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Mount Pleasant Road Bridge, Toronto

Reinforced Concrete Structure Consisting Essentially of a Pair of Cantilevered Beams of Arched Form, with Free Joint at Center—Piers and Abutments on Skew, Parallel to Railway Track

By J. S. BURGOYNE

Designing Engineer, Department of Railways and Bridges, City of Toronto

THE extension of Mount Pleasant Road from the Toronto city limits southerly across Mount Pleasant Cemetery to Home Avenue will relieve the growing congestion of traffic on Yonge Street and later take care of the future communication requirements of North Toronto. This new artery runs parallel to and about half a mile east of Yonge Street. This civic improvement necessitated the construction of a bridge over the ravine and the Grand Trunk Railway (old Belt Line) at a location just south of Merton Street.

The south approach to the bridge is an earth ramp through the cemetery on a 3 per cent. grade, while the north approach consists of a timber trestle between the concrete structure and Merton Street and earth fills to the north, east and west.

In order that the grade of the north approach should strike Merton Street with as little difference in elevation as possible consistent with the maximum allowable of 5 per cent., it was thought advisable to use an easy vertical curve over the centre span from the ends of which straight

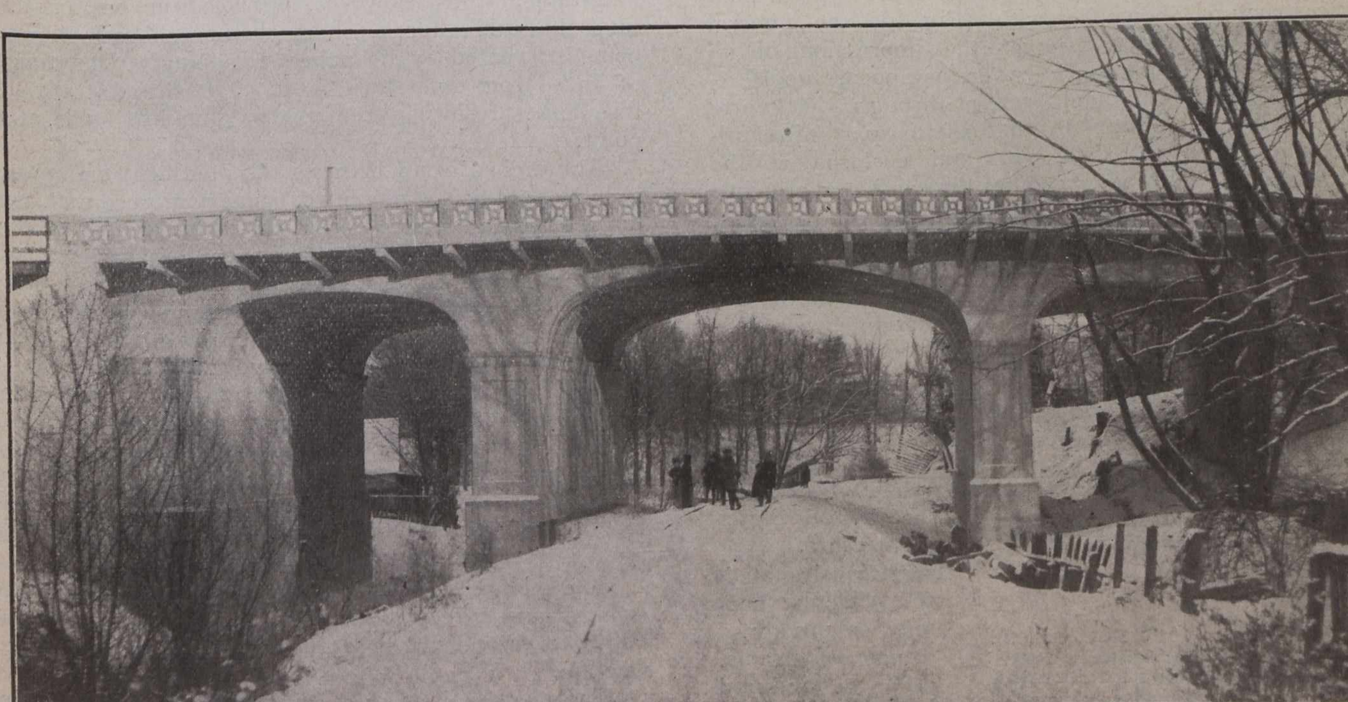


Fig. No. 1.—General View of Bridge, Looking East from Belt Line Tracks

grades were provided, 5 per cent. for the north approach and 3 per cent. for the south. When this improvement as a whole is completed the north approach grade will run out about 500 feet north of Merton Street, which will be raised about 6½ feet at the intersection with 4.8 per cent. grades east and 3.8 per cent. grade west.

Alternative plans for this structure in steel and in reinforced concrete were prepared and tenders received for the two types of construction. The contract was finally awarded for the construction of a reinforced concrete bridge.

The bridge proper, as will be seen from Fig. 4, consists of a central span providing a clear track allowance [illegible] feet in width and a standard vertical clearance of 22 feet 6 inches for the old Belt Line railway. The southerly span provides 24 feet clear for a future roadway in the cemetery, and a similar span to the north crosses the small creek parallel to the track.

Owing to the fact that the railway track is at an angle of 73° with the centre line of the street, it was deemed advisable on the score of economy to place the piers and abutments on the skew, approximately parallel to the railway right-of-way. The central span was thus reduced to a minimum.

This skew in the bridge, while to a certain extent increasing the difficulty of form work and consequently also the cost thereof, effected a substantial saving in the amounts of concrete and steel which would have been required had the piers and abutments been placed at right angles to the centre line of the bridge, while at the same time the appearance of the structure as a whole was not materially impaired.

The deck of the bridge provides a roadway 46 feet between curbs with two street railway tracks having a 4-foot 4-inch devil strip in the centre, and two 7-foot sidewalks.

The General Specifications of the Ontario and Railway Municipal Board govern the loading and the allowable working stresses used in the design, which are briefly as follows:—

For the electric railway, two 40-ton cars; for the roadway, one 20-ton road roller or one 12-ton (loaded) motor truck and 135 lbs. per square foot for otherwise unoccupied roadway; for the sidewalks, 100 lbs. per square foot.

For 1:2:4 concrete: Compression in beams, 600 lbs. per square inch; compression in columns, 500 lbs. per square inch; shear, 40 lbs. per square inch.

For reinforcing steel: Compression or tension in beams, 15,000 lbs.; compression or tension in columns, 10,000 lbs.; maximum shear, 1,000 lbs.; modulus of elasticity, 30,000,000 lbs. Bond stress, 60 lbs. per square inch, equals 65 diameters for plain, round rods.

As will be noted by an inspection of the general plan of the structure, shown herewith (Fig. 4), the general outline gives the casual observer the impression of an arched bridge. In reality, however, as appears upon examination the longitudinal section through the centre of the bridge, the design is that of a span of cantilevered beams supported on piers and enclosed at the abutment ends. This adaptation of the cantilever principle has two distinct advantages, *viz.*, economy of material and vertical pier loads; in this case the load on the the foundation being less than two tons.

This is a new type of structure for Toronto, though several bridges of similar design have been built in the United States in recent years.

As previously stated, the structure consists essentially of a pair of beams, each cantilevered over a pier and anchored at an abutment. The joint where the ends of the cantilevers meet is free insofar as the concrete is concerned. The longitudinal rods, however, project from one cantilever into the other for a short distance, bond, however, being prevented by tar-paper wrapping. The function of these rod extensions is to take care of any local inequalities resulting from the passing live loads at this point.

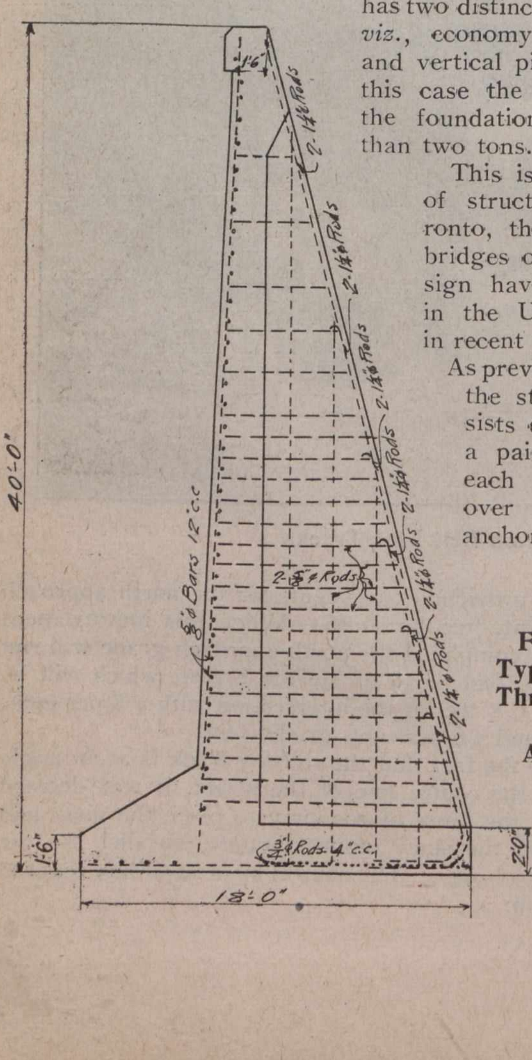


Fig. No. 2. Typical Section Through Wing Wall of Abutments

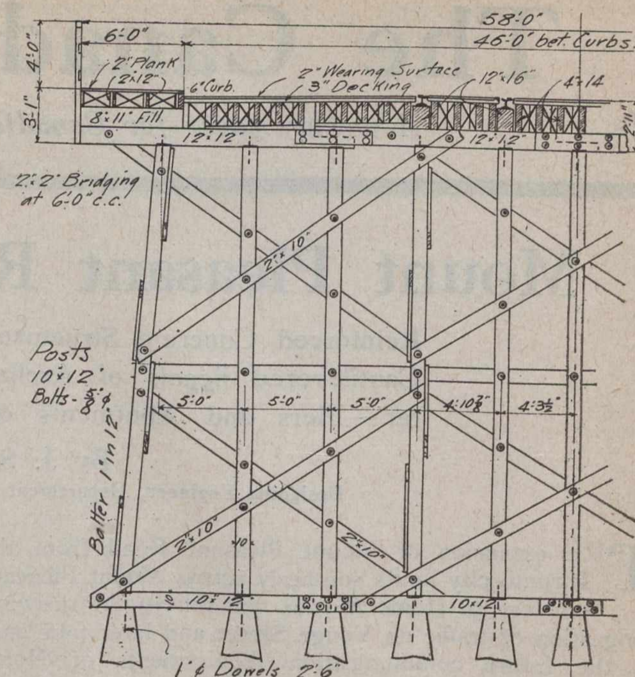


Fig. No. 3.—Typical Trestle Bent
(Half Bent Shown)

The arched beam between the abutment and the pier is 36 inches thick at its centre, being reinforced with 1-inch diameter round rods, spaced 4½ inches centre to centre in the bottom and 1¼-inch diameter rods spaced 4½ inches centre to centre in the top.

The top reinforcing rods are continuous over the pier to the end of the cantilever, two-thirds of the rods being bent down near the end to provide for shear. At the abutment or anchor end of the beam the top rods stop at intervals, one-third of the number continuing a certain distance down the back of the abutment to provide anchorage, as shown in Fig. 4. Of the bottom reinforcing rods it will be observed that one-third of the number extend into the pier and abutment while the remainder are bent up at intervals to provide for shear stresses.

The pier reinforcement consists of ⅝-inch diameter rods, spaced 2 feet apart vertically and 4 feet longitudinally, to provide against surface cracking due to contraction.

The pier footings are reinforced with three ⅞-inch diameter rods longitudinally on each side and ⅞-inch diameter rods at 6-inch centres transversely.

The main sections of the abutments are designed as reinforced slabs supported against the pressure of the earth fill by the floor of the bridge on top and the footings at the bottom.

The north abutment varies in effective thickness from 50 inches at the bottom to 32 inches at the top, and is reinforced vertically with 1-inch diameter rods 4 inches centre to centre.

The south abutment has an effective thickness of 34 inches throughout and is reinforced vertically with 1-inch diameter rods spaced 6 inches centres, both abutments being reinforced longitudinally by ½-inch rods spaced 24 inches centres.

As will be noted (see Fig. 4) the footings are of the standard spread type and are reinforced as mentioned above.

The wing walls of both abutments are of the counterfort type. Fig. 2 is a section through the east wing of the north abutment. This sketch is typical of all the wing walls.

For the section shown the counterforts are spaced 10 feet apart and taper from 10 feet deep at the bottom to zero at the top. They are 24 inches in thickness and are reinforced along the outer edge by 1¼-inch diameter rods varying in number from ten at the bottom to two at the top. These rods are bent at their bottom ends and carried into the longitudinal slab for anchorage. In the body of the counterfort ⅝-inch rods in pairs are spaced as shown.

The bottom slab, forming the heel of this part of the wing wall, has an effective depth of 22 inches and is reinforced longitudinally with ⅞-inch diameter bars spaced 4 inches centres. The vertical slab varies in effective thickness from 32 inches at the bottom to 16 inches at the top, and is provided at the top with a frost batter running down to a depth of 4 feet. The reinforcing of the vertical slabs consists of ⅝-inch rods spaced 1 foot horizontally and 2 feet 6 inches vertically.

The 4-inch sidewalk slabs reinforced with 3:9:25 steelcrete are supported upon brackets spaced 6 feet apart and cantilevered out from the main deck slab to which they are securely anchored. These brackets are 9 inches thick with an effective depth varying from 9 inches at the outer end to 22 inches at the point of juncture with the superstructure proper. The tension reinforcement consists of three ¾-inch diameter rods and the compression of two ½-inch diameter rods. The balustrade is carried between brackets on a reinforced beam which forms its base.

The balustrade shown in the general sketch (Fig. 4) was that originally designed, but the design was later changed and the hand-railing constructed, as shown in Fig. 1.

The timber trestle (forming the temporary north approach) consists of framed bents spaced 13 feet centres supported on concrete pedestals.

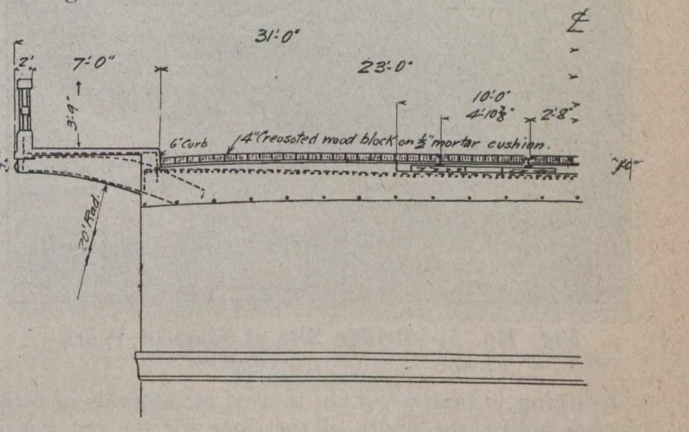
The pedestals rest on a continuous footing 18 inches thick and 36 inches wide which serves in distributing the load uniformly over the foundation.

Fig. 3 shows a typical trestle bent. It is composed of eleven 10-inch x 12-inch posts with 10-inch x 12-inch sill and 12-inch x 12-inch cap, braced transversely with 2-inch x 10-inch and longitudinally in pairs joining towers with 3-inch x 10-inch timbers. The sill is anchored to the concrete pedestals by 1-inch diameter dowels 2 feet 6 inches long.

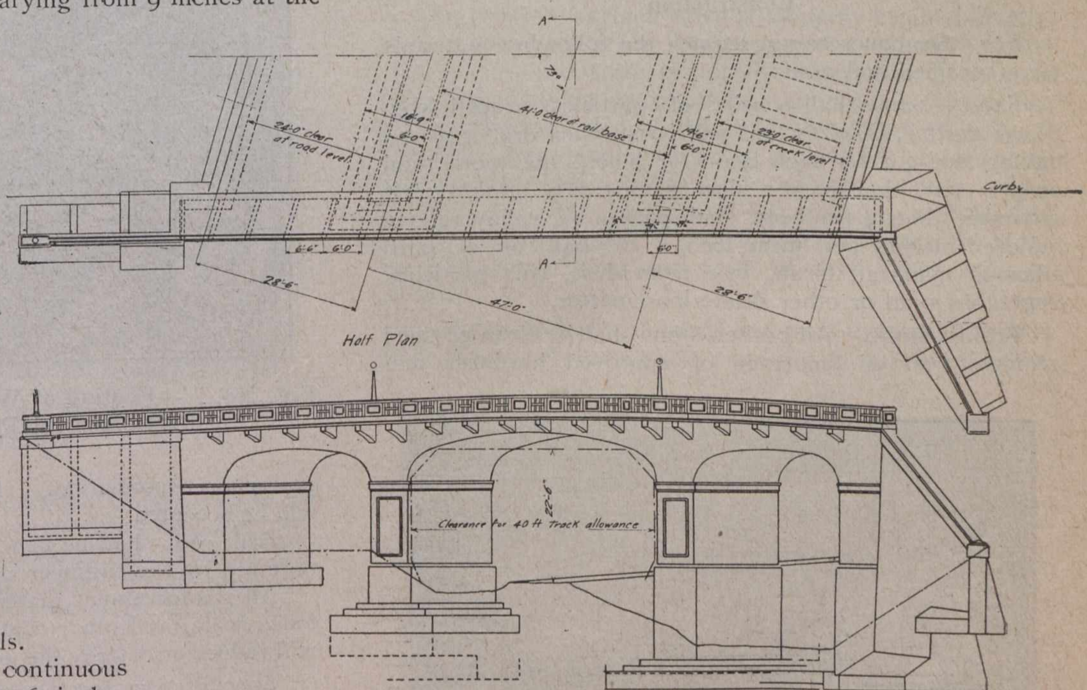
All posts are dowelled to cap and sill by 1-inch diameter dowels 8-inches long and all bracing connections are made with ⅝-inch diameter bolts with cast-iron washers.

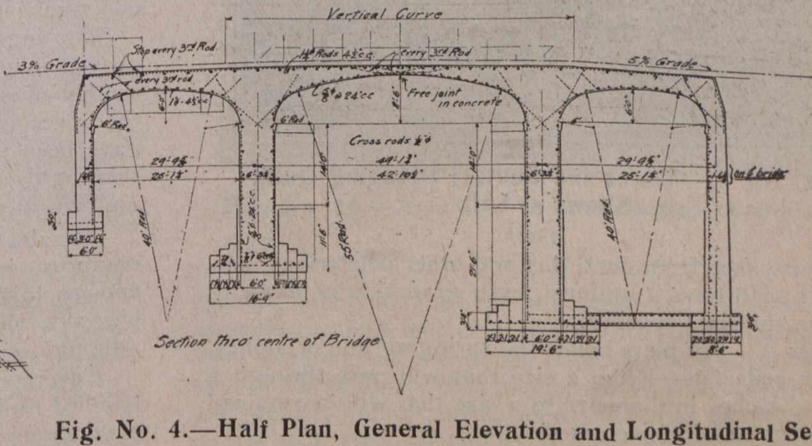
The car tracks are carried on 12-inch x 16-inch timbers, one under each rail and the roadway stringers consist of 4-inch x 14-inch timbers spaced 1-foot 3½-inch centres. The roadway decking consists of a 2-inch wearing surface superimposed upon a 3-inch underdeck.

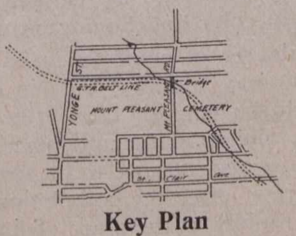
The sidewalk is carried on 2-inch x 12-inch stringers spaced 1-foot 11-inch centres and is composed of 2-inch planking.



Cross Section AA







Key Plan

Fig. No. 4.—Half Plan, General Elevation and Longitudinal Section

The hand-rail upon the trestle is made up of 4-inch x 4-inch posts 6-foot 6-inch centres, two side rails 2 inches x 6 inches and a top rail 4 inches x 4 inches.

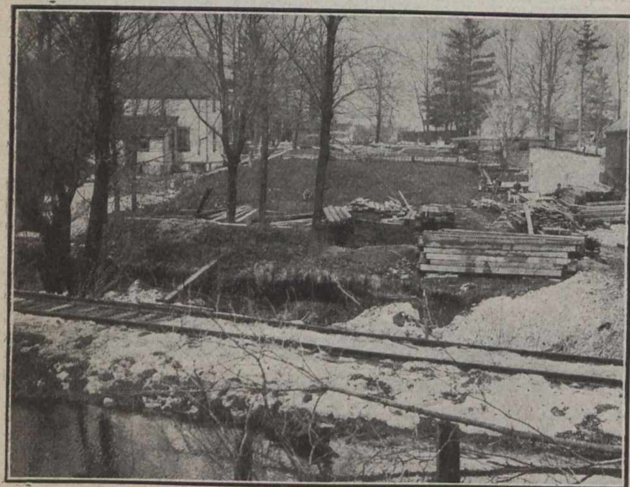


Fig. No. 5.—Bridge Site at Start of Work

Bridging, 2-inch x 2-inch, is used at intervals of 6 feet 6 inches across the width of the floor for the purpose of securing additional rigidity.

Construction

For the concrete aggregates the following materials were specified and used:—

Sand.—Sand shall consist of particles, graded from coarse to fine, of sizes that will pass, when dry, a screen having one-quarter inch diameter holes; not more than 20 per cent. shall pass a sieve having fifty meshes, and not more than 4 per cent. shall pass a sieve having one hundred meshes per linear inch. It shall be of hard silicious material, clean, free from dust, soft particles, vegetable loam or other deleterious matter.

Broken Stone.—All broken stone shall be clean crushed granite, trap or limestone of approved hardness and toughness, free from dust, dirt and other deleterious matter. It shall have a uniform, even gradation of particles between the sizes specified.

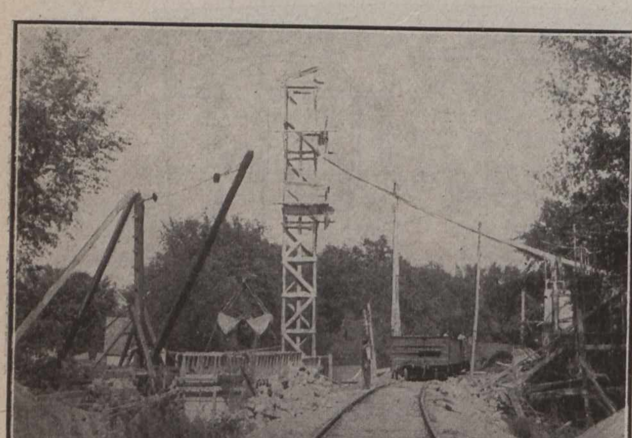


Fig. No. 6.—Tower and Chutes; Dredging Outfit Shown at Left

Class A: For piers below the springing line of arches, and for pedestals—From a size that will pass through a ring 2¼ inches in diameter to a size that will be retained upon a screen of ¼-inch mesh.

Class B: For sidewalk and curbing veneer layers, sidewalk balustrade and lower 2 inches of slabs—Crushed granite or trap rock of approved color or colors from a size that will pass through a screen of ¼-inch mesh to a size that will be retained upon a screen having 100 meshes per linear inch.

Class C: For all portions of the work not included in Classes A and B—From a size that will pass through a ring 1 inch in diameter to a size that will be retained upon a screen of ¼-inch mesh.

Crushed stone having more than the following content of objectionable material will be rejected: (*a*) More than 1 per cent. of earthy or clayey matter; (*b*) more than 10 per cent. of fine stone or stone dust of less size than minimum given in the above grades; (*c*) more than 5 per cent. of soft stone.

In case of the above defects occurring in combination, the percentages will be modified as the engineer may direct.

Reinforcement Metal: Reinforcement material shall fulfil the chemical and physical requirements of the Standard Specifications of the American Railway Engineering Association. No so-called re-rolled material will be accepted.

Fig. No. 7.—Footing of West Wing of North Abutment; Reinforcement Rods for Counterforts

Bent rods shall be bent true to dimensions, and when required by the engineer shall be bent to templet.

All reinforcement material shall be free from rust, loose scale, and other coatings of any character, which will reduce or destroy the bond between concrete and steel.

Specifications for the mixing, placing and finishing of concrete were in part as follow:—

The ingredients of concrete shall be mixed in an approved machine of the batch type. They shall be thoroughly mixed to the desired consistency by revolving in the mixer not less than one minute after all the ingredients have been placed in the mixer, or longer if required, to thoroughly distribute the cement and render the mixture uniform in color and homogeneous.

The degree of consistency or wetness shall be as the engineer may direct; but, in general, it shall be wet enough to be poured from the mixers or the wheelbarrows, and to settle into place without being rammed, although it may require to be spread with a spade.

Concrete, after the completion of the mixing, shall be handled rapidly to the place of final deposit, and under no circumstances shall concrete be used that has partially set.

Before concrete is placed in the forms they shall be thoroughly wetted (except in freezing weather) to fill all the pores of the wood. Oil shall not be used for this purpose.

In all piers and abutments, when required by the engineer, all joints between layers shall be bonded by the embedding of approved hard stones of one-man size in the concrete of the lower layer. These stones shall not be placed nearer than the width of a man's foot to each other or to any face of the piers. All embedded stones shall have the concrete placed first, and shall then be embedded by being forced down into the concrete mass an amount equal to one-half their size.

The sidewalk surface was specified as follows:—

The surface veneer layer shall consist of a layer 1 inch thick composed of 1½ parts cement, ½ part hydrated lime, and 2 parts crushed granite screenings; the last shall be specified under "broken stone" Class C.

All exposed surfaces shall be finished by wet-rubbing to an extent sufficient to produce a fine-grained paste covering the entire surface. Immediately upon the completion of the rubbing this paste must be brushed with a wet whitewash brush to form a thin, even coating upon the

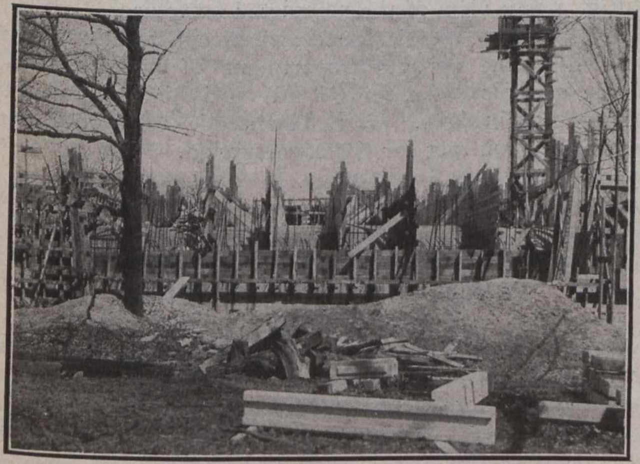


Fig. No. 8.—Forms in Place for Alternate Sections of Superstructure

surface of the concrete. This method has been found to give a finish of a lighter and more uniform color than by the ordinary wash finish with cement grout, probably for the reason that the paste formed from the rubbing is of the same color and composition as the body of concrete.

Excavation for the footing of the piers and abutments was done by clam-shell, horse scraper and by hand labor.

When the excavations had been made the foundation proved to be a dense cemented gravel, so that good bearing value was secured without the use of piles. The soil pressure from piers and abutments is in no case in excess of two tons per square foot and generally less.

The specification for forms in part was as follows:—

Sheathing for forms shall not be less than 1¼ inches in thickness. The face forms shall be of sound, straight, tongued and grooved sheathing, accurately matched and planed smooth on side next the concrete.

The sheeting or lagging of all curved slab centering shall be narrow, accurately matched, tongued and grooved, and planed smooth on the side next the concrete. Joints shall be close-fitting, and all uneven joints or other irregularities shall be planed off. The lagging shall be rigidly supported upon the falsework.

All lagging and timbering of main slabs shall be thoroughly saturated with water prior to commencing the construction of the slabs, and shall be kept so saturated until the concreting of the deck slabs and floor system is completed, and shall then be permitted to dry out gradually as a means of slowly relaxing their support.

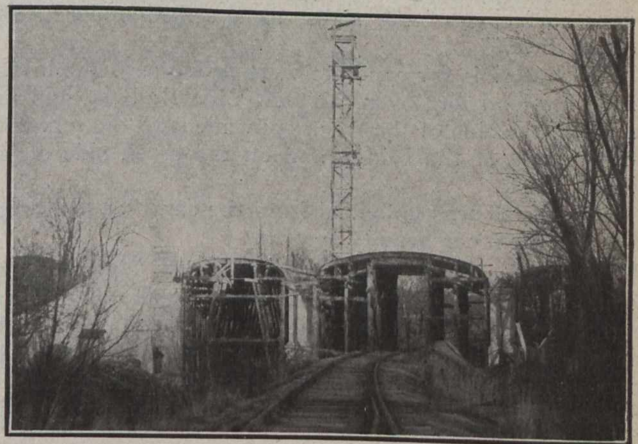


Fig. No. 9.—Falsework and Centering for Arched Superstructure

The roadway and sidewalk surfaces were waterproofed under the following specification:—

The concrete surface when thoroughly cleaned of dirt, loose concrete or other foreign material, shall be first covered with a coating of approved asphaltic material to bond the overlying waterproofing material to the surface of the concrete. Upon this shall be applied two ply of 8-ounce burlap, two ply of heavy asphalt felt and a course of asphaltic mastic; the latter to be not less than 1 inch in thickness. The burlap and felt shall be carefully laid in alternate layers and in such a manner as to permit the layers to break joints and shall be free from folds or pockets.

Between each ply of fabric and over the top surface of same there shall be applied a coating of approved water-

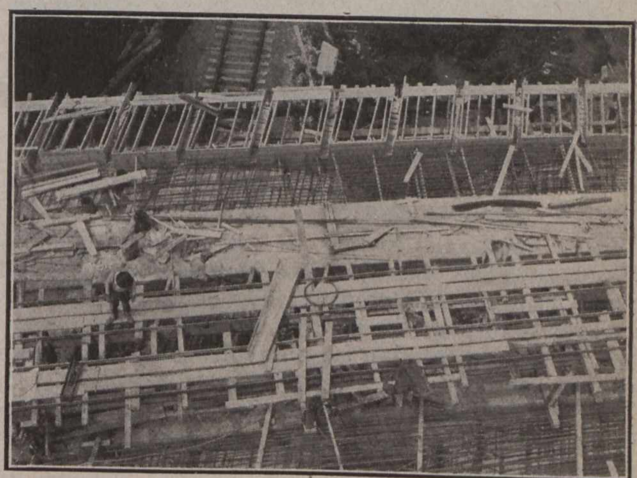


Fig. No. 10.—Aviator's View of Partially Completed Deck

proofing compound in such a manner as to thoroughly saturate, cement and bond the several parts together to form a waterproof membrane covering the whole roadway area of the bridge. This membrane shall be covered with one ply of building paper, upon which the asphalt mastic course shall then be applied to form a continuous layer over the waterproofing membrane specified above.

Special care must be taken in thoroughly bonding the edge of the waterproofing course into the vertical edge of the concrete curb.

The sidewalk slab shall be waterproofed by the use of hydrated lime mixed with granolithic concrete of the veneer surfacing of the slabs, as specified under "sidewalk surface."

The materials for concrete were brought to the bridge site in car-load lots over the Belt Line Railway and unloaded by the side of the track convenient to the mixer on the east side of the bridge and on the creek side of the railway track.

The cement was unloaded from the cars to the storage shed by a twin car gravity system.

Concrete was placed in the piers and abutments by means of a tower equipped with two hoppers at different heights, so located as to permit gravity distribution of the cement by chuting to the various parts of the work. The slope of the chutes and the consistency of the concrete was such as to prevent segregation of the component materials of the concrete.

Fig. 6 gives a good idea of the tower and chute. This view also shows the dredging outfit which was used in excavating the north pier and abutment.

Fig. No. 11.—Waterproofing the Roadway and Track Allowance

Fig. 7 shows the footing of the west wing of the north abutment in place, also the bent reinforcement rods in position in the counterparts. The chute may be noted placed ready to pour the main abutment.

Fig. 9 shows centering for the centre and north arches, also piers and north abutment stripped.

The arched slabs forming the deck of the bridge and the sidewalk brackets and slabs were placed from two buggies travelling on parallel tracks, running the length of the bridge and at an elevation of 8 feet above the roadway level. These tracks were laid on stringers supported on bents resting at first on the arch centering and as the work progressed, on the completed portions of the superstructure.

The buggies were filled by the tower chutes and provided a very flexible method of placing the concrete exactly where it was required with the minimum amount of handling and segregation of materials. The adjustable gates provided in the buggies enabled the operator to control the flow of concrete with great precision.

The above-mentioned superstructure was placed in seven longitudinal sections each of which was placed complete in one day's operation. The sections were placed alternately and by this means considerable formwork was avoided. This is clearly shown in Fig. 8, looking north from the cemetery, which shows forms in place for alternate sections. In the foreground of the picture may be observed sections of the pre-cast top rail for the balustrade.

The aviator's view, taken from the tower (Fig. 10), shows the top of the arch forms for the south and middle arches, the sidewalk bracket forms, the steel reinforcement in place, two longitudinal sections of the floor cast and the tracks for the concrete buggies.

Fig. 11 shows the street railway tracks in place and the waterproofing being applied on the track allowance and on a portion of the roadway. The north end of the east balustrade and the pre-cast lamp-posts may also be observed in this illustration. The bottom sections of the balustrade were cast in place, the panels and the small intermediate vertical sections and the top rails were precast and then set in place and cemented. Finally, the main posts were cast in place.

Fig. 5 shows the site of the bridge at the commencement of operation, looking north from the cemetery.

Fig. 1 is a view of the completed structure.

The structure was designed and the construction superintended by the Toronto Department of Works, R. C. Harris, commissioner, and G. A. McCarthy, engineer of railways and bridges. C. J. Townsend, of Toronto, carried out the contract for the construction.

CANADIAN SOCIETY OF CIVIL ENGINEERS ELECTIONS AND TRANSFERS

At a meeting of the council of the Canadian Society of Civil Engineers held December 28th, the following elections and transfers were announced:—

Bonnycastle, William Robinson, of Vancouver, B.C., elected member. Mr. Bonnycastle was born at Louisville, Ky., U.S.A., 1874; educated at Washington and Lee University, 1891-93, taking an electrical engineering course at Massachusetts Institute of Technology from 1893-97. He was engineer with R. S. Masson, Los Angeles, in charge of design and water power construction developments in Azusa, Mentone and Kern River from 1902-05, and was in complete charge of the Kern River development of 15,000 horse-power, and 125 miles at 67,500 volts. In 1907 he was electrical engineer with Stave Lake Power Co., and two years hydraulic and electrical designing engineer with Western Canada Power Co. (Stave Lake Power Co.); 1912, engineer for Smith, Kerry & Chace until Mr. Smith's death; since then to present time, in private practice as consulting hydro-electrical engineer, specialty, water power development; engineer for the Bridge River Power Co., and Indian River Power Co., of British Columbia.

Bourgoing, Silvio, of Montreal, Que., transferred from student to associate member. Mr. Bourgoing was born at Tadoussac, Que., December 25th, 1884, and is a B.Sc. of Queen's University, class of 1909. He is at present assistant engineer to the city of Montreal, supervising construction of sewers for western division under S. Howard.

Buck, Cameron Alexis, of Toronto, Ont., transferred from student to junior member. Mr. Buck was born at Fonthill, Ont., April 28th, 1892, and is a B.Sc. of Alberta University, class of 1916. He is at present Brinell testing engineer for Imperial ministry of munitions in Toronto district.

Connell, Thomas Clark, of La Loutre Dam Post Office, Quebec, elected associate member. Mr. Connell was born at Dunoon, Scotland, 25th September, 1886. For two years he was chief assistant to burgh engineer and one year as deputy engineer of Dunoon, having full charge of preparations of plans, specifications, surveys, and supervision of construction of large retaining sea wall, harbors, etc. For six months he was on the reconstruction of the C.N.R. span to Cap Rouge; two years with the St. Maurice Construction Co. at La Loutre Dam; one year as instrumentman and one year as chief assistant to Mr. Luscombe, engineer in chief, which post he still holds.

Devereux, Lawrence James, of Prince George, B.C., elected junior member. Mr. Devereux was born at St. Peter's, Cape Breton. He is at present assistant engineer on maintenance and in responsible charge of bridges and construction of depots, etc., and appropriations; also engineer representing the Grand Trunk Pacific Railway Company in connection with proposed railway changes which is handled by engineers of the Dominion government.

Douglas, Frederick William, of New York, transferred from student to associate member. Mr. Douglas was born at Toronto, Ont., April 27th, 1887, and is a B.A.Sc. of the University of Toronto, class of 1914. He is at present with the Foundation Co. of New York, as resident engineer on various contracts.

Dupuis, Joseph Herve, of Montreal, Que., transferred from student to junior member. Mr. Dupuis was born at St. Jacques L'Achigan, January 10th, 1889. He is at present civil engineer for Malcolm D. Barclay (A.M.Can. Soc.C.E.), Montreal.

Ford, Walter Stimson, of Stave Falls, B.C., transferred from junior member to associate member. Mr. Ford was born at Vancouver, B.C., December 6th, 1887, and is a B.Sc. (M.E.) of McGill University, class of 1909. He enlisted in January, 1915, and until November, 1916 was with the Canadian Railway Construction Corps, attached to Belgian engineers in Belgium and France. He is at present with the Royal Garrison Artillery,—2nd Lieutenant, 122nd Siege Battery, B.E.F.

Galbraith, John Stupart, transferred from student to associate member. Mr. Galbraith was born at Toronto, Ont., August 20th, 1891, and is a B.A.Sc. of the University of Toronto, class of 1913 (honors in all four years). From 1913-15 he was demonstrator in the fourth year Faculty of Applied Science and Engineering, University of Toronto. In 1915 he enlisted with the Royal Grenadiers, and in 1916 was on the staff of camp engineer, Valcartier. For the past year he has been with the 123rd Canadian Pioneer Battalion, Royal Grenadiers, France.

Henderson, Charles Elliott, of St. Augustine, Fla., transferred from associate member to member. Mr Henderson was born at Elmira, Ill., January 16th, 1879. He is a graduate of the University of Illinois, class of 1906, and from 1909-10 was instructor in civil engineering at the same university. He is at present county engineer, St. Johns County, Fla., in charge of design and construction of reinforced concrete bridge 2,400 feet long, and 55 miles of paving.

Howrigan, Clyde Paige, of East Fairfield, Vt., U.S.A., elected associate member. Mr. Howrigan was born at Bakersfield, Vt., August 13th, 1879. He is at present in the employ of Fraser, Brace & Co., in charge of railway construction and assistant superintendent on the Loutre Dam, Champlain County, Que.

Johnson, Ernest Nicholas, of Regina, Sask. Mr. Johnson was born at Newport, Monmouth, Eng., April 12th, 1879. In 1916 he was lieutenant with the Canadian Engineers and Royal Engineers in France, and since last April has been resident engineer on construction for the C.P.R. at East End, Sask.

MacGillivray, John Alexander, of Point du Bois, Lac Bonnet, Man., elected junior member. Mr. MacGillivray was born at New Glasgow, N.S., January 7th, 1889. He took a two-year engineering course at Dalhousie College. At the present time he is resident engineer on the 1917 extension of the city of Winnipeg hydro-electric plant at Point du Bois, with W. M. Scott.

Main, Thomas Clouston, of Winnipeg, Man., elected associate member. Mr. Main was born at Northumberland, Eng., April 13th, 1887. In January, 1915, he joined the Canadian Engineers and was sent back from France to England to take position in Royal Engineers in August, 1916. At the present time he is in charge of construction and maintenance of Seres Road in Salonika, Macedonia, with 139th Army Troop Company, Royal Engineers.

Main, Daniel Todd, of Winnipeg, Man., elected member. Mr. Main was born at Kirkintilloch, Scotland, June 18th, 1882, and educated at King William's College (Isle of Man), and Glasgow Technical College (applied mechanics. He was master mechanic for Moose Jaw, 1912-13; master mechanic for Vancouver, 1913-15; superintendent of motive power, Montreal, 1915-16. Since 1916 he has been works manager at Winnipeg.

Mitchell, Archibald Francis, of Victoria, B.C., elected associate member. Mr. Mitchell was born at Clitheroe, Eng., November 5th, 1882. He is at present acting district engineer for Major-General G. B. Hughes, D.S.O., C.B., in charge of harbor improvements, Victoria and Nanaimo; construction and maintenance of Dominion government wharves, Esquimalt graving docks. Quarantine station, wharves, roads and pipe line and other works of the department in Vancouver, which position he has held since 1914.

Mitchell, Coulson Norman, transferred from student to associate member. Mr. Mitchell was born at Winnipeg, Man., December 11th, 1889. He is at present lieutenant with the Canadian Engineers, No. 1 Tunnelling Co., B.E.F., France.

Moore, Ulric Robert, of Ottawa, Ont., elected junior member. Mr. Moore was born at Toronto September 27th, 1891. He is at present adjuster, Imperial Munitions Board.

Noonan, William F., of Kingston, Ont., transferred from student to junior member. Mr. Noonan was born at Kingston, Ont., August 31st, 1890, and is a B.Sc. of Queen's University, Kingston, Ont., class of 1914. He is at present civil draughtsman, C.R.C.E. Office, Military District No. 3, Kingston, Ont.

Tilt, Edwin Bingham, of Madrid, Spain, elected associate member. Mr. Tilt was born at Waterloo, Ont., 6th March, 1879, and is a B.Sc. of McGill University, class of 1903. From 1915-16 he was chief inspector of steel, Imperial Munitions Board, and at the present time is president and general manager of the Sociedad Hispano Americano, Gaston Williams, of Wigmore, C.A., Madrid, Spain.

Wing, Daniel Oscar, of Toronto, Ont., elected associate member. Mr. Wing was born at Camden, Ont., April 6th, 1886, and is a graduate of the University of Toronto, class of 1908. He is at present a land surveyor for British Columbia.

OXY-ACETYLENE AND ELECTRIC WELDING AND CUTTING PROCESSES IN LOCOMOTIVE SHOPS*

By A. F. Dyer
General Foreman, Welding Department, G.T.R., Montreal.

WITH the present prices of material, scarcity of labor, and difficulty of obtaining steel and iron, welding and cutting by both the above-mentioned processes have proved a great boon and an almost indispensable factor in railway repair shops. Seven years ago we employed one man as an acetylene welder, and owing to failures, through his lack of experience, the process was nearly condemned, but as we gathered experience, both gas and electric welding developed, so that now instead of one man we employ 18 and have often to work them overtime.

The low-pressure acetylene gas system is used, and the whole shops are piped for the acetylene, every other repair pit has a drop connection, in locomotive houses we use Prest-O-Lite dissolved acetylene in cylinders, which saves the expenses of a generator and piping where the process is only in use occasionally. There is a great difference in opinion as to the relative merits of high or positive pressure and low-pressure gas, the manufacturers of pressure outfits contending that you save oxygen by using their type of generators and that you cannot get so near to a neutral flame with the low-pressure gas as you can with the high. The makers of the low-pressure outfits claim that by the use of an injector embodied in the torch or welding head, a neutral flame can easily be obtained. We find we can obtain a flame as nearly neutral as can be obtained, with the outfit we use, although with pressure gas you can obtain a much larger flame for the same sized head than with the low pressure. The principal factor, however, that made us decide on the low-pressure outfit was the fact that our main supply pipes are carried overhead throughout the shops, and as nearly all, if not all, oil, steam and water pipes are overhead, we had to consider a very well known motto, *viz.*, safety first, for if a man was working overhead and by mistake broke a joint of the gas pipe, his torch or candle might cause an explosion which might wreck the shop. Though we have been using acetylene gas for eight years, we have never had an explosion of any sort. Our low-pressure generator went through a big fire two years ago, and we were enabled to repair it and use it for several weeks, till we received our new outfit.

There are many kinds of electric welding outfits on the market, and, of course, each one is claimed to be the best by its respective makers; each has its advantages and, whisper it, its disadvantages, and the old prejudice very often exists among operators that the machine they are using and are familiar with is the best, and they will stick to that opinion until they become accustomed to a new machine. A new equipment, using alternating current instead of the direct current, is now being put on the market, and only weighs 150 lbs., and gives from 20 to 200 amperes, and is about 50 per cent. cheaper than any d.c. machine on the market. The electric welding outfit consists of two generators, each operating four welding circuits; the shops are wired and at convenient places connection boxes are placed, and only need a lead and ground wire connected to them and the work on which the welder is engaged. The outfit used has panel controls, which allow each man to control his amperes independent of the other welders.

The processes have proved themselves fit to be ranked amongst the greatest time and labor savers, and also we may safely say money savers, introduced for a long period. For instance, in the not very distant past, a locomotive with a broken frame had to stay several days in the shops before the men could strip down one side and remove the frame to the smith's shop, weld it and perhaps have it machined and then replaced. Now we drop the pair of wheels which may cover the break, cut out the crack with the cutting torch, to the shape of a double V, at an angle of 90°, clean off the oxide caused by cutting, and weld up with the metal electrode, using soft steel for Swedish iron, a frame 4 x 5 ins. being cut and welded in under 14 hours, and it can be done in less time by having two operators on the frame at once, but the men do not like facing each other's arcs, as when they are changing their filling rods their eyes get sore.

Frames, when worn by brake gear and stays, are built up, and worn holes are plugged and welded, instead of reaming them out to a larger size and thereby weakening the frame. In rebuilding and superheating engines, the same boilers are seldom used on their original frames, and as in very few cases do the various holes in angle irons, furnace bearers, etc., come into alignment with frames or boilers, the holes are welded up and re-drilled.

The present price of tool steel demands that none shall be wasted, therefore we use it down to the last inch, by welding it to tire steel. Twist drills, taps, and reamers, when broken near the socket end, are welded and put into use again. For this purpose we use either the electrode or gas, but in both cases we use vanadium steel filling rods, as we find this gives the best results. Spokes of driving wheels are welded, and flat spots on tires have been successfully welded up when it was necessary to do so.

We have not had much success on cast iron, with the iron electrode, although with the carbon you can make a fair job, but the gas is unquestionably the best for any of this material. We have successfully welded with the gas, steam shovel engine frames, slides and cylinders, by welding in patches of cast iron where worn or broken. When our contract for shells was completed and the lathes that were used for this purpose were being overhauled, it was found that most of the V slide beds were worn down by the tool carriers; these were built up with the gas, which saved machining these beds down in many cases ⅜ in.

Most of the boiler welding is done with the iron electrode, using a mild steel or Swedish iron as a filler. It is found that the electric process localizes the heat more than the gas does though it is the writer's opinion that gas makes a closer and neater weld, as all welds made by the electrode are more or less porous, unless hammered up. It pays better, whenever possible to do so, to put quarter or half sides, in order to get out of the fire line, in preference to putting in a patch, for, as a rule, however well the patch is welded it generally gives out in from 12 to 18 months' service, and the same applies to cracks, whereas the half or quarter side should last as long as the firebox.

When a nest of small cracks is found round the staybolts, the bolts are removed and the holes countersunk and welded up. This method has been found to be very successful. Corner patches are welded in by running the patch into the tube or back sheets, as the case may be, at the same time removing the flanges. If it is decided to do away with a number of tubes, plugs are welded in the holes, first countersinking the holes and having the plugs

(Concluded on page 42)

*Abstracted from paper read before the Canadian Railway Club in Montreal.

THE FLOW OF WATER IN SIPHONS*

By Mark Halliday

An analysis of the flow of water in siphons, simple and compound, suggested itself to the writer after the perusal of the discussion of Mr. George R. Nicholson's paper on "The Horsley and Nicholson Automatic Compound Siphon."

Consider first the simple siphon shown diagrammatically in Fig. 1, which is arranged to siphon water from the tank A over the point B to the tank C.

Let H_1 = static head in tank A above datum;
H_2 = static head at point B above datum;
H_3 = static head in tank C above datum;
p_1 = pressure in pipe at entrance A;
p_2 = pressure in pipe at point B;
p_3 = pressure in pipe at exit C;
v_1 = velocity of water at entrance to pipe at A;
v_2 = velocity of water in pipe at point B;
v_3 = velocity of water in pipe at exit C.

Then, by Bernouilli's theorem—

$$\left.\begin{aligned} & H_1 + \frac{p_1}{62{\cdot}4} + \frac{v_1^2}{2g} \\ &= H_2 + \frac{p_2}{62{\cdot}4} + \frac{v_2^2}{2g} + \text{friction head from A to B} \\ &= H_3 + \frac{p_3}{62{\cdot}4} + \frac{v_3^2}{2g} + \text{friction head from A to C} \end{aligned}\right\} \quad (1)$$

The friction head in feet $\dfrac{4\,f\,l\,v^2}{2\,g\,d}$ for round pipes - (2)

where f = coefficient of friction; l = length of pipe, in feet; v = velocity of water, in feet per second, and d = diameter of pipe, in feet.

Transposing equation (1) gives—

$$H_2 - H_1 = \frac{p_1}{62{\cdot}4} + \frac{v_1^2}{2g} - \frac{p_2}{62{\cdot}4} - \frac{v_2^2}{2g} - \frac{4\,f\,l_1\,v_2^2}{2\,g\,d} \quad (3)$$

l_1 being the length of pipe from A to B, the loss at entry to the pipe is neglected.

Also, if the pipes are of equal diameter throughout, $v_1 = v_2$.

In order to obtain the maximum velocity at point B, $p_2 = 0$.

$$\text{Then} \quad H_2 - H_1 = \frac{p_1}{62{\cdot}4} - \frac{4\,f\,l_1\,v_2^2}{2\,g\,d} \quad - - - - \quad (4)$$

but $\dfrac{p_1}{62{\cdot}4}$ = head of water, in feet, equivalent to atmospheric pressure or, say, 34 ft.

$$\text{Then} \quad H_2 - H_1 = 34 - \frac{4\,f\,l_1\,v_2^2}{2\,g\,d} \quad - - - \quad (5)$$

$$\text{Let} \quad H_2 - H_1 = h_2 \quad - - - - - - - \quad (6)$$

$$\text{Then} \quad v_2 = \sqrt{\frac{2\,g\,d\,(34 - h_2)}{4\,f\,l_1}} \quad - - - - \quad (7)$$

$$\text{Also let} \quad H_1 - H_3 = h_3 \quad - - - - - \quad (8)$$

$$\frac{p_1}{62{\cdot}4} = \frac{p_3}{62{\cdot}4} = 34 \text{ ft.} \quad - - - - - - - \quad (9)$$

And $v_1 = v_3$ if the pipes are of equal diameter.

From equation (1)—

$$H_1 = H_3 + \frac{4\,f\,l_2\,v_3^2}{2\,g\,d} \quad - - - - - - - \quad (10)$$

l_2 being the length of pipe from A to C.

$$\therefore v_3 = \sqrt{\frac{2\,g\,d\,h_3}{4\,f\,l_2}} \quad - - - - - - - - - - \quad (11)$$

$$v_3 = v_2 \quad - - - - - - - - - - - - - \quad (12)$$

$$\text{Then} \quad \frac{2\,g\,d\,h_3}{4\,f\,l_2} = \frac{2\,g\,d\,(34 - h_2)}{4\,f\,l_1} \quad - - - - - - \quad (13)$$

$$\text{or} \quad \frac{h_3}{l_2} = \frac{34 - h_2}{l_1} \quad - - - - - - - - - - - \quad (14)$$

Unless this relationship holds, the siphon will not work continuously without a regulating valve. It will be noted that h_2 equally as much as h_3 governs the discharge. If h_3 is excessive, then v_3 tends to become larger than v_2, and cavitation in the pipes will result.

This explains the statement made by so many that some siphons work better when the valve at the delivery end is partly closed. This must necessarily be the case, as the valve must be regulated until (v_3 × area at C) = (h_2 × area at B).

The same reasoning when applied to the Nicholson compound siphon results in the following deductions:

Fig. 2 shows the diagrammatic arrangement of the siphon; H_2, $\dfrac{p_2}{62{\cdot}4}$, and v_2 are the static pressure, velocity and energies per pound of water respectively at the air inlet N of the compound siphon. Then if the air inlet and trap N, S, N, is fixed in a position according to the relationship in equation (14), *viz.*, such that $\dfrac{h_3}{l_2} = \dfrac{34 - h_2}{l_1}$ (14), the compound siphon will discharge as much water as any simple siphon.

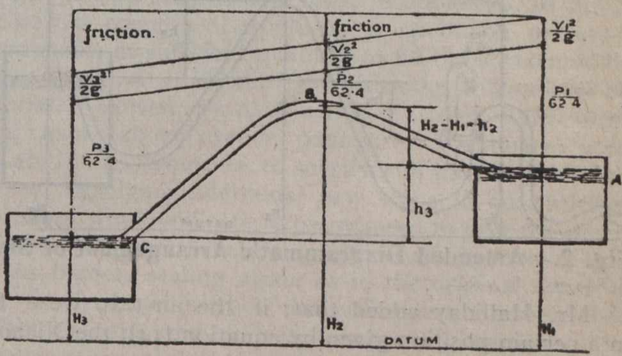


Fig. 1.—Single Siphon Shown Diagrammatically

It has been assumed throughout that f, the coefficient of friction, is the same for the whole length of pipe considered; also, in order to simplify the argument, that $p_2 = 0$.

For a maximum discharge, this would be so, but the analysis would hold equally well if p_2 had a value of a few feet.

In that case the figure could be inserted to slightly modify the result in equation (14).

Discussion.

Mr. G. R. Nicholson, whose paper had inspired Mr. Halliday's analysis, remarked that he wished Mr. Halliday had enlarged on the question of cavitation. Whenever a simple siphon was worked on a long length of pipe line, considerable friction occurred, and when an extensive length of pipe dropped a considerable depth below the level of the water at the intake, by the law of gravitation the velocity at the outlet would be greater than the velocity at the intake and cavitation occurred at the highest point of the siphon, i.e., a partial vacuum

*From a paper read before the North of England Institute of Mining Engineers.

was formed by the increased speed of the falling or pulling leg being greater than the speed on the intake side. After a time, cavitation extended to a point at which the column of water in the siphon was broken in two parts, one column dropping down each leg of the siphon, which became empty. Many siphons worked better with a cock at the outlet. This required careful adjustment and close attention to get the best results. In the Nicholson automatic compound siphon, cavitation was impossible, and a regulating cock was not required. It was self-contained and self-adjusting in every circumstance that might arise. It had no mechanical action, being entirely atmospherically controlled.

Mr. Halliday stated that the whole analysis pointed to the fact that, unless the relationship in equation (14) held good, they must have a throttle outlet. If that were provided, and the velocity at the outlet equalled the velocity at the top of the pipe, cavitation would not take place. No doubt there were in that neighborhood hundreds of siphons working under these conditions without ever breaking down. He had occasion to put in a siphon recently delivering quite 3,000 gals. per minute. It was a simple siphon, with a lift of a few feet. It had been working nine or ten months now, and had never stopped once. He held that cavitation could occur with the Nicholson siphon.

Mr. Nicholson: Not to the extent of breaking up.

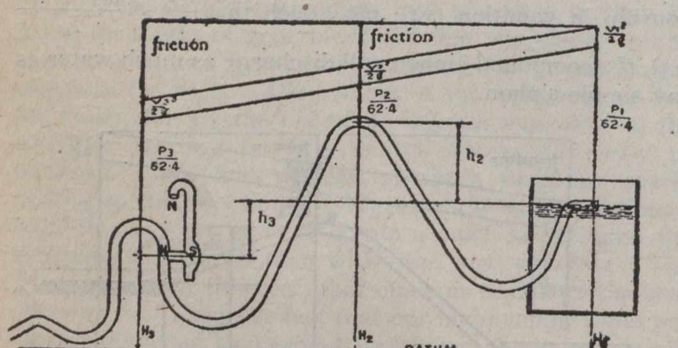


Fig. 2.—Amended Diagrammatic Arrangement of Siphon

Mr. Halliday added that, if the air-trap were fixed in a certain position given by equation (14), the Nicholson siphon would deliver as much water as any other siphon. In the previous discussion on Mr. Nicholson's paper, that had been disputed, but it was so.

Mr. Nicholson said that a short time ago he had an enquiry from a Lancashire colliery where there was a siphon working. To make sure that it was perfectly tight, they had taken the pipes off and re-laid them three times. They put a valve on the outlet and said that, when it was left at full bore—it had an excessively long leg—it simply broke up after three or four hours' working. After he put a cock on and readjusted it, however, it sometimes worked for several days.

Mr. Mark Ford remarked that there was a good deal of bother with siphons in mines. He asked whether that was because mine water contained air and gas, and that the reduced pressure at the top of the siphon caused the air and gas to cling to the top of the pipe.

Mr. Halliday replied that that might be the cause if air accumulated at the top of the siphon. When once that pressure reached a certain figure, the siphon would stop work. He assented to Mr. Ford's suggestion that the pressure of water would be reduced at that point, and that the tendency would be for the water to give up its air or gas at that point.

The president said he had seen gas gathering at the head of a siphon so that, if one opened the plug, one could have lit it. They had a lot of trouble many years ago with water containing so much gas. He dared say that that could be got rid of by regulating the outlet, so as to keep the gas out in a great measure.

Mr. Ford questioned whether there was anything to prevent the accumulation of gas at the top.

Mr. Halliday agreed that, if they had considerable quantities of gas in solution in the water, when they commenced siphoning, the gas was naturally given off at the highest point of the siphon. He asked Mr. Nicholson how he dealt with that problem.

Mr. Nicholson replied that there was a T-piece at the inlet end of his siphon, which stopped atmospheric air from getting into it. He quite admitted that gas in solution might be in the water, however. As the water passed through, this gas formed a small air lock in the first instance, and that air lock was carried through like a solid cartridge. The gas came off in small globules right through the pipe, but, if there was any flow of water at all, these globules did not adhere to the side, but were carried through. If the siphon were standinng, these globules adhered and, after a time, rose to the top. The siphon would have to stand a very considerable time, however, before there was enough gas generated from the water to break up the siphon. In practice, he thought that the amount of gas generated in the pipe was very, very small.

Mr. Halliday remarked that it might amount to 3 or 5 per cent.

BUILDING SHIPS IN RECORD TIME

The Foundation Company, on December 27th, launched the first of the ships outlined on the Imperial Munitions Board Emergency shipbuilding programme.

Last spring the Imperial Munitions Board placed several orders for wooden ships, and these are being constructed in different parts of Canada. The ships are rated at approximately 2,500 tons, and have a length of 250 ft. and a beam of 43 ft. 6 in. The elapsed time from the breaking of the ground to the launching of this ship was approximately six months, which bears testimony to the ability of Canadian organizations to rise to the assistance of their country in these times of emergency.

The Foundation Company's shipyard is in charge of W. I. Bishop, who is well known in the contracting and engineering field in Montreal and Toronto.

MOUNTAIN FOR WATER-FRONT FILL

The engineer who is undertaking the cutting down of the Costello Hill at Rio de Janeiro, Brazil, and using the material to reclaim a large area of submerged land on the water-front is Luiz Barretto Filho, of Sao Paulo, Brazil. The present property on the hill would have to be purchased, but the levelled site and the newly-filled site would become the property of the syndicate for development purposes. The cost of removing the 4,700,000 cu. yds. and depositing them in the fill is estimated at $10,000,000. The removal of this hill has been proposed at various times for more than 100 years, the object being to improve the ventilation of the city, as cool winds are now obstructed.

RELATIVE EFFICIENCY IN METHODS OF REPAIRS TO BITUMINOUS MACADAM AND BITUMINOUS CONCRETE PAVEMENTS*

By George H. Biles,
Second Deputy State Highway Commissioner of Pennsylvania.

IN recent years there has been marked development in the methods of repairing and rehabilitating bituminous pavements. There are innumerable instances where pavements had apparently arrived at a stage of such failure that their entire reconstruction seemed justifiable, but by scientific, efficient and economic methods of the highway engineer they have been repaired at a great saving in cost, which in the end is one of the most essential factors in all construction work.

Bituminous macadam is represented principally by the penetration method types of pavement. Naturally, in the analysis of this subject, the first thought is directed to the causes of the various forms of disintegration or failure in pavements of this type, and whereas it is extremely difficult in all cases to arrive at definite conclusions, observation, experiment and laboratory analyses of samples taken from the pavements furnish invaluable data from which fair judgment can be made. Before taking up the efficiency of the actual methods of repair, some of the failures and causes of disintegration common to these types of pavement will be described briefly.

The bituminous penetration method road in its various stages of disrepair or disintegration furnishes a fertile field of opportunity for study and experiment. The most common deficiency in this type of work is found in the non-uniformity of the surface. As an example, we have, first, a section of road where the surface is composed of spots of excess bituminous material, and bare or lean areas, where the binder is lacking in quantity, which condition results in a short time in a ravelling or breaking up of the road surface. This condition is usually caused by improper distribution or by incorporating the bituminous material when the stone is not thoroughly dry.

Second.—A rough surface is presented where the stone is loosened or ravelled, the binder showing rapid deterioration, generally causing a series of pot-holes. This may be occasioned by improper or overheated bituminous material, unsatisfactory aggregate or faulty subdrainage.

Third.—At times we have apparently a lifeless surface in so far as the bitumen is concerned, but upon further examination it is found to contain bituminous binder with considerable life a slight depth below the surface. This condition is due in many cases to an insufficiency of bituminous material.

Fourth.—A pavement may present a wavy and uneven appearance, and this is usually due to an excess of bituminous material, or is caused by the bituminous material being too soft to withstand the action of traffic.

Fifth.—There are surfaces which consist of ridges of material which are the result of irregular or improper pouring—in most cases, careless hand-pouring. A surface of this kind suffers quickly from the impact of traffic and the attack of the elements, and early disintegration is the result.

Sixth.—We have a fairly well-shaped, uniform surface becoming porous. This condition is true of all bituminous highways in time, as it represents the beginning of the deterioration of the bituminous material.

It will be seen that before repairs are taken up on bituminous macadam roads, careful study and examination are necessary in order to select the most effective method. Taking the several conditions in order as hereinbefore mentioned, the first case, if taken in time, can be repaired by sealing the dry or lean spots in the surface with a light, heated application of bituminous cement of the binder grade, or the cold bituminous surface treatment materials in quantities ranging from one-tenth of a gallon to three-tenths of a gallon to the square yard of surface, covered with chips or pea gravel, using between fifteen and twenty pounds to the square yard. Unless the surface is badly worn, repairs of this character will even up the surface to a true cross-section, giving added life to the pavement.

The second condition calls for heroic treatment if of any great extent, and a complete scarifying and harrowing of the surface becomes necessary. All disintegrated material must be removed and sufficient new stone added to give the required depth before the surface can be repenetrated and sealed as in the original construction. If, however, the affected portions are only occasional and do not represent the greater area, they may be cut out, cleaned thoroughly and filled with new stone, making due allowance for compression, then penetrated, etc., in the manner hereinbefore mentioned. If drainage conditions are responsible for the failure, they must be corrected before any surface repairs are taken up.

The condition described in the third example may be treated in two ways. The most economical, so far as first cost is concerned, would be to give the pavement a treatment, in sufficient quantity to fill the surface voids, with a material that will penetrate and enliven the old material, followed by a covering of good, hard stone chips, using about twenty pounds to the square yard. The alternative would be to scarify and harrow the whole surface, supplying additional new stone in quantities as the rolling would indicate to be required to give the proper cross-section, and penetrating the surface with a bituminous binder, sealing again as in the original construction. In the latter method the surface must first be thoroughly cleaned, and in scarifying and harrowing the remaining bituminous material in the road must be distributed as evenly as possible. If the material found in the pavement, however, does not possess life, this method is a hazard.

In the wavy, corrugated surface, where there is found to be an excess of bituminous material, it is generally more economical and satisfactory to scarify and reshape the surface, adding new stone in order to take up the excess bitumen, and again sealing the surface. This same method should be followed where waves have been caused by the bituminous material being too soft, only, perhaps, more stone would be required in the reconstruction, and it would be essential to incorporate a harder bituminous binder than was used in the original construction.

Occasional waves in the surface may be taken out in the due course of ordinary repairs by cutting off the high places and resealing if the conditions are very pronounced, or by cutting out the depressions and replacing with new material.

A surface full of ridges, due to improper pouring, if not too pronounced, may be evened up by painting between the ridges with bituminous cement and covering with stone chips or gravel. This method may be continued from time to time until the surface is entirely evened up. This condition may also be corrected by scarifying the

*Paper presented before Section "D" of the American Association for the Advancement of Science, December 28th, 1917.

surface with the object of obtaining a more uniform distribution of the old bituminous material, and, after rolling to the proper shape, by applying a surface treatment of a cold bituminous material that will enliven the existing material and seal the surface. This treatment is covered with stone chips in the manner prescribed for regular bituminous surface treatment work.

In the last case we have a properly constructed bituminous penetration pavement, but the bituminous material is starting to deteriorate. This can be enlivened or revived by cleaning the surface and applying a seal coat of material in quantities, depending upon the degree of disintegration. Caution should be exercised to avoid applying an excess amount, which results in a slippery condition, and is very objectionable to horse-drawn traffic. Generally, one-tenth to one-sixth of a gallon is used and brushed into the surface with hand-brooms. The surface is then covered with chips or gravel approximating twenty pounds to the square yard. In the use of certain slow-drying, cold bituminous materials it will be observed that this new material softens up the old bitumen somewhat, giving the appearance at first of an excess application, and, having a hard surface underneath, the road becomes quite slippery, but this condition obtains for only a short period of time.

To insure the best results, one-half of the road should be treated at a time in order that the traffic may use the other portion while the bituminous material is setting up. This method has become quite effective, and results in increased life to the pavement.

In the repairs of breaks, depressions and local defects, which may occur under any one of the general conditions previously outlined, it is more satisfactory to use hot bituminous binders, and if replacements are necessary, they can be made after the fashion of the original construction. This work can be done very efficiently in this manner with little equipment and the average class of labor. There are a number of instances where cold bituminous compounds can and are being used successfully in certain seasons of the year on pavements of this kind, but in cold weather there is usually difficulty with some of this material, owing to its composition. As an example, the emulsified products break down or separate, and their adhesiveness is destroyed at low temperatures. Materials that are cut back with natural solvents can be used later and give very good results. The mixtures can be prepared at some point, not exposed to the weather, but convenient to the work, hauled to the site of the repairs and deposited. This is an effective method in case of emergency.

Bituminous Concrete Pavements

The various mixed bituminous pavements, with the exception of sheet asphalt, are included in the class of bituminous concretes.

Careful observation in locations where there is considerable bituminous paving shows that different streets, in spite of the fact that they have been constructed of the same material, present different appearances. Cracking of the surface is one of the greatest, as well as one of the earliest, defects that may develop in bituminous pavements. This may be due to one cause or a combination of several causes. Frequent cases are noted in bituminous wearing surfaces, which, although apparently satisfactory mixtures in all other respects, contract as the base contracts, and crack open at exactly the same point as the foundation. Again, cases are noticed of otherwise satisfactory pavements which crack because of their failure to receive the amount of traffic necessary to give the pavement its full compression, or to iron out and close up the surface after low temperatures have tended to open it up by stretching the bituminous binder.

A condition of the sort last described, however, may have been hastened considerably, or even caused directly, by what might be called improper design of the pavement in the first place.

The bituminous surface mixtures expected to receive heavy traffic should be tough and fairly hard in order to resist displacement. Those designed for light traffic should be softer and more yielding, and this is accomplished by using a softer bitumen, that is, one of a higher penetration. Failure to do so means that as the pieces of mineral aggregate contract or shrink in volume during cold weather, they exert a spreading force in the surrounding bitumen, which it cannot withstand because of its lack of light fluxing oils and corresponding ductility or ability to stretch; in other words, pavements containing hard or non-ductile bituminous material will have a greater tendency to crack in cold weather. Similar results, and even general disintegration of the wearing surface, may have been produced by too little bitumen in the mixture, since this is largely a measure of the life and elasticity of the pavement; and, similarly, overheated mixtures suffer a hardening and reduction of bonding power of the bitumen, with consequent tendency to crack and wear. Aside from faulty drainage, poorly proportioned mixtures and unsuitable ingredients contribute largely to the failures in this type of pavement.

A bituminous concrete pavement which is satisfactory in all other respects may show surface indications of slight disintegration. The material in all probability has been attacked by the elements and evidence of wear is shown as the gloss is gone and the discoloration of the surface, which approaches a light brownish hue, is noticeable. This is speedily followed by a general porous condition and, if not promptly attended to, will allow the surface to retain moisture, which will eventually break the bond of the material and result in ravelling and failure of the pavement.

The wavy condition of the surface found in the bituminous macadam roads is also common to the bituminous concrete types. This condition is usually found on well-travelled streets, especially on grades, and is caused mostly by the bituminous mixture being too soft, which gives it a tendency to push under traffic. A wavy surface may be attributable to the methods used in the construction of the pavement for, if in the building the material was not at a temperature suitable for raking to a uniformly loose condition, or crept under the roller as a result of careless handling or being rolled while too hot, an irregular surface would result. Pushing or waving in local spots may often be traced to the laying of the mixture on a dusty or dirty surface.

The wearing and deterioration along the edges of bituminous pavements where there is no header, is responsible for one of the most troublesome and expensive forms of repairs to roads of this type. The traffic continually irons out the surface along the edges and this spreading or flattening out produces a feather edge along the sides. The moisture and foreign material tracked on from the shoulders soon attack the bituminous material and result in the crumbling or breaking away of the surface which occasions extensive repairs. This condition is more pronounced when the material in the shoulders is of a non-porous nature or is poorly drained.

In the repairs to the bituminous concrete pavements, special care is required in determining the methods and materials to be used. Taking the several conditions enumerated in the foregoing in their order, we first have a cracked bituminous surface and, unless the cracks are caused by some serious form of disintegration in the pavement, they can be repaired by cleaning them out thoroughly and pouring them full of either a hot or cold bituminous material of the proper grade, and thereafter tamping or wedging stone chips into the crack, thoroughly sealing it. If the crack is wide enough and the edges have crumbled or broken off, they should be cut down evenly and the opening filled and tamped with a mixture of the bituminous cement and stone chips in a proportion of one part bituminous cement to nine parts chips, in sufficient quantity to insure complete closure.

When the entire surface is cracked or broken and is uniformly bad and gradually crumbling away due to the disintegration of the material from any of the several causes hereinbefore mentioned, it becomes necessary to remove the old material and replace with a new surface. If the condition exists only in local spots this will develop into pot holes or depressions which can be repaired by cutting out the affected areas down to the foundation and replacing with a new mixture.

The character of the bituminous material to use depends entirely upon the conditions in each case. Unless the repair work is extensive, it is not deemed advisable to use hot bituminous compounds in this work, not only from an economic standpoint but from a point of convenience as well. Small repairs in the proper season can be handled economically and efficiently with cold bituminous cement and if the proper mixture is used in the regular working season excellent results can be obtained.

It is conceded that hot bituminous repairs are not generally satisfactory when made at low temperatures, but in some places the avoidance of this practice has been carried almost to a fault. As an example, in some of the larger municipalities where defects have developed in the surface during the winter months, the affected portions have been removed and repaired with brick or stone block. This method is not only objectionable on account of the annoyance to traffic but when the regular season for repairs arrives it is usually found that additional work is required, occasioned through the inequality of the surface. It has been stated by some of the advocates of this method that it is an assurance that the affected portions will not be overlooked when the repair work is taken up in the spring. It has been demonstrated, however, that where conditions are so acute that this method is warranted, there is justification for making special arrangements for preparing and placing a suitable bituminous mixture which will be more satisfactory in the interim and, whereas, probably not a complete success, will offer as good, if not better, opportunities to correct later than the first method, which seems only to be justified when repairing cuts made in the pavements by public service corporations in the winter season.

When the surface of a bituminous concrete pavement begins to show that the bituminous material is disintegrating and the surface has a dry, porous appearance, similar to the appearance of the bituminous macadam pavement previously described, the surface can be revived by a light bituminous surface application the same as in the former case.

The wavy, irregular surface on bituminous concrete pavements is one of the most unsatisfactory conditions pertaining to the bituminous type of pavement. It is a defect that in most cases is proof positive of the inability of the pavement to meet the traffic requirements, except when the fault may have resulted from the methods used in the construction rather than the materials. If the materials have been found unsatisfactory and the irregularity of the surface is increasing steadily, reconstruction will eventually be necessary.

If the surface is only affected in local spots due to any of the other causes enumerated, this area may be removed and replaced with a new mixture which has been properly selected and strict attention should be given to the requirements of the mixture in order that a repetition of the original deficiencies cannot obtain.

When the proper material has been used in the original construction and the surface is irregular through careless methods in spreading, beneficial results can be obtained from rolling the surface in hot weather with a tandem power roller operated by a competent man.

In the repairs to the edges of a bituminous pavement not confined by headers, the first and most essential thing to do is to correct the cause, if possible. If the drainage of the shoulders or base is faulty, this should be taken into consideration first and ample provision made therefor. On shoulders which are composed of non-porous material, it is advisable to cut scuppers or small surface ditches at intervals of approximately twenty feet along the road and, in addition to this, the material immediately along the edge of the pavement should be replaced for a depth of a few inches with broken stone or gravel tamped into place to produce a more stable buttress for the new bituminous material. The patches should be made by removing the affected area and replacing with new mixture. Successful repairs should neither be above nor below the surrounding surface when finally compacted.

In municipalities where there is enough yardage to warrant a central mixing plant, this is the most satisfactory method of handling bituminous repairs. With every facility at hand to compound the mixture properly, more uniformity is assured and much of the personal equation resulting from separate organizations is eliminated. There are localities where possibly small portable mixing plants would meet the requirements and give satisfactory results. However, under ordinary conditions, the problem is generally a small town with probably several short streets or some other unit, such as a county or state, with continuous stretches of miles of interurban bituminous pavements or highways. In either case, it means one or a number of outfits performing the repair work, which conditions give strength to the demand for simple and efficient methods. With trained men, good hot bituminous mixtures have been prepared by hand, but considering the chances taken in over-heating the material, the careless proportioning and mixing and the extra expense in connection with the handling of the equipment, etc., it does not justify this method. The cold bituminous mixture with the proper material is the most economical and fool-proof method for ordinary repairs. The material can be mixed on a regular mixing board, stock prepared for future use, if need be, and stored at convenient intervals along the road and, aside from the small tools, such as shovels, rakes and tampers, no other equipment is absolutely necessary. Repairs have been made with cold bituminous mixtures on extremely heavy-travelled roads that are in excellent condition after four seasons of wear.

In a recent report of the Coal Conservation Sub-Committee on the Supply or Electrical Power, proposals are made which would revolutionize the industry of Great Britain. The main reforms advocated are as follows: Construction of 16 super-power stations in different parts of the country; supervision, with adequate compensation, of 600 smaller undertakings now in existence; utilization of the by-products at each of the big stations; national control of the whole undertaking by a national board of electricity commissioners.

THE BASIS OF WATER CHARGES IN URBAN AREAS FROM THE POINT OF VIEW OF COMMON UTILITY*

By E. C. Rodda
Waterworks Engineer and Manager, Southampton.

I FEEL convinced that any discussion on water charges will be largely barren of any useful result unless there can be found some common ground of agreement with respect to the general principles upon which moneys should be raised for a great public service of common utility.

If we can show that the public water supply is not the least important of the great public services, and is not primarily of individual benefit, we are entitled to say that no class or individual of the community should be allowed to escape from a due and proper share in the cost thereof.

We are in danger, and by we I mean the people who enjoy the benefits of water supply on the one hand and ourselves who administer the supplies on the other—by a long and close familiarity of the many and great blessings accruing from a modern water supply—of losing sight of that characteristic which distinguishes it from all the other public services—*viz.*, that of its indispensability.

Our modern water supplies are essential to life itself; they are essential to the public health; they are essential to the security of property; and they are essential to the increasing comfort and well-being of the community.

You may think I am exaggerating this danger. Let us take a typical example of the consumer. Here is a man who has a combined residential and business premises. Finding that the value of water consumed per meter is less than what he is asked to pay as a minimum charge, and finding also that he has already paid for the public sanitary purposes, he desires to know what the balance is for. He is often told that if his premises are threatened with fire, the water used for extinguishing the fire will be supplied free of cost. But this answer does not satisfy him, because his property is covered by insurance, and he points out that except he goes to the expense of a sprinkler installation the premium he pays is very little less than he would pay for a house in the country miles from the nearest water main and miles from the nearest fire-brigade station.

Benefits of a Water Supply

On the face of it, then, the individual has no interest in the public water supply so far as it might protect his own property. But is this really so? Can we imagine the effect of any of our great urban areas being suddenly deprived of the water mains simultaneously with a great outbreak of fire? . . .

Without pursuing the matter any further, it is evident, I think, that no individual can deny his obligation to the public water supply, inasmuch that, despite the aids from fire insurance and the fire brigade departments, the great fundamental safeguard to property is the existence of an abundant supply of water at an adequate pressure.

Now note that in this typical case of the consumer the individual pays for police protection, for public lighting and paving, for the purposes of public health, for old age pensions, for the care of the poor, for the education of his neighbor's children, even supplying them with free meals, and so on. But in regard to the water supply he questions his obligations. Yet his obligation to the water supply as a safeguard of public property is not the only one.

Take the public health. I find it a difficult matter indeed to put in a few paragraphs what can only adequately be dealt with in a much larger space, and I am awake to the difficulties of justly attributing to the water supply its particular benefits on the public health, and of appearing to be unfair to the other important agencies—*e.g.*, the removal of refuse, sewage disposal, the better housing of the poor, education, etc.; but when all is said for these other agencies, it must still remain true that most of the labor of the Health Department would be wholly undone in the absence of a good water supply. When first introduced there was a great prejudice against drainage, many of the sewers being nothing more or less than elongated cesspools, and remained generally ineffective until water mains were laid in the streets.

The Meter System

I believe the great majority of those whose duty it is to administer our water undertakings are opposed to the idea of the universal supply of water by measure—a system which is largely in use in Germany and America—for it is recognized that in order to supply water to the poorer classes absolutely without restrictions and at the lowest possible price—invariably at a loss—the present basis of charging on the rateable value for domestic supplies is never likely to be improved upon.

But nevertheless there are a number who, while refusing to go to the extent of metering every service pipe, are obsessed with the idea that the revenue from each class of consumer—*viz.*, the domestic consumer, the occupiers of combined business and domestic dwellings, and lock-up shops, and the trade consumer—should bear an equal proportion of the cost per unit of assessable value. Now there are two main questions to answer here: (1) Who is to bear the loss on the lower rated domestic dwellings, and (2) who is to bear the loss of water by unavoidable waste?—a large item in some towns.

One of the strongest reasons for the writing of this paper is the necessity I see of attacking the tendency to regard the supply of water by measure as the only equitable, or the most equitable, means of raising revenue therefor.

This view was prominent in the Metropolis Water Bill of 1884, promoted by the Corporation of London, for regulating the water supply of London, but this bill, like the purchase bills of 1878 and 1880, was a failure. It was proposed to supply water by measure, it being urged that a charge based on the rateable value was not fair, being irrespective of the consumption. The consumer had the option, however, of taking the water by meter with a minimum charge at 6d. per 1,000 gallons, or being charged upon the rateable value.

The water companies cried out against the proposal to supply by meter as a measure of confiscation, and warned the corporation that it would result in a large public rate for sanitary purposes owing to a certain stint in use of water under a meter system. The corporation tried to meet this argument by recognizing "that sanitary requirements demanded that water should be used without stint, and that it is necessary that the wealthier consumers should, by paying an enhanced price, cheapen the cost of water to their poorer neighbors, and encourage them to use it freely." This in turn was denounced as socialistic.

*Extracts from paper read at a meeting of the Municipal Waterworks' Association held at Birmingham, England.

What the Consumer Pays

Let us see what a better-class domestic consumer pays for water. Take the rate at 1s. 6d. in the £, which is a little above the average for the whole of the boroughs and county boroughs; a dwelling rated at £100 per annum, containing seven persons, including servants, and the actual quantity of water used at 14 gallons per head per day. (I assume here that the domestic supply including waste is 20 gallons per head per day.) This consumer then pays 4s. 2½d. per 1,000 gallons, and a consumer occupying a house rated at £200 per annum would pay, other things being equal, 8s. 5d. per 1,000 gallons.

From an inquiry made a few years ago it was found that out of thirty-two towns that distinguished between the charges for combined residential and business premises and lock-up shops, the average charges made were respectively 83½ per cent. and 47¼ per cent. of the charges for domestic dwellings.

Now, the argument for these rebates, as they may be termed, is mainly based on the facts that in these cases less water is generally used than in the case of domestic dwellings, and that the rateable value is generally higher. But is this all that can be said on the matter?

What are the relative obligations of the domestic consumer and the trader towards the communal interests? As regards the public health they are identical except that the trader benefits to a much greater degree from the increased efficiency of his employees. And as regards the security of his property, the obligation is greater on the part of the trader because generally he has much more at stake. And what is the relative obligations from an individual point of view?

The domestic consumer uses his water mainly for the base necessities and amenities of life, which use is largely in the interests of public health, whereas the trader uses water as a raw material for the purpose of profit, indirectly if not always directly.

I am therefore of opinion that there are not sufficient grounds for a discrimination between the domestic consumer and the occupier of combined and residential lock-up premises.

What general principles are there to guide us in the sale of water by measure? First of all, the trader, whether he takes his water supply from the city in which he enjoys the profits of his trade or whether he does not, should pay a due and proper share of his obligation to the communal interests, and that share should be in some proportion to the extent of his business and his profits, or the rateable value of his property.

You cannot hope to get parliamentary powers to compel a trader to use the water supplied by a municipality even if you agree to supply water for trade purposes on demand, if the trader can prove that the water is unsuitable for his purposes; but you can hope to compel a trader who sinks his own well with the object of evading his obligations in the common interest to pay his proper share in the manner above described.

Fixing Charges

The charge per 1,000 gallons at which water should be sold bears directly on the cost of water, and in fixing approximately the amount that charge should exceed the cost we have to consider many interesting points.

(1) In the general interest of trade, the endeavor should be to sell as low as possible.

(2) The charges should be large enough to cover a certain amount of the loss in supplying the lower-rated domestic dwellings, for the reason that trade supply, being used as a means of private profit, should legitimately ease the burden of the domestic consumer in the comman interest.

(3) The charge, in my opinion, should be a flat rate, excepting in the case of very large quantities, and under special circumstances.

Commodities in general cost more in smaller packets because of the increased cost of handling and conveyance, and book-keeping expenses, etc., but this does not apply in anything like the same degree in the case of water, and, on the other hand, the small trader should have equal encouragement with the large.

(4) Water should not be sold below cost price. In exceptional cases, when it becomes a question of selling surplus water at a trifle below cost price or letting it go to waste, it is good business to sell it below cost. But in the sale of surplus water in large quantities, say, to outside authorities, the agreement should be for short periods only, for the city may require that surplus sooner than expected, and in that case considerable capital outlay will become necessary and a large surplus created for which there is no sale. The result is an increased cost of water within the city and a greater loss in sale outside.

Our aim should be not only to raise revenue for the purposes of water supply in the most equitable manner, but also in the simplest manner. We live in an age of heroic measures, when indeed no other measures will do—at a time when only the large vision, a strong imaginative grasp of the difficulties and their remedies, and a courage in proportion, will be of any avail.

Foundation of Local Taxation

The revenues for the purposes of water supply, like the other great public services, are raised on the annual value of the premises, and for this great principle we are indebted to the famous statute of the Poor Relief Act of 1601. Shortly after the passing of the statute the Judges of Assize declared that the assessments ought to be made according to the visible estate of the inhabitants both real and personal. Thus the standard of ability, or rather of rateability, was decided (in accordance with the obvious intention of the statute) to be visible estate. To avoid the mischief of a local inquisition into incomes was no doubt the aim of the legislature; and in accordance with this principle stock in trade was eventually exempted from valuation for rating purposes, so that "visible property" for rating purposes practically came to mean real property. Thus was laid the foundation stone upon which is built the whole structure of local taxation in England. Local expenditure is still defrayed by rates, rates are based upon the poor rate, and the poor rate is still governed by the principle laid down in this unrepealed statute of Elizabeth. It is not too much to say that there are few legislative achievements which can compare for simple grandeur and constructive foresight with the Poor Relief Act of 1601.

Some Proposals

Now, my point is this: Are we making the best use of this machinery for raising the revenue? What I should like to see is a wider and more intense application of this method applied to all properties in the area of supply.

A very few towns who have not the power to make a water charge under a private Act raise their revenue under the Public Health Act of 1875 as a part of the general district rate. In some cases a public water rate is raised on all rateable property irrespective of supply—for the purposes of street watering and cleansing, sewer flushing, public fountains, baths and wash-houses, etc.—and in many towns where the limit imposed by parliament has been reached a "rate in aid" is made.

I am in favor of a public water rate varying in amount according to local conditions; of the rateable value being the basis of the minimum charge, and that the charges for trade supplies should be an addition to the minimum charge. I do not agree with differential rates, or, in other words, the rebates on higher-rated properties, opposed as they are to the fundamental principles of local taxation for public services.

To many, I am sure, some of my proposals will appear to be drastic. But if you look the problems before you calmly in the face, can you frankly say that the haphazard increase of this or that particular charge, based on narrow views, and without any reference to basic principles, is at all likely to be adequate in the solving of those problems?

FLEX-OR-CRETE NAILING COMPOSITION

A new nailing composition called Flex-or-crete is being marketed by the Flexner-Taylor Company, South Boston, Mass. It is a concrete through which nails can be driven, which is about half the weight of Portland cement concrete. It is being largely used as a sub-floor to which the top floor boards can be nailed, and as a sub-roof to which slate, copper or other material can be nailed.

The material is being used for the roof of the Parliament Buildings at Ottawa, sheet copper being nailed on top of it. At the Military Hospital, Whitby, Ontario, the material was used as flooring, on top of which linoleum was glued and nailed. The manufacturers state that they expect to put on the market partition blocks made of this material to which all woodwork, door trim, baseboards, etc., can be nailed without wood grounds. The material is also being used for wall plugging, replacing wooden plugs. It can be applied in plastic state over metal reinforcement for roof construction or wall construction.

In a test made last year for the Stone & Webster Engineering Corporation at the Massachusetts Institute of Technology, a small test slab of Flex-or-crete withstood a maximum load of 2,550 pounds, although a bad crack developed at 2,100 pounds. The load was concentrated at the centre of the slab, distributed to the slab by means of damp sand under a metal bar 2 inches wide. The slab was supported at the ends by metal bars 2 inches wide. The width of the span was 24 inches, length 30 inches and thickness 3¼ inches.

On compression tests of two cubes, each 8 inches x 8 inches x 8 inches, maximum loads of 116,600 pounds and 116,800 pounds respectively were withstood without cracks of any amount appearing before these loads were reached.

The manufacturers publish a table showing that the safe superimposed loads for flex-or-crete vary from 59 pounds per square foot for an 8-foot span (using 3 inches of flex-or-crete above the mesh, with steel of 0.173 cross-section area) up to 597 pounds per square foot for a 4-foot span (with 4 inches of flex-or-crete on steel of 0.277 cross-section area). Flex-or-crete slabs as thin as 2 inches can be used for 6½-ft. spans to carry 43 pounds per square foot, using steel of 0.173 cross-section area, while a similar slab of 4-ft. span will carry 104 pounds per square foot. The weight of one square foot of flex-or-crete one inch thick is six pounds.

METHOD AND COST OF CLEARING CUT-OVER LAND WITH POWDER*

UNDER a co-operative plan with the Land Department of the Potlatch Lumber Company, the Forestry Department of the University of Idaho has been carrying out extensive land clearing operations with a view of determining the most efficient methods.

The site selected for the operations was on level bottom land in the valley of the Palouse River, Idaho. The soil is classified by the U.S. Bureau of Soils as "potlatch silty clay loam with a tendency to be clayey." The soil was underlaid with a hardpan formation at an average depth of about 3½ ft. It had been covered formerly with a dense stand of western yellow pine. Douglas fir and western larch, in approximately equal proportions, as shown in the following table:

Percentage of Timber

(Ft. diameter)

Plot No.	Red fir.	Yellow pine.	Tamarack.
1	35.7	30.5	34.7
2	49.3	23	27.7

Some of the pine had been cut eight years. Most of the tamarack and fir had been logged more recently; some only two years before. All except the smaller stumps were sound.

Two working plots each of five acres were carefully selected with the view of securing representative cost figures. Each plot was handled in exactly the same manner as regards preliminary work, the making of holes, piling and burning logs, brush and stumps, and leveling the ground after all clearing work had been done. The explosive used in Plot No. 1 was a 20 per cent. stumping powder; on Plot No. 2 a potassium chlorate powder equivalent to 60 per cent. dynamite was employed.

The number and per cent. of sound stumps in each plot were as follows:

Number and Per Cent. of Sound Stumps

Diameter.	Plot No. 1		Plot No. 2	
	Feet diam.	Per cent.	Feet diam.	Per cent.
6-in.	26	5	4	1
8-in.	12.8	2.4	7.8	1.7
10-in.	19.1	3.7	12.5	2.8
12-in.	3.1	6	2.0	4.7
14-in.	22.2	4.2	11.8	2.7
16-in.	38.8	7.1	40	9
18-in.	28.5	5.4	28.5	6.4
20-in.	48.4	9	26.6	6
22-in.	57	11	55	12
24-in.	46	8.4	24	5.4
26-in.	39	7.3	32.5	8
28-in.	30.4	5.7	21	4.8
30-in.	12.5	2.3	17.5	4
32-in.	21.4	4	26.7	6
34-in.	14.1	2.6	21.6	4.8
36-in.	24	4.5	15	3.4
38-in.	12.6	2.3	12.6	2.8
40-in.	6.7	1.2	6.7	1.5
42-in.	10.5	2	14	3.1
44-in.	18.3	3.4	29.3	6.6
48-in.	8	1.5	8	1.8
56-in.	4.6	0.7	9.3	2.1

*Abstracted from Bulletin of the University Agricultural Experiment Station.

A crew of from 4 to 6 men was used for the work of swamping and sawing, while two men with teams worked to best advantage after the material was cut up and rolled out where it was easily accessible. The large logs were thrown into heaps and constituted the base of all the piles. The lighter logs with limbs, brush and stump fragments were then thrown on top, completing the work preparatory to burning. The tools used were the axe, the cross-cut saw, canthooks, mattocks, shovels, augers, block and tackle, 5/8-in. wire cable, a snatch block open at the side to admit cable without passing the end through the block (a very great advantage), and a digger with a 3-in. cylindrical bit open on one side and welded to an 8-ft. handle of 1-in. gas pipe, which is an excellent tool, capable of cutting its way through roots and frozen ground. A battery costing about $18 with lead wires completed the outfit of tools.

Swamping, Sawing and Piling Logs, Brush, Etc.

The preliminary work consisted of swamping and sawing and placing all brush and unsound logs, limbs, brush, etc., in piles for burning. The cost of the preliminary work was as follows:

	Plot No. 1			Plot No. 2		
	Hours.	Rate.	Total.	Hours.	Rate.	Total.
Swampers ..	176	$0.25	$44.00	143	$0.25	$33.75
Sawyers	39	.25	9.75	44	.25	11.00
Teamsters ..	40	.25	10.00	19	.25	4.75
Teams	40	1.00*	4.45	19	1.00*	2.10
Feed	..	1.00*	4.45	..	1.00*	2.10
Total ..			$72.65			$73.70
Per acre			14.53			14.74

*Per day.

Locating and Making the Holes

One should have a good knowledge of the root system of the different species before undertaking this part of the work. Nothing is of more importance than determining upon the position, number, and depth of holes to be made under the large stumps. The exercise of proper judgment on these points will do more than anything else to reduce the amount of powder used and to secure the highest possible efficiency.

Large yellow pines generally have large, strong, and heavy tap roots. White pine and Douglas fir, as a rule, have no tap roots, but have large spreading laterals that are fairly easy to lift with properly placed powder. Larch roots are mostly lateral, but enter the ground obliquely and are hard to remove. Holes should run well toward the centre in yellow pine, intermediate for larch, and well toward the periphery of the base of the stump between the large laterals for large firs and white pine.

Various species tend to develop stronger tap roots on sloping, well-drained and aerated soils, than on level or mucky soils or in swamps. The laterals tend to be more oblique when growing under the former conditions than under the latter. These are important general rules which hold good for all species.

The number of holes to be placed under a stump in order to remove it completely and yet not waste powder was a point which received the most careful attention. One hole was found to be sufficient for removing stumps up to 18 ins. in diameter, while two holes were sufficient for removing stumps up to 30 ins. in diameter, and three holes for 40-in. stumps. Four holes were generally found ample for removing larger stumps, though for the largest five holes were sometimes found necessary.

The depth of the holes is also a very important feature and the success or failure of any blast often depends as much on the depth as on the location of the holes.

It was suggested that the vertical depth of the hole should equal the diameter of the stump. This rule was found to work well until the diameter of the stump exceeded 4 ft. It seemed that the sinking of the holes to a greater depth was of doubtful utility, at least for the soil conditions found on these two tracts.

In order to insure the perfect removal of the laterals it was found necessary to rupture an area of soil having a radius about three times greater than that of the stump, and in going deeper than 4 ft. the weight of the earth to be removed is so great as to yield unsatisfactory results. It was found, therefore, to be impracticable to go deeper than 4 ft. No more earth should be removed than is necessary in order to secure efficiency on account of the added expense of filling the holes. Holes should be deeper in sandy or dry, loose soil, and shallower where the hard-pan is near the surface or where the ground is moist or well frozen on top.

The cost of making the holes for the powder was as follows:

	Plot No 1			Plot No. 2		
	Hours	Rate.	Total.	Hours.	Rate.	Total.
Boring holes.	152	$0.25	$38.90	168	$0.25	$42.00
Per acre			7.78			8.40

Placing the Powder

In loading the holes great care should be exercised relative to the proper amount of powder to be used under the stump and also to its proper distribution in the case of larger stumps. Here again the powder man must study the root-system and the slope and be guided accordingly. He must strive to place the powder in the various holes in proportion to the amount of work to be done in each place. The proper way to put a charge of dynamite into a hole is to split the cartridges down the side and cut them in two. This puts the powder into a small, compact space. The cap should be put into the end of a half unsplit stick, which should be placed well down in the charge in the hole. If electric fuses are to be used, a half hitch around the end of the cartridge is desirable in order that the cap may not be pulled out in tamping the powder and adjusting the wires. This tamping should be done firmly but very carefully with a wooden tamping stick until the charge is covered to a depth of 5 or 6 ins. The earth used in filling the remainder of the hole should be very firmly tamped, as the efficiency of the powder in a properly tamped charge may be nearly double that of one tamped in a loose and careless manner. One should remember that the force of the explosive depends more on the degree of confinement than on any other single factor, and any crevices or air spaces greatly reduce the power of the explosive; for this reason water is the best possible confining medium, but cannot be recommended for general use, since it is often not conveniently at hand. Waterproof fuse must be used in tamping with water and great care must be exercised to render the caps watertight around the fuse, by means of soap, tallow, or some other sealing medium.

When more than one charge is to be used under a stump, it is highly desirable to fire by means of electric fuses and a battery. This is because of the fact that it is nearly impossible in using the ordinary time-fuses to bring about all the explosions at the same instant. Since the efficiency of the powder and likewise the work, depends in a great measure on this one factor, it should not be neglected. Where one charge explodes before the others,

Table I.—Average Amount of Powder Used for Each Size of Stump

Plot No. 1.

Diameter, ins.	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	48	52	56
Sticks powder	1	1.5	2	3	4	4.5	5	6	7.5	8.5	10.5	12.5	13.5	14.5	15.5	16.5	18	19	20	21	24	26	28
Pounds	.6	1	1.2	2	2.5	2.8	3.1	3.7	4.7	5.3	6.6	7.8	8.4	9.1	9.7	10.3	11.2	11.9	12.5	13.2	15	16.2	17.5
Pounds per ft. diam.	1.2	1.5	1.5	2	2.14	2.1	2.06	2.22	2.5	2.65	3.04	2.63	3.36	3.41	3.42	3.44	3.53	3.57	3.57	3.60	3.75	3.74	3.75
Cost per ft. diam. (cts.)	19	24	24	32	34	34	34	35	40	41	39	42	54	55	55	56	56.5	57	57	57.5	60	60	60
Cost per stump (cts.)	9.6	16	20	32	40	45	50	59	75	85	105	128	134	145	155	165	179	190	200	211	240	259	280

Plot No. 2.

Diameter, ins.	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	48	52	56
Pounds	7	1	1.2	2	2.5	2.6	3.3	4.2	5	5.5	6.2	7.5	8.1	8.8	9.3	10	11.5	12	12.5	13	15	16	17.5
Pounds per ft. diam.	1.4	1.5	1.5	2	2.14	1.9	2.2	2.52	2.7	2.75	2.86	3.21	3.26	3.3	3.28	3.6	3.63	3.6	3.57	3.54	3.73	3.69	3.75
Cost per ft. diam. (cts.)	24	25	25	34	36	32	37	43	46	47	49	55	55	56	56	61	62	61	60	60	63	63	64
Cost per stump (cts.)	12	17	21	34	42	44	56	71	85	93	105	127	138	149	158	170	195	204	212	231	255	272	297

its energy is expended in loosening the soil without removing the stump and the effectiveness of the other charges is thus greatly reduced, whereas if all are exploded at once each has equal lifting power because of the proper conditions of soil firmness under which each does its work.

Where only one hole is used in removing the stump it is cheaper to use blasting caps rather than electric fuse, and is usually as effective. This is true unless the stumps are so close together that the ground around others will be loosened. In such cases a battery should be used and the entire group fired at once.

The labor cost of the blasting was as follows:

	Plot No. 1			Plot No. 2		
	Hours.	Rate.	Total.	Hours.	Rate.	Total.
Powderman .	58	$0.35	$20.20	41	$0.35	$14.35
Helper	58	.25	14.50	68	.25	17.00
Total ...			$34.70			$31.35
Per acre			6.94			6.27

Strength of Caps

The lower the strength of powder the greater the strength of cap necessary to secure the greatest efficiency. This had been definitely determined by the United States War Department. Many persons make the serious mistake of using low-power caps because they are cheap. The War Department has shown that 40 per cent. dynamite is 15 per cent. stronger when a No. 5 cap is used than when a No. 3 cap is used; while the difference is only 6 per cent. when 60 per cent. dynamite is used. When several stumps stand together, electric fuses and a battery should be used, the stumps being connected in a series.

Quantity of Powder to Use

Great care was used to determine just the proper amount of powder necessary for different sizes and species of stumps. In general, one should so strive to place the charges under a stump, both in position and amount, as to exert a pressure under each main division of it sufficient to just throw the stump out of the ground. Either a larger or a smaller charge is wasteful. The use of an insufficient amount of powder cracks the stump and so loosens the soil as to make the final removal with powder costly. When a second blast is necessary more powder is often required to remove the shattered stump than would have been necessary to have completely removed the stump in the first attempt. For this reason it is always better to use a slight excess of powder as a factor of safety, thus insuring the removal of the stump at the first trial.

Since the efficiency of powder varies with the varying conditions of soil, moisture, stumps, etc., this problem must be worked out in a general way for each locality. A little careful study and experimentation in starting work in a new field will save much powder, time and labor.

Piling and Burning the Stumps

In piling the stumps, four men were found necessary with each team in order to secure the greatest efficiency. All the loose fragments were drawn to the log heaps and piled as high as possible by hand; sometimes separate piles of stumps alone were made when this was most convenient. A ginpole was not used as it was thought that by being careful to bring the larger fragments to the piles at first and while they were low, nothing would be gained

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HEAD OFFICE: 62 CHURCH STREET, TORONTO, ONT.
Telephone, Main 7404. Cable Address, "Engineer, Toronto."
Western Canada Office: 1208 McArthur Bldg., Winnipeg. G. W. GOODALL, Mgr.

Principal Contents of this Issue

THE COAL SITUATION

"City Coal Situation Worst of Winter; Supplies Gone, Zero Weather Threatened." That was the two-column heading which appeared a couple weeks ago in the New York Herald. New York is only about six hours' freight haul from the heart of the anthracite coal-mining region, yet the Herald article stated that "despite the activities of administrators, railroads and increased production at mines, the coal supply throughout New York has been steadily decreasing for days and the city never was worse off for coal than right now. . . . Thousands of families are moving from houses and apartments where fuel bins are empty. . . . Conditions in the poorer residential sections have made it necessary for the police to guard coal yards and administration offices since the last big storm. . . . While the coal supply obtained from New Jersey tidewater has averaged 22,000 tons daily, it was learned yesterday that a surplus of 70,000 tons, which had accumulated at the tidewater points ten days ago, has diminished, so that there is scarcely a day's reserve now awaiting transportation to New York."

When conditions are so grave in the most important city in the United States—a city almost bordering the coal-producing district—it is high time for Canada to look with alarm upon the fuel situation in Ontario, Quebec and Manitoba.

W. J. Dick, mining engineer of the Commission of Conservation, has estimated the lignite resources of Canada to be over one hundred billion tons, of which nearly two-thirds are in Saskatchewan. The Research Council desires to encourage the development of these lignite fields. Briquetted lignite is good fuel; the proposition is beyond the laboratory stage; it needs now only a full-size plant to determine whether it is commercially feasible. The Council has suggested to the Dominion government that an appropriation of four hundred thousand dollars be made with which to build a plant that will demonstrate how cheaply briquetted lignite can be sold under practical manufacturing conditions.

This grant should be made at once—from the last Victory Loan, as a war measure, if necessary. It is of the utmost importance to the efficient prosecution of war work in Canada that our fuel supply be ensured without householders being required to chop down shade trees. As Mr. Arthur V. White, consulting engineer to the Commission of Conservation and the International Joint Commission, said in an article in The Monetary Times Annual, recently published, statements to the effect that we cannot afford to produce and transport lignite because the selling price may have to be even a few dollars a ton more than imported anthracite coal, are simply ridiculous.

"Anthracite coal," says Mr. White, "due to war conditions, is now practically unobtainable in the countries of Western Europe. In the winter of 1916, for such coal as was available, France was paying about $40 per ton and Italy $50 per ton. Recent reports from these countries state that coal at present is selling at $60 per ton. Now, Canada imports annually about four and one-half million tons of anthracite from the United States. Suppose that circumstances prevailed for a year such as would make the citizens of Canada willing to pay even a fraction of the advance in European countries—say, $10 advance—this would amount to about $50,000,000. When one thinks in such terms of increased *yearly* outlay, surely a million dollars, or even a few millions of dollars if necessary, placed at the disposal of technical officers, assisted by men of sound commercial judgment, in order to get our own lignite and peat resources under national development, constitutes so intrinsically small a sum in comparison to the results as to be practically unworthy of debate."

Mr. White's argument is essentially sound. For many years he has studied and written about the fuel problem in Canada, not in its temporary aspect, but upon broad, national grounds. In the article above mentioned, which is well worth perusal by all who are interested in Canada's economic situation, he makes it clear that the government should take immediate and forceful action. The Research Council should have, without delay, all the funds that they can profitably use.

OUR NATIONAL DEBT

On October 31st, 1917, the net debt of the Dominion was $948,236,372. In 1913, before the war commenced, the debt was only $314,000,000. Thus there has been an increase of 200 per cent. in the debt. It is almost entirely due to war. The total increased by $47,000,000 in October last. At that rate, we shall have in March next a debt of over $1,000,000,000. At 5 per cent. per annum, the annual interest will amount to $50,000,000. This sum with a substantial amount added yearly for a sinking fund, can be met from the future revenue of the Dominion, provided strict economy be practised by governments and by the people of Canada. In national finance, if debts can be funded, the practical question is that of payment of annual interest. But while this is so, the fact must not be overlooked that debt is debt, a financial obligation and burden upon the body politic, whether owed to investors at home or abroad.

Our war expenditures are approximately $1,000,000 daily. Up to July 20th, last, the war expenditure in Canada was $388,627,000 and elsewhere, $234,600,000, making the total to that date, $623,000,000. Since then, the war expenditures have been approximately $167,000,000, making a grand total of $790,000,000 to the end of 1917.

Dominion revenues for the seven months ended October last, of the current fiscal year, totalled $145,719,000, an increase of 11 per cent. over the corresponding period of the previous year. The gain was largely due to customs collections which changed from $75,000,000 to $91,763,000 in the seven months period of the two years respectively. Expenditures on capital account reached $144,213,352, of which $133,254,798 was due to the war, and $10,599,242 was on account of public works. In the previous year the war expenditure for the same period was $127,487,147, and the public works expenditure, $13,540,236.

PERSONALS

R. H. Long has been appointed power superintendent of the Winnipeg Electric Railway. Mr. Long was formerly electrical superintendent.

John N. Timturlake, formerly power apparatus sales engineer for the Northern Electric Company, has resigned his position to become Montreal district sales manager of R. E. T. Pringle, Limited.

Lieut. Allan Leslie has been invested with the Military Cross. He is a graduate of the School of Practical Science, Toronto, and before going overseas was connected with the Bell Telephone Company.

W. J. Wilkinson, formerly manager of the Northern System of the Ontario Hydro-Electric Commission, with headquarters at North Bay, has accepted a position as manager of the North Bay Toy Company.

J. D. Cumming, formerly with the Canadian Copper Company, Copper Cliff, Ont., has accepted the position of assistant to works manager of the Westmount plant, P. Lyall & Sons Construction Co., Limited, Montreal.

Lieut. Orville Douglas Vaughan, of the Applied Science Class, '17, formerly at the C.A.S.C. depot at Ross Barracks, Shorncliffe, Eng., has been discharged in order to undertake special work under the Ministry of Munitions.

Lieut. O. B. McCuaig, B.A.Sc., of the University of Toronto, has been awarded the Military Cross. Lieut. McCuaig was quartermaster-sergeant with the 2nd Field Company, Civil Engineers, and was later promoted to be lieutenant.

Lieut. Robert Vernon Macaulay, B.A.Sc., has been awarded the Military Cross. He enlisted as bombardier with the Canadian field Artillery and was promoted to a lieutenancy on the field in June, 1916. He was on the headquarters staff during the winter months of 1916-17.

Harry F. Clayton has resigned as works engineer of the Thor Iron Works, Toronto, and has accepted a position as Ontario representative of the Joliette Steel and Iron Foundry Company, Limited, of Joliette, P.Q., manufacturers of steel castings. Mr. Clayton has opened an office at 407 Lumsden Bldg., Toronto.

Major J. A. Trebilcock, a graduate of Forestry, class of 1915, School of Applied Science, Toronto, enlisted as a gunner with the C.F.A. He secured a commission in the Royal Field Artillery on reaching England. Since then he has been promoted first lieutenant, captain in April last, given the Military Cross in September, and now is serving in Italy with the rank of major in the Imperial forces.

OBITUARIES

William Earle, C.E., former manager of the St. John Street Railway, and latterly district engineer of Dominion Public Works in Manitoba, died last week.

J. H. Smith, secretary-treasurer of the William Hamilton, Co., Limited, Peterborough, Ont., died Monday, January 7th, after very brief illness. He was a member of the City Council and the Board of Education.

Captain W. J. Wilson, a graduate of McGill University in civil engineering, class of 1913, was killed in action December 31st. He went overseas with the 74th Battalion as lieutenant in March, 1916, and later became attached to the 2nd Canadian Mounted Rifles. He won his captaincy on the field.

Charles Unwin, Dominion and Ontario land surveyor, who died in Toronto recently, was born in Mansfield, Notts, Eng., December 30th, 1829. After having served as assessor for many years, he became city surveyor of Toronto in 1905, and held that position until 1910, since which time he had been on the city surveyor's staff as consultant. He studied his profession under the late J. Stoughton Dennis at Weston, Ont., and received his "certificate of admission as a provincial land surveyor in and for Upper Canada" on April 12th, 1852. One of the most important of his works was the survey of the Thousand Islands in the St. Lawrence River.

CAN. SOC. C.E., TORONTO BRANCH

That the members of the Toronto branch of the Canadian Society of Civil Engineers have shown considerable interest in the nomination of officers and members of committees for 1918, is evidenced by the fact that the following names will be submitted to the meeting to be held this evening, when officers and committeemen are to be elected:—

For chairman of the branch—Messrs. P. Gillespie (university), and A. H. Harkness (private practice).

For secretary—Messrs. W. S. Harvey (city), G. Hogarth (government), E. M. Proctor (private).

For committeemen, six of whom are to be elected—Messrs. J. R. W. Ambrose (railway), Frank Barber (private), E. T. Brandon (hydro), W. A. Birche (hydro), Willis Chipman (private), E. L. Cousins (harbor), W. Cross (harbor), F. A. Dallyn (government), T. U. Fairlie (hydro), R. Ferguson (harbor), N. R. Gibson (hydro), F. B. Goedike (harbor), H. A. Goldman (harbor), H. E. T. Haultain (university), T. Hogg (hydro), H. W. McAll (city), W. A. McLean (government), N. McLeod (contractor), J. Milne (city), P. H. Mitchell (private), E. G. Newsom (railway), J. N. Stanley (hydro), T. Taylor (city), E. T. Wilkie, F. Willsie (harbor), W. R. Worthington (city), R. O. Wynne-Roberts (private).

The following is an unusual accident which destroyed an oil distributor, tank and 100 ft. of road surface. A live coal, dropped on the road by the steam roller pulling the oiling equipment, ignited the hot-oil spray and set fire to the oiling equipment.

METHOD AND COST OF CLEARING CUT-OVER LAND WITH POWDER

(Continued from page 38)

by using the pole. Hanging fragments were removed occasionally with a second blast, but generally by means of the team and single block and cable. Occasionally two double blocks and a ⅞-in. wire cable were also brought into action, the single block being attached to the running end of the large cable from the double blocks. This arrangement proved to be very efficient, multiplying the power of the team approximately six times.

At first a few piles were made around large shattered stumps in the hope of removing them by means of fire, but this was found to be expensive and unsatisfactory, as the piles were consumed long before the stumps were burned out, and much labor and trouble were necessary in keeping the fires going till the stumps were consumed. In burning, it was found best to fire first a pile of stumps and logs here and there. This gave abundant live coals for readily kindling the remaining piles and proved a great saving of time. One man with a long-handled shovel could quickly have all the rest burning. As the piles burned out it was necessary to throw the material from the outer edges into the centre, until all was consumed and the ground thus left ready for leveling.

The cost of piling the stumps was as follows:

	Plot No. 1 Hours.	Rate.	Total.	Plot No. 2 Hours.	Rate.	Total.
Swampers ..	168	$0.25	$42.00	220	$0.25	$55.00
Teamsters ...	42	.25	10.50	52	.25	13.00
Teams	42	1.00*	4.65	52	1.00*	5.80
Feed	..	1.00*	4.65	..	1.00*	5.80
Total			$61.80.			$79.60
Per acre			12.35			15.92

*Per day.

Leveling.

The larger holes were all filled by turning one or two deep furrows into them; then the balance of the field was plowed, and a large V-shaped road drag made of 3 by 12-in. planks was used for further leveling. This drag was equipped with a heavy ring on each leg at the rear and when alongside a large hole an extra team was hitched to this ring with a cable and the drag pulled sidewise, thus depositing the load of earth in the hole. This operation may be repeated from two or more sides if necessary. A metal plate fastened to the bottom of the drag and extending outward from 2 to 3 ins. will increase its efficiency. This method was found to be cheap and very efficient.

The estimated cost of leveling the ground per plot was as follows:

	Hours	Rate	Total
Teamsters	20	$0.25	$ 5.00
Helpers	20	.25	5.00
Teams	20	1.00*	2.00
Feed	..	1.00*	2.00
Total			$14.00
Per acre			2.80

*Per day.

The estimated cost of burning per plot was: One man 80 hours at 25 cts. or $20, making the cost per acre $4. The average amount of powder used for each size of stump is shown in Table I.

General figures on the clearing of the two plots follow:

	Plot No. 1	Plot No. 2
Area, acres	5	5
Number of stumps	479	365
Total feet diameter	703.3	674.7
Average diameter, ins.	14.4	21.2
Powder used, lbs.	1,678	2,000
Cost powder, cts. per lb.	16	17
Cost powder per ft. diam., cts. ..	39.3	50
Blasting holes, ft.	1,220	1,228
Cost blasting per ft. hole, cts. ..	.032	.034
Blasting caps, No. 5, No.	297	6
Electric fuses, No. 6, No.	340	595
Triple tape fuse, ft.	422	9

The final cost figures were as follows:

	Total cost Plot No. 1	Total cost Plot No. 2	Per acre Plot No. 1	Per acre Plot No. 2	Cents Perft. diam. Plot No. 1	Cents Perft. diam. Plot No 2
Prelim. work	$72.65	$73.70	$14.53	$14.74	10.3	10.4
Making holes	38.90	42.00	7.78	8.40	5.5	6.2
Blasting ...	34.70	31.35	6.94	6.27	4.8	4.6
Powder	276.50	340.00	55.30	68.00	39.2	50.4
Caps	24.77	38.73	4.95	7.74	3.5	5.7
Fuse	4.22	0.09	0.84	0.02	0.6	0.0
Piling stumps	61.80	73.80	12.36	14.76	8.8	10.8
Burning ...	20.00	20.00	4.00	4.00	2.8	3.0
Leveling ...	14.00	14.00	2.80	2.80	2.0	2.1
Total	$547.54	$633.67	$109.50	$126.73	77.5	93.7

OXY-ACETYLENE AND ELECTRIC WELDING AND CUTTING PROCESSES IN LOCOMOTIVE SHOPS

(Continued from page 28)

punched by a countersunk die which gives the proper bevel for welding.

A great deal of trouble was experienced in welding in the superheater flues and tubes when it was first started, but after a little experience much better success was arrived at. Some operators prefer the tubes belled, and others prefer them beaded; some prefer the water in the boiler and others do not. The operators I am connected with like the belled methods best and with the water in the boiler. This keeps the tube sheet from heating, especially round the smaller tubes. Tubes are set in with copper ferrules set back 1/32 in. and the flues are belled out 3/16 in. to 7/32 in. and the small tubes 3/16 in. The sheet is roughened all round the tubes and flues, and the oil is then burnt off with the oxy-acetylene flame and tubes, and flues welded in with electrode, using ⅛ in. mild steel or Swedish iron; the latter is preferred if caulking is needed.

For cutting steel and wrought iron, the oxy-acetylene process has practically no competitor, it being impossible with the carbon point to cut as fast, or as fine and neatly, as the gas torch, although for scrapping fireboxes and frames, the carbon point is cheaper, if time is no object and labor cheap.

A new wood, called balsa, growing principally in South and Central America, is remarkable on account of its lightness, microscopical structure, absence of woody fibre, elasticity and heat insulating qualities. So far as investigation has disclosed, it is the lightest commercially useful wood known. It has also considerable structural strength, which makes it suitable for many uses.