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The Canadian Engineer

An Engineering Weekly.

STANDARD PLANS AND SPECIFICATIONS FOR RETAINING WALLS.

The City of Seattle, Wash., through its City Engineer, Mr. R. H. Thomson, and its Board of Public Works, has formulated complete standard plans and specifications for the various classes of municipal structures employed. These standards are interesting as showing the practice of a large municipality in its city engineering work and as a source of suggestion for the engineers of other municipalities. Incidentally too they are worth notice as an example of business management and systematic organization in city engineering.

Concrete Retaining Walls.

Foundation.—The foundation for any retaining wall shall be excavated to the depth called for on the plan, or to such depth as the City Engineer shall determine as necessary to insure a proper footing for the wall. Where the location of the wall comes on soil which, in the opinion of the City Engineer, is not firm enough to insure its safety, piling or other suitable form of sub-foundation shall be placed, as the City Engineer shall direct. The foundation pits shall at all times be kept dry and free from water by pumping or otherwise as may be directed. Where permanent drainage of the foundation, or other than that shown on the plan is necessary, a suitable tile or sewer pipe drain shall be laid and connected with the sewer or suitable outlet.

Forms.—Forms for retaining walls shall be constructed in accordance with the details given on the plan or, where no details are given, in a manner satisfactory to the City Engineer. They shall be constructed of sound merchantable lumber, thoroughly braced and stayed, so as to produce the finished surfaces true to line and grade, and free from wind or warp or objectionable depressions and projections. Lumber used for forms shall be evenly sized and free from knot holes or other imperfections affecting the finished work. Where monolithic construction is required, particular care shall be taken to construct the forms of sufficient strength to prevent bulging.

All grooves, joints, moldings, pilasters, panels and copings shall be formed true to line and dimensions. Particular care shall be exercised in constructing the forms for copings or other projecting parts of the wall or parapet that the same may be released and allowed to settle slightly after the concrete has partially set in order to prevent the expansion of the form from lifting or cracking the concrete at such projecting portions.

All forms shall be so constructed that in stripping them from the finished work, the edges of moldings, etc., shall not be defaced.

Concrete.—The concrete used in retaining walls shall be mixed in the proportions of 1 part Portland cement, 3 parts sand and 6 parts gravel. The proportion of cement to the total aggregate used shall be invariable but the relative proportion of sand and gravel may be varied by the engineer from time to time.

The materials used shall be of the same quality and mixed in the same manner as herein provided for "Concrete Sidewalks" except that in plain or gravity walls, gravel up to maximum diameter of 2½ ins. may be used. The concrete shall be deposited uniformly in layers but shall not be deposited in any part of the wall faster that it can be properly handled and spread into place. Depositing the material from a height into place, without properly remixing and spreading the same will not be permitted. Unless otherwise directed, the concrete shall be mixed wet enough to readily spread and fill the forms but it shall not be mixed so wet that there is any tendency to wash the gravel free from the grout coating. All concrete shall be thoroughly spaded as soon as deposited. The face of the wall shall be formed by spading back the gravel therefrom in such a manner as to leave a smooth cement finish. Before any concrete is deposited on top of a previous day's work, the latter shall be made rough by picking or chipping. All loose material and cement scum, or laitance, shall be thoroughly removed, the surface washed clean and then grouted with neat cement. The scum, or laitance, shall be removed before the concrete has set hard.

All walls shall be constructed as monoliths, where practical, that is, any section of a wall shall be deposited in one continuous operation, including the final finish at the top. Where monolithic construction is impractical, for the purpose of keeping each successive step of the work together, a recess 6 ins. deep and of a width equal to one-third the width of the wall shall be left at the end of each day's work for the entire length of such work in all walls where the cross-section is 2 ft. or more in thickness. In thinner walls the contractor shall furnish and set steel dowel pins not less than ¾ in. square and 2 ft. long at intervals of not less than 3 ft. for the entire length of each day's work where the same is not brought to the finished height.

In all walls, the forms, moldings, etc., along the finished sides shall be kept cleaned of any dry mortar or concrete which may mar the finished appearance.

Joints.—Joints shall be made in all walls as indicated on the plan or as directed by the City Engineer. Where joints are required the wall shall be built in alternate sections. In the ends of each completed section shall be formed a recess 4 ins. deep and of a width equal to one-third the thickness of the wall, but not exceeding 1 ft., for the purpose of keying the sections of the wall together, or steel dowel pins ¾ in. square and 2 ft. long shall be set at intervals of 2 ft., as may be directed.

Before the intermediate sections are built the ends of the alternate sections shall be coated with one coat of tar pitch or asphalt and four layers of No. 2 tarred roofing felt, each layer of roofing felt being coated with pitch or asphalt as laid.

At the finished face of the wall, the joint shall end in a "V" shaped groove 2 ins. wide and 1 in. deep unless otherwise shown on the plan.

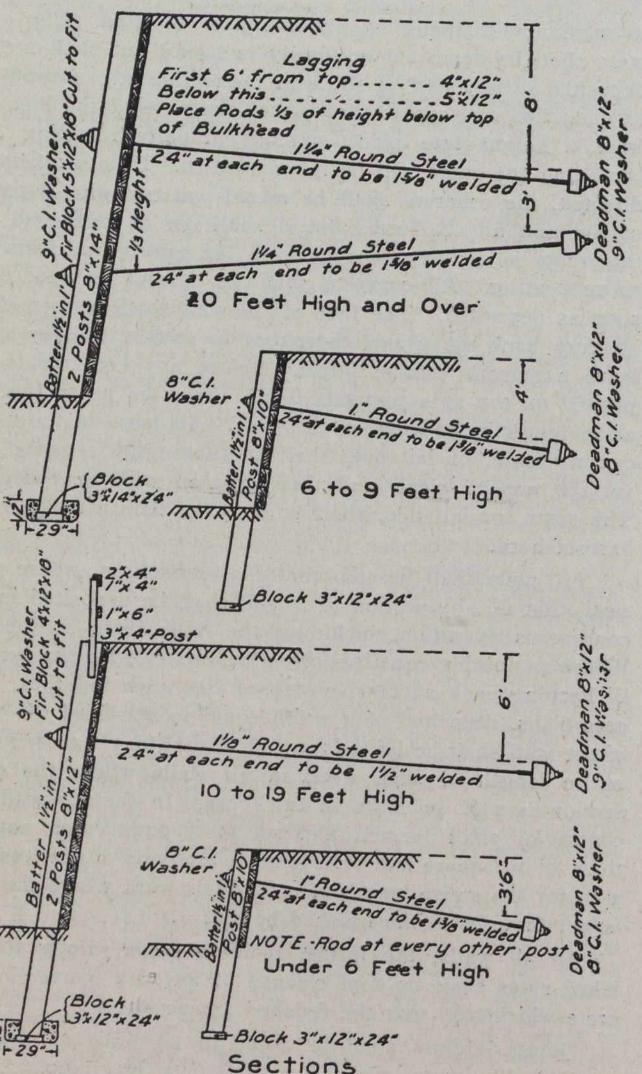
Finish.—The faces of all retaining walls shall be finished as called for on the plan. Where the kind of finish is not stated it shall be carried out as follows: As soon as the forms are stripped, the surface of the wall shall be gone over with a chipping hammer and all projections brought down to an even surface. All wires shall be snipped to the surface of the wall and all holes or rough spots pointed up with a mortar of sand and cement of the same proportions used in the concrete.

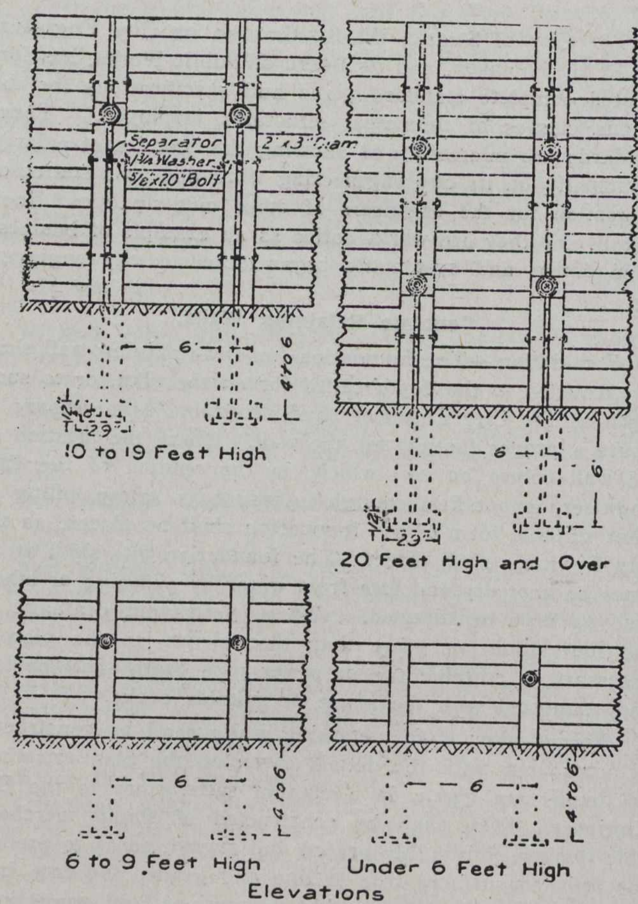
The wall shall then be floated with a mortar of 1 part cement to 2 parts fine sifted sand. The mortar may be applied with a steel trowel but the final finish shall be made with a cork float, all mortar other than just sufficient to fill and true the face of the wall being rubbed off.

Gravel.—A layer of coarse gravel not less than 4 ins. in thickness shall be placed at the back of the wall for its entire height.

Tile Drain.—A tile drain of the size called for on the plan shall be placed at the back of the wall at the bottom and connected to the sewer where shown in the plan.

Backfilling.—The backfilling behind retaining walls shall not be made until the walls have been allowed to set two weeks or longer. The filling shall be made in layers not exceeding one foot in thickness and thoroughly rammed.



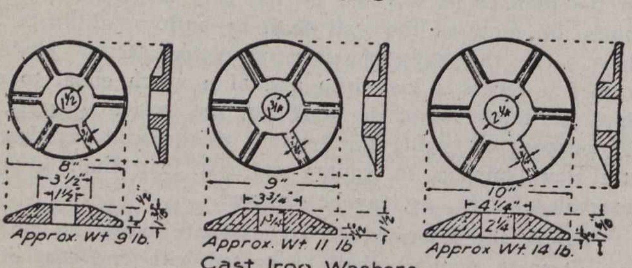


Material	Size Inches	Wt per ft. in Pounds	Wt of each in Pounds	Material	Size Inches	Wt. per ft. in Pounds	Wt. of each in Pounds
Rods	1	2.67		Nuts	1⅜		2.5
"	1⅛	3.38			1½		3.2
"	1¼	4.17			1⅝		4.0
"	1⅜	5.05		C.I. Washer	8		9.0
"	1½	6.01		"	9		11.0
"	1⅝	7.05		"	10		14.0
Separators	2x3 Dia.		3.7	W.I. Washer	1¾		0.1
Bolts	⅝x20		2.0				

Unit Weights

Height	Ft B.M per Ft. Length	Pounds Steel per Ft. Length	Length of Rods	Height	Ft B M per Ft Length	Pounds Steel per Ft. Length	Length of Rods
4	33.9	6.0	15	15	134.8	22.2	22.5
5	40.1	6.0	15	16	142.4	23.0	24.0
6	46.3	12.0	15	17	150.1	23.9	25.5
7	52.4	12.0	15	18	157.8	24.8	27.0
8	58.6	12.0	15	19	165.4	25.6	28.5
9	64.7	12.0	15	20	193.6	58.7	30.0
10	96.4	18.0	15	21	201.7	60.8	31.5
11	104.1	18.8	16.5	22	209.8	62.9	33.0
12	111.8	19.7	18.0	23	217.9	65.0	34.5
13	119.4	20.5	19.5	24	226.0	67.0	36.0
14	127.1	21.4	21.0	25	234.1	69.0	37.5

Bill of Material



Figs. 31 and 32.—Details of Wood Bulkhead.

The finish shall be an extremely thin coat and uniform in appearance. A plaster finish will not be allowed. The finishing shall be done in a thorough workman-like manner giving true lines and edges to all moldings.

Waterproofing.—The back of the wall shall be coated with tar pitch, asphalt or other approved substance. Unless otherwise directed such waterproofing shall consist of two coats of the substance selected. The waterproofing shall be applied hot and only on a dry surface.

Filling in with loose earth and puddling the same will not be permitted except by express permission of the City Engineer.

Measurements.—The quantities of materials to be paid for in concrete retaining walls shall be the actual quantities in the completed work. Volumes will be determined by the prismoidal formula.

Payment for plain concrete retaining walls shall include all necessary excavating, concrete, tile drain, dowel pins, joints, backfilling, finishing the surface, moldings, and the furnishing, placing and removing of all necessary forms.

Piling for sub-foundation work, gravel, waterproofing and extra sewer pipe will be paid for at the rates bid for the same.

Reinforcing Steel.—All steel used in reinforced concrete shall be deformed steel bars or rods of the dimensions shown on the plans. They shall be rolled from billets of either open-hearth or Bessemer steel, and shall have an ultimate strength of not less than 80,000 lbs. per sq. in. and a yield point of not less than 50,000 lbs. per sq. in. The minimum percentage of elongation in eight inches shall be 1,000,000 ÷ T. S. It shall be capable of being bent cold, without fracture, 180° around a diameter equal to 3 times the thickness of the bar. All steel bars shall be carefully bent to the form required as shown on the plan.

Payment.—Payment for reinforcing steel will be in full for furnishing, bending, fitting and placing the same in the work as called for on the plan. The measurement of steel will be for the length called for on the plan or as the City Engineer may direct to be placed in the completed work.

Wooden Bulkheads.

Lumber.—All lumber in bulkheads shall be well fitted, bedded and nailed. All posts shall be set on blocks, laid in

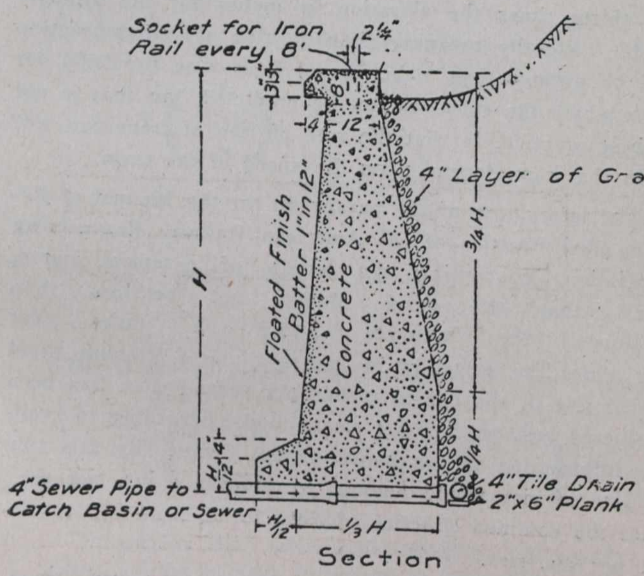


Fig. 30.—Section of Concrete Retaining Wall.

holes, excavated to the depth as shown on the plans, or as directed by the City Engineer. In refilling such holes, the earth shall be thoroughly tamped. "Deadmen" shall be bedded to the depth shown. No excavations, such as trenches for "deadmen" and holes for posts and other unexposed work in bulkheads shall be filled or covered until the same have been fully inspected. All lumber used for bulkheads not exposed, except ends of timbers (unless otherwise specified) shall be painted with two coats of hot coal tar or some other preparation approved by the City Engineer. The lagging shall be well nailed to the posts using 8 in. wire nails for 4 in. lagging and 9 in. wire nails for 5 in. lagging. There shall be two nails to each post. Where directed by the City Engineer, concrete of standard mixture shall be placed at the foot of the posts. Payment for concrete will be as listed on the proposal.

Payment for bulkhead lumber will include the cost of digging and refilling of post holes and painting of the lumber.

Iron.—Rods used in bulkheads shall be of good quality of steel and shall be of the dimensions shown on the plans. Threads at each end shall be 8 ins. in length. All rods shall have welded ends 2 ft. long, ⅜ in. larger than main rod. Each rod shall be provided with the standard size nuts and 6 in. washers. All shall be thoroughly painted with two coats of "P. & B." or other preparation approved by the City Engineer. Blocks of the dimensions shown on the plans shall be used under each washer and will be included in the measurement of lumber used.

ECONOMICAL COAL PURCHASING.

How the "best" coal must be most surely and cheaply obtained, the word "best" being interpreted in the light of the conditions of a particular power plant, is stated in a recent paper by Dwight T. Randall, of Arthur D. Little, Inc., Chemists and Engineers of Boston.

There is a wide difference says Mr. Randall, in the character of the various coals on the market and a considerable variation in the quality of the coals sold under the same general trade name. These differences make it difficult to secure the most economical coal for a given plant without an intimate knowledge of the coals and of the engineering problems connected with their combustion.

Careful investigations have shown that if coals are suited for use in the furnaces installed, they may be burned with practically the same efficiency and are of value in proportion to their heating values. Investigations have also shown that almost any fuel may be burned in suitably designed special furnaces so as to give results which are nearly proportional to their available heating value. In many cases it has been found advisable to change furnaces to utilize a low-grade fuel rather than to purchase an expensive coal for the existing equipment.

The management of any plant should know the quality of the coal in use and be able to locate the cause of variations in the boiler room economy. Poor results are not always chargeable to the coal. Operating conditions are frequently at fault. An analysis of a representative sample of coal which is suitable for the furnaces is a more accurate measure of the value of the coal than the performance of the boilers.

This method of purchasing coal has already been adopted by many of the larger and most progressive consumers of coal. Its advantages are so clearly demonstrated to engineers thoroughly experienced in power house practice that few who are in a position to purchase large quantities of coal are willing to do so without a guarantee as to its quality. With information as to the coal bed, the district and the mine from which the coal will be furnished and the guaranteed analysis, an experienced engineer can select a coal for the plant which is both suitable and cheap when quality and price are considered.

A contract based on a guaranteed analysis provides for a definite procedure in settling for variations in the quality of the coal delivered and avoids the necessity of devoting much time to personal arguments and correspondence regarding poor coal. If both the consumer and the seller are familiar with the technical points involved in the sale of coal on a guaranteed analysis, it will prove a fair method by which the purchaser pays according to the value of the coal delivered to him and the dealer is reimbursed for any expense due to better preparation of the coal.

SELECTION OF LENGTH OF TRANSITION SPIRAL.*

In fixing the alinement of a projected fast interurban electric railway recently, the writer was confronted with a dearth of information concerning either theory or practice for rigorously selecting proper lengths of easement or transition curves. The only line of thought or suggestion on the subject which could be found was that outlined by Prof. Talbot in his work on the transition curve, and that appeared to be more or less specially applicable to his particular spiral. Because of the fact that standard spirals of the Searles type had been adopted and were in use on the road in question, it seemed inadvisable to make any radical change in the type of easement curve. None of these standard easement curves, however, were of a length greater than 100 ft., while the theory which is presented herewith demands lengths up to and in some cases exceeding 300 ft.

The old spirals having chord lengths of 10 ft. were adopted as "base tables," and new easement curves were developed from these by merely increasing the chord lengths to 20, 30, 40 and 50 ft., maintaining the same central angles with, of course, the same "angle of increment," which term will be readily understood by those familiar with the Searles spiral. For the benefit of those not familiar with this type, the Searles spiral may be defined as a compound curve with successive equal chord lengths sub-tended by 2, 3, 4, 5, etc., times the angle sub-tended by the first chord length, which latter, of course, may then be defined as the "angle of increment."

The determination of the proper length of transition, however, was as far from a reasonable solution as ever. Further search was then made of printed information on the subject, and a practically complete bibliography of existing English literature on the proper lengths of transition curves and rate of rise of superelevation of outer rail was compiled together with brief synopses of the main features in each article.

Almost on the day of the completion of this compilation, and while the writer was engaged in an attempt at a rigorous solution of the problem, with practically his only suggestion a mass of "rules of thumb" or tracklayer's experiences, there appeared a very creditable report of the Committee on Track of the American Railway Engineering Association and published in Bulletin 108 of that body. The report is replete with compiled information, some, it is true, of the "rule of thumb" order, but with a principle, new to the writer, from several of the roads, namely, a length of curve dependent upon the rate of rise of the outside of a train on a curve (at the rail) in inches per second. There were letters from two roads with diagrams from one, both very suggestive of a method of attacking the problem; namely, the Cleveland, Cincinnati, Chicago & St. Louis Ry., and the Pittsburg & Lake Erie R. R.

With this new material, it proved to be an easy matter to establish a relation between superelevation of outer rail, radius of the central curve, speed of the train, rate of rise of train on outer rail in inches per second, and the proper length of transition curve, on a scientific basis. The result of these computations and a brief discussion of the basic principles involved, with reasons for their adoption, are presented as follows:—

* A paper by Frank H. Carter, in Appendix B. Report of Committee on Track, American Railway Engineering Association.

The rate of rise of superelevation on easement curves is largely, if not entirely, a question of its effect on passengers as to whether the rapidity of vertical rise of one side of the train produces a disagreeable sensation. An attempt to formulate the proper length of transition curve from the rate of rise of rail in inches per 100 ft. without regard to the speed of the train, is approaching the problem from the wrong standpoint. In any formula of type $I = C D V^2$ the constant C, as will be shown, fixes the rate of rise of superelevation of rail; therefore, but one curve and one speed will satisfy this equation in regard to rapidity of rise of train in inches per second. All other curves or speeds will convey different sensations of ease of riding to the passenger. The average rate of rise of the outside of the train (at the rail) in inches per second should be the governing function for the determination of the length of transition curve, as will be discussed a little later. In fixing alinement, smoothness of riding is all important for comfort; hence, the same rate of rise of superelevation on curves in inches per second should govern for the entire road, where a schedule can be predicted with any degree of certainty; a difficult matter, of course, in most cases for new roads, but almost always capable of realization in realinement, when timetables are established.

It appears to the writer that the clause for insertion in the Manual of the American Railway Engineering Association, viz.: "that the length of the curve should not be less than thirty times the elevation in inches for the ultimate speed" (literally meaning that no rise of superelevation shall be greater than 1 in. in 30) is a wise provision for places where the speed cannot be predicted, but that is not the best practice, in that the rate of rise of transition will not in that case depend upon the speed of the train.

The last clause of the paragraph for the Manual of Recommended Practice of the American Railway Engineering Association, concerning the length of easement curve, viz.: "that the curve should not be less than two-thirds the ultimate speed in miles per hour times the elevation in inches," places a more rapid rate of rise of the car in inches per second than has been considered best practice for steam roads, according to available information in the hands of the writer. By this rule the rate of rise would amount to about 2.1 ins. per sec., while the common practice appears to be from 1¼ to 1½ ins. per sec. rise.

The length of easement curves used on the Cleveland, Cincinnati, Chicago & St. Louis Ry. is apparently based on an assumed rate of rise of 1¼ ins. per sec., and the practice of the Delaware, Lackawanna & Western Railroad is given as 1½ ins. per sec.

It is true that cases may be cited where faster rates of rise have been used; notably a local fast urban electric railway has several spirals where the rate of rise is 1 in. in 20 ft., corresponding to 2.20 ins. per sec. vertical rise at 30 miles per hour.

These curves are said to be easy riding curves from the standpoint of electric road practice, but jolts and roughness of riding which might be tolerated by passengers on an urban electric road or an elevated road, would not be considered good practice for steam roads, where the demand is for smooth riding, such, for instance, that passengers might be able to write a letter comfortably while on a car in motion. It may be of interest to note at this point that this same railway has lately made radical changes in increasing its length of transition curve.

To formulate the foregoing discussion, let

e = the superelevation in feet,
g = distance in feet between centers of rail heads,
V = speed of trains in mile per hour,
v = speed of train in feet per second,
R = radius of central curve in feet,
D = degree of curve,
L = length of transition curve in feet,
l = distance in feet transition curve superelevation 1 ins.,
and a = inches per second a train is assumed to rise vertically on transition

$e = .06688\, g \frac{V^2}{R}$ — from the well-known formula for superelevation of the outer rail on curves.

$$\text{But } \frac{L}{l} = 12e; \quad \frac{1}{l} = \frac{12e}{L} = .06688 \frac{gV^2}{LR} 12.$$

Assuming $g = 4.92$.

$$\frac{1}{l} = 3.94 \frac{V^2}{LR} \quad (2) \text{ or } l = \frac{LR}{V^2} 0.254.$$

$$\text{Whence, } L = 3.94 \frac{V^2}{R} l. \quad (3).$$

$$\text{By definition, } a = \frac{v}{l}: \text{ simplifying, } a = \frac{v}{l} = \frac{V\left(\frac{5280}{3600}\right)}{l}; \quad l = 1.468 \frac{V}{a} \quad (4) \text{ by } (2),$$

$$l = 0.254 \frac{LR}{V^2} \text{ and by } (4)\ l = 1.468 \frac{V}{a},$$

$$\text{equating equals } 0.254 \frac{LR}{V^2} = 1.468 \frac{V}{a}.$$

$$L = 5.78 \left(\frac{V^3}{aR}\right) \quad (5) \qquad L = 0.00101 \left(\frac{V^3 D}{a}\right) \quad (6).$$

Diagrams have been made showing graphically the relations of the various functions to each other. With these diagrams a comparative study may be made of the practice of some of the companies given in Bulletin 108, previously referred to, and other information gathered elsewhere, by assembling the data on a common basis.

PRODUCTION OF SPELTER.

Statistics compiled by the United States Geological Survey show that the production of spelter or metallic zinc from ore for the first six months of 1911 was 140,196 short tons, a gain of more than 5,000 tons over half the record output of 1910. Of this production, 5,135 tons was made from foreign ore. Spelter stocks were reduced from 23,232 tons to 17,788 tons. Imports remained about the same but exports were nearly double those of half the preceding year. The apparent consumption of spelter was 135,497 tons, an increase of more than 12,000 tons over the half of 1910 but about the same as in half of 1909.

TESTS OF OIL-CEMENT CONCRETE IN ROADS.

The U.S. Office of Public Roads has recently published a bulletin on Experiments in Dust Preventions and Road Preservation, which contains some figures on the subject of oil-cement concrete. The following is one of a series of tests carried on in various cities:—

The part of the street selected for this work runs from Center Street east towards Fourteenth Street, a distance of 356.1 ft. It is 19.5 ft. between gutters. The soil forming the subgrade is a coarse gravelly red clay, which after a rain becomes sticky on the surface, but remains firm below. The grade here is light and slopes toward the west. Meridian Place is subjected to light traffic consisting of delivery wagons and pleasure vehicles.

The foundation of the road was constructed in two courses, the first of which consisted of from ½-in. to 1½-in. broken stone placed to a depth of 5 ins. loose upon the prepared subgrade. After this course had been rolled until firm with a 12-ton 3-wheel roller, screenings ranging from ½-in. to dust were applied, and the surface finished as in ordinary macadam road work. This method of construction was followed by the preparation of the foundations for all of the experiments.

Common labor for this work cost $1.50 per 8-hr. day; foreman, $4; double team, $4; a 5-ton tandem roller, $8; the 3-wheel roller, $12; and a "bug" concrete mixer, $4 per day. Stone and sand cost $2.50 per cu. yd., delivered on the work. The oils and cement were donated, but their cost, including freight, is given in the cost data. The following experiments are given in the order in which they were conducted.

Experiment No. 1, Section No. 7—Fluid Residual Petroleum.

Section No. 7 is 65.8 ft. in length. A stiff mortar of 1 part cement to 2 parts sand was first prepared by hand on a mixing board, and oil to the amount of 10 per cent. by weight of the cement was then mixed with the mortar. The resulting mixture was laid over the prepared foundation to a depth of 1¼ ins. and immediately covered with broken stone similar to that used in the foundation, to a depth of 2½ ins. One side of the street was thus laid at a time and, when about 20 lin. ft. had been covered, an attempt was made to force the stone down into the mortar by rolling it with the 5-ton tandem roller. After the entire section had been rolled, it was found that the mortar had not been worked up into the voids of the stone course sufficiently. The road was, therefore, sprinkled and again rolled in the hope that a homogeneous mixture might thus be made. As this did not give the desired results, it was decided to grout the surface. A thin mortar of the same composition as that previously described was therefore prepared, poured over the surface, and "broomed" in. This last process roughened up the surface somewhat, but otherwise the section was finished off in good condition by the application of a light coat of stone screenings running from ½-in. to dust. The characteristics of the oil used in this experiment are shown in Table I.

TABLE I.—ANALYSIS OF PETROLEUM RESIDUAL OIL USED IN EXPERIMENT NO. 1—OIL-CEMENT CONCRETE.

Specific gravity 25°/25° C.	0.936
Viscosity at 50° C., Engler, 100 c. c., specific	44.1
Per cent. of loss at 163° C., 5 hrs.* (20 grams)	1.26
Per cent. of bitumen insoluble in 86° B. paraffin naphtha	1.99
Per cent. of fixed carbon	3.40

* Fluid very slightly sticky; too soft for consistency test.

Per cent. of bitumen soluble in CS_2, air temperature (total bitumen)	99.92
Organic matter insoluble	.06
Inorganic matter	.02
	100.00

Experiment No. 2, Section No. 6—Fluid Residual Petroleum.

This section is 24.3 ft. in length. The concrete aggregate for this experiment was composed of 1½:2:4 mixture of cement, sand and broken stone. The same oil as described in experiment No. 1 was added to the extent of 19 per cent. by weight of the cement, after a mortar of the cement and sand had been prepared and before the broken stone was mixed in. The stone in this and the following experiments consisted of crushed trap ranging from 1½ ins. to ½ in. in diameter.

The mixture was laid to a depth of 2½ in. over the prepared foundation and tamped until the mortar flushed to the surface and filled all voids. The resulting surface was not troweled, but was purposely left somewhat rough. While rolling an adjoining section the next day, the roller was run over this surface, causing slight cracks to develop in places. When last inspected, on January 31, however, no evidence of these cracks could be found.

Experiment No. 3, Section No. 5—Fluid Residual Petroleum.

Section No. 5 is 45 ft. in length. In this and the following experiments the concrete was first prepared in a "bug" mixer. The sand or stone screenings, or both, as the case might be, were first placed in the mixer and the mixer was then driven to the stone pile, so that the cement and fine aggregate were mixed dry. Here the proper proportions of broken stone, water and oil were added and, after the mechine had been driven about 500 ft., the concrete was dumped upon a board. As it was not thoroughly mixed, it was then turned twice by hand before shovelling it upon the road. After it had been placed in position, it was raked with the back of steel rakes to the desired grade and crown.

In this experiment the same oil as described in experiment No. 1 was used to the extent of 10 per cent. by weight of the cement, and an attempt was made to use stone screenings in place of sand. The first batch was composed of cement, stone screenings and broken trap rock, in the proportions 1½:2:4. As the voids of this mixture were not well filled, the proportions were changed to 1½:3:4 for the remainder of this section. Tamping failed to bring the mortar uniformly to the surface, so the section was rolled with this object in view. As this did not produce the desired result, a cement grout similar to that used in experiment No. 1 was poured over the first 20 ft. of this section adjoining section 6 and "broomed" in. The remaining 25 ft. of the section were thoroughly tamped and troweled off with the back of a shovel.

Experiment No. 4, Section No. 4—Fluid Residual Petroleum.

Section No. 4 is 37 ft. in length. As the screenings used in experiment No. 3 did not produce as dense an aggregate as desirable, it was thought well to replace a part of them with sand. The proportion of 1½:1:2:4: of cement, sand, screenings and broken stone was then decided upon for this experiment. This aggregate was also used in the three succeeding experiments. The same oil as described in experiment No. 1 was used in this experiment to the extent of 15 per cent. by weight of the cement. The concrete was laid and tamped in the manner previously described and finished off with the back of a shovel.

Experiment No. 5, Section No. 3—Cut-Back Petroleum Residue.

Section No. 3 is 68 ft. in length. This experiment was identical in every respect with experiment No. 4, except that a different oil product was used to the extent of 15 per cent. by weight of the cement. The properties of this oil are given in Table II.

TABLE II.—ANALYSIS OF CUT-BACK PETROLEUM RESIDUE* USED IN EXPERIMENT NO. 5—OIL-CEMENT CONCRETE.

Specific gravity 25°/25° C.	0.962
Flash point C., open-cup method	35°
Burning point °C., open-cup method	170°
Per cent. in loss at 163° C., 5 hrs., (20 grams)	13.23
Penetration of residue† (N. 2 N. 5 seconds 100 grams, 25° C.)	116°
Per cent. of fixed carbon	8.90
Per cent. of bitumen soluble in CS_2, air temperature (total bitumen)	99.85
Organic matter insoluble	.12
Inorganic matter	.03
	100.00

* Viscous, fluid, sticky; too soft for penetration determination.

† Semi-solid, sticky.

After laying, no difference between this section and section No. 4 could be noticed, except that the surface of the latter was slightly lighter in color.

Experiment No. 6, Section No. 2—Cut-Back Petroleum Residue.

Section No. 2 is 72.4 ft. in length. The experiment is identical with experiment No. 5, with the exception that the cut-back oil was used to the extent of 10 per cent. by weight of the cement instead of 15 per cent.

Experiment No. 7, Section No. 1—Plain Cement Concrete.

Section No. 1 is 39.4 ft. in length. In this experiment the cement concrete was prepared and laid in exactly the same manner as sections Nos. 3, 4, 5 and 6, except that no oil was used in the mixture. This was done for the purpose of comparing ordinary Portland cement concrete with the oil cement concretes.

Summary.

In the work described it was found that the concrete could be handled best when made sufficiently wet for the mortar to flush to the surface upon tamping, but not so wet that it would not hold its shape after being tamped. The best surface finish was obtained by troweling the wet concrete with the back of a flat No. 2 shovel until smooth and uniform.

All of the sections were closed to traffic for at least seven days after being laid and they were sprinkled with water daily during this time. A thin layer of sand was spread over part of the surface and a thin layer of stone screenings ranging from ½ in. to dust was spread over the remainder.

When last inspected, on January 31, all of these sections were in excellent condition, although the street was covered with a slight coat of mud brought in from other roads. No important difference between the sections could be seen at that time and a considerable period of time will probably be required to determine what practical differences, if any, do exist. The materials and cost data for these experiments are given in Table III.

TABLE III.—MATERIALS AND COST DATA OF EXPERIMENTS WITH OIL-CEMENT CONCRETE AT WASHINGTON, D. C.

Description.					Quantity of material.					Cost data (cts. per sq. yd.)							Total Cost.	
Experiment No.	Section No.	Oil	Length of section (ft.)	Area of section (sq. yds.)	Stone (cu. yds. per sq. yd.)	Screenings (cu. yds. per sq. yd.)	Sand (cu. yds. per sq. yd.)	Cement (cu. yds. per sq. yd.)	Oil (gal. per sq. yd.)	Stone at mixer.	Screenings at mixer.	Sand at mixer.	Cement at mixer.	Oil at mixer.	Mixing and laying concrete.	Foundation and miscellaneous.	Cents (per sq. yd.)	Entire section.
1	7	Fluid residual petroleum........	65.8	142.6	0.063	....	0.027	0.015	0.534	15.75	....	6.75	14.18	4.01	24.20	52.52	117.41	$167.43
2	6	" " "	24.3	52.6	.047	....	.024	.018	.640	11.75	....	6.00	17.01	4.80	23.05	52.52	115.13	60.56
3	5	" " "	45.0	97.5	.047	0.036	....	.018	.640	11.75	9.00	....	17.01	4.80	23.05	52.52	118.13	115.18
4	4	" " "	37.0	80.2	.047	.024	.012	.018	.960	11.75	6.00	3.00	17.01	7.20	23.05	52.52	120.53	96.67
5	3	Cut-back petroleum residue....	68.0	147.3	.047	.024	.012	.018	.937	11.75	6.00	3.00	17.01	12.18	23.05	52.52	125.51	184.88
6	2	" " "	72.4	156.9	.047	.024	.012	.018	.625	11.75	6.00	3.00	17.01	8.13	23.05	52.52	121.46	190.57
7	1	None	39.4	85.4	.047	.024	.012	.018	....	11.75	6.00	3.00	17.01	....	23.05	52.52	113.33	96.78

SCIENTIFIC COST RECORDS IN CONSTRUCTION WORK.

Ignorance of real costs is a danger whose seriousness every contractor will appreciate. What is less clearly appreciated is the extent to which real costs are not known, and the degree to which construction estimates are based on gravely unreliable data. Discussing this matter, Sanford E. Thompson, Consulting Engineer, who has been associated for years with Frederick W. Taylor, the pioneer in Scientific Management says:—

Besides being of use as a preliminary step toward the introduction of scientific management, cost keeping, that is, cost determination of work in progress, is of value to the engineer for making up estimates and checking the work of the builder, and to the builder in bidding on subsequent contracts and keeping track of the cost of the work as it progresses from day to day. In construction work based on the principle of cost-plus-a-fixed sum, and other similar systems, the accurate recording of detail costs on different parts of the work is absolutely essential for submitting the accounts to the owners.

To accomplish any of these aims, the cost records must be accurate enough to serve:—

(1) As records for estimating costs of subsequent jobs.

(2) For immediate use.

(a) To determine whether the builder is making or losing money.

(b) To fix any point of loss or of too small profit.

(c) As an incentive to the foreman and workmen.

As generally practised, cost keeping is so approximate and inaccurate as to be of comparatively little value for any of these purposes.

The point just made may be illustrated simply by a comparison of the methods now usually employed in estimating materials and labor. In estimating materials the engineer or contractor notes every item, usually taking the schedule from the plans, and by adding a percentage for contingencies reaches a total which will check fairly well with the actual subsequent cost. Before he starts to do any work he must order the required amount of each material separately, and the cost of each item is carefully looked into to see that the lowest figures are obtained consistent with the quality of the work required.

With labor, on the other hand, the plan heretofore adopted has been largely a system of guess work. Frequently one hundred or more carefully tabulated material items are set down while the estimate for labor is given in one lump sum, and yet the labor may amount to one-fourth or one-third the sum total of the materials. The variation in the actual cost of the labor from that given in the estimate almost always makes the difference between a profit and a loss to the contractor. These "guesses" at labor costs are commonly excused because it is claimed that the work done by different workmen varies to a great extent, or that it is impossible to provide for unforeseen contingencies. This, however, is merely dodging the whole responsibility. The real reason for such approximations is that in many cases the contractor does not know the time and cost of doing each kind of work with any certain degree of accuracy; and the fact is only just coming to be recognized that it is possible to determine in advance how fast each element of the work should be done nearly as accurately as the cost of supplies and materials are now determined, and that once having the fundamental data, it is possible to estimate labor nearly as accurately as material.

STEEL PIPES FOR WATER MAINS.

At a meeting of the Birmingham (England) Association of Mechanical Engineers, held recently, a paper was read on welded steel pipes for water mains. The following is a synopsis of this paper: "The most important requirement of a pipe is reliability, by which is meant not merely that the pipe must be strong, but that the engineer should have a reasonably good idea of just how strong it is. Mild steel pipes are at once the strongest and most reliable, and are gradually but surely taking the place of cast iron, not only for water but for sewage and gas mains. Another advantage which the lapwelded steel pipe claimed over cast iron was its increased carrying capacity, the smoothness of the bore, reducing the friction, known as 'skin friction,' between the fluid and the surface of the pipe. This is an important point frequently overlooked or often underrated, but seeing that the capacity of a pipe of a given bore may be more than doubled by substituting a smooth for a rough interior surface, it would be understood that it is a matter worth careful consideration. The smoother rolled surface of the lapwelded pipe took an excellent coating or protective solution having a hard glossy surface. Added to this the pipe was a smooth cylinder from end to end, as there was a complete absence of anything in the nature of rivets, butt straps or lapped plates. In consequence, the frictional resistance was less, and the velocity and carrying capacity greater with lapwelded than with any other form of pipe. The question of the life of steel pipes had long been the subject of much conjecture, owing to the fact that there was no data on which to base a rule. All that could be said was that the oldest and best known steel pipe lines were as far as could be ascertained, in as good condition and as free from corrosion now as when they were laid."

OWNED VS. RENTED CONCRETE CONSTRUCTION PLANTS.

The accompanying table gives some very interesting figures compiled from ledger records kept on four Concrete Mixers by the Aberthaw Construction Company, of Boston, Mass., during the past seven years. The yardage given is as close an approximation as it was possible to obtain.

This company runs a ledger account for each machine charging the original cost, repairs, etc., against it, and crediting a rental of so much per day for the elapsed time while the machine is on a job. The rental is fixed as near as possible at what the rate would be if the machine were leased temporarily from the manufacturer.

An analysis of the table shows a saving of 11.00c. less 8.4 c. or 2.06c. per yard on plant cost for a plant bought outright over a rented outfit, it being assumed that the cost to the Aberthaw Construction Company of renting would be practically the same as their charge to clients as shown in Table B. This saving was effected when the mechanics were on the jobs 45.4 per cent. of the time owned. It will be noted on referring to mixer No. 4 that the saving is 7.84c. per yard when rented 62.7 per cent. of the time owned, while on mixer No. 2 there is actually a loss of 0.55c. per yard when rented 28.1 per cent. of the time owned.

Another variable entering into the question is the time owned. It seems that mixer No. 4 owned 1,302 days shows the maximum economy for the owner, although No. 6, a newer machine on larger yardage showing considerably less plant cost per yard is not as economical for the owner as No. 4.

There are so many conclusions which might be drawn from a careful analysis of these figures that it is left to the reader to draw his own. However, in closing, attention is called to the fact that it appears to the contractors advantage to buy his plant outright when he expects to work on moderate yardage over a considerable length of time. On large yardage quickly placed, there is not much difference between renting and buying.

Furthermore, he should have his plant on jobs at least 50 per cent. of the time and the life of a machine for maximum efficiency is apparently in the neighborhood of 1,300 to 1,500 days—say 4 to 5 years. After that, interest, repairs and depreciation soon throw the balance in favor of rented plants. It is also evident that the entire cost of the original machine should be charged off to depreciation account in about 6 to 7 years. This charge to be over and above all repair costs.

A.					Totals and Ave.
Mixer Number	2	3	4	6	
1. Date of purchase	8-18-03	6-10-04	6-7-06	6-5-07	
2. Original cost	$ 625.00	$ 975.00	$ 975.00	$ 935.00	$3,510.00
3. Interest at 6 per cent to January 1, 1911	281.51	368.90	220.57	153.37	1,024.35
4. Repairs to January 1, 1911	941.87	350.29	216.43	437.01	1,945.60
5. Total cost to January 1, 1911	1,845.35	1,694.19	1,412.06	1,521.38	6,479.95
6. Inventory value to January 1, 1911	125.00	325.00	400.00	500.00	1,350.00
7. Net cost to January 1, 1911	1,723.38	1,369.19	1,012.00	1,025.38	5,129.95
8. Total yards mixed	12,350	15,500	10,500	19,000	57,350
9. Plant cost per yard	$0.1395	$0.0883	$0.0964	$0.0540	$0.0894
	−4.15%	x15.25%	x44.8%	x14.7%	x18.72%
B.					
10. Days owned to January 1, 1911	2,325	2,029	1,302	939	6,595
11. Days rented to January 1, 1911	827	7.8	816	536	2,997
12. Per cent. of days rented	28.1%	28.3%	62.7%	57.0%	45.4%
13. Rental rate per day	$ 2.00	$ 2.25	$ 2.25	$ 2.25	
14. Total rental to January 1	$ 1,655.00	$1,616.25	$1,835.25	$1,204.50	$6,311.00
15. Total yards mixed	12,350	15,500	10,500	19,000	57,350
16. Plant cost per yard	$1,340	$0.1042	$0.1748	$0.0634	$0.1100
C.					
Plant cost per yard A	$0.1395	$0.0833	$0.0964	$0.0540	$0.0894
Plant cost per yard B	0.1340	0.1048	0.1748	0.0634	0.1100
Per cent. saving by owning plant		x15.25%	44.8%	x14.7%	18.72%
Based on rental cost	−4.1%				

ECONOMICAL PROPORTIONING OF CONCRETE.

"Economical proportioning of concrete does not always consist in using the leanest possible mixture. If the quantity to be laid is small, it is sometimes cheaper to use materials at hand, selecting the proportions arbitrarily and adding an excess of cement to insure the required strength and water-tightness, rather than to make the tests required for the more scientifically proportioned mixture. On the other hand, upon large or important work it pays from the standpoint of dollars and cents to make thorough studies of the aggregates, carefully grading the materials so as to use the smallest possible quantity of cement, which is always the most expensive ingredient.

"The fact has been seriously overlooked in the past, and thousands of dollars sometimes have been wasted on single jobs by neglecting laboratory tests and studies or by errors in theory. By adjusting the proportions of the aggregates instead of selecting them arbitrarily a concrete of equal density, strength and water-tightness may be made almost always with the use of less cement. On a certain job, for example, where water-tight concrete was required, a net saving was effected of 74 cents per cubic yard by carefully grading the materials, the resulting concrete being as water-tight as the richer mixture, having proportions selected by judgment."—Sanford E. Thompson, Consulting Engineer.

ELECTRIC FURNACES.*

Carl Hering, M.E., Consulting Electrical Engineer.

The electric furnace is to-day no longer a laboratory device; it has taken a prominent place in the industries and has become a very important commercial apparatus, its importance growing daily Among the present uses of the electric furnace may be mentioned the refining of steel, the reduction of iron ores by means of water power, the production of aluminum, silicon, graphite, carborundum, alundum, calcium carbide, other carbides, bisulphide of carbon, ferro alloys, fused jewels, etc.

The electric furnace even promises to affect the wealth of nations. Sweden, one of whose national products for many generations was the famous Swedish iron, has for some time past been losing this important industry owing to the greatly increased cost of charcoal. But owing to the enormous water powers in that country, and the generous and wise aid of its parental government in developing them, Sweden will now be able to again recover that important national industry by means of the electric furnace, which requires only a fraction of the charcoal that the blast furnace does, and which enables the iron to be converted directly into refined steel of considerably higher money value.

Canada and the states along the Pacific coast, which abound in water powers and mines, but have no cheap coal, will no doubt also be greatly benefited by the electric furnace for reducing and refining the metals, provided nature's generous gift of water power will not be allowed to become monopolized by private interests, whose charges for power are governed only by the rule to charge "the highest price that the traffic can bear." The developments of the electric furnace industry will depend greatly on whether or not the governments can keep control of the water powers and regulate the charges.

In its general principle, the electric furnace is an extremely simple device, as it merely converts the most available form of energy, namely, electric energy, into the lowest and most degenerate form, heat.

The engineering skill required in the design and construction of electric furnaces lies not in the fundamental conversion of energy, but in building them well and efficiently, the latter being of far greater importance than in combustion furnaces in which the cost of a unit of heat is so much less that great economy is not of so much importance.

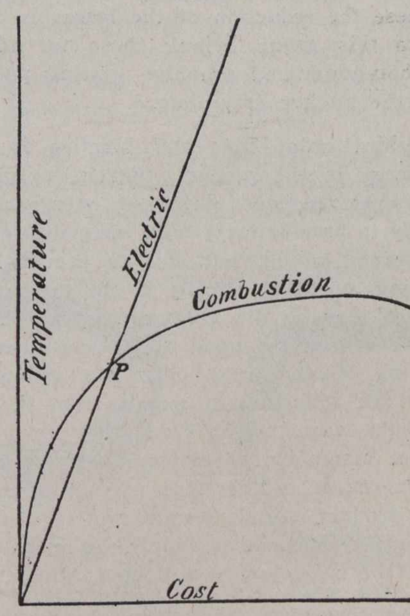
A comparison of the costs of electric and fuel heat depends so largely on local conditions, that a general comparison would not be of much value. But there are certain important characteristic differences between the two which can be compared in a general way, and a comparison of these is quite instructive.

In the accompanying diagram, Fig. 1, let the horizontal distances represent costs and the vertical ones temperatures, and let the curves represent the costs of heating a given body, say a ton of steel, to the various temperatures, neglecting such modifying factors as latent heats and variations in the specific heats. The general shapes of the curves for the combustion heat and the electric heat will be roughly about as shown. For the combustion heat the costs for the lower temperatures will be seen to be quite small, but as the temperatures become high the costs increase very much more rapidly, so much so that the curve finally becomes horizontal and even falls again, hence has a maximum point. Beyond this point the volume of gases in the blast becomes so great that they carry off the heat more rapidly than the fuel can supply it, hence they actually reduce the temperature by chilling the fuel or the gases.

The corresponding curve for electric heat is roughly a straight inclined line; in other words, the cost increases at an approximately constant rate, and there is no maximum point, as long as there exists a material to carry the current. The two curves therefore always intersect each other, and at this point P the costs are equal.

It will readily be seen therefore that low temperature heat is in general generated more cheaply by combustion, while for the high temperature heat it is cheaper to use electricity; also that for temperatures above the point P the cheapest way would be to combine the two, using combustion heat for the lower temperatures, below this point of intersection, that is, for melting or preheating cold charges, and electric heat for the higher temperatures, above the point P. This is what is now common practice in the electric steel industry, in which the melting is done by combustion heat, the hot metal being then run into the electric furnace for further treatment. If it were possible to so construct an electric furnace that both kinds of heat can be applied in the same furnace, then the advantage and the economy of this ideal combination could be fully realized. Such a furnace will be described below.

Fig. 1.



The relations of these two curves will, of course, vary with local conditions, and their shapes will also change somewhat; they should therefore be considered as showing only the general characteristics.

The maximum temperature for the combustion curve in commercial furnaces is in the neighborhood of those used in the iron industry, roughly between 1,500° to 1,900° C. (2,700° to 3,400° F.). The maximum for the electric arc furnace with carbon electrodes is their volatilization point, about 3,500° to 4,000° C. (6,000° to 7,000° F.), or just about double, hence far greater than necessary for most metallurgical purposes.

The chief advantages of electric furnaces over those of the combustion type are too well known to require more than mention here. They include the neutral atmosphere, that is, the heat is neither oxidizing nor reducing; the pos-

* Abstract of a paper presented before the Franklin Institute.

sibilities and ease of obtaining the higher temperatures; the rapidity of heating; metallurgical cleanliness (that is, no impurities like ash, sulphur, etc., introduced by the heating process); no losses in waste gases; greater possible economy in the heat losses; the heat may be generated in the material itself (in resistance as distinguished from arc furnaces); the heat may be generated at the bottom instead of at the top, at least in some resistance furnaces; ease, accuracy and reliability of control and regulation; greater uniformity and reliability of product; greater output for a given size of furnace or a smaller furnace for a given output; reduction of labor and sometimes of the plant; incidental advantages such as better castings due to greater fluidity of metal, less waste of metal, etc.

The purpose of furnaces may for convenience be divided into three general groups, although these often overlap. In the first group the chief purpose is merely to melt, vaporize, dry, etc., that is, to merely change the physical state, as for instance in the simple melting furnaces, the steam boiler, the drying furnaces, etc.; this is the chief field for the combustion furnaces.

In the second group the chief purpose is merely to provide a high temperature atmosphere so as to enable certain desired chemical reactions to take place which will take place only at those temperatures; little or no heat is actually consumed in these (except that to raise the cold materials to those temperatures), hence the only heat necessary to provide continuously is that required to supply the losses through the walls, chimney, electrodes, doors, etc., hence in these the reduction of the losses is of prime importance; to this group belong those for refining steel, making carborundum and graphite, glazing pottery, baking stonewares, the kitchen stove, etc.

In the third group the chief function is to store up chemical energy in the product, that is, to produce endothermic chemical reactions; in these, energy must be supplied not only to provide for a high temperature atmosphere, as in the second group, but also to provide that energy which is being stored chemically in the product and which in some cases may be the greater amount; the energy so stored cannot be counted upon to produce heat for raising or maintaining temperatures. To this group belong the furnaces for the reduction of metals from their ores, like iron, aluminum, zinc, silicon, etc., the production of calcium carbide, bisulphide of carbon, etc. In the designing of such furnaces it is therefore very important to know whether the product is endothermic, and to what extent, for unless the furnace is made to supply the energy which is to be stored in the compound it will be a failure.

As temperatures rise, the chemical affinities or bonds between the various elements become weaker and weaker until finally they cease to exist; when water, for instance, is heated to a high enough temperature, the oxygen and hydrogen composing it will exist free and uncombined as elements, as their bond has been broken; the water is then said to have been dissociated.

The electric arc furnace, apparently for the first time during millions of years, enables us now to reproduce the extremely high temperatures of those earlier periods, hence to again break most and probably all of those chemical bonds. Iron, aluminum, silicon, zinc, lead, and other reduced metals, which nature has not given us as metals in the rock, are produced in this way, though not necessarily always in the electric furnace.

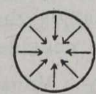
In general, electric furnaces may for convenience be divided into two types called resistance and arc furnaces, although the distinction is somewhat artificial.

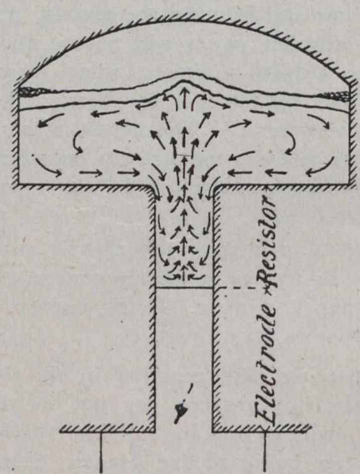
In the arc the current forms its own conductor by vaporizing the end of the electrode. Hence its temperature is always that of the boiling point of the electrode material.

This extremely high temperature is the chief advantage of the arc furnace; it is reached instantaneously in the arc itself.

By far the greater part of the total heat is believed to be generated in the arc and at the end of the electrode, only a smaller part being set free in the furnace product itself which generally forms the other electrode; hence the larger part of the heat has to be transmitted to the material by radiation and by whatever convection there may be due to the hot vapors coming into contact with the material; in both these methods of heat transmission, however, the speed of transmission increases with the temperature of the generated heat, and this speed is a very important element in furnace design. This is the redeeming feature in that high temperature, as in other respects it is very objectionable, because it increases the losses very greatly; in an ideal furnace the temperature should not be higher than needed, on account of this increased loss.

FIG. 2.





As carbon or graphite electrodes are usually used in arc furnaces, the vapor is that of carbon, which presumably acts reducingly, and is known to tend to form carbides with the materials. The advantages of metallic electrodes to reduce the electrode losses cannot be made use of in arc furnaces. Another disadvantage is that in heating liquids with the arc (and everything seems to melt in the arc), the heating must necessarily be from the top only, hence the transmission of the heat from the lower terminal of the arc to the rest of the material must be by the slow process of conduction, except in so far as agitation may distribute it by convection. It is evidently wrong in principle to heat a liquid from the top, as it is then necessarily a slow process; this is therefore an intrinsic disadvantage of the arc furnace, but is partly compensated by the extremely high temperatures which tend to hasten such transmission of heat. The mechanism required for regulation, the constant attention required by such regulators, and the breaking off of the ends of the electrodes, are further objectionable features of arc furnaces.

Resistance furnaces have other advantages and disadvantages. When the resistance conductor, usually called the resistor, is a solid, there seems to be no limit to the temperatures that can be produced in it, so long as the material remains a solid. This is the case in the carborundum and graphite furnaces in which exceedingly high temperatures are generated. This seems to apply also to those resistance furnaces in which the heat is generated in a solid resistor, as for instance in a bed of coke or in blocks of carbon, and is then radiated to the material to be treated. In the latter case, however, the temperature of the furnace products must necessarily be considerably lower or else no heat would reach them, and the speed of heating depends on the rapidity at which the heat can be radiated across the intervening space.

When the material through which the current passes is a liquid in an open channel, there is a very decided limit to the temperature that can be produced, and it is sometimes a seriously low one. This is due to the fact that there is a limit to the current which can be passed through a horizontal open channel containing a liquid, for when the current reaches a certain amount, depending on the cross section and shape of the column and on the specific gravity of the liquid, the column is suddenly contracted by electromagnetic forces until it breaks the circuit; this produces rapid interruptions of the current, which prevent a further increase of current and are fatal to the operation of the furnace. This curious electromagnetic phenomenon was described by the writer some years ago and was named the "pinch phenomenon," by which it is now generally known.

Were it not for this phenomenon, the resistance furnace would approach the ideal in some respects for liquids because the heat is generated in the material itself.

In an endeavor to overcome this serious limit in liquid resistance furnaces imposed by this pinch effect, the writer has derived a form of furnace in which this obstructing force not only cannot sever the conductor, but is even made to produce a very valuable property, namely, rapid circulation of the liquid in the resistor and in the hearth. The principle is shown in Fig. 2.

FIG. 3.

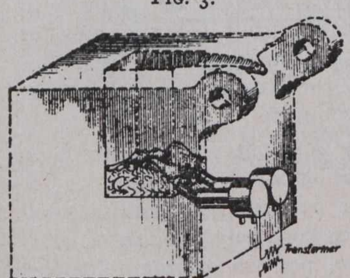
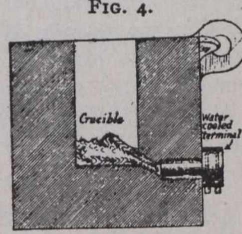


FIG. 4.



If a column of liquid conductor is confined in a vertical cylindrical hole in the bottom of the hearth, opening into the body of the liquid and closed at the bottom by means of the electrode, and if a current be then passed lengthwise through it, the effect of the pinch phenomenon will be to contract this column toward its central axis; the liquid will therefore tend to move radially from the circumference to the center, as shown in the small circle at the top of Fig. 2. These forces in turn, by hydraulic action, then produce an axial force which will force the liquid upward and out of the column, while at the same time the suction will draw in fresh liquid around the circumference, producing a circulation about as shown by the arrows in the lower figure. This peculiar phenomenon acts like a valveless pump, forcing the liquid upward and producing a small fountain.

These liquid columns or resistors, of which there are two, one for each electrode, are so proportioned that the whole heat for the furnace is generated in them, and the diameter and current are so proportioned that the pinching force is sufficient to produce the desired circulation. The freshly heated metal is forced to the top where, in the case of steel refining, it comes into intimate contact with the blanket of slag where the chemical action which constitutes the refining, takes place. The cooler material at the bottom flows into the resistor and is in turn heated and ejected. For three-phase current there are three resistors and electrodes.

Among the advantages claimed are: quick action, which means a large output per day and less standby losses per ton; a very large effective surface of contact with the slag, as this surface is continually being renewed, hence rapid refining action; rapid purification of suspended matter (slag, gases, oxides, etc.), as this is freed as the liquid reaches the top and deposits such matter in the slag; heating from the bottom, which is the more rational method.

Figs. 3 and 4 show it in its outlines only, a small, crude form of crucible tilting furnace of this type. The sketches are self explanatory. It is shown as tilting around the lip, so as to pour directly into moulds. It is started either with a small liquid charge, just enough to connect the ends of the electrodes when tilted; or by melting a small charge in it with an oil flame; or by a casting made to fit the bottom and then melted electrically; a small charge is always left in it and this can readily be melted with the current when it may have become frozen.

Figs. 5 and 6 show how these resistors or squirting tubes and their electrodes may be applied to the usual type of tilting furnace. Fig. 5 is a vertical section through one of the two electrodes and tubes; Fig. 6 shows a top view of a horizontal section at about the level of the doors.

Another form of liquid resistance furnace, which was originally intended to dispense entirely with the electrodes and their troubles, is known as the induction furnace. The

FIG. 5.

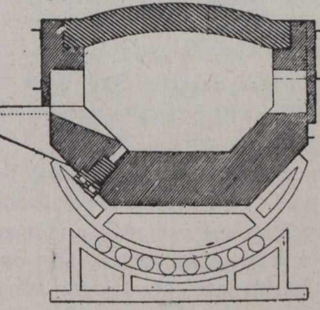
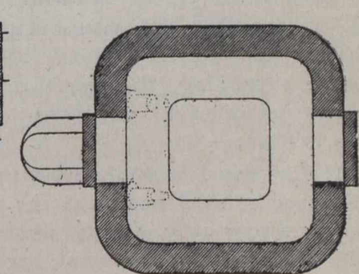


FIG. 6.



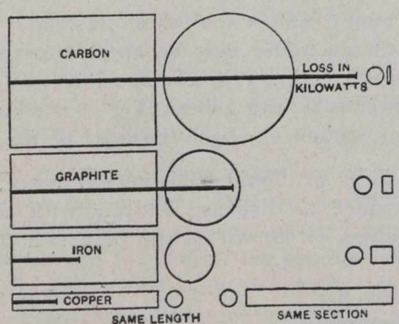
liquid is in a narrow circular channel which forms the secondary circuit of a transformer, hence the current is induced in it without the necessity of electrodes. It is so well known, having been invented about twenty-five years ago, that a further description need not be given here. (Numerous forms of it were shown among the lantern slides.) It has come into use in Germany chiefly for steel refining, and its introduction seems to be increasing; it is not yet in use to any extent in this country. It possesses the advantages which liquid resistor furnaces have over arc furnaces, as mentioned above. Its disadvantage, besides its cost, is that the frequency of the alternating current must be quite low or else the power factor becomes very low. This means larger machinery, though not necessarily more power. This disadvantage increases with the size of the furnace.

One of the chief features in the work of the engineer, in the designing of electric furnaces, is the reduction of the losses of heat, that is, the increase of the heat efficiency of the furnace; electric heat being much more expensive than heat from fuel, the only way it can be expected to compete successfully, as far as the cost of the heat is concerned, is by the best possible utilization of the energy; it is possible to control the losses to a far greater degree in electric than in combustion furnaces. The practice in the heat insulation of combustion furnaces would be quite inadequate for well built electric furnaces.

The reduction of the heat losses in electric furnaces, which have no chimney losses, involves the flow of heat through solids, a subject which until recently has not been given the attention which its importance demands. Apparently the only way a high temperature furnace can be insulated effectively with present materials is to provide for a certain allowable flow of heat through the walls, which shall be as small as possible, but not so small as to run the risk of over-insulation, which is more serious than insufficient insulation, as the walls and roof are then destroyed.

There are two kinds of losses of heat from the interior of an electric furnace, namely, those through the walls and through the electrodes, which are subject to the control of the designer, assuming, of course, that the doors and openings of other kinds are made as few and small as possible. A few years ago the writer made analytical studies of these two sources of losses, some of the conclusions of which were

FIG. 7.



Comparison of sizes and losses.

quite surprising, showing that former practice had been in some respects far from correct. The chief results are briefly as follows:—

The usual formulas used for calculating the thermal resistance of such bodies as the walls of furnaces were found to be very greatly in error, as much as 100 per cent. and over, for thick walls. In general, for a flaring conductor, like one of the thick walls of a rectangular furnace, the proper mean cross section is not the arithmetic mean between those at the two ends, but the geometric mean, that is, the square root of their product.

Using the strictly correct formulas, it was found that the losses diminished very rapidly at first as the walls are increased in thickness, but that after the thickness has been increased to about one-half or three-fourths of the inside diameter, any further improvement in reducing the losses becomes small. The space in the inside of a furnace should be as small as possible to hold the charge, as the losses for the same charge increase rapidly with an increased inside surface. The losses in a large furnace can be made far smaller relatively to the charge than in smaller ones.

Concerning the losses in and through the electrodes, the problem was far more involved, and former practice was in some respects found to have been radically wrong. An electrode naturally should be a good electrical conductor in order to reduce the resistance losses. But it then also is a good heat conductor and therefore will tend to abstract considerable heat from the charge in the inside, thereby chilling it. Increasing its cross section decreases one of these losses and increases the other, thereby complicating matters. The results of the analysis are briefly that, by so proportioning an electrode that the current in it will heat its inner end to the furnace temperature, the total combined losses will be the least possible, and the electrode will at the same time abstract no heat from the charge; it will then in effect act as a perfect heat insulator, better even than the walls, as far as chilling the product is concerned.

Another result was that our former practice to base the size of electrodes on certain allowable current densities was found to be entirely wrong. Still another unexpected and surprising result was that graphite with its higher heat conductivity was more economical in size and losses than carbon, and that the metals were far better than either, the best electrode material being copper, quite the contrary to what would have been supposed. The accompanying illustration, Fig. 7, shows the relative sizes and losses when the electrodes for the same furnace are made of different materials. It is a good illustration of the commercial value of an analytical research. As the physical constants for determining electrodes did not exist, the writer had to determine them by means of tests made under electrode conditions, whereby certain troublesome factors in the theoretical analysis become eliminated. The complete analysis, description of the test, and the data for the calculation of electrodes are given in the original papers.

In conclusion, the following statistical data concerning existing commercial furnaces may be of interest.

For the melting and refining of steel there seem to be at present nearly 100 arc furnaces in use mostly in France and Germany, although the few in this country include the largest ones. They are chiefly of the Heroult and the Girod types. They are mostly of about 300 to 800 kilowatts, and are for charges of 2 to 5 tons; the largest ones are in South Chicago and Worcester, having a capacity of 15 tons and requiring about 2,000 kilowatts. There are also several ore reduction arc furnaces in use and under construction on the Pacific Coast, and in Domnarfvet, Sweden, the latter producing 2,500 tons per year and requiring 400 kilowatts, or about 6,500 pounds of pig-iron per horsepower per year. In Norway two furnaces are under construction, each for 7,500 tons annually, requiring 1,850 kilowatts.

The Government of Sweden is about to make available 600,000 horsepower, a large part of which will be used for reducing iron. Electric furnace reduction of iron is said to save about two-thirds of the carbon, only one ton of charcoal being used instead of three, per ton of iron. The escaping gas is three times richer as it contains no nitrogen, and is only one-eighth in amount, hence correspondingly less heat is carried off by it. Finely powdered ore can be used without briquetting; there is less labor cost and less cost of erection.

Of the induction furnaces there are between 30 and 40 in operation, mostly in Germany. They are mostly of 200 to 500 kilowatts; maximum 750. The charges are from 1½ to 5 tons; maximum 8½ tons. In some cases the material is charged hot and in others cold.

SAO PAULO COAL IMPORTS.

The United Kingdom enjoys a practical monopoly of the coal trade with the Brazilian State of Sao Paulo. The imports during the past five years have been as follows:—1906, 173,399 tons; 1907, 191,844 tons; 1908, 180,493 tons; 1909, 184,322 tons; 1910, 220,916 tons.

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CONTENTS OF THIS ISSUE.

A SCIENCE GRADUATE AND RAILWAY OPERATION.

The appointment of Mr. S. B. Clement, Chief Engineer and Manager of Maintenance for the T. & N. O. Railway, this week serves to draw attention to the field, and the possibilities of that field, of railroading as a vocation for the graduates of the Faculties of Applied Science of our Canadian university.

First, we wish to congratulate Mr. Clement upon his appointment to the position of chief of affairs on a road which is so successfully meeting the requirements not only of a colonized road, but of a direct transportation route feeding two transcontinental systems.

Engineering, which has to do with the maintenance of way and the general business of the road, outside of train operation, are so intimately connected that we are surprised Canadian railroads have not encouraged in a greater degree their engineers to combine with their engineering training the business end of railroading. This has been done very successfully in the United States, and in the few isolated instances where it has been tried in Canada it has worked out most successfully, both for the corporation and the individual.

The careful training the Science student receives in the University, his field experience—both technical and executive—while carrying on his engineering work, and his wide general knowledge should make him an exceptionally good man to handle the business of a railway.

Recently there was brought to our attention the various steps necessary to secure the consent for a siding on one of our Canadian railways. The merchant applied to the terminal superintendent, the terminal superintendent sent it on to the division superintendent, the division superintendent transferred it to the division engineer, the division engineer requested the resident engineer to report, and this report had to go back the same four steps that the request came. What a saving to the railway in time and how much better would the customer have been satisfied if the superintendent and the engineer had been one so that direct dealing would have been possible!

We have written on this subject before, and although very little progress is being made in the appointment of resident engineers as superintendent or for an amalgamation of the two departments, yet we believe the day will come when the engineers will not only have the control of the track and bridges but will be the managers of operation.

CAST IRON PIPE SPECIFICATIONS.

About a year ago, the Canadian Society of Civil Engineers issued standard specifications for cast iron water pipe. This move was the outcome of the extremely confused condition that existed with reference to cast iron water pipe specifications—every engineer or community having different opinions as to what was desirable in such a pipe.

Although these specifications have been before the engineering profession for considerable time, yet there is still a great deal to be desired in the bringing about a reformation in the confused state intimated above. The buyers of cast iron water pipe still cling to their antiquated specifications; or worse still, forget to specify anything definite, with the result that they think themselves outraged when supplied with a heavy grade.

A few of the up-to-date municipalities have adopted Canadian Society Specifications but others are extremely lax in this regard. The latter cases are more marked in this regard, as their engineers are prominently connected with the Society. Of course, in any such argument a case against existing specifications is always demanded and because of the lack of definite information, one is often at a loss what to advance other than the all important argument of the desired standardization throughout Canada. But if engineers will enquire into the actual conditions of manufacture and inspection, it will be found that the specifications of certain municipalities err too much on the side of lightness in certain sizes, the thickness and weights specified being good only if the pipe is perfect, but if the allowable variation in thickness be deducted, it is seen that there is really too small a margin of safety for certain errors which cannot be caught by any method of inspection. This is a matter that demands the attention of all who have to do with the buying of cast iron water pipe. If the reader is one of these, we woudld suggest one question: Do you use Canadian Society of Civil Engineers' Specifications?

EDITORIAL COMMENT.

The Boston Insulated Wire and Cable Company is to establish a branch factory at Hamilton, Ont., about September 1st, and have purchased the land of the Dominion Axminster Company.

No time was lost in commencing the new C.P.R. depot at Brandon, Man. Contract signed one day; operations begun the next.

THE EARNING POWER OF CHEMISTRY.

At the recent meeting of the American Chemical Society in Indianapolis, one of the main features of the sessions was the public lecture by Arthur D. Little, of Boston, on the earning and waste-avoiding power of chemistry, and its services to modern industry and the comfort and convenience of modern life.

To-day, he said, the United States alone is richer by $30,000,000 a year by Kirchof's discovery that starch could be changed to glucose. The improvements in incandescent lamps during the past ten years had saved $24,000,000 a year in the cost of lighting. The cost of lubrication in manufacturing plants has been cut in two. Pointing to our waste of materials, Mr. Little declared that of our annual coal bill of a billion dollars, chemistry could easily have saved a million dollars. Especially striking from a man of Mr. Little's long experience with every side of industrial chemistry, was his support of Harrington Emerson's estimate of the waste on American railroads. On this point he said:—

"A few of us have been surprised and none more than the railway managers themselves, by the well supported statement before the Interstate Commerce Commission that the railroads of the country could save $300,000,000 a year by the application of scientific management to the operation of their properties. Every chemist who has studied the problem is well aware that the entire amount in question could be saved through utilization of the proved results of chemistry alone."

FLOW THROUGH LOCOMOTIVE WATER COLUMNS.

A recent bulletin issued by the University of Illinois deals very thoroughly with the resistance to flow through water columns used by railway systems. The summary of the work is as follows:—

1. The tests give the loss of head for various rates of discharge in the principal types of locomotive water columns in use in the United States. The loss through the valve and through the riser of the water columns were each determined.

2. At a discharge of 4,000 gals. per min. the loss of head through the water columns ranged from 15.4 ft. of head to 46.5 ft. of head. The resistance to flow is surprisingly high—much higher than has usually been estimated. It is evident that the discharge of water columns under working conditions is smaller in many cases than has been estimated. It is worth noting that the water columns which give high resistances, include types which are used in large numbers by the railroads of the country.

3. A comparison with the frictional losses through pipes and elbows will help to give a fuller conception of this high loss of head. For the water column which gave the highest resistance, the loss of head is equal to the frictional loss for the same discharge through a 10-in. line of straight pipe 566 ft. long. Similarly this loss is 25 times as much as that through a 10-in. elbow.

4. An examination of some of the types shows that the forms of the valves and passages do not accord with the principles of good hydraulic design. Sudden change in direction, sudden contraction and expansion of the section of the stream, and tortuous passages are among the objections to be found, and high local velocities are especially troublesome. Mechanical features of construction, inspection and repair seem to have crowded out consideration of hydraulic efficiency.

5. The telescopic adjustable spout with its large cross section shows lower losses than the fixed spout, though it must be borne in mind that the point of discharge taken in water columns with telescopic adjustable spouts is at the end of the riser, and that for this reason the lift is greater than with the fixed spout. The ball and socket spout gives about the same friction loss as the rigid spout, but it has the advantage that the point of discharge is usually lower. It may also be noted that the anti-splash devices use up head in providing a solid stream.

6. The maximum velocity allowable through a water column will depend upon such matters as the satisfactory operation of the valve and also upon the effect of closing the valve in the development of water hammer in the supply main. With a short line from the supply tank a velocity of 12 or 15 ft. per sec. through the water column may be considered as the maximum desirable velocity for ordinary conditions, and for longer lines the limiting velocity may perhaps be as low as 8 ft. per sec. It would seem that 3,000 gals. per min. for an 8-in. water column, 4,000 gals. per min. for a 10-in. water column, and 6,000 gals. per min. for a 12-in. water column may be considered to be the limit of desirable discharge. It would seem that for the rates of discharge just noted the allowable loss through the water column itself should not be much more than 20 ft., and that the limit may well be placed at less than 20 ft.

7. The method outlined for making calculations of the losses of head and discharge in water service installations is a convenient one. By means of diagrams for friction in pipe and elbows and for loss through the water column and the use of the trial ratio, the discharge given by any flow

head may be calculated without the labor attendant upon the use of the usual formulas for flow of water in pipes.

8. There is an advantage in a large pipe by reason of the large discharge for a given head and also in the smaller opportunity for water hammer. In an installation having a high head available (as in some gravity lines) the pipe may well be smaller than in the common installation, provided the arrangement of the valve closure guards against water hammer and proper relief valves are used.

9. The water hammer pressure generated in a pipe line when a valve is closed suddenly and no relief valve is used, for the sizes and thicknesses of pipe used in ordinary water service installations, will be, in lbs. per sq. in., about 54 times the velocity of water in the pipe in ft. per sec. The term "sudden closure" is here taken to mean that the time consumed in that part of the valve movement which gives relatively high valve resistance is less than the time required for the pressure impulse to travel from the valve through the pipe line to tank and back at a speed of about 4,000 ft. per sec. This effective portion for all but two of the water columns tested was the last 15 per cent. of the valve movement.

10. For a slow closure the resistance through the valve opening is the chief force in stopping the mass of water.

11. In all but one of the water columns tested the resistance through the valve opening was not markedly larger than that at full opening until the valve had attained at least 85 per cent. of its closure. Since during the first 85 per cent. of the valve movement little work is done in stopping the water and since during this portion of the valve movement water hammer will not be developed even with rapid closing, it follows that it is immaterial how quickly this first 85 per cent. of closure is made. The time thus saved may well be used in lengthening the time for the remaining 15 per cent. of closure. The time pressure diagram and the valve movement pressure diagram of one of the newer forms of water column illustrate the hydraulic advantages which may be gained in this way.

12. From general considerations it is reasonable to expect that 8-in. and 12-in. water columns will have losses approximately the same as those found in the 10-in water columns at the same velocity of flow.

CANADIAN ASSOCIATION OF STATIONARY ENGINEERS.

The convention of the above named society was held in Stratford, Ont., last week, and was a most successful gathering. At the close of the convention the following officers were elected for the ensuing year:—

President, W. Norris, Chatham; Vice-President, J. A. Robertson, Stratford; Secretary, W. A. Crockett, Hamilton; Treasurer, A. M. Wickens, Toronto; Conductor, H. R. Clarke, Hamilton; Doorkeeper, S. E. Cosford, London.

The Exhibitors Association of the C.A.S.E. also elected officers as follows:—President, Earl F. Hetherington, Goldie & McCulloch, Galt; Vice-Presidents, J. E. Fiddes, James Morrison Brass Manufacturing Company, Toronto; John B. Goff, Dart Union Company, Toronto; Secretary, Gordon E. Keith, Toronto; Assistant Secretary, J. N. Charles, Canadian Fairbanks Company, Toronto; Treasurer, H. V. Tirrell, Toronto; Superintendent of Exhibits, W. R. Stavert, Jenkins Bros., Montreal; Chairman Entertainment Committee, Peter Bain, Toronto.

Belleville was chosen as the next place of meeting.

DEPRECIATION AS RELATED TO ELECTRICAL PROPERTIES.*

Henry Floy.

The courts repeatedly use "fair value" as the only one which should be recognized, and it is this value that the engineer must bear in mind when estimating depreciation. Fair value includes something in addition to physical values, in which the engineer is primarily interested.

There is much evidently sincere but nevertheless mistaken opposition to the application of any principle of depreciation in determining the value of going properties; and yet a consideration of what depreciation—if any—has taken place in the physical property of every corporation must be had, in order to obtain a safe—though it may be only approximate—indication as to proper or improper capitalization.

Application of Terms.

Depreciation. — Webster defines "depreciation" as the "act or state of lessening the worth of," and in this sense it will be used by the writer regardless of the source or method of worth reduction, or by what means it may or may not be removed.

Physical Value.—This includes primarily "those things which are visible and tangible, capable of being inventoried"; but, secondarily, certain non-physical charges "which are an inseparable part of the cost of construction but which do not appear in the inventory of the completed property." These secondary values are expenditures for such items as engineers' and architects' fees, administration expenses chargeable to construction and provision for various incidentals and contingencies, incomplete inventories, unforeseen requirements, etc.

Development Expenses, Intangible or Overhead Values. —Development expenses generally cover most or all of the following expenditures:

1. Legal and other expenses of preliminary promotion, incorporation and organization, procuring consents of property owners, condemnation proceedings, obtaining franchises, consents and certificates from public service commissions and other public bodies, title examinations and insurance.

2. Technical expenses in connection with preliminary work, surveys, expert estimates, etc.

3. Interest on capital and bond issues, wages of superintendence and administration not chargeable to construction ordinarily necessary in connection with putting a property in going order; and also sometimes the deficiency in operating expenses and taxes until the property is put on a paying basis.

4. Taxes which must be paid until the property is completely a "going concern."

5. Discounts on securities, brokerage or other customary and necessary expenditures in connection with financing such an undertaking and marketing securities.

6. Reasonable promotion profit, possibly also compensation for risk of capital estimated at 5 per cent. to 10 per cent. of the cash investment.

Development expenses are not ordinarily depreciated in the same way as the physical property, though some authorities have indicated that such procedure is proper. Development expenses may well be amortized. The rate of amortization might well be based on the life of the securities, whereas the depreciation of the physical property would have to be based on its rate of deterioration through life,

* Abstract of paper read at the twenty-eighth annual convention of the American Institute of Electrical Engineers.

which the Wisconsin commission reports to average for electric lighting properties 17.46 years, telephone plants 11.24 years, and electric railways 18.02 years.

Original Cost. — This refers to the actual amount of money paid for the physical property including original construction plus all additions since that time.

Cost to Reproduce New, or Cost of Reproduction.—These terms refer to an estimated value based on the cost of reproducing the physical property new, on the basis of prices current at the time of estimate—prices that fluctuate considerably are averaged for five years preceding—and includes everything that can be inventoried.

Scrap Value.—All physical property unless offset in whole or in part by cost of removal, has a certain scrap or junk value beyond which there is no depreciation.

Wearing Value.—If from the cost—taken on whatever basis is determined to be the correct one—there is subtracted "scrap" or "salvage" value of given physical property, the remainder is a value known as "wearing value," which will deteriorate and entirely pass away.

Service Value.—Physical property honestly and intelligently purchased with a view to its suitableness for the service intended, aside from some hidden defect or untoward accident, maintains its original value practically throughout its life except for such deterioration as results from wear and tear or deferred maintenance. Going value may or may not accrue in addition to and over and above service value. Going value relates to establishment of earnings while service value exists regardless of earnings.

Present Value.—The more frequent application of the term is to that value obtained by deducing from "original cost" or "cost to reproduce new" the accrued depreciation, which may be either absolute depreciation or the sum of both absolute and theoretical depreciation. Appreciation as well as depreciation must be considered in determining "present value" as indicated by the Supreme Court. (Wilcox vs. Consolidated Gas Company, 212 U. S., page 52.)

Going Value.—This refers to an estimated worth recognized by the highest courts and ingeniously figured and allowed for by at least one State commission in connection with a wise expenditure made in increasing the business of an established plant.

Good Will.—A monopoly, as is generally admitted, has no good will which can be valuated, and the courts have sustained this view.

Franchises.—The present tendency, largely by reason of legislative enactments, is to prohibit the capitalization of franchises beyond the absolute expenditures made in good faith in obtaining said franchises.

Classes of Depreciation.

The subject of depreciation from an engineering standpoint practically divides itself as follows:—

Wear and Tear, or Maintenance.—This includes such depreciation as may ordinarily be removed or offset by proper expenditures at such times as the worn-out parts may be economically replaced.

Age of Decrepitude.—Depreciation of this sort is due to the ageing of apparatus that usually has a life extending over a period of years.

Inadequacy of Supersession.—When street railway service has increased to such an extent that many and frequent small single-truck cars are required to do the work that can be done by larger double-truck cars at less cost and with less interference with street traffic, both economy and necessity compel superseding the smaller equipment by the larger, and thus, through inadequacy, investment in the smaller equipment is depreciated before the property is worn out or becomes decrepit. Furthermore, the introduction of heavier cars may make inadequate the rails and carhouses.

Obsolescence.—Obsolescence means the depreciation of property through the development of something newer and either more economical or more of a fad. By reason of rapid advance and development in the art, obsolescence has heretofore probably caused the greatest expenditure for depreciation account, unless it is wear and tear; but as time goes on obsolescence may become a less important factor, though it would probably be at the cost of improvements and development.

Deferred Maintenance.—The several classes of depreciation hereinbefore referred to assume that the property will be kept in good operating condition and efficiency. Deferred maintenance is only another term for neglect and always reflects to the discredit of the management or the financial ability of a corporation.

"Absolute" and "Theoretical" Depreciation.

Where property is no longer of service it must be depreciated down to the value at which it may be sold, even though that value is as low as scrap value. On the other hand, apparatus that is in use and rendering a service economically may, for the purpose for which it was intended, be as valuable as when originally installed, although its age may be approaching the limit of its life.

The erroneous application of rates of depreciation in the attempt to determine present commercial values is fairly common, one of the most notable cases, because of the large amounts of money involved, being that of the Public Service Commission of New York, First District, in the matter of the Third Avenue Railroad reorganization.

The "straight line" method of depreciation has been more largely used than any other, probably because the life of much apparatus is brief; and, furthermore, the application of this method is the most simple, direct and easily understood, and hence favored by the legal fraternity and a large proportion of the members of public utility commissions, many of whom, not technical men, naturally incline toward the more easily appreciated elements of the questions which they are compelled to consider and discuss.

As indicating the possible error in determining to estimate "theoretical" depreciation, it is frequently found that the length of life assumed has been greatly surpassed by apparatus which is still giving reliable and satisfactory service. For apparatus still giving satisfactory service after the expiration of its assumed life it is only fair in estimating theoretical depreciation to allow a value greater than scrap value. The minimum value of all types of engines, boilers, pumps, heaters, condensers, line transformers and shafting is, at present being taken by the Wisconsin commission, for example, at 25 per cent.; generators, motors, rotaries, arc lamps, wood and iron poles, 20 per cent.; station transformers, 40 per cent.; storage batteries, 35 per cent., and switchboard instruments and electric meters, which must be kept in a high state of repair, 80 per cent., as the minimum percentage of reduction cost for apparatus still in use though theoretically "dead."

Depreciation Accounts or Reserve Funds.

For a small company or where relatively large proportions of the invested capital are locked up in few or single pieces of property, it is preferable to accumulate, in advance out of operating income, reserve funds from which to provide for all classes of depreciation. But such method may be unnecessary and possibly an inexpedient accounting complexity with large corporations, where the investments in any single piece of physical property are small relative to the total investment. In brief, where the properties are large enough depreciation becomes only normal wear and tear, but in any case operating expenses should be made to provide for ultimate loss in value, whether reserve funds are accumulated or all depreciation is charged to the "wear and tear account." It is on this theory that, a large property having numerous physical elements, all deterioration becoming simply "wear and tear" and a part of operating expenses, the receiver of the Third Avenue Railway in New York City declines to obey the order of the Public Service Commission and provides no depreciation fund whatever, simply removing deterioration when it occurs and charging it as maintenance in operating expenses.

It has been the too frequent practice in the past to regard wear and tear as the only elements of depreciation chargeable to the operating expense, and to charge capital account in whole or in part with expenditures for age, inadequacy and obsolescence. The error of this procedure is now almost universally recognized and the injustice of such improper handling of depreciation to both the investor and the public served is clear.

Application of Depreciation.

There has been such marked development and improvement in all mechanical appliances, particularly along electrical lines, that inadequacy and obsolescence have usually come into effect before age, and, in consequence, knowledge of the depreciation of all electrical properties due to age has not yet been fully established.

The determination of depreciation due to inadequacy and obsolescence is a particularly delicate matter, it depends so largely on local conditions and especially upon individual judgment and equipoise. Inadequacy and obsolescence usually develop so quickly that very frequently the property in question becomes inadequate or obsolete within a few weeks or months, and has depreciated to scrap value almost as soon as these classes of depreciation are recognized; a space of time entirely too brief in which to apply ordinary methods of offsetting depreciation.

Information should be collected so as to make clear the cause of depreciation and the rate at which it has progressed. For example, wear and tear would probably have to become subdivided into maintenance and accident. Obsolescence might be divided so as to show whether the obsolescence was caused by city ordinance or the invention of new apparatus. In obtaining age depreciation, care must be exercised that the apparatus is abandoned through exhaustion of life, not through inadequacy or obsolescence.

In determining the total amount of deterioration due to inadequacy and obsolescence, only those elements of the property which have clearly and unequivocally so depreciated should be written off to this account. On the other hand, in determining the rate of depreciation for making provision covering inadequacy and obsolescence, the engineer should be sure to provide a rate high enough to take care of these classes of depreciation out of the operating income.

As the United States Bureau of Internal Revenue provides that reduction in value authorized for depreciation "shall include all expense items under the various heads acknowledged as liabilities," it will be seen that the proper understanding of the question of depreciation is a vital one for those connected with corporation management, because if no depreciation fund is set up nothing can be included in the cost of operation as necessary to provide for depreciation, as would be essential in a case involving rate regulation, for example. Moreover, the State public service commissions are now generally requiring depreciation accounts and reserves on a basis to be decided by each corporation itself.

The manner of determining the amount to be set aside for annual depreciation varies, there being three general methods recognized.

a. An estimate based on a percentage of the cost of the property being depreciated. The special master in the Columbus (Ohio) case held that the amount of operating expenses chargeable to depreciation should be "5 per cent. o fthe total cost of the plant including real estate, real estate constituting but 7 per cent. of the total valuation." The present laws of Massachusetts provide in respect to municipally owned gas or electric plants that there shall be included an amount for "depreciation equal to 3 per cent. of the cost of the plant exclusive of land and water-power appurtenant thereto."

b. A fixed percentage of the gross earnings. This method is sometimes taken to include wear and tear and sometimes not. The practice in this regard is illustrated by the following companies:—

Name of Company	Per Cent. of Gross Revenue Expended or Appropriated for	
	Maintenance.	Depreciation.
Milwaukee companies:		
Railway departments	11.3	9.9
Gas, electric light and steam heat department	6.15	8.12
United Railways Company of St. Louis..	13.67	10.0
Union Electric Light & Power Co., St. Louis	4.95	16.0
Suburban Electric Light & Power Co.....	7.10	10.85
Detroit Edison Co. and subsidiaries......	6.45	10.23
Omaha & Council Bluffs Street Railway Co.	....	10.0
Chicago street railways	6.0	8.0

c. On the basis of kw-hours output or car miles run. The New York Edison Company charges monthly for renewals and replacements, etc., one cent per kw-hour on current sold to general consumers in addition to wear and tear. In Cleveland 5 cents per car mile is provided to cover both maintenance and other deterioration. In Brooklyn the subsidiaries of the Brooklyn Rapid Transit System allow amounts varying from 2.7 cents to 4.4 cents per car mile for equipment of surface roads and from 1.4 cents to 2 cents per car mile for equipment of either elevated or partly elevated railways; from 2.2 cents to 2.4 cents per car mile for way and structures for surface roads; from 1.1 cents to 1.8 cents for elevated or partly elevated railways, to cover not only obsolescence, inadequacy, renewals and replacements, but also repairs and maintenance.

Total Depreciation.—From the cost should be deducted the absolute depreciation in order to obtain the present real or service value of the property. If it is desired to go further than this and obtain a theoretically depreciated value, the absolute depreciation must be increased by a theoretical depreciation determined by the use of estimated amounts to cover assumed deterioration for age and non-existent, but expected, inadequacy or obsolescence.

Very many authorities agree that in making an estimate of the amount of depreciation effective in any property, "used or useful," there should at least be included in the amount to be deducted an estimate of the amount of wear and tear, deferred maintenance, if any, also scrap value of property that has been worn out or superseded as well as inadequate or obsolete property provided it is still inventoried.

The only allowable exception to the inclusion of inadequate or obsolete property as a part of depreciation is where inadequacy or obsolescence has so suddenly and largely effected a property that its earnings have not permitted the writing off at the time or since such developed depreciation; then in such cases it may be that capitalization or earning basis should not be reduced by taking account of any such depreciation.

Whether or not "theoretical depreciation" should be included a part of the total depreciation in determining fair value of physical property is a mooted question. The public service commissions have rather leaned to the opinion that such depreciation should be considered in determining fair value. On the other hand, many, if not all, of the court decisions are against such inclusion of theoretical depreciation.

Provided a property is kept in good order and at 100 per cent. working efficiency so as to render service to the public equivalent to that of a new plant, the question of rates or value of property in its service to the public has absolutely nothing to do with the amount of reserve funds the corporation may or may not have accumulated. While the engineer must be quick to recognize loss of value where it actually exists and to make deductions for property that has been worn out or superseded, he should not be misled into including purely hypothetical or academic values.

The confused state of mind that prevails with regard to the application of depreciation in determining present value results largely from the misapplication of the principles established by the courts in rate cases. These decisions expressly provide that allowances to cover the deterioration of all sorts, including ultimate replacement, are to be provided out of operating income.

Fifty Per Cent. Method.

A quick and it seems to the writer very fair method of obtaining the theoretical depreciation of certain classes of physical property has been used in some utility appraisals and may be called the "50 per cent. method." It has been used by Prof. M. E. Cooley in connection with his figuring of depreciation in the Michigan State appraisal; H. P. Gillette in the appraisal he conducted for the State of Washington; B. J. Arnold in appraisal work for the Public Service Commission of the First District of New York, and the writer in connection with the reorganization of the Third Avenue Railway in New York City. It has, I understand, also been approved by the Master Car Builders' Association in connection with the appraisal of rolling stock. It will be seen that this method of determining depreciation will be fallacious if the installation does not consist of a large number of similar elements or has not been in use for a sufficient length of time to permit the repair account reaching its normal maximum, which it would not do unless practically all parts have been renewed once and renewals are constanty taking place; hence it could not be applied to the buildings of a corporation which owned new buildings and probably not even to engines or generators because usually they would be too few in number—except for the very largest organizations—to permit their being replaced without abnormally affecting the amount annually appropriated on account of depreciation. The net result of the application of the 50 per cent. method is at once apparent; 50 per cent. of the cost, less salvage, will be immediately written off as depreciation.

Depreciation of Contingent Percentages.

The percentages added to structural costs to cover engineering, incidentals, contingencies, etc., in order to obtain physical values have usually been considered an inherent part of the cost of the physical property and treated as such in connection with the depreciation of the physical property. With certain parts of the property this is undoubtedly a correct procedure and for the sake of simplicity and consistency may be recommended; but, as a matter of fact, the original engineering investment in certain parts of the physical equipment, for example, road-bed and track, still remains there and is as much a part of the property as the real estate, although the rails and ties, which have been cited, may have been many times relaid and paid for as a part of operating expenses. It would be no more unreasonable to leave such investment percentages undepreciated than it is to depreciate the physical property entirely independent of development expenses or going value, which seldom, if ever, has been practised. It has been held by some that the discount on securities should be written off at the same rate as depreciation of the physical property; but the more usual plan is to amortize such costs at a lower rate, determined by the life of the bonds. In some cases it may not be advisable to amortize investments of this character at all.

Summary and Conclusions.

1. The necessity for more general agreement on and uniform use of the terms used in considering and discussing depreciation.

2. The rate of depreciation adopted for accruing depreciation must not be confused with the total sum of depreciation in physical property, which is an estimate for a given time.

3. The difference between absolute and theoretical depreciation should be recognized and the amounts separately considered.

4. Theoretical depreciation must be assumed and provided for as operating expenses if capital is to remain unimpaired and rates are to give maximum service at minimum expense.

5. Service value, determined from consideration of the "absolute" not the "theoretical" depreciation of physical property, is to be used, in connection with certain proper non-physical values, as the basis on which rates are to be fixed, capitalization allowed and taxes assessed.

6. While usually preferable, there exists no necessary reason for always writing off certain costs such as engineering, incidentals, etc., at the rate at which the physical property of which they are an inherent part is depreciated.

7. Development expenses bear no fixed relation to the cost of the physical property and their amortization has no necessary relation to the rate of depreciation of the physical property.

8. The amount of depreciation of physical property can be accurately determined only by inspection on the part of competent and conscientious engineers.

9. There exists an urgent demand for co-operation among engineers, manufacturers, and service corporations for the intelligent collection and correlation of data on which properly to base estimates of depreciation.

A LONG CONCRETE SPAN.

The longest concrete span in the world is that which is under construction at Spokane, Wash. The central span is 281 feet. The bridge of which this span is a part, is in New Munroe Street, and will support the car tracks, as well as a team roadway and walks for pedestrians

WATER LOSSES IN IRRIGATION CANALS AND METHODS OF PREVENTION.*

When it is recalled that in large irrigation systems the water losses usually range from 30 to 60 per cent. of the total supply taken into the canal and that the limitation of irrigation development in the arid regions of the United States is the result of water shortage rather than of land shortage, the relation of canal losses to the sufficiency of water supply for any irrigation project and to the need for their prevention is apparent. Where an adequate water supply exists the engineer must still give careful consideration to canal losses in order to arrive at intelligent designs of the capacities of the various canals and laterals to meet the needs of economy of construction and adequacy of delivery of water to the land. Even after an irrigation system has been designed with provision for canal losses, the irrigation engineer must take steps in many cases to prevent canal losses in order to protect the canals from breaking and the irrigable lands from seepage water.

Canal losses are due to evaporation and percolation. Evaporation can again be divided into direct and indirect evaporation, or that occurring from water surface itself and that occurring from the adjacent soil wetted by percolation. Direct evaporation is clearly independent of percolation, but indirect evaporation is evidently dependent upon and contributory to percolation. Direct evaporation is so small that for all ordinary purposes it may be neglected in considering canal design except where reservoirs are involved. At Boise, Idaho, the minimum evaporation occurs during January, at which time it amounts to 0.1 to 0.2 ft. for the month. The maximum evaporation occurs in July and amounts to from 0.6 to 0.8 ft. for the month. The total annual evaporation is approximately 5 ft., about 4 ft. of which occur during the legal irrigation season covering the period between April 1 and October 31. These figures indicate that the loss of canal water due to surface evaporation during the period of greatest loss will not be far from .025 cu. ft. per day per square foot of water surface, and that the average daily loss for the total irrigation season will be approximately 0.02 cu. ft. per square foot of water surface per day. These losses are, in most cases, considerably less than 5 per cent. of the probable losses from percolation. In estimating canal losses, therefore, it is sufficiently accurate to assume a seepage rate that will cover losses due both to percolation and evaporation.

Seepage losses are usually expressed in per cent. of canal flow per mile, but such a unit of measure is not satisfactory because the loss is more properly a function of the canal cross section than of its capacity. It has been found from experiment that seepage losses hold a direct relation to the wetted area of the canal section. This relation naturally lends itself to the practice of expressing seepage losses in canals in terms of cubic feet per day per square foot of wetted area of the canal. In determining the carrying capacity of canals and laterals, however, it is most convenient to express the seepage loss per mile as a percentage of the canal or lateral flow at the beginning of the mile. The convenience of this method is, therefore, probably sufficient excuse for adhering to its use, but it should be clearly understood that the percentages should be arrived at from studies of rates of flow expressed in cubic feet per day per square foot of wetted area of canal channel.

Numerous investigations have been made to determine seepage losses in canal systems and it is to be regretted that much of this information has been compiled on the percentage of flow basis with inadequate data of canal cross sections for comparison with data compiled on the basis above recommended. Below is given a most interesting and valuable table (Table I) of results compiled by Saville in his report on Gatun Dam in the Annual Report of the Isthmian Canal Commission for 1908.

This table shows a daily seepage loss in cubic feet of water per square foot of wetted area varying from .23 to 6.40. The greatest number of the experiments, however, show a rate of seepage varying from about 0.5 to 1.5 cu. ft. per square foot of wetted canal surface per day. The figures in this table correspond approximately with results obtained by Allen Hazen for average conditions under which seepage would occur. J. C. Stevens, district engineer, U.S. Geological Survey, has published some data in the Transactions of American Society of Civil Engineers, covering experiments made by him on the Sunnyside canal in Washington that are of interest to irrigation engineers in the volcanic region of the northwest. The Sunnyside canal, diverting water from the Yakima river, near North Yakima, runs through soil composed in places of pure volcanic ash or volcanic ash mixed with sand or loam. In other places it runs through extremely sandy soils and over porous lava areas. Mr. Stevens' experiments show that the loss in the first 30 miles of this canal during the season of 1909 was

TABLE I.—SEEPAGE FROM SOME CANALS.
(Cubic feet of water per square foot.)

	Seepage per day.	Remarks.
Fort Morgan, Colo.	0.98	Sandy soil.
Fort Morgan, Colo.	5.00	New canal.
Hoover Ditch, Colo.	1.2	Sandy soil.
Kings River and Fresno	1.5	Sandy soil.
Kings River and Fresno	1.7	Sandy soil.
Fresno	0.4-2.8	Different sections.
Fresno Laterals	1.2-6.4	
Naviglio Grande, Italy	0.9	Italian canals 100 years old in very pervious soil.
Muzza, Italy	1.7	Italian canals 100 years old in very pervious soil.
Canale Martesana, Italy	1.5	Italian canals 100 years old in very pervious soil.
Languedoc, France	.23	Carefully constructed.
Chesapeake	.42	American canals in rather impervious soils.
Chenango	.42	American canals in rather impervious soils.
Erie	.42	American canals in rather impervious soils.
Morris	.71	American canals in rather impervious soils.
Delaware and Raritan	.71	American canals in rather impervious soils.

*A paper by F. W. Hanna, Boise, Idaho, before the Idaho Society of Engineers.

approximately 0.48 cu. ft. per square foot of wetted area per day. In the next 16 miles this loss is 1.05 cu. ft. per day, and in the next 12 miles 1.66 cu. ft. per day. The lighter losses indicated by these experiments occur in soils composed of volcanic ash and loam and volcanic ash and sand, and the heavier of them occur in more sandy soils and in porous lava beds. Measurements have been initiated and are still in progress on the Boise project under the direction of the writer for the purpose of determining the rate of percolation for the soils of the project. These measurements indicate a loss of from about 0.25 to 1.50 cu. ft. per day per square foot of wetted area for new canals with hard-pan bottoms and loam banks in a lava formation district. An old canal in this district showed a seepage of 0.25 cu. ft. per day in the upper portion and 0.86 in the lower. This canal is well silted both on the side slopes and on the bottom. The measurement of two laterals on the first bench showed a loss of 0.69 and 1.17 cu. ft. per day per square foot of wetted area. These laterals were new and run through lands with a light hardpan layer lying between gravel below and sandy loam above. From careful consideration of the data above cited and data from other sources, it would appear that a seepage loss of 0.5, 1 and 1.5 cu. ft. per square foot of wetted surface per day might be assumed for canal losses respectively, for rather impervious and rather pervious soils.

Assuming an average relation of bed width to depth of water in laterals to be given by the formula, $b = 1.5\,d^2 + 1.5$, a mean velocity in feet per second of 2 and side slopes of 2:1, a table of losses in per cent. of flow per mile of lateral can be compiled as shown below:—

d	b	A	p	L	Q	P c=05	P c=1	P c=15
2.5	11	40	22.20	1.33	80	0.8	1.7	2.5
3.0	15	63	28.44	1.71	126	0.7	1.4	2.1
0.5	3	2	5.24	0.31	4	4.0	8.0	12.0
1.0	3	5	7.48	0.45	10	2.3	4.5	6.8
1.5	5	12	11.72	0.70	24	1.5	2.9	4.1
2.0	8	24	16.96	1.02	48	1.0	2.1	3.1

In the above table d equals water depth in feet, b lateral bottom width in integral feet with a minimum limit of 3; A area of water cross-section in square feet; p wetted lateral section per linear foot in square feet; L seepage loss in second feet per mile of lateral for C equalling l; C the rate of seepage in cubic feet per square foot of wetted surface per day; Q the lateral discharge in second feet; P the per cent. of less flow per mile. By use of these symbols it may be shown that L equals 0.06 Cp, and P equals $6Cp \div Q$ equals $100L \div Q$.

Inasmuch as computations on seepage losses are necessarily rough approximations, the following general values for use in the design of lateral capacities will be sufficiently accurate and sufficiently large also to account for evaporation losses. Table II.

The office of experiment stations, U. S. Department of Agriculture, in one of its circulars, gives the following values as a result of all of its expermimiments, including numerous measurements made during a long series of years: For canals carrying more than 100 second feet 0.95 per cent.; between 50 and 100 second feet 2.58 per cent.; between 25 and 50 second feet 4.21 per cent.; less than 25 second feet 11.28 per cent. For data based on a multiplicity of varying conditions, it will be noted that these results agree quite well with those arrived at in the above table. The figures of this table may, therefore, be relied on to give fair average values for soils of varying degrees of imperviousness in average conditions with sufficient accuracy for lateral design.

The prevention of canal losses is yet in an incipient stage, but as the scarcity of water becomes more strongly felt and the magnitude of canal losses becomes better understood, there will be a rapid development along this line of engineering. The methods now employed for canal seepage prevention consist in carrying the water in wooden and steel flumes, or in wooden, iron and concrete pipes, or in channels, lined with concrete, stone masonry, plaster, clay or oil. All of these methods are expensive except where the additional cost is partly borne by some other necessity, or where the value of the products of the irrigated lands is high. The engineering problem is, therefore, to determine which of these methods is adaptable to the particular conditions under consideration and whether the saving of water effected by the prevention of losses will bear the cost of the necessary improvement.

TABLE II.

Lateral capacities in second-feet.	Lateral class designation.	Losses in per cent of flow per mile c=0.5	Lossos in per cent of flow per mile c=1	Losses in per cent of flow per mile c=15
10 or less	1	4	8	12
11 to 25	2	2.5	4.5	7
26 to 50	3	1.5	3	4.5
51 to 75	4	1	2	3
76 to 100	5	0.75	1.5	2.5

The United States Department of Agriculture has conducted in test pits similar to canal sections a series of experiments in co-operation with the University of California to determine the comparative effectiveness and cost of different kinds of lining. Table III shows in a condensed form the result of these experiments taken from the Annual Report of the Office of Experiment Stations for 1907:

In California Station Bulletin 188 are given considerable data on the cost of and methods of placing stone masonry, concrete and cement plaster lining in canals in Southern

TABLE III.—EFFECTIVENESS OF DITCH LININGS.

Description of Lining.	Saving per cent.	Experimental cost of lining per sq. ft. (a)—cts.	Actual cost of lining per sq. foot (a)—cts.
Cement concrete 3 ins. thick	86.6	8.30	7.50
Cement lime concrete, 3 ins. thick	65.5	8.30	7.50
Cement mortar	63.3	3.88	3.25–3.50
Heavy oil, 3 2-3 gals. per sq. yd.	50.4	1.20	1.20
Clay puddle, 3.5 ins. thick	47.8	3.90	1.20
Heavy oil, 3 gals. per sq. yd.	38.0	1.00	1.00
Heavy oil, 2⅓ gals. per sq. yd.	27.3	.77	.77
Thin oil, 2.5 gals per sq. yd.	7.3	1.00	.80
Earth, (no lining)	.0	....	....

(a) Excluding the preparation of the ditch.

California. The various methods used in placing the same and different kinds of lining is interesting and well worth careful study by engineers engaged in irrigation work.

The United States Department of Agriculture notes in the report herein before referred to an instance in Southern California of the use of road oil for canal lining for the purpose mainly of preventing the growth of weeds and aquatic plants. The oil was applied to a length of 1½ miles of canal having a bottom width of 20 ft. and a depth of 1 ft., and the method of placing and the results are summarized in the following language:

The oil used was crude petroleum from the Sunset district southwest of Bakersfield, and contains a large percentage of asphaltum. Its specific gravity is 11½ on the Baume scale. This oil when cold will not run freely. It was used hot and sprinkled with an ordinary road sprinkler. The ditch had been previously cleaned of all vegetation and allowed to dry. The road sprinkler was driven first on the bottom of the ditch and then on the banks. The oil was applied at the rate of 1½ gallons per square yard. The oil was then thoroughly harrowed in until it was well mixed with the soil, which was very sandy.

When examined about seven months after the application of the oil there was no vegetation in this part of the canal, while other parts of this same canal which had received no oil had been cleaned two weeks previously showed a vigorous growth of vegetation. The contrast is very striking and clearly shows the value of oil in preventing the growth of aquatic plants. Not only was this part of the canal free from vegetation, but it was only about one-third full, while the canal full of weeds had to be full to carry the same amount of water.

During the past two years the writer has had charge of the placing of about 30,000 cu. yds. of concrete lining covering nearly 6 miles of the Main South Side Canal of the Boise Project of the Reclamation Service in the vicinity of Boise, Idaho. This lining has been placed for the triple purpose of reducing seepage, preventing breaks in the canal banks and obviating a heavy expense of enlarging the canal section.

From experiments conducted on the canal flow in the lined portions during last summer, it was found that the value of n in Kutter's formula is about 0.014, giving a discharge on a 40-ft. base, 1½ to 1 side slopes and 8-ft. water depth approximating that in the same canal for an earth section of the same water depth and side slopes and a base of 70 ft. On side hill work, the cost of lining the old 40-ft. canal was much less than that of enlarging it to a 70-ft. canal.

The lining consisted of a 1:3:6 mixture of cement, sand and gravel placed in a 4-in. thickness with trnsverse joints at 16-ft. intervals and longitudinal joints at either 8 or 16-ft. intervals. The concrete was mixed at gravel pits located on the canal bank and was transported from the mixers to the points of deposition in one-horse carts, where it was dumped on to the ground and shovelled into place on a foundation that had been carefully levelled to subgrade and tamped. The joints were obtained by the use of 4 x 4 in. x16 ft. timbers placed at the proper intervals. Alternate panels were then placed to permit of the setting of the concrete and the removal of the forms. After the concrete was placed and compacted with shovels, a heavy straight edge reaching across the 16-ft. panel was run over it until the concrete was levelled down to the proper thickness. Following this a finishing coat of cement mortar was floated over the concrete giving it a smooth surface.

This work was done for a little less than 10 cts. per sq. ft., excluding the cost of preparing the foundation, and the lining thus far promises to give very satisfactory service.

A NOVEL METHOD OF OVERCOMING PEAK LOAD TROUBLES.

Users of electric power are sometimes compelled to buy on a "peak load" basis, that is, not exceeding a fixed current consumption at any time during the year but paying constantly for that fixed maximum regardless of how much current is used. On this basis of payment, it is evident that continually running close to the specified limit or vice versa keeping the current consumption low at the time of greatest load is advantageous. The former procedure is impossible in many manufacturing processes, as it is in lighting and street railway work; the latter is usually attempted by the use of storage batteries.

Those who have studied this peak load problem will be interested in a novel solution which has been quite successful in the municipal lighting and waterworks plant of the City of Lachine, Canada. In this instance the low cost and satisfactory operation of a 400 h.p. steam turbine unit is utilized in effecting the economy. In the Lachine plant, a 14-inch two-stage double suction turbine pump with a capacity of 6,000,000 gallons per 24 hour day is utilized to provide water supply and fire protection for the city, the water pressure being ordinarily 80 pounds per sq. in. and for fire 120 pounds per sq. in.

Current is purchased by the year on a basis which is all right for lighting the city and for pumping at all times of the year except the three winter months during which the lighting load is greatest. It was figured that operating the pump by steam for four or five hours a day during that period could be made less expensive than buying sufficient electric current to operate entirely by electricity. As further advantages of an auxiliary steam installation, the insurance rate on the pumping station could be reduced and the city could be better lighted during fall evenings without incurring unreasonable additional expense.

It was therefore decided to arrange the pump for operation by a 400 h.p. induction motor the greater part of the time but by a steam turbine during the peaks in the lighting load in winter and in case of accident in the electric line.

The installation was furnished by the John McDougall Caledonian Iron Works, Montreal. The pump, of Worthington make, runs at 900 r.p.m. and is direct connected to an Allis-Chalmers-Bullock motor on one side and a 400 h.p. four-stage Kerr Turbine on the other. Either driving unit can be thrown into or out of use instantly by means of clutches on the shaft.

IMPROVED ROADMAKER.

Within a few months past a new method of treating roadways, in order to enable them to resist the destructive effects of motor traffic, has been tried in France. Instead of employing tar to cement the materials, a special form of machine is used to wedge the bits of stone together without grinding and pulverizing them as ordinary steam rollers do. The machine carries a set of cast-iron rammers, which deliver their blows vertically, and produce no tangential movement of the stones. The apparatus travels on wheels, and when at work advances about 200 feet an hour. It is said that a roadway thus treated is much more durable than one made with the aid of a steam roller, which not only produces too much fine material, but rounds the stones and makes them liable to roll.

THE NECESSITY OF STEEL HIGHWAY BRIDGE INSPECTION, INVESTIGATION AND MAINTENANCE.*

By N. B. Garver, C.E.

Governor Deneen of Illinois, in his message to the Forty-seventh General Assembly of that state, makes the following statement: "The rural taxpayers are spending to-day upwards of six millions of dollars on roads and bridges, and all who have observed at all closely are agreed that results are not what they should be for this large expenditure." He also says, "The maintenance of our bridges is a matter of great importance, as about half the expenditure for roads and bridges is for bridges." The above statements coming from the governor of a great state, coupled with what information may be obtained from the reports of the highway commissions of various states, give sufficient evidence of the importance of this subject.

The actual physical condition of practically all steel highway bridges is neither known nor realized by the general public, for the very obvious reason that they have not made a study of this particular subject, neither have they been informed, by those who know, as to the proper methods of investigating, repairing and maintaining bridges.

Many of the existing structures were built under a system in which those representing the public knew nothing of bridge construction, no definite specifications or loadings were used in the design, in fact, in many cases no design was submitted, and the contract was made with the lowest bidder, the bid being on a lump sum basis. It can readily be seen how disastrous the results would be under this system, if the contractor was unscrupulous, as many of them were. Many of the bridges built under this system are now standing, a danger and a menace to those who use them. It is indeed strange that more accidents have not resulted from this method of building highway bridges, a method which has been in almost universal use in past years.

Another necessity for the inspection, repair and careful maintenance of the older steel highway bridges is this: At the time many of the bridges were built, there were no automobiles travelling the public highways, there were few traction engines and road rollers, the maximum load being that which could be hauled on the ordinary farm wagon over a very poorly constructed dirt road. These conditions have changed wonderfully during the last few years. The following extract from the statutes of the state of Illinois indicate that some effort has been made to take care of this increased load which highway bridges are required to carry, although this law has a defect which deprives it of its usefulness. "Act of the General Assembly approved April 21, 1899. Be it enacted by the People of the State of Illinois, represented in the General Assembly: That it shall be unlawful hereafter to construct any bridge or culvert over any ravine, creek or river upon a public highway or street in any town, county or city in this state, unless such bridge or culvert shall have the capacity of sustaining a weight of at least one hundred pounds to the square foot." In this law no factor of safety has been specified and the bridge may be calculated to carry a load up to the ultimate strength of the material of which it is constructed.

It is the purpose of this article to discuss an investigation of some structures which have been built for a number of years, and wherein the safety of each was determined in its present physical condition and under the loads which they are required to carry at the present time. In each case the investigation was made under a definite set of specifications and the structure was classified according to those specifications.

The dead load was calculated from actual measurements of the structure. The field measurements were taken by T. M. Pittman, J. A. Scanlan, and E. A. Randall, senior students in the University of Illinois, to whom the writer wishes to express his indebtedness for that work.

The efficiencies were calculated in the following manner: The actual unit stresses were calculated from the dead, live and wind loads. The allowable unit stresses were calculated according to the specifications. The ratio of the allowable unit stress to the actual unit stress is the percentage of efficiency.

Conclusions will be drawn from these investigations which will show the necessity for the inspection and investigation of all highway bridges which have been in use for any appreciable length of time. It will also be shown that the maintaining of these bridges in good condition is a matter of economy.

The first structure investigated is located at Danville, Illinois, and is locally known as the Woolen Mill Bridge. It is 776 feet long and spans the North Fork of the Vermillion River and connects Vermillion Heights with Danville.

It is made up of 19 trestle bents, a ten panel deck Whipple truss and 5 four panel deck Pratt trusses. It was built about 1885 by the Lafayette Bridge Company, of Lafayette, Indiana. The trusses are on a level grade, while the west approach is on a three per cent. grade, as are also the three short spans at the east end. The east end of the Whipple truss is carried on two steel cylinders filled with concrete and about 25 feet high. The bents are set on square stone bases, as is also the west end of the Whipple truss. The trusses are 17 feet centre to centre and the roadway is 18 feet wide with a 4-foot walk on each side.

Cooper's Highway Bridge Specifications, 1909, were used in the investigation of this structure, which is rated as a Class A1 bridge.

This bridge carries a considerable amount of heavy traffic, due to the fact that there are coal mines and brick yards located in and near Vermillion Heights. At a wagon scale located near the end of the bridge there are records of loads of about 16,000 pounds which were hauled across this bridge. At each end of the bridge there is a sign, "Not more than four teams allowed on this bridge at one time," but there is no one there to enforce the rule.

The investigation of the stresses in this bridge showed that the efficiencies of the various members vary greatly. In the Whipple truss it was noted that the bottom chord, intermediate posts and hangers, and the diagonals were fully up to the required cross sectional area. The end post showed an efficiency of 84 per cent. and the top chord showed an efficiency as low as 77 per cent., but these efficiencies are not so low as to be dangerous if the bridge was in good physical condition. The sway bracing is ample.

The Pratt trusses have about the same efficiencies as the Whipple truss. Th lower chords, posts and diagonals have ample section, while the top chord has a low efficiency at the middle of the truss.

The bents in the approaches have very low efficiencies. In one of the posts the efficiency was only 46½ per cent.

The floor system consists of 3-inch plans laid on 3 x 12 inch joists, spaced two feet centre to centre. These joists rest on the floor beams composed of four angles and a web plate. The joists have an efficiency of 60 per cent. and the floor beams an efficiency of 83½.

*From the Iowa Engineer.

The physical condition of this bridge is very poor. Apparently it has not been painted since erection, and consequently some parts of the bridge are badly corroded. The top chords of the trusses have corroded until the cover plates are practically of no value. The floor beams are in almost as bad condition, which reduces their efficiencies to a dangerous point. The wood joists are in a serious condition. Where the plank floor rests on them they have decayed to a depth of two inches. Many of these joists, after they have rotted until they do not hold the nails, have been taken out and turned upside down and put back in the floor.

One of the diagonal tension members in the north Whipple truss is broken, as is also a similar member in the south truss. These members have a calculated efficiency of 119 per cent. Attempts were made to splice these members, but the splices, which were less efficient than the members, were also broken. A bottom lateral in one of these trusses was also found broken.

Many of the details are of a very poor design, are in bad condition, and would not be tolerated in a new structure if in charge of a competent engineer.

The long bents that support the Pratt trusses have low efficiencies and in addition are badly corroded. They are in an unsafe condition.

There is one expansion joint in the structure, and that is at the west end of the Whipple truss. Theoretically, it has an efficiency of 130 per cent., but practically it has no value whatever. Dirt has filled in around the shoe until it has clogged the rollers. The roller nest has been crowded out until it is only partially on the bearing plate. Apparently, little effort has been made to put this bridge into even a moderately safe condition.

This bridge should be condemned and a new one constructed in its place.

The next bridge investigated was the Gilbert Street bridge, which spans the Vermillion River at Danville, Illinois, just to the southwest of the main business section of the city.

This bridge is about 1,050 feet long and was built by the Chicago Bridge Company in 1893. It is made up of two 275 ft.-0 in. subdivided deck Warren truss spans, two 4-panel deck Pratt truss spans, four 3-panel deck Pratt truss spans and four tower spans. The Warren truss spans are supported on stone masonry piers, and the other spans are supported on four towers, one rocker bent and the abutments. The tower posts are set on square stone bases.

The trusses are 20 feet centre to centre. The roadway is 22 feet wide with a 4½ foot walk on each side.

The floor system is made up of 6 x 16-in. wood joists spaced 2 feet centre to centre with a floor of yellow pine plank and creosoted wood block paving. The floor is new, having been laid in the fall of 1910.

Cooper's Highway Bridge Specifications were used in the investigation of this structure and it is rated as a Class A-2 bridge.

The vehicle traffic over this bridge is very much the same as the traffic over the Woolen Mills bridge, consisting principally of the hauling of coal and brick from the mines and brick yards just outside the city. For several years an interurban electric line crossed this bridge, but the tracks have been removed.

It was noted that the efficiencies of practically all the members of the deck Warren trusses are low and that they are comparatively uniform throughout the truss. This would indicate that this bridge was designed for a lighter load than that assumed in the investigation. The laterals and wind bracing are all very efficient.

The efficiencies of the 4-panel deck Pratt truss are about the same as for the Warren trusses, except for the middle section of the top chord, which show an efficiency of only 55 per cent.

The 3-panel Pratt trusses have sections practically the same as the 4-panel Pratt trusses and would, therefore, have proportionately higher efficiencies.

The lowest efficiency in any of the posts of the tower bents was 84 per cent. The posts are made up of 4 angles laced, forming a box column.

The joists have an efficiency of 68 per cent. The floor beams have an efficiency of 55 per cent. for uniform and 37 per cent. for concentrated loads.

There are expansion rollers under the shore ends of the Warren trusses. These rollers have a calculated efficiency of 96 per cent.

The wood floor system is in good condition, having been renewed in the fall of 1910. The steel work, with some few exceptions which will be discussed, is in very good condition.

The lower struts in the owers are badly corroded and in some cases the lower end of the post is in bad condition. Some of the struts were badly damaged when the new floor was being laid. The old joints were dropped from the floor above and evidently some of them struck the tower struts. Some repair work has been done on the bases of the towers by encasing the strut and the base of the post in concrete. This kind of repair work is of doubtful value, unless the concrete is designed to take the stress formerly taken by the steel, as the steel may continue to corrode inside the concrete until it is entirely gone.

The expansion joint under the right hand end of the second Warren truss was renewed in the fall of 1910. The rollers in this joint are only 3 inches in diameter, which is entirely too small for the length of span. The old roller nest, when removed, was in such condition that it was impossible for the rollers to turn, and evidently they had not turned for a number of years. The new rollers will be in the same condition in a short time if they are not carefully watched and kept clean. The other expansion joint has not been repaired or cleaned and is of little value. The portal struts in the Warren trusses are badly corroded. They are made up of four angles laced, and are placed in such position that one angle forms a trough which holds water, thus causing corrosion to take place rapidly.

The efficiencies of the members in this bridge are low for the loadings assumed. This bridge carries heavy wagon traffic and at one time carried an interurban electric line. The tracks for the interurban line have been removed and there is little likelihood of their ever being replaced. The wagon traffic is not continuous and there is slight chance for the bridge ever to become fully loaded. If the bridge is repaired, the traffic regulated, and the bridge carefully maintained, it should be safe for some time to come.

This structure should be put in safe condition by renewing or reinforcing both the struts and bases of the posts in the towers, and by renewing the damaged struts in the Warren trusses. The entire structure should be thoroughly scraped to remove all old paint and rust, and then given two good coats of paint. Car tracks should never again be permitted on this bridge, and wagon traffic should be regulated whenever there is a tendency toward congestion.

The third bridge which was investigated is known as the Interurban bridge. It is located just at the west edge of Danville, Illinois, and spans the North Fork of the Vermillion River.

This bridge is a seven-panel single span of the Pratt truss type and is 120 feet centre to centre of bearings. There is nothing to indicate when, or by whom, the bridge was built, but it has evidently been built for at least fifteen years. The abutments are of stone masonry.

Ostrup's Specifications for Highway Bridges were used in the investigation of this bridge, and it is rated as a Class A bridge. In addition to highway traffic, it carries an interurban electric line, and street cars between Vermillion Heights and Danville. The car loadings are of the heaviest for interurban electric lines, consisting of 100,000-pound locomotives followed by coal cars with a weight, when loaded, of 11,000 pounds, or passenger cars of 86,000 pounds unloaded, and estimated at 101,000 pounds when fully loaded.

The highway traffic is light when compared with the car service, and the efficiencies were calculated for car loads only, as both kinds of loadings are very unlikely to be on the bridge at the same time. The car tracks are located to one side of the centre line of the bridge, thus bringing a great deal more of the load on one truss than on the other. The truss taking the heavy load only was considered.

The efficiencies of the different members of the truss were determined under two different conditions, one with impact, and the other without impact. At each end of the bridge is a sign "Stop." If all cars stop before going onto the bridge, and then proceed very slowly, the impact will be slight. This rule appears to be effective so far as passenger traffic is concerned, but the rule is not observed very closely with freight traffic. With impact, it was noted that the efficiencies are very low, and fell as low as 56.4 per cent. in the upper chord and 63.6 per cent. in the lower chord. Without impact, the efficiencies were considerably higher, but are not to be considered entirely safe. The steel joists for the highway traffic are efficient. The stringers under the car tracks have an efficiency of 108 per cent. for the main section, but the riveted connection to the floor beam has only 8 rivets where it should have 13. The floor beams have an efficiency of 105 per cent. for the main section, but the rivet spacing, in the flanges, is 3-inch at the ends, where it should be 1.52-in.

The steel work is in fair condition so far as corrosion is concerned, but it needs paint badly. The south abutment has a crack extending from top to bottom just inside the west pedestal. This crack is about 5 inches at the top. The short end of the abutment has settled about two inches. In order to take care of this settlement in the abutment, a plank has been placed between the cast bearing plate and the shoe. The cast bearing plate at the southeast bearing is only about half under the shoe. The floor beam at the south end is loose from the west end post and the end post has moved out about three inches. The lower laterals and connections at this end of the bridge are badly bent. One hanger loop rod in the east truss is broken in the weld. This bridge is not anchored to the masonry at any point.

This bridge is unsafe, in fact, is in a dangerous condition for interurban traffic, and evidently was not built to carry such heavy loads. Almost all the efficiencies are low and the bridge shows signs of failure, apparently due to overloading.

The interurban and street car tracks should be removed from this bridge at once. The south abutment should be renewed or repaired, and the end floor beam should be reriveted to the end post. The entire bridge should be scraped and painted. If these changes and repairs are made this bridge will carry highway traffic for a number of years.

The three structures considered in the foregoing articles are not unusual or exceptional types, but are typical of what may be found in almost any locality in the middle west. The writer calls to mind a number of similar cases. One is that of a bridge across the Des Moines River at Farmington, Iowa, which consists of 5 Pratt truss spans of about 120 feet. The spans are exceptionally light and have every appearance of being very inefficient. Another case is that of a single Pratt truss span at St. Joseph, Illinois. This span needs paint badly, the nailing strips in the floors are rotten and the floor planks are loose. The expansion rollers are buried under several inches of dirt, and are valueless.

The Woolen Mill bridge was built 26 years ago. It was built when Danville was a small town, and at a time when the coal mines and brick yards in that vicinity were undeveloped. At that time it carried only light highway traffic for which it was designed. The traffic has increased in weight and the bridge has not been maintained in good condition, which makes it very unsafe at the present time.

The Gilbert Street bridge is not as old a bridge as the Woolen Mill bridge, but yet it was not designed to carry the loads that it has been required to carry. It was built at a time when there were no interurban electric lines in its locality. However, when the interurban lines were built the company desired to make use of this bridge and was permitted to lay a double track the full length of this structure. The bridge began to fail at several points, and the company was compelled to make some repairs, and finally to build a bridge of its own and remove its tracks from this bridge. The pier at the south end of the second Warren truss span had settled several inches. The shoes that supported the floor beams at the tops of the tower bents had failed, and it was necessary to put in new struts at the tops of these bents. All this unnecessary risk and expense of repair work could have been avoided if this bridge had been properly looked after.

The Interurban bridge is another case similar to that of the Gilbert street bridge. It is carrying loads much greater than it was designed to carry, and at a great risk to the travelling public. The car tracks should never have been allowed on this bridge, and they would not have been if under proper supervision. This bridge can not now be made safe for highway traffic, without a considerable outlay for repairs.

Evidently there should be invested in some commission, possibly the Highway Commission, the power and authority to inspect, and investigate if they deem it necessary, all of the steel highway bridges, especially those that have been built for a number of years. They should also have the power to condemn, or compel the repair, where necessary, of any bridge by county or city authorities. Public safety demands that the public be saved from the dangers of the overloaded or the unrepaired bridges. It is also true that the public would be saved a great amount of money if the highway bridges were properly maintained.

COOLING HOT BEARINGS.

A satisfactory mixture for cooling hot bearings is recommended by T. L. Darling, in Power, and it is said that it seldom fails and that the action is rapid. The recipe follows:

Mix half and half by volume No. 6 Keystone grease and ammonia and feed through the oiler as fast as possible by drops. If No. 6 is not available, common engine oil will do, but it will have to be stirred almost continuously.

A NEW THEORY FOR THE DESIGN OF REINFORCED CONCRETE RESERVOIRS.*

Hiram B. Andrews.

In circular water receptacles the water pressure at the base per square foot equals the product of the weight of water per cubic feet by the depth in feet. The tension in the wall per foot in height equals the product of the water pressure per square foot by the radius. For example, in the Manchester reservoir (50 ft. diam., 72 ft. high) the water pressure per square foot at the base equals 62½ by 72 = 4,500 lbs. per sq. ft. The tension in the wall for the first foot in height equals 62½ by 71½ by 25, equal to 113,300 lbs. It has generally been assumed that this tension should be taken up entirely by steel reinforcement in the shape of horizontal steel rods bent to the radius of the reservoir and sufficiently lapped or mechanically attached to each other to develop the tensile strength when enveloped in concrete. It has been further assumed that a thickness of concrete sufficient to encase the steel reinforcement and to transmit the stress from one tension rod to another should be used. Empirical rules have been used for determining this thickness, relating only to obtaining the necessary bonding strength and a thickness of concrete supposedly enough to prevent seepage of water through the walls. No assumptions, to the writer's knowledge, have heretofore been made with the idea of utilizing the tensile strength of concrete prior to the construction of the reservoir at Rockland. The mixture of concrete that has generally been used in the past is one part of cement, two parts sand and four parts gravel or crushed stone with the addition of hydrated lime or special compounds for densifiers, if I may use that term. As it is almost impossible to so thoroughly mix a 1:2:4 concrete either by hand or machine so as to make it entirely impermeable to water, the walls and floor have been usually coated with a cement mortar or with some other waterproofing compound.

As there is a tendency for the diameter of a reservoir to increase after it is filled with water due to the elasticity of the steel in tension, and as the base of the reservoir is practically rigid, due to its intimate contact with the foundation upon which it rests, it has been deemed necessary to install some reinforcing material extending from the base up into the walls to take care of the bending moment and shear at the base. The writer does not know, nor has he been able to find any exact method of obtaining, the amount of steel required here, but he thinks that in most cases heretofore it has been underestimated.

As the several operations of building up forms, placing steel and concrete preclude making the concrete work continuous, it is advisable to make as short intervals as possible between successive layers of concrete, and where these joints occurred to bond together the successive layers in the best possible manner. These instructions as outlined were followed out in the construction of the reservoirs at Waltham, Manchester and Lisbon Falls, except that the two latter reservoirs were made with a 1:1½:3 mixture of concrete plus 5 per cent. hydrated lime. For the Manchester reservoir the thickness of the wall at the base is 20 ins., and at the top 12 ins. The steel is designed for a unit working stress of 12,000 lbs. per sq. in. when the reservoir is full of water. At the base are installed rods which are embedded in the floor and turned up into the walls. These rods are 1 in. in diameter and are laid 12 ins. on centers and extend into the wall about 4 ft. 6 ins. The floor was finished with 1 in. granolithic, and the walls were plastered with two coats, making about 1 in. thickness of 1:1 cement mortar. But after the filling of the reservoir various features were observed which showed that some improvement might be made in the design of future work.

There developed at several of the horizontal joints—and especially at the three lower joints—between each day's work, some seepage of water, which in three places increased to positive leaks. The seepage, however, at the upper joints gradually stopped, presumably due to the filling of the pores by hydrated lime. We at first saw no reason why any leakage should develop. We had supposed that the concrete was rich enough, that the inside coating of 1:1 plaster, put on in such a manner as to make a double lap over the joints, and that the care taken in grooving and grouting the joints between each day's work, was sufficient to make the reservoir absolutely tight, and when we found that a little leakage did occur after taking all these precautions, we naturally began an investigation to determine the reasons therefore and to obtain for future work some protection against it. Upon examination of the reservoir after it was emptied, we found that there were horizontal cracks at the joints mentioned, about 30 ft. long, and extending through the wall, also that there were vertical cracks in the plastering extending upward for 20 ft. or so, and furthermore, that there were checks in the plastering from which the water oozed back into the reservoir after it was emptied.

From these observations we made the following deductions: that there was not enough vertical steel properly distributed to fully distribute the bending moment and shearing stress between the rigid base and the walls, and that the lack of this probably was the cause of the horizontal cracks. Second, that the ultimate strength of the concrete was probably exceeded when the reservoir was filled with water, thus producing the vertical cracks, and that these vertical cracks allowed the water to permeate into the walls and through them to the lines of least resistance, which would be the horizontal joints. Third, that the addition of a rich plaster coat with a more or less permeable concrete back of it was useless, as the usual crazing and the vertical cracking which would occur due to the tension would also allow the percolation of water through it.

This second deduction is the basis of this paper. From tests which have been made on concrete beams, it has been found that microscopic cracks have developed in the concrete on the tension side when the steel reinforcement was stressed to 4,000 or 5,000 lbs. per sq. in., or perhaps less; that these cracks gradually widened until they were finally visible. It is presumable that these cracks began when the ultimate strength of the concrete in tension was reached, and at a time that the unit stress in the steel was approximately ten times that in the concrete. These microscopic cracks were made visible by the application of water, and water lines following them could be seen. If these cracks developed in beams when the stress in the steel was only 5,000 lbs. or thereabouts, sufficient to admit water, why should they not develop in reservoir walls when the steel was stressed to the same point? And furthermore, if the walls were made so thin that they took little of the tensile stress, it being all thrown in the steel, at 12,000 or 16,000 lbs. per sq. in. or at any intermediate working value between these, why would no vertical cracks show in the walls, and permit water to seep into the walls?

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* Abstract of a paper read before the Boston Society of Civil Engineers.

One of the first requisitions in a concrete reservoir is to make it water-tight. The writer did not see how he could be sure that it would be water-tight if he so designed it, that the cracks in the concrete were predetermined. The only remedy seemed to be to make the walls so thick, and of such a composition, that their tensile strength would never be exceeded.

Having this in mind when we came to the design of the reservoir for Rockland, Mass., we decided to use an especially rich mixture of concrete, a thickness of wall which would insure that the ultimate tensile strength of the concrete would not be reached when the reservoir was filled, to use an increased amount of vertical reinforcement especially between the base and the walls, and to install a steel dam at each horizontal joint between each day's work to prevent any direct seepage of water through the joint, provided it entered it. The hydrated lime was omitted, as we considered the proposed density of the concrete did not require it for unpermeability, and also that where it had been used previously it had caused an unsightly efflorescence on the wall wherever there had been seepage. The plastering was omitted as we considered that any rigid coating upon this mixture of concrete was unnecessary, but instead, we applied three coats of soap and alum solution, commonly known as Sylvester Compound, to fill pinholes due to air bubbles, etc.

The thickness of the wall at the base was determined as follows:

We assumed that a 1:1:2 concrete in tension was good for approximately 400 lbs. per sq. in., that the working stress in the steel, if by any chance the full tension was thrown upon it, would be 16,000 lbs. per sq. in.. and that the ratio of moduli of elasticity between steel and concrete was 10, so that if the concrete was stressed to 300 lbs. per sq. in. the steel would be stressed to 3,000. The tension at the base of a standpipe 46 ft. in diameter and 104 ft. in height when filled with water would be 62½ x 104 x 23 = 149,500 lbs. per ft. in height. At 16,000 lbs. per sq. in. this would require 9.35 sq. ins. of steel per foot in height at the base, which was the section used. We made the thickness of wall 36 ins. at the base, the sectional erea of concrete being (36 x 12) — 9.35 equal to 422.65 sq. ins.

Let x equal unit stress in concrete, and 10 x the unit stress in steel, then 422.65 + 9.35 (10 x) = 149,500 lbs.; solving x equals 290 lbs., which was considerably lower than the ultimate strength of 400 lbs. which we assumed. As we could find no tests of concrete in tension, we decided to have some made of large-sized briquettes at the Watertown Arsenal. We thereupon ordered our superintendent of construction on the Rockland job to make up some briquettes of special design, having a minimum cross section of 4 ins. square. These briquettes were made of the same material and in the same manner as the concrete was made for our regular work, the 1:1:2 concrete being taken from the mixture while the regular work was going on.

We also made twelve 6-in. cubes for testing the compressive strength of the same concretes. The test pieces were made between August 1 and September 8, and the tests were made 60 days thereafter, between October 29 and November 7. The average tensile strength of the 1:2:4 concrete was 113 lbs. per sq. in. of the 1:1½:3, 202 lbs. per sq. in. and of the 1:1:2, 281 lbs. per sq. in., there being no great variation from this average in any one of the tests. The average compressive strength of the cubes were as follows: 1:2:4, 2,280 lbs. per sq. in.; 1:1½:3, 3,657; 1:1:2, 4,845. Upon examination of the fractured tension pieces it was evident that the increasing ratio of tensile strength when the richness of mixture was increased was due to the larger amount of mortar in cross section in the 1:1:2 concrete. As this concrete showed very few stones at the fractured section, while the 1:2:4 concrete showed a large number, it was plain that the adhesiveness of the mortar to the stones was not equal to the cohesiveness of the mortar.

In regard to the tensile specimens we quote from the paper made by the engineer in charge of the test:

No change in the specimens was observed until rupture occurred. This took place quietly on a plane approximately perpendicular to the axis of the specimens and followed the surface of the gravel in nearly all cases.

From the results obtained we checked our previous assumptions. The average tensile strength of 1:1:2 specimens was 281 lbs. per sq. in. We assumed that in large-sized sections this possibly would be increased 25 per cent., and that if these sections were reinforced by steel, that a further increase in strength of at least 10 per cent. might be expected. Our first assumption was made by reason of the fact that large-sized specimens in compression usually showed about this percentage of increase over small ones, and our later assumption was based on the following theory:

If an unreinforced section is subjected to tension, when its ultimate strength is approached a crack will develop at the line of least resistance, and the fracture will always occur at this point.

If the section is reinforced, the ultimate fracture will not necessarily be at the point where the first crack developed, as the strain would be distributed nearly equally over the entire section by the reinforcing steel, and the fracture would take place at a plane in which was located the resultant of a number of weaker areas of concrete.

We however, assumed our original figure of 281 lbs. increased by first 25 per cent. and then 10 per cent., making a tensile strength of 386 lbs. per sq. in., which was probably nearly its actual value in the wall. It has been previously shown that the maximum tensile stress in the concrete would be 290 lbs. per sq. in., and the corresponding tensile strength in the steel 2,900 lbs., ao that there would be a margin of about 30 per cent. left for a factor of safety in the concrete without approaching the limitation of the steel. If, however, our assumptions had been wrong and no tensile stress whatever was taken by the concrete, which would be unreasonable, then we still had steel enough to take all the stress at 16,000 lbs. per sq. in. or its ordinary working value.

Applying this same line of reasoning to the Manchester reservoir, it is found that the tension at the base is divided proportionately between the steel and the concrete would be approximately 3,500 and 350 lbs. per sq. in., respectively. We have assumed that the ultimate tensile strength of the concrete plus the tensile be 202 + 25 per cent. + 10 per cent., equal to 278 lbs. per sq. in., so that it is evident that the tensile strength of the concrete of the reservoir wall is exceeded, and that the vertical cracks developed might be expected.

We further find that at a point 25 ft. up, the tensile strength of the concrete plus the tensile stress in the steel just equals the stress due to water pressure at this point, and it was at about this place that the vertical cracks in the plastering disappeared.

There was never any trouble with the Lisbon Falls reservoir. A few damp spots appeared at first on the surface, but these soon disappeared. This reservoir is 62 ft. high and 50 ft. diameter, and the walls are 20 ins. thick at the base; 1:1½:3 concrete was used and a 12,000-lb. per sq. in. working stress on the steel was assumed. The assumptions previously made would show a stress in the concrete of 235 lbs. per sq. in. and 2,350 lbs. per sq. in. in the steel. This stress in the concrete being less than its ultimate strength, we did not expect to find any vertical cracks with a resultant leakage.

The reservoir at Bridgewater is 78 ft. in height and 38 ft. diameter, and the walls at the base are 20 in. thick. This reservoir has never shown a particle of leakage. The stresses developed in concrete and steel are about 240 lbs. lbs. and 2,400 lbs. per sq. in. respectively. As an example of comparatively thin walls with a resultant leakage we will cite the reservoir at Attleboro, Mass. This reservoir is 100 ft. in height, 50 ft. in diameter, and the walls at the base are only 18 ins. thick; 1:2:4 concrete was used in its construction; 13,500 lbs. per sq. in. was the working stress adopted for the steel. From our previous examples, the stress in concrete and steel would be about 500 and 5,000 lbs. per sq. in., but the stress in the concrete so far exceeded its ultimate strength that numerous vertical tension cracks must have developed to a considerable height. In this case presumably the relative values of concrete and steel would not hold, but a stress of steel must have been developed to somewhere near the working value assumed. Several attempts have been made to make this reservoir water-tight, but each refilling has always resulted in leaks. The cracks in the concrete have probably been reproduced in any surface coating which has been applied.

A reservoir 70 ft. diameter and 22 ft. in height containing 20 ft. of water was constructed in Bondsville in 1908. The walls were 12 ins. thick, and composed of 1:2½:4½ concrete with 5 per cent. hydrated lime added to the cement. The unit stress in the steel is 14,000 lbs. and in the concrete at the base 260 lbs. per sq. in. The ultimate strength of a 1:2½:4½ concrete in tension may be assumed to be 100 + 25 per cent. + 10 per cent. = 137 lbs. per sq. in. Therefore the actual strength of the concrete was considerably exceeded. The owners expected an absolutely tight structure. When it was filled, considerable leakage developed at the joints, although there were no actual streams or jets of water coming through. The writer is informed that upon examination many vertical cracks were found in the concrete walls in the interior.

It is hard to say just what factor of safety against bursting there is in a concrete reservoir. We are, however, working on the side of safety in making the walls thick instead of thin. There is on record the case of the complete failure of a concrete reservoir in New South Wales described in Engineering News, of June 16, 1910. This reservoir is 40 ft. high and 40 ft. interior diameter, capacity 314,000 gals. The walls are 10½ ins. thick at the bottom and 4½ ins. thick at the top. It was built of a 1:2:2 concrete. The reinforcing rods are round rods with a working stress of 16,000 lbs. per sq. in. These rods are laid in one vertical plane.

NEW INCORPORATIONS.

A new firm known as the P. J. Mitchell Company, Limited, has been recently incorporated. Mr. Mitchell has secured sole agencies from the following firms for sale, in the Dominion, of their various manufactures, the benefit of which will be transferred to this company:—

Greenwood & Batley, of Leeds.—Small turbo generators, high pressure, mixed pressure and low pressure types and other plant.

Fullerton, Hodgart & Barclay, Ltd., Paisley.—Steam engines of all types, winding engines, reciprocating air compressors, dock pumping machinery and evaporators.

Lassen & Hjort, London.—Patent water purifying and softening apparatus and other specialties.

Aster Engineering Company, Limited, Wembley, Middlesex.—Oil and petrol engines, small gas producers and water meters.

Higginbottom & Mannock, Ltd., West Gorton, Manchester.—Electric wharf and dock cranes, jib cranes, haulages, electric winches, electric passenger and goods elevators and all types of cranes of their manufacture except large cantilever cranes for shipbuilders and large harbor floating dock cranes.

Boulton & Paul, Ltd., Norwich.—"Norvic" Petrol Gas Installations for lighting, cooking and heating.

The British Vacuum Cleaner Company, Ltd., London.—Vacuum cleaning apparatus.

Thomas C. Fawcett, Ltd., Leeds.—Brick making, cement, briquetting, and crushing machinery.

L. Sterne & Company, Ltd., Glasgow.—Refrigerating and ice-making machinery.

Mr. Mitchell is in negotiation on behalf of the company for further agencies with firms whose products he considers are likely to meet with a ready sale in Canada.

Nelson, B.C.—Elford Boat Company, $50,000.

Wilmer, B.C.—Windermere Orchards, $250,000.

Nelson, B.C.—Nelson Club Cigar Company, $50,000.

Phoenix, B.C.—Phoenix Investment Company, $250,000.

Kingston, Ont.—Church Life, $5,000. Mrs. V. K. Birkett, J. H. Birkett, L. H. Birkett.

St. John, N.B.—Natural Products, $4,000. C. D. Jones, F. P. Vaughan, W. E. Raymond.

Brantford, Ont.—Mohawk Land Company, $100,000. H. Cockshutt, L. Harris, J. A. Sanderson.

Hartland, N.B.—Hartland Woodworking Company, $15,000. J. T. G. Carr, D. H. Nixon, S. S. Miller.

Port Stanley, Ont.—Port Stanley Telephone Company, $1,000. N. Burton, E. Earnshaw, A. Burton.

Ottawa, Ont.—Mica Company of Canada, $300,000. H. S. Ross, R. Taschereau, T. Rinfret, Montreal.

Winnipeg, Man.—Griffiths Electric Contractors, $500,000. N. Griffiths, J. K. Bock, E. P. Powles, London, Eng.

Navan P.O., Ont.—Russell Rural Telephone Company, $9,000. G. J. Bonsfield, R. Clarke, W. H. Cox.

Walkerville, Ont.—Walkerville Hardware Company, $60,000. A. D. Green, J. R. Coate, J. W. Coatsworth.

Brockville, Ont.—Coleman Baking Powder Company, $50,000. H. A. Stewart, J. Culbert, A. M. Patterson.

Dryden, Ont.—Weiner, Presner & Company, $20,000. J. Weiner, K. Weiner, Dryden; P. Presner, Winnipeg.

Summerland, B.C.—Angove & Stinson Company, $25,000. Okanagan Commercial Orchards Company, $100,000.

Providence Bay, Ont. — Manitoulin Island Rural Telephone Company, $2,000. W. I. Wagg, F. Wagg, A. Caddel.

Victoria, B.C.—Coronet Coal Mineral and Oil Lands, $250,000. Omineca Water and Power Company, $50,000. West Pacific Canning Company, $50,000. British Realty, Ltd., $10,000.

Hamilton, Ont.—Canadian Mathews Gravity Carrier Company, $100,000. J. S. Lovell, S. G. Crowell, W. Bain, Toronto. Consumers Lumber Company, $75,000. C. H. Long, F. Burton, R. Stewart.

Toronto.—Rockwood & Company, $300,000. G. Grant, A. Dods, M. MacDonald. Sovereign Hall Company, $25,000. W. H. Skitch, J. M. McGowan, G. McKenzie. Dominion City Estates, $350,000. G. Fuller, Manchester, Eng.; J. J. Hoidge, A. E. Adams, Toronto. Sovereign Construction Company, $50,000. J. I. Grover, Misses L. O. Richardson, E. K. Avery. Leak & Company, $40,000. W. Leak, H.

A. Leak, Miss M. H. Leak. Standard Canadian Investments, $100,000. O. H. King, G. M. Willoughby, A. J. Wise. Boase, $60,000. J. B. Boase, C. E. Boase, Miss N. M. Jones. Georgian Land and Building Company, $40,000. J. S. Lovell, W. Bain, S. M. Mehr. Alonzo W. Spooner, $40,000. Miss M. A. Spooner, Port Hope; G. L. Smith, R. H. Greer, Toronto. Redstone Mining Company, $1,000,000. R. H. Parmenter, A. J. Thomson, W. S. Morlock. Plenaurum Mines, $2,500,000. H. E. Rose, A. G. Ross, H. Armstrong. Porcupine Kendall Gold Mines, $2,000,000. F. Fegan, C. M. Garvey S. F. Adalia. Noon Universal Coupler Company, $100,000. M. G. Hunt, H. J. Macdonald, C. S. Warner. G. P. Macagy Realty Company, $100,000. W. H. Pearson, T. W. Anderson, R. L. Kleiser. Canadian Hanson & Van Winkle Company, $100,000. R. W. Hart, G. M. Clark, C. H. C. Leggott.

Montreal.—Dominion Marble Company, $750,000. C. J. McCuaig, R. T. Hopper, R. C. Smith. Highland Estates, $150,000. J. C. Barlow, A. Labreche, G. A. Terrault. Corporate Securities, $50,000. W. F. Chipman, F. G. Bush, G. R. Drennan. Canadian Street Car Advertising Company, $250,000. W. J. Carrique, D. M. Coughlin, W. F. Thompson. Elie Jobin, $150,000. M. Jobin, P. F. Jobin, J. Metivier. G. W. Faust, $50,000. G. W. Faust, A. Bougie, C. Vincent. Ford Iron Company, $50,000. W. F. Chipman, F. G. Bush, G. R. Drennan. Thomas Davidson Manufacturing Company, $5,000,000. A. W. P. Buchanan, J. H. Dillon, E. C. Young. Canadian Sand & Gravel Company, $49,000. F. X. Dupuis, P. L. Turgeon, L. Robillard, Montreal. Luminous Locator Company, $150,000. A. R. McMaster, W. J. S. McMaster, Westmount; G. A. Campbell, Montreal. Dominion Building Corporation, $100,000. W. J. Bellingham, F. G. Robinson, L. Gosselin. Keyless Lock Company, $50,000. E. de Charette, J. de Charette, A. de Charette, of Charette's Mills. Italian Vermicilli & Macaroni Manufacturing Company, $100,000. E. Tammaro, V. Morin, J. Lemaistre. La Compagnie des Autobus de Montreal, $150,000. J. B. Baillargeon, R. Gaudry, G. Lefort. Longueuil Gardens Company, $20,000. M. A. Phelan, W. Bovey, Westmount; M. S. Nagle, Montreal. Adamson Muller Company, $20,000. J. T. Adamson, W. H. Martin, G. A. Campbell.

ENGINEERING SOCIETIES.

CANADIAN SOCIETY OF CIVIL ENGINEERS.—413 Dorchester Street West, Montreal. President, C. H. Rust; Secretary, Professor C. H. McLeod.

QUEBEC BRANCH—
Chairman, P. E. Parent; Secretary, S. S. Oliver. Meetings held twice a month at Room 40, City Hall.

TORONTO BRANCH—
96 King Street West, Toronto. Chairman, H. E. T. Haultain; Secretary, A. C. D. Blanchard,, City Hall, Toronto. Meets last Thursday of the month at Engineers' Club.

MANITOBA BRANCH—
Secretary, E. Brydone Jack. Meets first and third Fridays of each month, October to April, in University of Manitoba, Winnipeg.

VANCOUVER BRANCH—
Chairman, Geo. H. Webster; Secretary, H. K. Dutcher, 40-41 Flack Block, Vancouver. Meets in Engineering Department, University

OTTAWA BRANCH—
Chairman, A. A. Dion, Ottawa; Secretary, H. Victor Brayley, N. T. Ry., Cory Bldg.

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THE UNION OF NEW BRUNSWICK MUNICIPALITIES.—President, Mayor Reilly, Moncton; Hon. Secretary-Treasurer, J. W. McCready, City Clerk, Fredericton.

UNION OF NOVA SCOTIA MUNICIPALITIES.—President, Mr. A. E. McMahon, Warden, King's Co., Kentville, N.S.; Secretary, A. Roberts, Bridgewater, N.S.

UNION OF SASKATCHEWAN MUNICIPALITIES.—President, Mayor Hopkins, Saskatoon; Secretary, Mr. J. Kelso Hunter, City Clerk, Regina, Sask.

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ALBERTA ASSOCIATION OF ARCHITECTS.—President, G. M. Lang; Secretary, L. M. Gotch, Calgary, Alta.

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ASTRONOMICAL SOCIETY OF SASKATCHEWAN.—President, N. McMurchy; Secretary, Mr. McClung, Regina.

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BUILDERS, CANADIAN NATIONAL ASSOCIATION.—President, E. T. Nesbitt; Secretary-Treasurer, J. H. Lauer, Montreal, Que.

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CANADIAN STREET RAILWAY ASSOCIATION.—President, D. McDonald, Manager, Montreal Street Railway; Secretary, Acton Burrows, 157 Bay Street, Toronto.

CANADIAN SOCIETY OF FOREST ENGINEERS.—President, Dr. Fernow, Toronto; Secretary, F. W. H. Jacombe, Ottawa.

CENTRAL RAILWAY AND ENGINEERING CLUB.—Toronto, President, G. Baldwin; Secretary, C. L. Worth, 409 Union Station. Meets third Tuesday each month except June, July, August.

DOMINION LAND SURVEYORS.—President, Thos. Fawcett, Niagara Falls; Secretary-Treasurer, A. W. Ashton, Ottawa.

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ENGINEER'S CLUB OF TORONTO.—96 King Street West. President, Killaly Gamble; Secretary, R. B. Wolsey. Meeting every Thursday evening during the fall and winter months.

INSTITUTION OF ELECTRICAL ENGINEERS.—President, Dr. G. Kapp; Secretary, P. F. Rowell, Victoria Embankment, London, W.C.; Hon. Secretary-Treasurer for Canada, Lawford Grant, Power Building, Montreal, Que.

INSTITUTION OF MINING AND METALLURGY.—President, Edgar Taylor; Secretary, C. McDermid, London, England. Canadian Members of Council:—Prof. F. D. Adams, J. B. Porter, H. E. T. Haultain, and W. H Miller, and Messrs. W H. Trewartha-James and J. B. Tyrrell.

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ONTARIO PROVINCIAL GOOD ROADS ASSOCIATION.—President, W. H. Pugsley, Richmond Hill, Ont.; Secretary, J. E. Farewell, Whitby,

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WESTERN CANADA RAILWAY CLUB.—President, Grant Hall; Secretary, W. H. Rosevear, 199 Chestnut Street, Winnipeg, Man. Second Monday, except June, July and August, at Winnipeg.

CONSTRUCTION NEWS SECTION

Readers will conter a great favor by sending in news items from time to time. We are particularly eager to get notes regarding engineering work in hand and projected, contracts awarded, changes in staffs, etc. Printed forms for the purpose will be furnished upon application.

TENDERS PENDING.

In Addition to Those in this Issue.

Further information may be had from the issues of The Canadian Engineer referred to.

Place of Work.	Tenders Close.	Issue of.	Page
Brandon, Man., pumping machinery	Aug. 7.	July 20.	64
Gleichen, Alta., waterworks	Aug. 11.	July 27.	72
Guelph, Ont., bridge and viaduct	Aug. 5.	July 27.	72
London, Ont., waterworks supplies	Aug. 12.	July 27.	64
Moose Jaw, Sask., sewer and water extensions	Aug. 14.	July 27.	68
Ottawa, Ont., harbor works, Courtney Bay	Aug. 10.	June 22.	68
Ottawa, Ont., stations	Aug. 3.	July 13.	68
Ottawa, Ont., lockgates and valve gates	Aug. 4.	July 20.	91
Ottawa, Ont., public building, Tilbury, Ont.	Aug. 8.	July 20.	91
Ottawa, Ont., public building, Dundas	Aug. 8.	July 27.	121
Ottawa, Ont., pier and sheds	Aug. 10.	July 27.	72
Ottawa, Ont., bridge	Aug. 8.	July 27.	121
Ottawa, Ont., schoolhouse	Aug. 7.	July 27.	121
Penticton, B.C., generators	Aug. 10.	July 6.	68
Ridgeway, Ont., drain	Aug. 2.	July 27.	121
Saskatoon, Sask., school building	Aug. 5.	July 27.	122
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Toronto, Ont., special castings and valves	Aug. 8.	July 27.	121
Toronto, Ont., government house	Aug. 22.	July 27.	121
Toronto, Ont., special castings and valves	Aug. 8.	July 27.	68
Victoria, B.C., work on Parliament buildings	Aug. 15.	July 13.	54
Victoria, B.C., schoolhouse	Aug. 4.	July 27.	122
Victoria, B.C., schoolhouse	Aug. 10.	July 27.	122
Virden, Man., steam heating plant	Aug. 18.	July 27.	122
Wilkie, Sask., electrical machinery, etc.	Aug. 21.	July 27.	64

TENDERS.

Ottawa, Ont.—Tenders will be received until August 21st, 1911, for the construction of an extension to Tunnel Bay Dock, at Brockville, County of Leeds, Ont. Plans, specifications and form of contract can be seen and forms of tender obtained at the office of J. G. Sing, Chief Engineer, Confederation Life Bldg., Toronto, on application to the Postmaster at Brockville, Ont., and at the office of R. C. Desrochers, Secretary, Dept. of Public Works, Ottawa.

Ottawa, Ont.—Tenders will be received until August 15th, 1911, for the construction of a Post Office Building at St. Lambert, P.Q. Plans, specification and form of contract can be seen and forms of tender obtained on application at the office of Mr. H. N. Lymburner, Supt. of Public Buildings, Post Office, Montreal; at the Post Office, St. Lambert, and at the office of R. C. Desrochers, Secretary, Dept. of Public Works, Ottawa.

Ottawa, Ont.—Tenders will be received until August 21st, 1911, for the erection of a public building at Uxbridge, Ont. Plans, specifications and forms of contract can be seen and forms of tender obtained on application to Mr. Thos. A. Hastings, Clerk of Works, Postal Station F, Yonge Street, Toronto; at the Post Office of Uxbridge, and at the office of R. C. Desrochers, Secretary, Dept. of Public Works, Ottawa.

Ottawa, Ont.—Tenders will be received until August 23rd, 1911, for the construction of a public wharf at Papineauville, Labelle County, Que. Plans, specification and form of contract can be seen and forms of tender obtained at the offices of J. L. Michaud, Esq., Dist. Engineer, Merchants Bank Bldg., St. James St., Montreal, Que; on application to the Postmaster at Papineauville, Que., and at the office of R. C. Desrochers, Secretary, Dept. of Public Works, Ottawa.

Ottawa, Ont.—Tenders will be received until August 9th, 1911, for alterations and addition to Customs Fittings, Calgary, Alta. Plans and specifications to be seen on application to Mr. J. J. O'Gara, Resident Architect, Calgary, Alta., and at the office of R. C. Desrochers, Sec., Dept. of Public Works, Ottawa.

Harriston, Ont.—Tenders will be received until August 7th, 1911, for the construction of a municipal drain in the township of Minto. Estimated amount of excavation is 21,600 cubic yards. Profile and specifications can be seen at the office of W. D. McLellan, Clerk of Minto, Harriston, Ont.

Orangeville, Ont.—Tenders will be received until August 7th, 1911, for the construction of a 40-foot span over the Humber River, on the Seventh Line, Albion Township, about one mile from the village of Palgrave. Specifications may be obtained from C. R. Wheelock, County Engineer, Orangeville.

Walkerton, Ont.—Sealed tenders marked "Tenders for Bridge," will be received until August 5th, 1911, for the construction of two spans of 125 feet each and one span of 90 feet, over the Saugeen River, 10th Concession, Brant. Also, tenders will be received up to the above date for the concrete work for two abutments and two piers for the above bridge. Specifications may be had from James Warren, Engineer Walkerton, Ont.

North Toronto, Ont.—Tenders will be received up till September 30th, 1911, for providing and laying about 2,000 lin. ft. of 24-inch vitrified sewer pipe with all necessary manholes and junctions east of Bayview avenue. J. A. Brown, Mayor of North Toronto; T. Aird Murray, Consulting Engineer. (Adv. in the Can. Eng.)

Toronto, Ont.—Tenders will be received until August 8th, 1911, for laying and jointing thirty-six-inch reinforced concerete pipe for Toronto Junction Main Sewer. Specifications may be seen and forms of tender obtained at the office of the City Engineer, Toronto. G. R. Geary, Mayor, Chairman of the Board of Control, City Hall, Toronto. (Adv. in the Can. Eng.)

Toronto, Ont.—Tenders will be received until August 15th, 1911, for the supply and erection of electric lighting fixtures. G. R. Geary, Mayor, Chairman Board of Control, City Hall, Toronto. (Adv. in the Can. Eng.)

Toronto, Ont.—Tenders will be received until August 8th, 1911, for the manufacture and supply of 36-in., and 24-in. cast iron pipe. Plans and specifications may be seen and forms of tender obtained from the Water Works Department, at the office of the City Engineer, Toronto. G. R. Geary, Mayor, Chairman Board of Control, City Hall, Toronto. (Adv. in the Can. Eng.)

Toronto, Ont.—Tenders will be received until August 12th, 1911, for supplies for departments in connection with the Hudson's Bay Company's departmental store, Calgary, Alta. Burke, Horwood & White, Architects, 28 Toronto St., Toronto. (Adv. in the Can. Eng.)

Windsor, Ont.—Tenders will be received until August 22nd, 1911, for supplying all the labor, tools and machinery for constructing and completing a concrete outlet for Parent Avenue sewer under the Grand Trunk railway tracks. Stephen Lusted, City Clerk, M. E. Brian, City Engineer, Windsor. (Adv. in the Can. Eng.)

Riel P.O., Man.—Sealed tenders for a bituminous pavement will be received at the Municipal Office, St. Vital, until the 14th of August, 1911, for the following road:—Pembina Highway, 20 ft. in width, with two curbs, approximate length, 3½ miles. Specifications, forms of tender and information may be obtained at the office of the Municipal Engineer, Mr. D. R. Baribeault, 607 Builders' Exchange, Winnipeg. E. A. Poulin, Sec.-Treas., Reil P.O., Man.

Riel P.O., Man.—Sealed tenders for a bituminous pavement will be received at the Municipal Office, St. Vital, until August 14th, 1911, for the following road:—St. Mary's Road, eighteen feet in width, with one curb, approximate length, one mile. Specifications and forms of tender may be obtained at the office of the Municipal Engineer, Mr. G. Mullon, 372 St. Jean Baptiste St., St. Boniface, Man. E. A. Poulain, Sec.-Treas., Riel P.O., Man.

Whitehead, Man.—Tenders will be received until August 25th, 1911, for building of (1) a double or single span steel bridge and (2) cement abutments, across the Litale Saskatchewan river. M. Eaton, Sec.-Treas., Box 107, Alexander, Man. (Adv. in the Can. Eng.)

Winnipeg, Man.—Tenders will be received until August 8th, 1911, for the supply of steel plate forced and induced draft fans, together with engines for operation of same, required in the construction of an incinerator plant for the city of Winnipeg. Specifications and form of tender may be obtained at the office of the City Engineer, 223 James Avenue. M. Peterson, Secretary, Board of Control Office, Winnipeg.

Battleford, Sask.—Tenders will be received until August 14th, 1911, for supplying all materials and erecting a Town Hall. Separate tenders will be received for the heating plant. William Kitson, Town Engineer, H. C. Adams, Sec.-Treas., Battleford. (Adv. in the Can. Eng.)

Regina, Sask.—Tenders will be received until August 5th, 1911, for the erection of a hospital for the insane at Battleford, Sask. Plans, specifications, form of tender and all information may be obtained on application to Messrs. Storey & Van Egmond, Architects, Regina, and to F. J. Robinson, Dept. of Public Works, Regina.

Victoria, B.C.—Tenders will be received until August 31st, 1911, for the manufacture and delivering f.o.b. cars at Trail, B.C., the steel superstructure of a bridge over the Columbia River at Trail. Drawings, specifications, contract and forms of tender can be seen at the offices of the government agents at Rossland, Nelson, New Westminster; E. McBridge, Esq., Road Supt., 39 Fairfield Bldg., Granville St., Vancouver.; and at the office of J. E. Griffith, Public Works Engineer, Dept. of Public Works, Victoria.

Victoria, B.C.—Tenders will be received until August 31st, 1911, for the complete superstructure of a bridge over the Columbia River at Trail, B.C. Drawings, specifications, contract and forms of tender can be seen at the offices of the government agents at Rossland, Nelson, New Westminster; E. McBride, Esq., Road Supt. 39 Fairfield Bldg., Granville St., Vancouver; and at the office of J. E. Griffith, Public Works Engineer, Dept. of Public Works, Victoria.

CONTRACTS AWARDED.

Halifax, N.S.—The contract for the erection of the new Tower Road school was awarded to F. A. Ronnan & Co., the lowest tenderer, whose price was in the vicinity of $54,600.

Montreal, Que.—Tenders will be asked for in the near future for the construction of a bridge to be built over the Lachine Canal, between Lachine and Cote St. Paul.

Montreal, Que.—Messrs. John S. Metcalf Co., Limited, Engineers and Contractors, 54 St. Francois Xavier St., have been awarded a contract by the Grand Trunk Railway System for concrete foundations for the train shed of their new passenger station at Ottawa, Ont., together with extensive concrete platform work at the same station, approximate expenditures under contract being $50,000.

Montreal, Que.—The Dominion Coal Company has made a contract with the Furness Withy Company for the conveyance over a period of seven years of coal from Sydney. This has necessitated the building of two specially designed steamers, each of about 7,600 tons carrying capacity, and orders for the construction of these vessels have been placed.

Ottawa, Ont.—The contract for the addition to the New National Transcontinental Railway car shops at Transcona, will be awarded to Haney, Quinlan & Robertson, who are the lowest tenderers and the contractors for the first shop built. The contract price is $2,500,000, and the addition will be built to the north and west of the present structures and is to be finished within one year.

Ottawa, Ont.—A contract has been signed between the government and the Canadian Vickers, Ltd., of Montreal, for the construction of a drydock at Montreal, and the payment of a subsidy by the government on December 31st, 1913. It is to be of the first-class, and the government undertakes to pay 3½ per cent. for thirty-five years on an investment up to $3,000,000. The dock is to be a floating one, and will be built by Vickers' Sons & Maxim, of England, for the Canadian branch of the firm, of which F. O. Lewis is the head.

Brockville, Ont.—The contract for erecting the new factory for the Canada Carriage Company, opposite their premises, in which will be manufactured the Atlas Motors and Brockville Automobiles, has been awarded to A. F. Byers and J. P. Anglin, two well-known Montreal contractors, who at present are erecting a large building for the Parmenter & Bulloch Company in Gananoque. Work on the new building will be started immediately, the agreement calling for its completion by Sept. 1st. It will be of two storeys brick. Messrs. Byers & Anglin were the contractors of the new McGill building and A. E. Rea store in Montreal. They are graduates of McGill and civil engineers.

Dresden, Ont.—The different contracts in connection with the waterworks system here have been awarded as follows:—Pumps—Canadian Fairbanks Co., Toronto, $1,282.50; hydrants and valves, Kerr Engine Co., Walkerville, hydrants, $1,102.50; valves, $150. Laying pipe—Cryderman & Farrell, Thamesville, Ont., laying 8-inch pipe, 28c. per lineal foot; 6-inch pipe, 22c.; 4-inch pipe, 16c.; setting hydrants, $3.00 each. Tenders for pipe, special castings, and boiler have not yet been awarded.

Toronto, Ont.—The successful bidders for the laying of 3,500 feet of steel riveted pipe in connection with the Water Works Intake Supply for the City of Toronto are Messrs. Roger, Miller & Sons, No. 50 Front Street East, Toronto.

Brantford, Ont.—The Warren Bituminous Paving Company have received an important contract in Chatham. They are resurfacing the creosoted block pavement on William Street with bitulithic.

London, Ont.—W. S. Davidson was awarded the contract for the erection of the proposed new Masonic Temple. Mr. Davidson's tender of $43,000 was considerably lower than that of any of the several other contractors competing. The contract includes all excavating, brick work, stone work, and interior construction. The plans call for a building constructed along modern lines of brick, stone and reinforced concrete.

Espanola, Ont.—A contract has been awarded for the construction of the Algoma Central & Hudson Bay Railway from Hobon, on the Canadian Pacific Railway, to a point on the National Transcontinental Railway, a distance of approximately 101 miles, to Superior Construction Co., Limited. Sub-contractors desiring to secure sections of this work should communicate with the above company at Espanola, Ontario.

Port Arthur, Ont.—Messrs. Seaman and Penniman, of Fort William, have been awarded the contract for the completion of the Current River Service Dam. Approximate cost, $30,000.

Fort William, Ont.—Mr. P. T. Walsh has secured the contract for grading the line for 59 miles or so, as far east as Nepigon, and for track laying and ballasting for 275 miles east of Port Arthur. For some distance east of Nepigon the contract for grading has been awarded to the Nepigon Construction Company.

Winnipeg, Man.—The contract for the new addition at Calgary to the John Deere Plow Company's warehouse, was let to MacKissock and Thomas, Ltd., of Winnipeg and Calgary. The amount of the contract is in the neighborhood of $40,000.