these two in the damp closet until removed to the air apparently caused such excessive hydration that subsequent drying out could not cause sufficient gain in strength to bring back the maximum strength shown at the earlier period. A shorter period of damp closet storage before the removal to the air would have been necessary in these two cases to have brought out higher

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PRINCIPAL CONTENTS

EXCELLENT REPORT ON ONTARIO TRADE

In his first annual report on the trade of the Province of Ontario, Fred. W. Field, His Majesty's Trade Commissioner at Toronto, has covered a vast range of subjects in a most succinct and business-like manner. His report is not at all perfunctory, but to the contrary, enters into the subject in a most enthusiastic manner, and portrays real interest in the work.

While compiled entirely for the information of the British manufacturer, and presented to the British Parliament last month by command of His Majesty, the report will prove very interesting to the business men of Ontario and Canada generally. It is prefaced with a brief report on the trade of Canada and Newfoundland, owing to the fact that G. T. Milne, His Majesty's Senior Trade Commissioner in Canada, was transferred from Australia only a few months ago and had not been in Canada sufficiently long to undertake a report on general conditions.

The report is published in a booklet of 96 pages, 6 ins. by 9½ ins. The Canadian report covers financial conditions, crops, railways, minerals and mining, fisheries, lumber, immigration, scientific research, credit conditions and commercial failures, war work, iron and steel, shipbuilding and shipping program, pulp and paper, motor cars and trucks, and import trade.

The Ontario report, which forms the major portion of the booklet, covers representation of British firms in Canada, selling goods on consignment, invoices, New York agencies, designs and patterns, advertising, catalogues, moving pictures, keeping in touch with one's countrymen, visits to Ontario, engineering practice, conventions, correspondence, general conditions, crops, farm live stock, wool, minerals, lumber, fisheries, commodity prices, rubber, financial conditions, railways, canals, Toronto harbor improvements, Hydro-Electric Power Commission, road building, public works, vocational training for returned soldiers, Ontario Bulk Sales Act, Ontario Temperance Act, new lines being manufactured in Ontario, new works, munition works, national manufacturing works, banking assistance, earnings of industries, Reconstruction Association, supply of raw materials, raw materials and finished products, export trade, United States factories in Ontario, United Kingdom factories in Ontario, maintenance of industrial activity, industrial and trade organizations, iron and steel shipbuilding, lumber, pulp and paper, textiles, wool, linen, chemicals, dyes, motor cars and trucks, rubber industry, dry goods, cotton goods, gloves, metals and machinery, tools and hardware, cutlery, paints and varnishes, electric lamps, illuminating glassware, chinaware and groceries.

Appended to Mr. Field's report are brief reports from the Imperial trade correspondents at Halifax, St. John, Quebec, Winnipeg, Calgary, Victoria, Vancouver and St. John's, Nfld.; also appendices covering statistics of the pulp and paper industry for the year 1917 for the Province of Ontario, and imports into Canada for the fiscal years ended March, 1914 and 1918, compared.

In his advice to United Kingdom manufacturers seeking trade in Ontario, Mr. Field urges a larger measure of support of the Canadian representatives of British firms. The United States firms, he says, generally appoint the right man as agent and allow him adequate expenses and considerable freedom of action, whereas often a British representative is hampered by an inadequate allowance and other restrictions.

During the periods of trade depression, says Mr. Field, it is not advisable nor desirable to sever connections with a good agent as some British firms did, for example, at the outbreak of war. "A satisfactory local agent is an excellent asset," he states, "and it is a far better policy to make some arrangement to retain his services even when a dull business period arrives. This is done by our principal competitors in this market. A Toronto agency, for instance, was paid a substantial monthly retainer by a German house in New York, one of their principals, despite the fact that business was not obtainable in Ontario in their line for a considerable period. The German house wrote the Toronto firm saying: 'Even if you cannot sell goods at present, your experience and knowledge of the market are of value to us. Send us a detailed monthly report of conditions and the outlook in our line.'"

Mr. Field also urges more extensive advertising in the trade and technical journals of Canada. "With the keen competition to be met in all lines," he says, "and in a market which buys largely the goods for which publicity has helped to create a demand, it is necessary to have a continually favorable atmosphere to assist the salesman. Spasmodic advertising is of little value. A well prepared and properly conducted campaign, occupying a long period, then to be renewed, gives the greatest service."

Mr. Field has been extremely active during the first year of his office as trade commissioner, and his report reflects the great benefit that will accrue to British manufacturers and Canadian importers as a result of his further efforts. Few men are better posted than is Mr. Field on general economic and trade conditions in Canada; moreover, while working in the interests of British trade, he does not ignore the rights of Canadian manufacturers, and rarely does he encourage the importation of goods that can be satisfactorily supplied by Canadian factories.

AUTO TRUCK PERIL FOR HYDRANTS

During the round table discussion at the Buffalo convention of the American Water Works Association, it became very evident that a new problem has appeared for the water works engineers and superintendents of Canada and the United States, namely, the destruction of post hydrants by the heavy auto trucks that are now in general use. New York's experience has shown that the strength of the hydrants cannot be increased sufficiently to withstand the impact of a heavy auto truck skidding against it or backing into it. High pressure hydrants having a thickness of metal of 15/16-in. have been broken, as well as the ordinary type of hydrants.

William W. Brush, deputy chief engineer of the water works department of New York City, has advised the American Water Works' Association that there are several possible answers to the problem. First, there is the flush hydrant, but this type has not yet made appreciable progress. Secondly, in Boston a change has been made in the type of post hydrant which up to date has opened with the pressure. The compression type of hydrant opening against the pressure, is being substituted. A third possible solution is to move the hydrants from the curb line to the building line, but most water works superintendents will probably leave the hydrants in their present location and assume the additional cost of maintenance.

The cost of repairing the broken hydrants is materially reduced if the standpipes are repaired by welding, which can be done successfully with modern machinery, says Mr. Brush, at a cost of from $6 to $8 per standpipe.

CEMENTS PRODUCING QUICK-HARDENING CONCRETE

(Continued from page 115)

maximum strengths. It should be remembered that the high early strengths are due entirely to rapid and more thorough hydration in the short intervals.

After the high results of the 1:6 concretes were obtained, it was thought desirable to make some leaner concretes. Consequently a 1:3:9 gravel concrete was made, using certain of the cements of which there was a sufficient amount available. Even such lean concretes developed surprising strengths in several cases. This is especially true of cement No. 8 which developed a strength of 3,415 lbs. per sq. in. at 28 days and 3,980 lbs. at 90 days, and a maximum strength, by the combined storage, of 4.445 lbs. per sq. in. at one year.

In conclusion it may be stated, therefore, that the aluminates of lime, even when they contain such amounts of impurities as 10% silicia and 3% iron oxide, constitute a material which is a very valuable cementing medium when gauged with water. This particular value lies in the high early strengths which they develop. The greater the amount of the alumina present, as an aluminate of lime, the greater will be the early strength. Under certain conditions of curing there is a marked increase of strength with age, but this does not extend over a very long period of time. It also appears that if the concrete is subjected to an excess of water during curing there will be a decrease in strength. Such amounts of moisture as are usually present in the air do not materially affect the strength. It appears, therefore, that these cements might be of considerable value for certain special uses, where the principal requisite would be quick hardening.

The United States Engineering Societies' Employment Bureau received 2,891 applications for employment from December 1st, 1918, to May 1st, 1919, and placed 423 of the applicants. The total expenses from January 1st to May 31st were $5,815. The manager of the bureau states that there is every reason to believe that many more have been placed who have failed to notify the bureau, so that the average cost of placing these men probably did not greatly exceed $10.

The Ohio Electric & Controller Co., of Cleveland, Ohio, have appointed the following representatives:—Kelly Powell, Ltd., 403 McArthur Bldg., Winnipeg; Wonham Bates & Goode, Inc., Dominion Express Bldg., Montreal. They have also appointed the following export agents:—Gustave Neilson, A. S., Christiana, for Norway, Sweden and Denmark; Mitsui & Co., 65 Broadway, New York, for Japan, China, Phillipine Islands and Hawaii; Wonham Bates & Co., Inc., 17 Battery Place, New York, for Great Britain, France, Cuba and South America.

PERSONALS

Lt.-Col. Harold L. Trotter, who is a partner in the Henry Holgate firm of consulting engineers, Montreal, recently returned to Canada in command of the 11th Battalion, Canadian Engineers. Col. H. L. Trotter is a son of Col. W. C. Trotter, who for many years has been president of the Standard Clay Products, Ltd., of St. John's, P.Q., and New Glasgow, N.S. Col. H. L. Trotter graduated in 1903 from the Royal Military College, Kingston, with high honors, and then joined the firm of Ross & Holgate, consulting engineers, Montreal. When Mr. Ross and Mr. Holgate dissolved partnership, Col. Trotter joined Mr. Holgate as a junior partner. When war was declared, he enlisted immediately in the Canadian Engineers and was employed on fortifications below Quebec, and later installed new machinery in the Quebec Arsenal. He was also engaged in the construction of the Artillery Testing Depot in Quebec. From there he proceeded to Ottawa and, with the rank of major, took charge of an engineering company, but in England he was transferred to the 4th Division and placed in command of the 11th Field Company, which later became the 11th Battalion. This battalion particularly distinguished itself at the Somme in September, 1916, and at Canal du Nord two years later. The battalion was engaged in many other operations, however, including Vimy Ridge, Desire Trench, Arleux and Fresnoy, Lens, Hill 70, Passchendaele, Arras, Queant Drocourt Line, Denain, Valenciennes and the advance towards Mons. Col. Trotter was twice mentioned in despatches and was awarded the D.S.O.

Dr. Fred A. Adams of the Department of Health, Toronto, has been appointed medical health officer for the Essex border cities by the Essex Border Utilities Commission.

Lieut. Raymond Stevenson, of Fredericton, N.B., who recently returned home after four years' service overseas, has received an appointment on the Welland Canal staff.

Joseph Race, formerly city chemist and bacteriologist of Ottawa, Ont., returned home this week after six months' service in Siberia with the Canadian expeditionary force. Capt. Race will sail next week for a two or three months' visit to his former home near Manchester, England.

OBITUARY

Frank N. McReynolds, of the firm of Fussell & McReynolds, sewer contractors, Toronto, was accidentally drowned last Friday night at Honey Harbor, Ont., where he had gone for the purpose of repairing his summer cottage. A plank, across which Mr. McReynolds was walking, broke and dropped him into seven feet of water, where he was found on Sunday morning. It is thought that one end of the plank struck him on the head, rendering him unconscious. Mr. McReynolds was born 36 years ago at Cleveland, Ohio, but had resided in Toronto for the past eight years.

CONSTRUCTION NEWS SECTION

Readers will confer a great favor by sending in news items from time to time. We are particularly eager to get notes regarding engineering work in hand or proposed, contracts awarded, changes in staffs, etc.

BRIDGES, ROADS AND STREETS

Alnwick, Ont.—The contract for building the Hill Brook concrete arch culvert and roadway embankment in parish of Alnwick, Northumberland County, has been awarded to F. E. Berryman, Woodstock. Tender price about $6,800.

Annapolis Royal, N.S.—Tenders will be received until July 14th by board of highway commissioners, department of public works, Halifax, for concrete abutments and bridge sheets on ten existing piers.

Burlington, Ont.—The department of public works plans to construct new steel lift bridge across the channel at Burlington. Plans have not yet been prepared. It is thought probable that foundations may be put in this year and the superstructure completed early next spring.

Compton, Que.—Tenders for gravelling the Sherbrooke-Norton road in the limits of the village of Compton, from the south to the north limits of the macadam road of the township of Compton, will be received until July 5th, by J. A. Rivard, secretary-treasurer, Compton.

Crowland, Ont.—The Crowland township council has awarded contract for concrete pavement to be constructed from the M.C.R. to Ontario Rd. and then along the Ontario Rd. west to the canal, to Somerville and Dilworth, at $18,454. One other tender was received from Shaffey and Shaughnessy at $21,608.

Edmonton, Alta.—Repairs to Jasper Ave. estimated at $200,000 is proposed by the city council.

Edmonton, Alta.—It is proposed to repair road to Clover Bar and to construct several culverts.

Elora, Ont.—Tenders will be received until July 11th by S. Aitcheson, reeve of Pilkington township, Elora, for construction of 75-foot steel bridge, with concrete abutment, over Grand River.

Eriksdale, Man.—Contract for grading 24 miles of road has been awarded to Madden-Ledger Co., Eriksdale.

Fredericton, N.B.—New tenders have been called for the Harris bridge in Sunbury County and for the bridge at the mouth of Parks Brook, in Northumberland County.

Gladstone, Man.—Tenders will be received by P. St. C. McGregor, secretary-treasurer, Westbourne municipality, Gladstone, Man., until noon, July 10th, for the construction of two pile bridges over Whitemud River. Plans, specifications, tender forms and other information may be obtained from the secretary-treasurer's office, municipal hall, or from the highway commissioner, parliament buildings, Winnipeg.

Hading, Man.—M. Kelly, Winnipeg, has the contract for concrete culverts. Tender price, $9,555.25.

Kingston, Ont.—Arrangements are practically completed for a highway crossing the counties of Frontenac, Leeds, Lanark and Carleton.

Lachine, Que.—The town council will shortly present by-law for repairing portion of public highway.

Lunenburg, N.S.—Contract for pavement and sidewalk has been awarded by the town council to J. E. Lusby, Amherst, N.S.

Marmora, Ont.—The county council contemplates the expenditure of $30,000 on highways to the north in Tudor boundary to Maynooth. On the road from Belleville to Maynooth there has already been spent $10,175. Twelve bridges, at a cost of $21,000, are to be constructed.

Marquis, Sask.—Jedeberg and Gusa, Swift Current, have been given the contract for road work. Tender price, approximately $10,000.

Montreal, Que.—The Automobile Club of Canada has recently been taking up the matter of constructing a good road through to St. Anne de Bellevue, about 24 miles from the centre of the city. This road follows along the lakeshore.

Montreal, Que.—The city council is planning to construct 21,420 square yards of pavements on Cote des Neiges Rd. The total cost of paving with granite blocks will be $153,987. Grading will cost $7,568, concrete foundation $32,130, granite blocks $98,532, curbstones $1,061, gulleys and manholes $698. Inspection and engineering is estimated at about $13,998.

Montreal, Que.—The municipality of St. Victoire plans considerable macadamizing work this year.

Montreal, Que.—Paving of Redpath St., at a cost of $21,700 is contemplated.

Newmarket, Ont.—Tenders will soon be called for bridge on Prospect Ave.

North Bay, Ont.—Tenders will be received until noon, July 18th, by H. J. McAuslan, for curbs and gutters, sidewalks and pavements. Official advertisement in this issue.

Oakville, Ont.—Tenders will be received until July 7th, by the town clerk for material and construction of tarvia or asphalt-macadam pavements on six streets; also a concrete pavement and curb on Dunn St. N. Engineers, Jas. A. Bell and Son, St. Thomas, Ont.

Ottawa, Ont.—Tenders will be received until noon July 18th, by Lynwode Pereira, secretary, department of the interior, Ottawa, for construction of Castle-Laggan highway, second section from station 355+00 to station 960+00, Rocky Mountains Park, Alberta. Contractors may tender for the complete work, or separately, for two timber bridges, one over Corral Creek at station 785+00, and one over Pipestone Creek at station 732+00. Also for Mount Revelstoke highway, from station 643+00 to station 747+00, Mount Revelstoke Park, Field, B.C. Plans and copies of contract may be examined and specifications may be had from the commissioner of Dominion parks, Ottawa, Ont., the superintendents of the Dominion parks at Banff, Alta., Jasper, Alta., or Field, B.C., the Dominion lands offices at Moose Jaw, Edmonton, Calgary, Revelstoke, Kamloops and New Westminster, and the office of the inspector of Dominion lands agencies, Winnipeg, Man.

Ottawa, Ont.—The proposed new Cummings bridge will cost about $200,000.

Ottawa, Ont.—The county council has sanctioned the taking over of the Metcalfe Rd., Montreal Rd., Ottawa-Pembroke Rd. and the Ottawa-Kingston Rd. No estimate as to the proposed cost has been made.

Ottawa, Ont.—Work on the 84 miles of road, from Hull to Maniwaki Rd., will be started this summer.

Overbrook, Ont.—Tenders will be received until noon, July 7th, by Patterson and Byrne, 71½ Sparks St., Ottawa, for the construction of approximately 7,425 lineal feet of granolithic sidewalk, four feet in width, on Prince Albert and Queen Mary Sts., from the Russell Rd. to Victor St.

Owen Sound, Ont.—Tenders will be received until July 18th, for construction of asphalt concrete pavements. Official advertisement in this issue.

Pembroke, Ont.—The Renfrew county council at its recent session gave assent to a by-law for the raising of $150,000 for the county good roads system. The money will be secured by the issue of debentures over a period of twenty years. With the provincial grants which will go with the expenditure of this money, the total will aggregate about $225,000.