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NOTABLE C.P.R. TUNNELS IN BRITISH COLUMBIA

SPIRAL TUNNELS IN THE KICKING HORSE VALLEY—ROGER'S PASS TUNNEL THROUGH THE SELKIRK RANGE—FIRST OF THE SERIES OF ARTICLES DESCRIPTIVE OF DISTINCTIVE ENGINEERING FEATURES OF THE CANADIAN PACIFIC RAILWAY.

On October 21st, 1880, the Canadian Pacific Railway Company signed a contract with the Government of the Dominion of Canada to build a railway across the prairies and through the Rocky Mountains to the Pacific coast. The contract called for completion in ten years' time. This was deemed by many an out-and-out impossibility, owing to the topography of certain sections of the country and the inaccessible nature of the right-of-way for the supply of construction materials. By many, also, the project was pronounced a useless enterprise, to go down in history as one of the greatest blunders of the new Dominion. The country through which much of the railway would pass was believed by many to be a land "where nothing—not even a blade of corn—will ripen."

To the surmise regarding the engineering impossibility of the project within the time limit, it is a remarkable and equally creditable fact in the history of Canada that trains passed from tide-water to tide-water in November, 1885, and that during the year fixed for the completion of the contract, the line earned $20,000,000 for the builders. This latter accomplishment answers in a measure the traditional rumors of foolhardiness and blunder, as have likewise the annually increasing earnings of the company. During the past five years the gross earnings have amounted in round numbers to $10,500 per mile. The mileage of the line, as it stands at the present day, including branch services, amounts to 12,917 miles.

Fig. 1.—The Kicking Horse Valley Which the C.P.R. Follows Past Mount Stephen.

The speedy construction of the line in the early eighties necessitated a considerable amount of temporary work. The judgment of this has been fully warranted, first in the matter of early operation and later by a realization of a large saving in first cost and interest and a correspondingly large sum in ultimate cost.

It was to have been expected, therefore, that increasing trade, with its resultant changes to rolling stock and right-of-way, would see in the past thirty years many millions spent in grade reductions, in the erection of permanent structures and in the development of better terminal facilities. Those who have followed the railway development of Canada are fully aware that the Canadian Pacific Railway has outrun the railroads of older and more settled countries in this respect. It is with a view to calling attention in a cumulative sort of way to a few of the outstanding features of this track development that the present series of descriptive articles has been prepared. It is doubtful if there is in America a better illustration of what may be done in the way of grade reduction in mountainous regions than the improvement of the C.P.R. line in British Columbia. It has involved the construction, some six years ago, of one of the most interesting systems of tunnels in existence, and also the construction, now under way, of the longest tunnel on the continent. We refer in the former instance to the spiral tunnels in the valley of the Kicking Horse River, and in the latter to the Roger's Pass tunnel that is being driven through Mount Macdonald in the Selkirk Range.

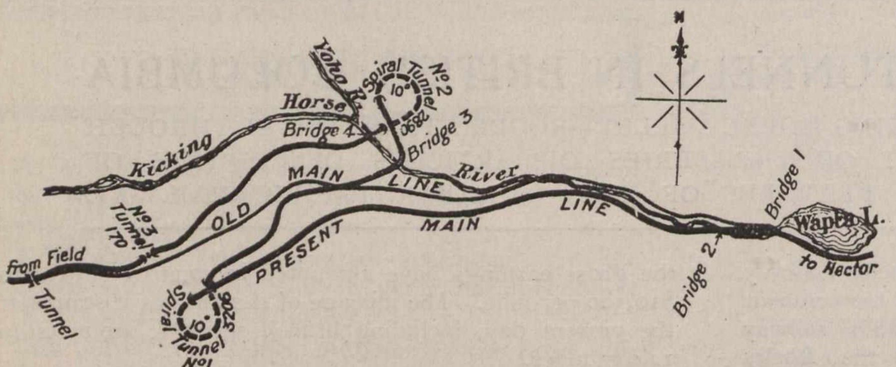

Fig. 2.—Grade Reduction Work on the Canadian Pacific Railway Between Hector and Field, B.C.

Spiral Tunnels Between Hector and Field, B.C.

Prior to 1908 these two stations were separated by such extreme grades that four 154-ton consolidation (2-8-0) locomotives were required to haul a trainload of 710 tons of freight over this section of the main line. For about three miles a grade of 4.5 per cent. prevailed, decreasing to 4 and 3.5 per cent. for the remainder of the distance. These grades involved the use of spring switches at different points along the line for the purpose of safety. Unless the engine-driver of a descending train signalled to the switchman that his train was under control, the normal setting of one of these switches would divert the train to a catch siding.

Increase in the density and extent of traffic made grade reduction practically a necessity. Reference to Fig. 2 will enable the reader to clearly understand the manner in which this was accomplished. The main line now traverses the valley of the Kicking Horse River between these two stations with an increased length of 8.2 miles and a maximum grade of 2.2 per cent. (compensated).

This development of length was rendered a difficult problem owing to the steep mountain sides on either bank of the river. The only solution lay in tunnelling a loop on each side and in the construction of bridges, as illustrated in the sketch. The driving of these spiral tunnels has been regarded by many engineers as one of the most interesting engineering features of the whole Canadian Pacific Railway improvement. Tunnel No. 1 is 3,206 feet in length, turning an angle under Mount Stephen of about 234 degrees on a 573-foot radius with a grade, as reduced by compensation, of 1.6 per cent., producing a difference of level at the portals of 48 feet. Tunnel No. 2 has a similar radius of curvature through an angle of 232 degrees. It is 2,890 feet long and the grade produces a difference in elevation of about 45 feet at the two portals. Thus the road now traverses the valley by three lines at different elevations. It crosses and recrosses the river by four bridges. The improvement further necessitated the

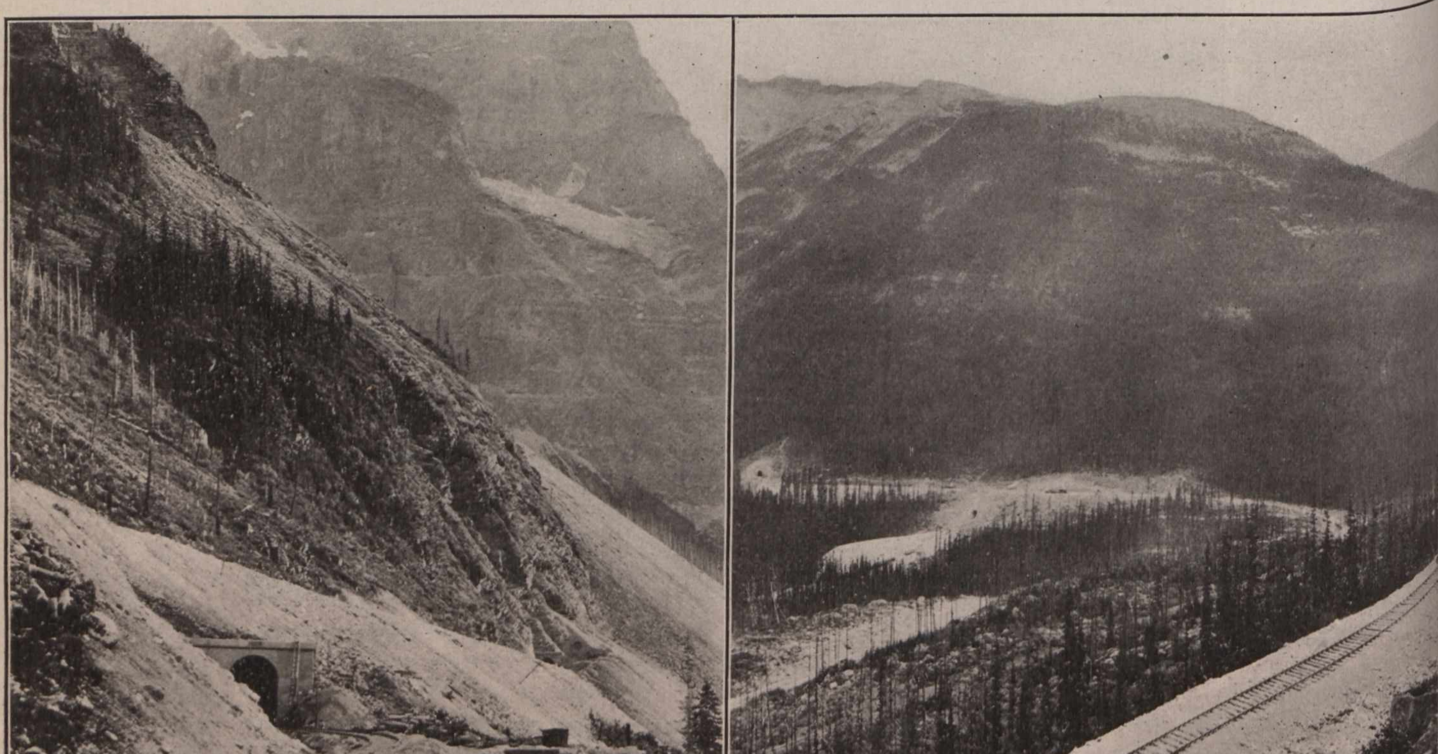

Fig. 3.—Portals of Spiral Tunnels Between Hector and Field, B.C.

driving of a 170-foot tunnel, this one on a tangent, before connecting with the old line near Field.

With the gradients improved to this extent, two engines of the same class as the four previously used can haul 980 tons of freight up the valley.

The spiral tunnels were driven through crystallized limestone of a widely distorted nature. In places, the stratification would vary from nearly horizontal to almost vertical, and in others from normal to almost parallel with the direction of the centre line. The hardness and brittleness of the rock varied every few feet, rendering drilling operations difficult. Water seepage through the rock crevices hampered progress on the down-grade ends of each tunnel, while the high altitude (about 5,000 feet) and severe winter weather added to the adverse conditions under which the task was so successfully accomplished.

Roger's Pass Tunnel in the Selkirks.

About 85 miles west of Field, there is at present under construction a double-track tunnel through the Selkirk Range of mountains in British Columbia. The driving of this tunnel is making itself a prominent place in the annals of notable engineering achievements. From portal to portal its centre line will measure 26,400 feet, thereby exceeding by three-fourths of a mile the longest existing tunnel in America. The method by which it is being driven involves the tunnelling of a "pioneer bore" paralleling the centre line of the main tunnel. This feature is new and the interest of tunnel engineers has naturally been aroused the world over. Its adoption arose from the keen desire of the C.P.R. to have the undertaking finished before the close of 1916. There is now no doubt that this aim will be achieved. The world's tunnelling records have been repeatedly broken, and the progress made has certainly vindicated the adoption of the pioneer heading method.

The estimated $12,000,000 expenditure connected with this undertaking is another indication of the efforts that are being made by the Canadian Pacific Railway to eliminate grades and snow troubles that have for years gone hand in hand with Western railway operation. The Selkirk tunnel may be considered an adequate winding-up of vast expenditures and enormous engineering undertakings which the C.P.R. has carried out with a view to perfecting the grade and alignment of its road both east and west of the great wheat fields of the Dominion. The tunnel will bring down the summit elevation of the Selkirk portion of the line from 4,330 feet to 3,791 feet. It will reduce the length of maximum grade from 22.15 miles as at present to 6.61 miles, the maximum grade, 2.2 per cent., remaining the same. It will dispense with about four miles of snow sheds in a length of thirteen miles of main line. It will incidentally reduce the length of the line by about four and a half miles. The total curvature will be considerably reduced and several loops eliminated. Thus, while the maximum train load will remain the same, the operating conditions will be much more favorable in consequence of the lower elevation, the shortening of the grades, and the reduction of expense and delay in the season of snow. In short, one of the most costly sections, from an operating point of view, of the whole system will be entirely eliminated. The large force of pusher engines, snow ploughs and equipment shops, that have necessarily carried on a busy existence at Roger's Pass, in service on both sides of the Selkirk Range, will shortly have to seek ranges anew.

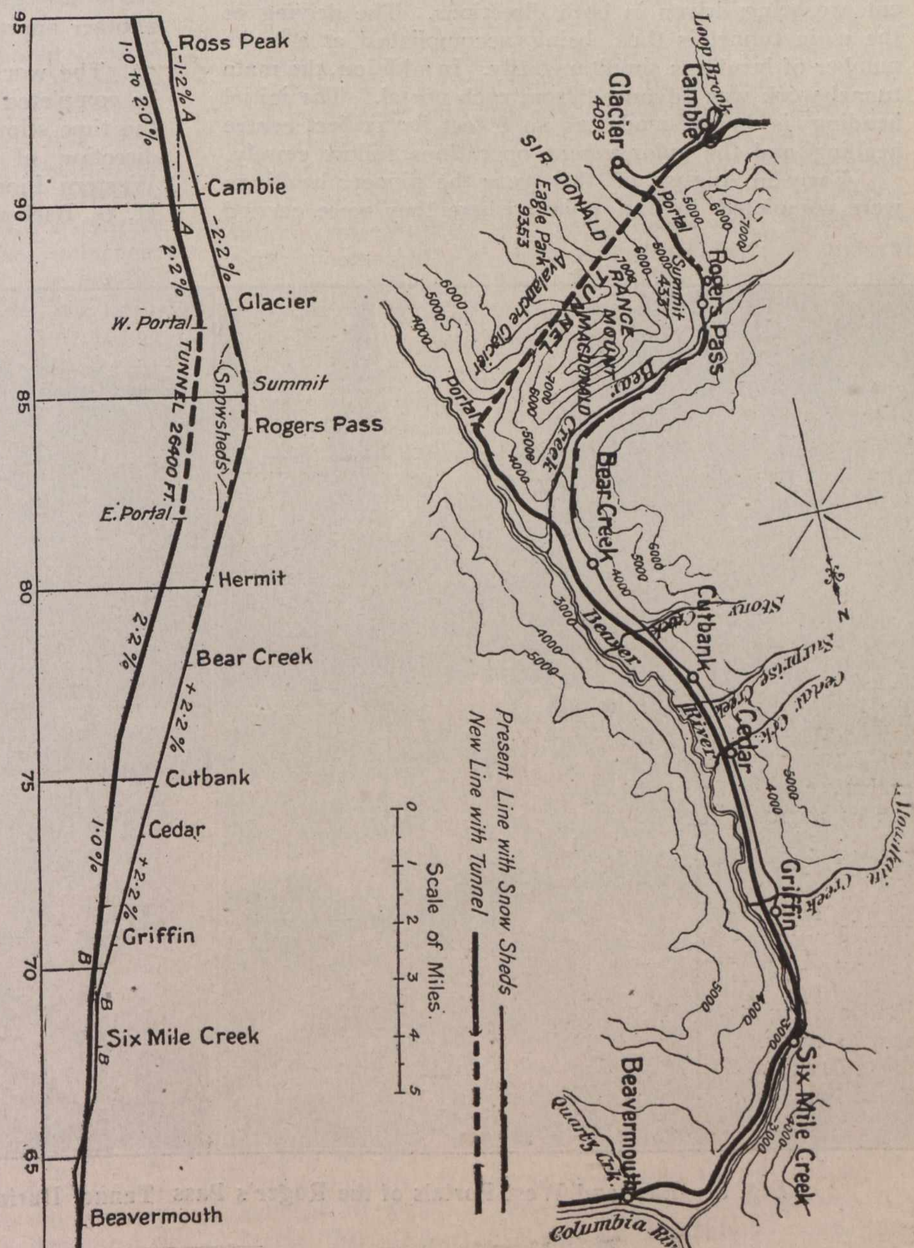

Fig. 4.—Plan and Profile of the Roger's Pass Grade Reduction.

The tunnel, with a bearing under Mount Macdonald of S. 38° 11′ W., is being constructed on a tangent throughout its entire length of five miles. The maximum depth of rock above it is 5,690 feet. For about 1,100 feet at each end the material encountered is clay and boulders, the balance being solid rock, mica, schist and quartzite. Throughout the softer materials the tunnel is being lined with concrete. The finished section will be 24 feet high by 29 feet in width.

The pioneer heading is for the greater part of its length about 45 feet from the centre line of the main tunnel, with its grade, for the most part, 10 feet above the subgrade of the latter, although the western portal is 135 feet and the eastern portal 53 feet above grade. Its headings are 7 feet by 8 feet, and each extends from its portal along the right side of the centre line of the tunnel except in the central portion where the pioneer headings, about a mile apart, are carried over to the centre line and are continued as the centre heading. Cross cuts from these headings to the line of the main tunnel are being made every 1,500 feet or so, and drifts from each cross cut are being driven in both directions. The driving of the main tunnel is thus being accomplished at a large number of headings simultaneously. In addition, the main tunnel work was advanced from each portal. The initial heading is being made as an 8 feet by 11 feet centre heading and the enlargement operations follow closely.

Early in August of this year the pioneer headings were completed to the points where they were carried over to the centre line, and on August 15th they only were 4,920 feet apart. About 2.95 miles of the centre heading has been driven and 1.69 miles of the enlargement completed. Concrete lining of the earth sections will be finished before the end of the year.

Besides necessitating about 18 miles of new track, the tunnel project involved, in its preliminary stages, a 900,000-cu. yd. fill in the centre of the Illecillewaet River valley, extending westward for a distance of 1½ miles. Between this fill and the west portal there is a 300,000-cu. yd. cut, the entrance being at a level of about 80 feet below the ground surface. In the east end there is another approach cut of about 100,000 cu. yd.

The work, commenced in June, 1914, will probably be completed in September, 1916, several months before the time stipulated. It is being carried out under the direction of Mr. J. G. Sullivan, Chief Engineer of Western Lines for the Canadian Pacific Railway. Mr. H. G. Barber is the engineer-in-charge.

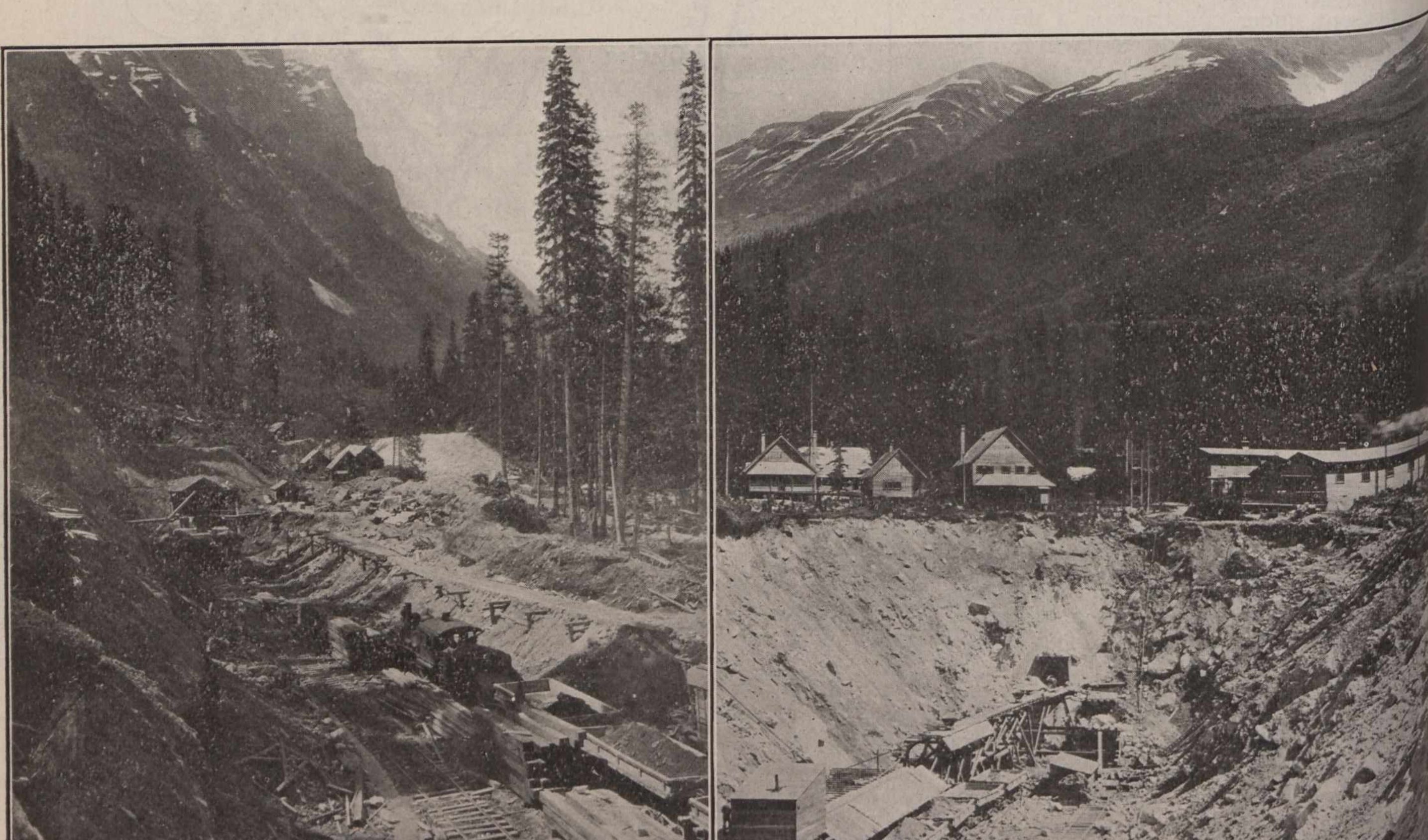

Fig. 5.—East and West Portals of the Roger's Pass Tunnel During Early Stages of the Work.

TUNNEL CONTRACTORS LOSE CASE.

In the British Columbia appeal court, McIlwee Brothers, contractors, Denver, Colo., won their appeal for half a million dollars judgment against Messrs. Foley, Welch and Stewart, contractors for the Rogers Pass tunnel. The plaintiffs sued for $527,000 for damages alleged to have accrued to them through breach of contract in building the great Canadian Pacific tunnel and on prospective profits. The trial judge in the appeal court allowed them only $30,000 and dismissed the remainder of their claim. The appeal court added approximately half a million dollars to the judgment.

COBALT ORE SHIPMENTS.

The following are the shipments of ore, in pounds, from Cobalt Station for the week ended August 6th, 1915:—

Chambers Ferland Mining Company, 58,350; Mining Corporation of Canada (Cobalt Lake Mine), 50,085; Mining Corporation of Canada (Townsite City Mine), 61,045; Dominion Reduction Company, 176,000; Coniagas Mines, 156,185; total, 501,665 pounds, or 250.8 tons.

Elk Lake—

Miller Lake O'Brien Mine, 48,000 pounds, or 24 tons.

The total shipments since January 1st, 1915, are now 18,444,873 pounds, or 9,222.4 tons.

TRANSPORTATION OF DETRITUS BY RIVER FLOW.

THE transportation of débris by running water is a subject that has been investigated by Mr. Grove Karl Gilbert, whose researches have recently been published by the U.S. Geological Survey. It is a subject affording considerable interest, as the flow of a river is at best a very complex phenomenon. The work of transporting the more or less insoluble residue of disintegrated rock from a higher to a lower level is accomplished in a variety of ways, but though the number of controlling causes is large, these do not act capriciously, and the influence of each should become apparent by a rigorously conducted analysis. Of course, certain factors depending upon the stream itself, as width, slope of bed, velocity of current, etc., will affect the result. The size, weight and shape of the detrital material carried will introduce another set of variables. The geological character of the banks, their curvature and frictional effects, will also exercise an influence; and, further, each of these operating causes may interact on the other, complicating the final issue. It need occasion no surprise, therefore, if categorical answers cannot be given to many questions that necessarily arise as we watch the progressive changes in the behavior of a river as it pursues its course. Though the main features may be recognized and explained on general grounds, it is clear that an adequate analysis with quantitative relations cannot be achieved by the mere observation of streams in their natural condition. It is necessary to supplement such observation by experiments in which the conditions are definitely controlled. Unfortunately, experiments arranged to exhibit special and singular effects, usually adopted as the one method of simplifying involved phenomena, entail a new set of complications, for the short mechanically-constructed channel differs materially from the lengthy bed of a typical river-course, and the applicability of laboratory results to natural streams becomes extremely hazardous. The chasm between the laboratory and the river can only be bridged with difficulty. No adequate theory at present exists. The demands of naval architecture have, however, made the construction of experimental tanks and artificial rivers a necessity, and rapid theoretical advance may be anticipated.

Mr. Gilbert's work has been commented upon to considerable length in "Engineering" (London), from which this valuable discussion has been obtained. It is apparent that to determine the influence and the mode of operation of some of the contributing factors by excluding others is the method that Mr. Gilbert has adopted, and, remembering that the results are applicable to particular conditions, he has done so with considerable success. The results are deserving of careful study, for the history of the subject shows that the information hitherto collected is vague and inaccurate. For instance, an opinion prevails, though, as far as Mr. Gilbert has been able to discover, without any basis in theory or observation, that the quantity of material transported by a river varies as the square of the slope. More frequently it is stated that the quantity of débris removable by flowing water varies as the sixth power of the velocity. There is no doubt about the origin of this latter assertion, but Deacon determined from actual experiment that the amount varied more nearly as the fifth power. The use of such loose statements shows the necessity for rigorously-conducted experiments and the construction of an accurate theory.

So little has the subject been studied that a convenient vocabulary to describe clearly the character of the motion to be observed has not been definitely settled. If a particle when carried down stream does not retain continuous contact with the river-bed, the process of progression is called "saltation." With small particles, or in swift streams, this want of contact may be indefinitely prolonged, and then the mode of transportation is known as "suspension," a term that explains itself. There is no sharp line of demarcation between "suspension" and "saltation," but the mechanical forces operating in each case are different. In the former the efficient factor is the upward component of motion in a complex current; in the latter, the motion parallel to and contiguous with the bed is the controlling force, and the dragging, rolling motion set up is conveniently described under the term "traction." Again, the form and nature of the bed give rise to differences of transportation. In artificial channels, flumes, and pipes the bed is comparatively rigid and unyielding; in natural streams, where the bed approaches in character the material carried and is moulded by the current, it becomes more plastic and irregular. From the experimental point of view, it is necessary to discriminate between the influences which the bed exercises on the velocity and amount of the material carried. Mr. Gilbert distinguishes between the motion over a rigid and over a yielding surface by the terms "flume transportation" and "stream transportation." Four conditions may, therefore, be recognized: "stream suspension" and "stream traction," "flume suspension" and "flume traction," though if a particle does not come in contact with the bed it is difficult to see wherein "stream" differs from "flume" suspension. This, however, is of little consequence, for the series of experiments under consideration, carried out at Berkeley University, Cal., had for its object the investigation of the laws of transportation that obtained in "stream traction" and "flume traction" only, in which contact with the bed is a necessity by definition.

The course of the inquiry was directed to determining the "capacity" or maximum load of a given kind of débris which a stream can support under varying conditions. "Discharge," defined by the quantity of water passing through a cross-section of the stream in a unit of time, can be made to vary. Similarly, other factors—as slope, width, and depth of bed, etc., to which reference has been made—swell the number of variables to uncontrollable limits. The number of possible combinations into which these variables enter is legion, all of which could not be fully examined. The actual number dealt with amounted to 130, while the number of separate observations was necessarily very large. Mr. Gilbert has pursued the inquiry with great enthusiasm, and we believe that there does not exist a similar mass of coherent measurements, especially directed to the end in view, though the employment of water under pressure to remove conglomerate rock has of late years directed increased attention to this department of hydraulic engineering, and to the laws which control the movements of colloids over fixed beds. Mr. Gilbert has, moreover, had in view the requirements of the geologist, who is concerned in the part rivers and river transport play in the work of earth sculpture. The derived results are necessarily more immediately applicable to hydraulics than to the operation of rivers. The sinuous character of a river, with its deeps and shallows, could not be imitated under the necessarily limited conditions of the Berkeley Laboratory. There is no necessity to emphasize the points of difference, of which the experimenter was perfectly aware.

In the course of the experiments the apparatus was occasionally varied to meet particular requirements, or to increase the accuracy of measurement, but the greater part of the observations was made with a wooden trough 31½ ft. long, 2 ft. wide, but capable of variation, with vertical sides, 1 ft. 8 in. high at the head, diminishing in steps to 1 ft. at the end. Sheets of glass were let into the sides of the trough to facilitate observation, and a device consisting of a small aperture in a moving shutter that could be made to travel at the same rate as a selected particle was a useful adjunct, that enabled much information to be collected concerning the trajectory of a saltatory grain and the manner in which eddies and currents of water acted. The end of the trough was open, permitting the passage of a stream of water whose discharge could be controlled and measured. For experiments in "stream traction" the trough was mounted horizontally; sand grains of approximately uniform size were fed to the running water, and at first accumulated at the upper end of the trough, but were gradually shaped by the current into a characteristic deposit having a gentle forward slope. This deposit spread itself throughout the length of the trough, and finally was discharged at the outfall end. The object of the observation was to determine when accumulation ceased, or when the escape of the outfall equalled the amount fed at the upper end. The stable slope of the sand, automatically assumed under the conditions prevailing at the moment, was then evidently just sufficient to enable the particular discharges to transport sand of known quantity and kind. Keeping other conditions the same, it was possible to vary any one factor, as the size of the sand grain, or the rate at which the sand was fed, and from measurement of the resulting slope and depth, in connection with other known quantities, to determine the effect of the variation on the "capacity" of the stream, thus supplying data for studying the quantitative relations between load, slope, discharge, etc., from which the law of variation might be derived by discussion of the equations of conditions or their equivalents.

Confining attention to "stream traction," the experiments were so arranged that the observed quantity was a function of six variables; the degree of fineness of the débris, whose separate particles varied from approximately one hundredth of an inch to pebbles of half an inch or more in diameter; width of trough, which could be contracted from 2 ft. to 8 in.; the rate of discharge, determined by flow through an aperture of adjustable size under an adjustable head; slope of bed; depth of current; and, finally, capacity of stream. Under ordinary circumstances, equations of condition and a most probable solution would be obtained, but in this case there is no theory available. The form of the function that expresses variation is not known, and there is no certain way of deciding inadmissible errors of observation. An empirical curve had to be derived, and it was possible to obtain the numerical coefficients and exponents of several, founded on interpolation formulæ or on parabolic forms, that represented fairly well the short trace given by observations. To test the relative merit of these, they were extended by extrapolation, and those were rejected that indicated forms that failed to satisfy known criteria that must be fulfilled at critical points. Some gave a negative capacity, which might be interpreted to mean a capacity for traction up-stream, clearly erroneous. The process of elimination was carried as far as possible, but a wide choice was left, and, doubtless, the number could have been increased. The form selected has the advantage of simplicity. In the typical instance of the slope factor, the "capacity" is made to vary according to a power of the difference between the slope of the bed and the "competent" slope, or C is made to vary as $S - \sigma)^n$. S, the slope in per cent. of the stream-bed, is a simple matter; the "competency" as used here, is more technical. The "competent" slope is that which is just sufficient to initiate traction. Under particular conditions of the controlling factors, capacity may be zero; but if one factor be changed just sufficient to give a positive capacity, that factor in its new condition is said to be "competent." For example, a stream may have so gentle a slope that it possesses no capacity, but if coming to a steeper slope it is just able to move the débris, then the steeper slope is "competent," and is expressed by σ. We are inclined to regard the results here obtained, as far as they can be expressed by exponents, as having a very limited application. Great doubt will be entertained of the legitimacy of the plan of considering any one factor, especially when near its limit of "competency," apart from the other operating factors. But Mr. Gilbert was committed to a difficult inquiry, in which he had little help from the experience of former experimentalists, and the complexity of the problem could not have been appreciated at the outset. It is easy to suggest that it would have been well to have given a greater variation to the several conditions whose effects were being sought, in order to have a greater range of values with which to compare the empiric law, but doubtless the practical difficulties were very great. The observations were extremely involved; a great many appear to have been discarded, and owing to the form of the discussion, it is not easy to estimate the accuracy of the probable error attached to those that have been utilized.

Mr. Gilbert carried his inquiry to such a definite conclusion that it is possible to express the effect that variation of slope and discharge of a stream, the character or degree of fineness of the débris, and some other factors have upon the quantity of load carried in a straight stream, by means of an equation of simple form. In the case of slope we have seen that the observations can be represented by the equation $C = b_1 \ (S - \sigma)^n$, where b_1 is the value of capacity when "competent" slope differs from that of bed slope by unity. In the same way, if Q be the discharge expressed in cubic feet per second, and κ is a constant relating to "competent" discharge, $C = b_2 \ (Q - \kappa)^o$ and the influence of the fineness of débris, gives rise to similar expression $C = b_3 \ (F - \phi)^p$. Each of these equations expresses the law of variation of capacity when the other two conditions are unchanged, and in that sense they are independent, "but there is a mutual dependence of parameters which is of so complete a character that they are essentially simultaneous." For example, b_1, σ, and n are constant so long as Q and F are unvaried: they do not vary with variation of S. But when Q and F are altered, the values of b_1, σ, and n are modified. The extent, therefore, to which the exponents can vary is a matter of prime importance, and their values and range are shown in the following table:—

Exponent.	No. of Determinations.	Mean Value.	Range of Values.
n	92	1.59	0.93—2.37
o	20	1.02	0.81—1.24
p	5	0.58	0.50—0.62

The variations in magnitude have a real significance, and are not to be attributed to defective observation. In the case of n the value diminishes when the discharge is smaller, or the débris is coarser. The exponent o, being smaller than n, shows that capacity is less sensitive to discharge than to changes of slope, while its numerical value increases with diminished steepness and larger particles of débris. The still smaller value of p intimates that the sensitiveness of capacity to the degree of comminution of débris is less than to either change in discharge or in slope. The magnitude of the exponent increases with increased steepness and greater discharge. As a rule, débris consisting of approximately equal particles was used, but in some trials with mixtures it was found that with less uniformity in size, the load moved more freely—that is to say, if fine material be added to coarse not only is the total load increased, but a greater quantity is carried.

The three factors considered here—slope, discharge, and fineness of material—have been regarded as of primary importance. Other controls of capacity, as stream velocity, depth, and the ratio of depth of stream to width of channel, called by Mr. Gilbert "form ratio," are not independent. It is feasible to treat only one of these in addition to the three main factors, and "form ratio," denoted by R, is the one selected. The formula chosen to represent it, though exponential in form, differs from the three preceding. Zero capacity is possible under two conditions: either when the stream is very wide and shallow or very narrow and deep. Between these extremes is a particular ratio of depth to width (ρ), corresponding to maximum capacity. Hence the function must rise to a maximum and return to zero. The form selected is—

$$C = b_4 \left(1 - \frac{m}{m+1} \frac{R}{\rho} \right) R^m$$

The values of ρ in the course of the laboratory experiments ranged from 0.5 to 0.04, the number increasing as slope, discharge, and fineness diminished. Collecting results, if regard be paid to units, the final equation expressing capacity may be written—

$$C = b\,(S - \sigma)^n\,(Q - \kappa)^o\,(F - \phi)^p \left(1 - \frac{m}{m+1} \frac{R}{\rho} \right) R^m$$

The measurement of velocity near the stream's bed, where the influence of velocity on capacity is greatest, was not unattended with difficulties, and it was found convenient to substitute a mean velocity. In tracing the relations between capacity and mean velocity it is necessary to assume constancy in some of the simultaneous conditions. The power expressing the sensitiveness of capacity to changes of mean velocity has a wide range of values, but, on the average, in no case reaches the sixth power. We have, in fact, the following results according to the selected constant:—

Constant.	Capacity Changes with	Capacity Varies as
Slope	Discharge	$V^{3.2}$
Discharge	Slope	V^{4}
Depth	Slope and Discharge	$V^{3.7}$

As slope, discharge and fineness of débris diminish, it is found that the sensitiveness of capacity increases.

If the discussion of the eroding and transporting capacity of rivers is valuable as throwing a possible light on the mechanism whereby the surface of the earth is being continually destroyed and reformed, the experiments on flume traction are of no less importance in hydraulic engineering, and possess the advantage of more immediate application. We are able to trace the influences of different textures and shape of bed on water carriage, and approach the determination of the most economical treatment of disintegrated rock, as it occurs in pulverized ores and similar problems. For, as already explained, the distinctive feature between flume and stream traction is the character of the bed, the rigid irresponsive support, artificially constructed, replacing the plastic varying bed formed from the materials of the débris itself.

For the experiments on flume traction, the trough was of wood, 60 ft. long, with vertical sides, giving a width of 2 ft.; but for the greater part of the work the effective width was reduced to 1 ft. The bed, which could be inclined to the horizontal at various angles up to about 3 deg., had five different degrees of roughness: planed and painted wood, sawn unplaned wood, wooden blocks with vertical grain, a pavement of sand-grains set in cement, and a pavement of pebbles. The débris was also more varied than in the case of stream traction, pebbles of over an inch in length being used in some experiments. This débris, whatever its size and nature, was fed to the current by hand with the aid of a scraper, the rate being modified till, by successive trials, it was adjusted to the capacity of the current. When the material was fed to the water, the current was retarded, with the result that there was an overflow at the feeding end of the track, and some portion was deposited, causing the débris in its upper course to travel over a bed of like material, while in the lower portion the débris was in direct contact with the bottom of the trough. The upper end of the trough was, therefore, clogged, although motion was free in the lower portions, and when this condition was observed the load delivered at the outfall was assumed to represent the capacity of the stream. It is important to know the process followed and the criterion selected for decision, though without more information it would be injudicious to criticize the method. It is satisfactory to note that the accuracy of the observations is greater than the description would suggest. Long experience enabled the experimenters to recognize the selected phase with considerable certainty. The degree of precision is more than twice as great as that attained in the experiments on stream traction. It is suggested that the constancy of slope gave some assistance, and that some of the rhythmical fluctuations in stream traction were avoided.

The fact that stands out prominently from the experiments is that, under similar conditions, "flume traction" gives higher capacities than "stream traction," but the laws of variation are different. This latter fact might be anticipated from the different character of the transportation induced by the altered form of bed. With the smoother bed, rolling and sliding become important modes of progression. This is not altogether a frictional effect, though on a smooth bed any particle with a broad facet is inclined to slide, and a rounded particle to roll; the motion is started by the current applying a greater force to the upper part of the particle than to the lower.

The recorded speed of the particles is on the average 75 per cent. of the mean velocity of the water, the ratio being greater as the velocity is greater, and the depth less. The size of the particles determines the speed and the mode of progress, the largest slide, the smaller roll, and the smallest leap. Increase of velocity tends to increase saltation at the expense of roll, and to increase roll at the expense of sliding. When the conditions are such that the principal movement is by sliding and rolling, the experiments show that the capacity of the current increases with the coarseness of the débris transported; but when saltation prevails, the greater the fineness, the greater the capacity. Under all conditions, capacity increases with steepness of the slope, and with enlarged discharge, but the rates of increase are less than in stream traction. As might be expected, a smooth channel-bed facilitates transportation. As roughness is increased, capacity is reduced until the texture of the bed becomes coarser than the débris of the load.

As of practical importance in the water carriage of loose material, it should be noted that flumes of rectangular shape have greater capacity than semi-cylindrical flumes of similar width, and that within limits it is advantageous to increase the width of channel at the expense of depth of current. Further experiment would be necessary to determine the most efficient ratio of depth to width, "but it is believed to be rarely greater than 1:10, and often as small as 1:30. For large operations the determination of width will usually represent a compromise between efficiency and the cost of construction and maintenance."

Although the main results deduced from the experiments have been summed up, and these include some that may prove of importance in the fields of physiography and hydraulic economy, not a small part of the interest of this valuable paper attaches to observations that lie outside the practical scope. To this class belong questions connected with the behavior of particles, singly or collectively, when submitted to the operation of regularly-induced currents. Some cogent reasons are given for modifying our notions of the forces that induce "saltation" or bring about suspension. In recondite phenomena, the plausible explanation is frequently incorrect, and the generally accepted assumption of the existence of upward minute currents supporting suspended particles is scarcely warranted by observation. To observe the motion of single particles, Mr. Gilbert made use of the diaphragm that travelled along the glass side of the trough at the same rate as the particle was carried by the current, and by thus eliminating the horizontal component, the vertical motion of the saltatory grain was rendered distinctly perceptible. This arrangement permitted the movement at different distances from the bottom of the trough to be studied, with the result that a sensible uniformity of process was manifested over the whole width of the channel, inconsistent with the suggestion that the saltation zone was invaded by eddies of such large dimensions as would be competent to sustain the grains by upward component of their motion. There was no evidence of ascending strands of current, such as the accepted theory requires. In place of the uplift theory, Mr. Gilbert suggests that each grain is projected from the bed with an initial velocity which gives a trajectory analogous to that of a cannon-ball. The application of ballistics to explain the motions of minute particles in a current may be unexpected, but the trajectory of saltation is worked out here with a completeness that at least demands consideration.

The collective movement of the sand under adjusted conditions also presents features of considerable interest. When, over a level surface of sand, a deep stream of water was allowed to pass, with a current so gentle that only a few grains were disturbed, it was perceived that the feeble traction did not affect the whole bed simultaneously, but led to the production of a regular pattern on the sand floor, punctuated by a system of waves and hollows, separated by uniform intervals. By continuing the current action, the up-stream face of the wave formation was gradually moved by erosion, and the down-stream face made steeper by the deposit of eroded material, causing the wave as a surface form to travel down-stream, analogous to the motion of a sand hill, or dune, under the influence of wind. With any progressive change of condition tending to increase the load, the dunes eventually disappear, and the débris surface becomes smooth. This phase passes and is succeeded by a second rhythmic phase in which the system of dunes travels up stream. This again has its counterpart in Eolian dunes. Dr. Vaughan Cornish, whose observation of wave surfaces is so extensive, has described a similar phase as occurring occasionally under natural conditions. Since their movement is affected by erosion and accumulation in the opposite direction to that of dunes, they are well described as "antidunes," but, like the dunes, they are initiated by rhythm of water movement, though the precise mechanism is obscure. Rhythm brings many puzzles and makes the way of the experimenter hard. Its unexpected manifestations introduced noticeable errors of observation that mechanical devices could not wholly remove, and whose physical explanation still baffles analysis. It may be assumed that the dominant rhythm originated at the intake, that it was started by irregularities of débris feeding or by variation of the size and texture of the material supplied. A screen would only ensure comparative uniformity in the particles present; the current proved much more sensitive to slight differences; and the small inequalities of motion, originated and increased by the interaction of constant forces, were probably responsible for giving rise to varying rhythmic periods that could not be separately analyzed.

In the presence of so many residual phenomena that defy complete explanation, it is difficult to decide how far the discussion partakes of a purely academical character, and to what extent the mechanical arrangements, by imitating the movement of rivers, permit the numerical results obtained to be applied to natural streams. We have already called attention to some marked points of difference; there is no need to dwell upon them. Rivers are of many kinds, and the same river in its course adopts different processes, according to its environment. It does not seem possible that the rigid limitations of laboratory experiments can accommodate themselves with sufficient closeness to the continually shifting conditions of season, soil, and situation, that the results derived from the one should be applicable to the other.

A sub-contract is reported let for grading the last 22 miles of the Central Canada Railway to Peace River Crossing, Alta. Track laying has already been completed to mile 34 from McLennan, where connection is made with the Edmonton, Dunvegan and British Columbia. The grading work yet to be carried out will be heavy. It is expected that the grading work will be finished by October 1, and track laying completed and the line ready for operation this year.

PRESSURES ON PILES SUPPORTING MASONRY.*

By R. P. V. Marquardsen.

Books on design of retaining walls, piers, abutments, etc., usually contain formulas for finding the intensity of pressure on the foundation supporting the structure under consideration, but none shows how to ascertain the pressure per pile if the masonry is resting on piles.

As the latter case is perhaps of more frequent occurrence than the former, it might not be out of place to discuss briefly the systematic procedure for finding the pressure on a given pile in instances where the wall, pier, or abutment is lodged on piles.

In the necessary derivation of formulas in connection herewith it will be assumed,

(1) that all loads are carried by the piles,

(2) that all piles are alike and sustain the same load under like conditions,

(3) that the pressure on each pile is concentrated at the centre of the pile,

(4) that all piles are driven vertical,

(5) that the tops of the piles are at the same elevation, and

(6) that the masonry at the horizontal plane of the tops of the piles is rigid (which is equivalent to neglecting the slight continuous-beam action that actually takes place in that region).

The following notation will be used:

Aa, Ab, Ac = perpendicular distance between line A-A and piles "a," "b" and "c," respectively. See Fig. 1.

Ba, Bb, Bc = perpendicular distance between line B-B and piles "a," "b" and "c," respectively. See Fig. 1.

G_1, G_2, G_3, ... Gn = perpendicular distance between line G-G and rows 1, 2, 3, ... n, respectively. See Fig. 2.

Gv = distance between the point where V must be applied in order to produce equal pressures on all piles and the actual point of application of V. See Fig. 2.

N_1, N_2, N_3, ... Nn = number of piles in rows 1, 2, 3, ... n, respectively. See Fig. 2.

Nt = total number of piles supporting the wall, pier or abutment under consideration.

Pa, Pb, Pc = total vertical pressure on piles "a," "b" and "c," respectively. See Fig. 1.

P'_1, P'_2, P'_3, ... P′n = vertical pressure per pile on piles in rows 1, 2, 3, ... n, respectively, due to force V′. See Fig. 2.

P''_1, P''_2, P''_3, ... P″n = vertical pressure per pile on piles in rows 1, 2, 3, ... n, respectively, due to couple V″—V. See Fig. 2.

P_1, P_2, P_3, ... Pn = total vertical pressure per pile on piles in rows 1, 2, 3, ... n, respectively. See Fig. 2.

V = vertical component of resultant of loads supported by the piles.

V′ and V″ will be referred to later.

Y_1, Y_2, Y_3, ... Yn = perpendicular distance between Y—Y line and rows 1, 2, 3, ... n, respectively. See Fig. 2.

Y = perpendicular distance between Y—Y line and point where V must be applied in order to produce equal pressures on all piles. See Fig. 2.

*Read at a recent meeting of the Western Society of Engineers, Chicago.

To comprehend the amount of work involved in analyzing a perfectly general case, consider a problem as indicated in Fig. 1, where the magnitude of V and its point of application with respect to the piles, as well as the location of each pile, is known.

By assumption (1) all loads are carried by the piles, and we may therefore write that

$$V = Pa + Pb + Pc \quad \text{(a)}$$

The forces acting being in equilibrium, the sum of the moments of the piles on one side of any line passing through the point of application of V, about the line, must equal the sum of the moments of the piles on the other side of the line, about the line, or

$$Pa\,Aa = Pb\,Ab + Pc\,Ac \quad \text{(b)}$$

$$Pa\,Ba = Pb\,Bb + Pc\,Bc \quad \text{(c)}$$

From (b)

$$Pa = Pb\left(\frac{Ab}{Aa}\right) + Pc\left(\frac{Ac}{Aa}\right) \quad \text{(d)}$$

and from (c)

$$Pa = Pb\left(\frac{Bb}{Ba}\right) + Pc\left(\frac{Bc}{Ba}\right) \quad \text{(e)}$$

Equating (d) and (e) and solving for Pb there results

$$Pb = Pc\left\{\frac{\left(\frac{Bc}{Ba}\right)-\left(\frac{Ac}{Aa}\right)}{\left(\frac{Ab}{Aa}\right)-\left(\frac{Bb}{Ba}\right)}\right\} \quad \text{(f)}$$

Substituting in (d)

$$Pa = Pc\left[\left\{\frac{\left(\frac{Bc}{Ba}\right)-\left(\frac{Ac}{Aa}\right)}{\left(\frac{Ab}{Aa}\right)-\left(\frac{Bb}{Ba}\right)}\right\}\left(\frac{Ab}{Aa}\right)+\left(\frac{Ac}{Aa}\right)\right] \quad \text{(g)}$$

Using the values given by (f) and (g) in (a) and solving for Pc we get

$$Pc = \frac{V}{1+\frac{Ac}{Aa}+\left(1+\frac{Ab}{Aa}\right)\left\{\frac{\left(\frac{Bc}{Ba}\right)-\left(\frac{Ac}{Aa}\right)}{\left(\frac{Ab}{Aa}\right)-\left(\frac{Bb}{Ba}\right)}\right\}} \quad \text{(h)}$$

That this method may be extended to solve problems comprising any number of piles is evident; but that it becomes impracticable if there are too many piles is equally obvious.

In practice, however, the piles generally are, or may be assumed to be, placed symmetrically about a given line, and the point of application of V usually falls, or may be regarded as falling, on this line.

For the purpose of deriving practical formulas, it may, therefore, in addition to the assumptions already made, be further assumed.

(7) that the piles are arranged symmetrically about a line passing through the point of application of V.

To analyze a general case under these conditions, contemplate a problem as indicated in Fig. 2.

As before, the magnitude of V and its point of application with regard to the position of the piles are known.

To find the point where V must be applied in order to produce equal pressures on all piles, draw, conveniently distant from the last row of the piles, a line Y—Y, perpendicular to the X—X line about which the piles are grouped symmetrically. The point in question is, of course, located on line X—X, and its distance Y from the Y—Y line may, as little consideration should make clear, be found by the following formula:

$$Y = \frac{Y_1N_1 + Y_2N_2 + Y_3N_3 + \ldots\ldots\ldots + Yn\,Nn}{Nt} \qquad (1)$$

Having located accurately to scale this point, draw through it and parallel to line Y—Y the line G—G, and obtain by scaling the distances G_1, G_2, G_3, ... Gn, and Gv.

At the point under consideration, we may, without changing the equilibrium, conceive applied two forces, V' and V'', of the same magnitude but of opposite direction, and each equal and parallel to V. (See Fig. 2.)

The single force V has now been replaced by a direct force V' which will produce equal compressive stresses in all piles, and by a couple V''—V causing compression in

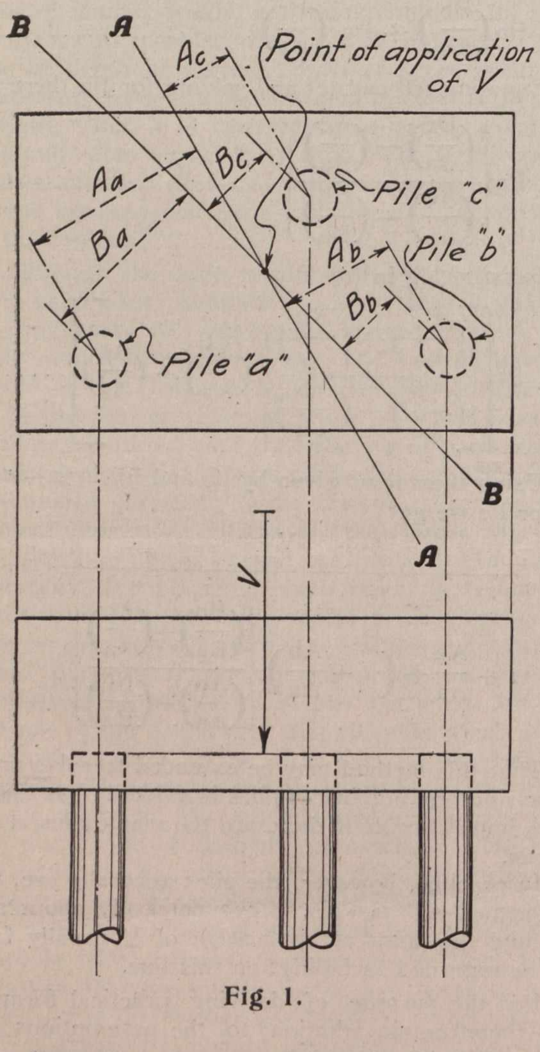

Fig. 1.

the piles located on the same side of the G—G line as the point of application of V and tension in the remainder of the piles.

The pressure per pile on piles in any row, as row 1, due to the direct force V', may be found by dividing V' (= V) by the total number of piles, or

$$\frac{V'}{Nt} = \frac{V}{Nt} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

The stress per pile in piles located in any row, as row 1, due to the couple V''—V, bears a certain relation to the stress per pile in piles located in any other row, as row 2, the stress in any pile being directly proportional to the

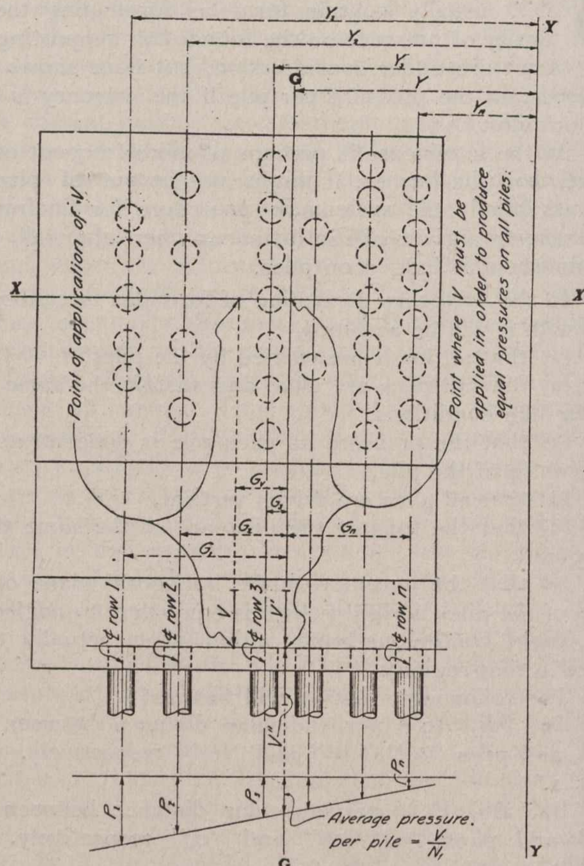

Fig. 2.

perpendicular distance between the pile and the G—G line; that is,

$$\frac{P''_1}{G_1} = \frac{P''_2}{G_2} = \frac{P''_3}{G_3} = \ldots\ldots\ldots = \frac{P''n}{Gn} \ldots\ldots\ldots\ldots \quad (3)$$

from which

$$\left.\begin{aligned} P''_2 &= P''_1 \frac{G_2}{G_1} \\ P''_3 &= P''_1 \frac{G_3}{G_1} \\ &\ldots\ldots\ldots\ldots \\ P''n &= P''_1 \frac{Gn}{G_1} \end{aligned}\right\} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

The moment of the couple V''—V (= VG_v) is resisted by the sum of the moments of the stresses in the piles about the G—G line, or

$$VGv = P''_1G_1N_1 + P''_2G_2N_2 + P''_3G_3N_3 + \ldots\ldots\ldots + P''n\,Gn\,Nn \ldots\ldots\ldots\ldots \quad (5)$$

Substituting in formula (5) equivalent values as given by formula (4), and solving for P''_1, we have

$$P''_1 = VGv \frac{G_1}{G_1^2N_1 + G_2^2N_2 + G_3^2N_3 + \ldots\ldots\ldots + Gn^2Nn} \quad (6)$$

The total pressure per pile on piles in any row, as row 1, is equal to $P'_1 + P''_1$; or by combining formulas (2) and (6)

$$P_1 = V\left(\frac{1}{Nt} \pm \frac{GvG_1}{G_1{}^2N_1 + G_2{}^2N_2 + G_3{}^2N_3 + \ldots\ldots + Gn^2Nn}\right) \quad (7)$$

the plus sign to be used if row 1 is located on the same side of the G—G line as the point of application of V, and the minus sign if on the other side.

The pressure per pile on piles in any row, as row 1, being known, the pressure per pile on piles in any other row can be found graphically by laying off to any convenient scale through the point where V must be applied in order to produce equal pressures on all piles the average pressure per pile as given by formula (2), and in its proper position the known pressure per pile, and drawing a straight line through the extremities of these two values. A study of Fig. 2 will best elucidate the details of the procedure.

If it is found by investigation that some of the piles are in tension, that is, if a pull is being exerted on them, and if it is thought that this pull is too great, the problem should be gone over again, the piles on which the pull is beyond the allowable limit being ignored, as a decrease in the number of piles acting will sometimes materially increase the pressure on the piles farthest away from those in tension.

PLUMBAGO (OR GRAPHITE) FROM CEYLON.

The most important source of plumbago in the British Empire is Ceylon, whence over a quarter of the world's supply is derived. There are about 450 plumbago mines in Ceylon, the chief mining centres being situated in the Southern, Western, Sabarafamuwa, Central and North-Western Provinces. During the last two years Ceylon producers have felt the competition of Madagascar plumbago, the output of which has largely increased, and since the outbreak of the war they have been met by a serious situation following on the restriction of exports of plumbago from Ceylon to foreign countries.

The following table of exports of plumbago from Ceylon in 1913 will serve to show the extent and the general direction of the trade in normal times:—

To	Cwts.	£.
United Kingdom	106,954	113,014
United States	289,218	305,607
Germany	123,559	130,561
Belgium	39,367	41,598
Other countries	11,709	12,373
	570,807	603,153

The chief use of plumbago is in the manufacture of crucibles and furnaces which resist the effects of great variations in temperature. The best crucibles are made from a flake plumbago, which breaks up easily along the cleavage planes. Compact plumbago, finely powdered for the purpose, is used for crucibles of inferior quality. These have not the same elasticity as the crucibles made from flake plumbago, and, when subjected to great heat, develop fine cracks which prevent their use a second time. The inferior crucibles are preferred for use at the very high temperature required for steel casting, on account of their lower cost, since under these conditions even the best crucibles cannot be used a second time.

Another important use for plumbago is in the manufacture of blacklead pencils, for which powdered plumbago, moulded to the required shape, is used. Compact plumbago and inferior flake plumbago are used in the manufacture of stove polishes. Plumbago is used as a facing for moulds in foundries, so that the castings may separate easily. Sometimes the mould itself is constructed of plumbago. Finally, plumbago is of great value as a lubricant for machinery, especially in cases where the pressure on the bearings is very great and the movement slow.

PRESENT KNOWLEDGE OF CONCRETE ROAD CONSTRUCTION.

Part III.

Methods, Organization, Equipment, Cost and Maintenance.

When it is considered that ordinarily from one-third to one-half of the total cost of constructing a concrete pavement is for the labor employed in doing the work after the materials are delivered, the importance of efficient organization, proper equipment, and economical methods becomes readily apparent. Failure to give these features proper consideration may easily result in adding from 10 to 20 per cent. to the cost of a concrete pavement, and has no doubt frequently caused road contractors to sustain a net loss on projects of this kind, where profits might have been made.

It is not the province of this article to furnish detailed rules for the guidance of contractors in planning and executing their work, but it seems desirable to discuss briefly a few important points which contractors and engineers in charge of force-account work should consider in connection with concrete-pavement construction. The points which are of most importance, and to which the discussion will be confined, are concerned with, first, the proper order and progress of the work; second, the economic handling of materials; and third, the amount of capital necessary to carry on such work economically.

Order and Progress of the Work.—In constructing a concrete pavement it is especially desirable that the work of mixing and placing the concrete be as nearly continuous as practicable after it is once begun. Where the mixer is permitted to stand idle for even a few days the force of laborers employed in operating it will usually become more or less disorganized, and an appreciable amount of loss and unsatisfactory work will generally result when the mixing is resumed. On this account the order and progress of the work should ordinarily be planned with the primary view to keeping the mixer going full time every working day that the weather will permit. This means that ample provision should be made for completing the drainage structures, the grading, and the preparation of the subgrade well ahead of the mixer, as well as for supplying the mixer with all necessary materials.

The drainage structures should preferably be completed in advance of the grading in order to obviate the necessity for moving embankment material the second time. Where the concrete materials are to be hauled out by means of an industrial railway, however, it is usually impracticable to extend the railway ahead of the grading, and the saving effected in hauling the materials for the drainage structures on the industrial railway may justify permitting the grading to proceed ahead of the drainage structures.

Rather than construct a concrete culvert sufficiently far in advance for the subgrade to be prepared before the mixer arrives, it may sometimes be economical to leave out a section of the pavement over the culvert. But the extra expense involved in going back and putting in a section of this kind after the work of laying the pavement has progressed a considerable distance ahead is usually considerable and is often underestimated by contractors. This method of doing the work also involves a delay in opening the road, and as a rule is very objectionable on that account.

The work of preparing the subgrade and setting the forms should preferably proceed sufficiently far in advance of the mixer to allow for two or three days' run. The prepared subgrade, if properly drained, dries out much more rapidly after rains than the rough grade, and thus it is possible to resume the placing of concrete much earlier than when the roadbed has not been shaped and rolled. A soaking rain will usually cause the prepared subgrade to heave slightly and make rerolling necessary, but ordinarily this is a very small item.

Operating the Concrete Mixer.—In general it is economical to employ a mixer of the street-paving type for mixing and placing the concrete, though in some cases it has proved satisfactory to do the mixing in stationary mixers and haul the concrete out to its place in the road. This latter method is applicable to relatively only a very few sets of conditions, however, and will therefore not be discussed in detail.

There are two sizes of street-paving mixers commonly used in concrete road construction. The smaller is capable of mixing a batch, of the proportions usually required, containing two bags of cement, and the larger will mix a batch containing three bags of cement. The larger size is economical where materials can be rapidly obtained and where the amount of work to be done is sufficient to warrant providing equipment for handling the materials necessary to keep the larger mixer running up to its capacity. Where the materials can be economically obtained only at a slow rate, or where the expense of providing facilities for handling large quantities of materials would be excessive, the smaller size of mixer is more economical to use. When efficiently operated, either size of mixer should ordinarily mix from 400 to 450 batches of concrete in a working day.

Organizing a force of laborers to operate a paving mixer efficiently requires considerable skill in handling men. The best results are generally obtained when a mixer is fully manned and each laborer is assigned definite work to perform.

Handling Materials.—One of the most difficult problems which has to be solved in connection with concrete road construction is that of determining the proper methods to employ in handling and delivering the materials for the concrete. The different kinds of material required must be delivered to the mixer in definite proportions at the same time, and it is evident that the location of the several sources from which the materials are obtained, with respect to each other and to the road, will have a very great influence in determining the most economical transportation methods.

Consider, for example, a project on which is used a concrete mixer of the street-paving type which mixes a batch containing three sacks of cement. If the work is to progress normally, the quantities of the different materials required each day will be approximately as follows:

Cement	barrels	320
Sand	cubic yards	70
Coarse aggregate	cubic yards	140
Water	gallons	8,800

In addition to the above, if the mixer runs continuously, about 10,000 gallons of water will be required each day for keeping wet that part of the pavement which will have been laid during the two preceding weeks, and for sprinkling the subgrade before the concrete is placed. This makes the total weight of water which may be required each day about 75 tons, and the total weight of all the materials combined about 420 tons per day.

The importance of the water supply is not always appreciated by contractors and engineers, and the provision made for delivering water on the work has sometimes been entirely inadequate. Another frequent error is that of overestimating the amount of water which a chosen stream is capable of supplying. In general, the most practicable method of delivering the water is to pump it through a pipe line laid along the road. The pipe should be at least 2 inches in diameter, and for the mixer under consideration the pump should be capable of furnishing about 25,000 gallons of water in 10 hours to any point on the pipe line. Ordinarily, at least 10,000 feet of pipe will be required if the concrete is to be sprinkled for two weeks after it is laid.

The proper method of handling the cement is sometimes considerably affected by the requirements which the specifications provide regarding tests. Some specifications require that the cement shall be held until the results of the 28-day test are reported, while others permit its use as soon as it has satisfactorily passed such tests as may be made within seven days. If any tests of consequence are required and the sampling is not done until the cement arrives at the nearest railroad station, it will be necessary either to unload and store it or pay demurrage charges. This difficulty may be overcome to some extent by placing an inspector at the cement plant to collect and forward samples to the testing laboratory as soon as the cars are loaded. The testing may then be begun while the cars are en route.

Another plan sometimes employed to lessen the demurrage and avoid rehandling is to purchase bin-tested cement and have the cars loaded under the supervision of an inspector. When this is done, the cement may be used as soon as it arrives on the work, but the custom of cement manufacturers to make a slight additional charge for bin-tested cement may entirely offset the economical advantages gained by its use.

No matter what the arrangements for testing the cement may be, provision should usually be made for storing near the work sufficient cement to keep the mixer going for four or five days, in case that shipments are delayed, as frequently happens.

In general, the most satisfactory method of hauling the materials for the concrete is by means of an industrial railway constructed along one shoulder of the road, though this method is not always the most economical. Teams, traction engines with trailers, and motor trucks with or without trailers have each been frequently used for this purpose, and are no doubt each economically best adapted to certain sets of conditions. But all of these are objectionable from a construction standpoint on account of the damage which they usually do to the subgrade.

Among the advantages possessed by an industrial railway for hauling the concrete materials are:

(1) Materials may be delivered without disturbing the subgrade.

(2) The railway may be readily operated along the shoulder of a newly laid pavement, which makes it practicable to prosecute the work at any desired point.

(3) Hauling is affected comparatively little by weather conditions.

(4) Where there is sufficient work to keep an industrial railway outfit busy, it is usually economical, especially where the size of the projects is such that the railway can be operated continuously throughout a season on the same project. The purchase of an industrial railway outfit, however, usually involves a greater outlay of capital than is desirable for a single project.

From a purely economical standpoint the choice of means for hauling the materials would probably be made about as follows:

(1) Where the maximum haul does not exceed 3 miles and the amount of concrete to be laid does not exceed about 5,000 cubic yards, team haul would probably be economical.

(2) If the amount of concrete to be laid exceeds about 5,000 cubic yards, or if the maximum haul exceeds about 3 miles, and the materials are hauled in from the same direction, an industrial railway, tractors, or motor trucks may be economically used.

(3) Where the materials are hauled in from each end of the road, or where it is desired to operate more than one mixer at the same time, the industrial railway is usually more practical and economical.

Where the sand and coarse aggregate are shipped in by rail, the work of unloading the railroad cars and loading the wagons or cars in which the materials are to be hauled out to the work can usually be most economically done by means of machinery especially adapted to this kind of work. In order to avoid paying demurrage, and to have the materials on hand when they are needed, it is nearly always necessary to handle a considerable part of the materials the second time. Hence it may be desirable to have two sets of unloading and loading machinery in cases where the stock piles and bins are located out in the work instead of at the siding where the materials are delivered.

The kind of unloading and loading device to employ depends to a very great extent on the quantities of materials to be handled and the other conditions to be met. If the stock piles and bins are adjacent to the siding where the materials are delivered, and a considerable quantity of work is to be done, a locomotive crane may frequently be used to advantage, while, if the stock piles and bins are out on the work, it may be economical to handle the material at the siding with scrapers or similar devices and install an elevating device at the bins where the materials are stored. In other cases the extent of the work may not be sufficient to warrant any machinery whatever for handling the materials, in which event the handling may be rather expensive.

Capital Required.—The amount of capital required to carry on concrete road construction successfully depends almost wholly on the size of the project and the circumstances under which the work is to be done. Where a considerable quantity of work is to be done in the same community it may be possible to keep a very elaborate equipment busy, even though the individual projects are comparatively small. On the other hand, it may be poor economy to provide more than the smallest practicable equipment for a rather large project in a community where few other concrete roads are likely to be constructed.

The equipment necessary for handling and hauling the materials frequently represents a much greater outlay of capital than all other expenditures combined, but, as has already been pointed out in discussing the handling of materials, the conditions affecting this feature of the work are subject to great variation. A general discussion as to the cost of this part of the equipment, therefore, would usually be of small value in connection with any particular project and will not be undertaken.

The equipment necessary for doing the rough grading in connection with concrete road work is not essentially different from that required for grading other types of roads. Since the amount of capital necessary to provide grading equipment to suit various sets of conditions is familiar knowledge to practically all road engineers and contractors, this feature will not be discussed here.

The capital required to provide equipment for preparing the subgrade and mixing and placing the concrete depends on the rate at which it is purposed to carry on the work. The lists given below show the approximate cost of outfits using either a 2-bag or a 3-bag mixer.

Outfit No. 1 (2-bag mixer).

1 rooter plow	$ 50
1 road grader	300
1 heavy 4-horse plow	30
Shovels, picks, and other small tools	75
1 10-ton macadam-type road roller	2,500
1,800 feet of steel forms, complete with stakes, etc.	200
1 pump and engine capable of delivering at least 1,500 gallons of water per hour	175
10,000 feet of 2 inch wrought-iron water pipe, with valves every 200 feet	950
400 feet of rubber hose, with couplings	80
12 wheelbarrows	60
1 concrete mixer, with skip and distributing device	1,600
Strike board, tamper, mortar hoes, sledges, etc.	100
Total	$6,120

Outfit No. 2 (3-bag mixer).

1 rooter plow	$ 50
1 road grader	300
1 heavy 4-horse plow	30
Shovels, picks, and other small tools	100
1 10-ton macadam-type road roller	2,500
3,000 feet of steel forms, complete with stakes, etc.	325
1 pump and engine capable of delivering at least 2,500 gallons of water per hour	300
10,000 feet of 2 inch wrought-iron water pipe, with valves every 200 feet	950
600 feet of rubber hose, with couplings	120
20 wheelbarrows	100
1 concrete mixer, with skip and distributing device	2,000
Strike board, tamper, mortar hoes, sledges, etc.	100
Total	$6,875

Ordinarily the method of paying for the work should enable the contractor to meet most of his bills for labor and materials after the first one or two estimates, so that the total amount of capital required for carrying on the work need not greatly exceed the cost of the equipment. For the average small project, where no very elaborate equipment is required to handle the materials, it seems that a total working capital of about $10,000 should be sufficient.

Cost of Concrete Pavements.—The cost of concrete pavements is almost wholly dependent on local conditions, and the conditions are seldom exactly the same, even for two projects in the same locality. It is therefore evident that a tabulation of cost figures for projects which have already been completed would be of little service in estimating the cost of new work, unless the conditions which affected the cost of the completed work could be fully compared with those under which the proposed work is to be done. Furthermore, some of the conditions which affect the cost of work are extremely uncertain. Among these are the weather, the efficiency of labor, and what is commonly called the element of luck. These may all influence the cost of a project to a considerable extent, but their influence can seldom be expressed in definite figures.

The most satisfactory method of arriving at the probable cost of a proposed pavement is first to ascertain by careful measurements and computations the quantities of the materials to be used and the various kinds of work to be done. An itemized estimate based on these quantities and the unit costs which prevail in the community for such materials and work may then be made. To this estimate should ordinarily be added a reasonable amount to cover unforeseen contingencies, and, also, if the work is to be done by contract, a fair profit for the contractor. From 15 to 20 per cent. of the estimated cost is usually considered sufficient to cover these items.

In order to appreciate the importance of considering the different items separately in preparing an estimate of cost, it is necessary only to consider briefly the great amount of variation in unit costs.

The grading is usually paid for by the cubic yard of excavation, and the cost varies not only with the quantity but is greatly influenced by the character of the soil. In light, easily loosened soils grading may usually be done at from 25 to 40 cents per cubic yard. In hard earth containing more or less loose rock the cost per cubic yard generally varies from 40 to 75 cents, while grading in solid rock may sometimes cost as much as $1.50 per cubic yard. It is well to consider the cost of the rough grading entirely apart from the cost of the pavement. The drainage structures, however, may be considered together with the grading. The cost of these varies over such a wide range that no attempt will be made to discuss them here.

The cost of shaping and rolling the subgrade after the rough grading is completed is generally from 5 to 10 cents per square yard. This cost should be included with the other items which make up the cost of the pavement proper.

The cost of the concrete depends largely on the cost of the materials of which it is composed. These materials, delivered on the work, vary in cost according to the location of the work and the freight rates about as follows: Cement, from $1 to $2.50 per barrel; sand, from $0.60 to $2 per cubic yard; and broken stone or gravel, from $0.60 to $2 per cubic yard. The cost of mixing, placing, and finishing the concrete ordinarily varies from $0.60 to $1.25 per cubic yard, and depends on the efficiency of the organization and on whether the mixing is done by hand or machine. For machine mixing and labor at $0.20 per hour, $0.80 appears to be a fair average cost per cubic yard, including all overhead and incidental charges. The cost of constructing forms, contraction joints, etc., including the materials, is usually from $0.03 to $0.10 per square yard. Where simple types of joints and forms are used this cost should not exceed about $0.05 per square yard of pavement.

Maintenance.—The shoulders, slopes, and drainage structures of concrete roads require the same kind of maintenance as other types of improved roads and will, therefore, not be given special attention here. The maintenance of the pavement consists, for the most part, in repairing cup holes, cracks, contraction joints, and perhaps the renewal of an occasional defective area.

Cup holes are spots in the surface of the pavement which break down under traffic and which may result from any one of a number of causes. The most frequent cause for such defects is the presence of sticks, lumps of clay, particles of unsound stone, or other objectionable material in the aggregates. When cup holes first appear they are usually from 1 to 2 inches in diameter and from ½ to 1 inch in depth, but they become gradually enlarged by the action of traffic in loosening and abrading the concrete around their edges, and unless promptly repaired they may soon have an area of several square feet and a considerable depth. The action of traffic also gradually breaks away the concrete at the edges of cracks and joints, and if proper maintenance is not provided a considerable area of the surface of the pavement will be destroyed. The maintenance of cup holes, cracks, and joints usually consists of filling them with tar and covering the tar with coarse sand, pea gravel, or stone chips. Satisfactory results can be secured by this method only when a crew with proper equipment and materials goes over the road making necessary repairs at least two or three times a year.

Where defects of any considerable size are to be repaired the edges should be chiseled down until they are approximately vertical and not less than about 1 inch deep. The hole should be thoroughly cleaned and painted with tar, after which it should be filled with clean, coarse stone chips thoroughly grouted with tar. The surface of the patch should then be covered with coarse sand, pea gravel, or fine stone chips.

Either refined water-gas or coal-gas tar may be used for making such repairs, and satisfactory results may be obtained with both kinds. There is some difference of opinion among engineers as to just what consistency the tar should possess in order to give the best results, but the most general requirement in this particular seems to be that the tar when subjected to the float test in water at 50° C. will permit the float to sink in about 100 seconds. In order to apply a tar of this kind satisfactorily it is necessary that it be heated to about 225° F.

The repair equipment may consist of a small portable tar kettle, a horse and cart, pouring pots, wire brooms, hammers, and stone chisels.

When it becomes necessary to renew any portion of the pavement with Portland cement concrete that portion should be entirely closed to traffic, and the concrete should be mixed, placed, and cured in the manner described in the discussion of construction. The edges of the old concrete should be thoroughly cleaned and coated with neat cement mortar before the new concrete is placed.

A properly constructed concrete pavement ought to wear down uniformly and develop few defects. Poorly constructed and poorly maintained contraction joints are probably responsible for more defects of the kind described than can be attributed to any other one cause. For this reason the contraction joints should be given very careful attention at the time of construction.

[This is the third and final article of the series, prepared from information on concrete roads by the Office of Public Roads, U.S. Department of Agriculture.]

RAILROAD EARNINGS.

The railroad earnings for the first week of August are as follow:—

Canadian Pacific Railway

	1914.	1915.	Decrease.
August 7	$2,236,000	$1,787,000	— $449,000

Canadian Northern Railway

August 7	$ 259,500	$ 354,400	— $ 94,500

The Canadian Northern Railway earnings, July 1st to August 7th, were $1,466,000, and for the corresponding period last year, $1,948,700, being a decrease of $482,700.

Gross earnings of the Canadian Pacific Railway for the first week of August showed a decrease of $449,000. This compares with a decline of $705,000 for the last ten days of July, $562,000 for the third week of that month, $650,000 for the second week, and $677,000 for the first seven-day period. From July 1st to August 7th the earnings were $9,235,000, showing a decrease of $3,043,000.

HEAVY TRAFFIC.*

By Harcourt E. Clare.

In considering the subject of heavy traffic, regard must be had on the one hand to the benefit and assistance to trade and to the convenience that will accrue to a portion of the travelling public by encouraging it, and on the other hand to the increasing burdens that must fall on the taxpayer and ratepayer if the roads are maintained in a satisfactory condition to carry the traffic, and also to the convenience and safety of all other kinds of traffic having a right to use the roads.

The conditions pertaining to the transit of both passengers and goods in this country have been for the last few years and still are changing and developing along new lines, and although this has mainly been brought about by the extension of mechanical science in the construction of the vehicles, the change has also been accelerated by the inconveniences to trade caused by disputes between employers and employed in connection with our railways and sea ports. The development of motor traction has made it possible for traders to a certain extent to counteract the evil effects to trade arising from the congestion of traffic on the railways and at the docks, and has no doubt, generally speaking, reduced the cost of transit on the goods conveyed and facilitated quick delivery.

In such circumstances there has been a tendency for those who could see their way to make money or save expenditure by using the newer class of heavy vehicles to exercise their public right of user of the roads in a manner and to an extent not previously anticipated, and with little regard to the increased expenditure thrown on the public purse, or to the inconvenience caused to other traffic by breaking up roads which would otherwise be satisfactory. But the continuance of such excessive exercise of a public right may be the means of bringing about its own undoing by compelling those who have the care of the public purse to take up a hostile position to the heavy traffic development, and, with the support of the great majority of the public, to obtain parliamentary curtailment of the existing privileges to an extent that may seriously hamper the extension of heavy traffic on the public roads.

This, however, is much to be avoided, and the whole subject requires to be approached without delay, and with a desire to act with consideration for the different interests concerned, and all parties interested should co-operate in an earnest endeavor to agree on a set of conditions which, while placing reasonable limitations on the user of heavy vehicles on the roads, will yet not go to the extent of seriously checking the development of methods for cheapening and facilitating the transit of goods and passengers.

The main difficulty of road authorities at the present time has arisen through the extension of mechanical traction in road transit having outpaced their capacity to adapt roads which were, generally speaking, constructed and maintained for the lighter horse traffic to the new requirements. The new kind of traffic has also brought with it a great expansion in the distances travelled. Roads which, so far as the user is concerned, were previously almost purely parochial have become county, and those which were previously county have become national. While these changes have quickly come about, the financial burden of the maintenance of the roads, based on the old conditions of user, have still remained substantially unaltered, and many thousands of miles of road in the country are not constructed in a manner that makes them capable of bearing the wear caused by this heavy traffic. To put it shortly, the road authorities are faced with two difficulties—namely, the practical impossibility of so reconstructing the roads within a short period as to adapt them to the new character of traffic, and secondly, the injustice to ratepayers if the money for the purpose has to be found under the existing financial conditions.

But the financial question is, after all, the crux of the whole position, and until that is satisfactorily settled the progress of the reconstruction and improvement of the roads will necessarily be slow.

It is impossible exactly to define the line when the exercise by an individual of his legal right of user of a highway becomes, by nature of the user, such an abuse or public nuisance as to require the intervention of parliament. As a general principle, if a road is constructed to bear heavy traffic, then, subject to reasonable limitations with regard to weight, size, character of tires, and pace of the vehicle, the traffic should be encouraged in the general interests of trade; but if an individual chooses, for his own profit, to send heavy vehicles along roads which have neither foundations nor surfaces fitted to carry the weight of the loads, instead of sending them by another route where the roads can bear the effect of the traffic (and the extra distance would not be unreasonable), then it becomes desirable in the public interest that power should be given to the road authorities, if they think fit, to cause him to refrain from using the shorter route, unless the traffic comes under the definition of "extraordinary traffic," and he becomes liable to pay for the special damage done. It is unfair to the ratepayers that two or three of their number should be able to save a few hundred pounds a year in railway rates at a cost of some thousands of pounds a year to the public purse.

It is to the interest of every authority that has to levy rates to try to increase the assessable value of its area, and, subject to special exceptions, it may safely be left to the road authority to decide if it is in the interest of those they represent to exclude certain unfit roads from traction engines and heavy motor traffic, and especially motor-bus traffic, altogether, or to allow the traffic provided the vehicles comply with certain limitations as to weight, etc., and with or without a special contribution towards the repair of the roads. Heavy castings or other indivisable articles must be allowed to go by road, and would be among the exceptions; but, as a general rule, such a user of the roads comes under the description of "extraordinary traffic," and the special damage done is liable to be paid for by the person responsible for causing it.

But in the case of articles which can be divided in bulk, it is very desirable, in the public interest, that the load on any vehicle shall be more limited than it is at present, and that certain kinds of tires on wheels which by experience have been proved to cause special damage to roads shall be prohibited.

From reports made by road surveyors it would appear that motor buses running frequently on a definite route, and picking up passengers by the way, do more harm to what is ordinarily known as a waterbound macadam road than other vehicles, which, though carrying heavier weights, run less regularly and at a less speed; and this also applies, in a lesser degree, to the tarmacadam roads.

*From a paper read at the recent National Road Conference in London, England.

In the case of a road tramway for passengers the owners of the undertaking have to reconstruct that portion of the road which is occupied by the track at their own expense; they have afterwards to maintain it; they have to pay rates on the assessable value of the track; and usually they are placed under obligations with regard to regularity of service, and in giving cheap fares morning and evening for the working classes. None of these burdens or obligations attach to a company which chooses to start a service of motor buses between certain points along a road, and it is unfair to the general body of ratepayers that they should have to bear the burden of the extra expenditure incurred in keeping the road in repair in consequence of this particular service. It is only reasonable that a special contribution towards the increased expenditure should be required from the company running the motor buses, and this will only be putting the motorbus service somewhat on a level with the tramway service.

Where motor buses are used more or less casually, the road authorities should have power to schedule any roads which, by reason of their want of width, bad corners, or dangerous inclines and construction, make it undesirable, in the general interests of safety to other traffic, that these vehicles of large size should be allowed on those roads.

It is desirable that the question of regulating motorbuses and the special charges to be imposed on their user, be dealt with separately from that relating to other heavy traffic.

Leaving motor buses for the moment out of the question, there ought not to be much difficulty in representatives of road authorities, and manufacturers and users of heavy vehicles of all kinds, agreeing upon a classification of the vehicles, and the conditions to be made applicable to each case.

Class I. might include vehicles with limited weights which should be allowed without question (except in some special circumstances) to use any road.

Class II. might include vehicles not exceeding some greater weight, but in regard to these the road authorities should have power to exclude their user (except with consent) of certain roads which for the time may be scheduled as unfit to bear the traffic.

Class III. might include vehicles of still heavier weight than Class II. (including traction engines), which should require the license of the road authorities before being used.

If some scale of this kind could be settled, then both manufacturers of vehicles and the users would know exactly the conditions pertaining to each class, and could regulate their business accordingly.

With regard to every kind of traffic, it would be to the general public interest to give road authorities power to regulate traffic along a section of a road while it is under reconstruction or repair. As indicating generally what is proposed, if a road authority will take care when doing repairs on a road to leave a track sufficient to allow one vehicle at a time to pass without going on the part under repair, they should then have power to regulate the traffic in the interest of the public purse, as the police have power in boroughs to regulate it for the safety and convenience of the public, so as to provide that only one vehicle shall pass at a time along the track coterminous with the section of the road under repair. In fact, in cases where the traffic could, without inconvenience, be temporarily diverted along another road, it would be a great advantage for the road authorities to have the power of closing a road altogether during reconstruction; but this, of course, would not apply so as to affect ordinary access to property.

License duties upon some sliding scale should be imposed on all heavy vehicles, with an additional provision for the payment to the road authority for special damage done to the road by motor buses and extraordinary traffic.

There are other points of detail relating to drivers and their conduct which should at the same time be dealt with.

The writer has for many years past held the view that the best remedy for some of the difficulties with regard to railway rates and delivery which have arisen between the railway companies and traders is by the development of road transit, and that it would be to the best interests of the country for a large capital expenditure to be incurred in the widening of roads, the improvement of steep gradients, and the reconstruction of the foundations and surfaces where required, in order to provide facilities by road for the quick delivery of goods without transhipment from the point of production to the distributor or consumer. Within a period of, say, twenty years after the expenditure, a permanent value of probably 50 per cent. would remain in the roads with the debts discharged. But before such a scheme could be entered upon there must be made the financial readjustment of the burden between the Imperial and local purse, and also between special users of the roads and the public.

MEASUREMENT OF HIGH TEMPERATURES.

Measurement of temperature from a distance by means of radiation or optical pyrometers is apt to fail for two chief reasons: (1) The temperature of the surface on which the instrument is sighted is lower than that of the interior, even in the case where no oxidation occurs and no slag is present. In practice the presence of oxide or slag in layers of varying thickness renders it impossible to establish any fixed relation between the temperature of the surface and the true internal temperature, and hence concordant results cannot be obtained. (2) When fumes are rising from the ladle, as is frequently the case with alloys, the radiations received by the instrument are seriously diminished, and the reading, even if otherwise reliable, would be too low on this account. These difficulties have been partially overcome by Whipple's modification of Féry's radiation pyrometer, in which the pyrometer is permanently mounted at the open end of a fire-clay tube so as to be focused on the closed end, which is inserted in the molten metal. This method, while suitable for crucibles and small ladles, cannot be applied to large masses, as the readings would be affected by the intense heat existing in the vicinity of the pyrometer. The solution of the problem, therefore, appears to lie in some suitable application of the thermo-electric or resistance methods of measuring high temperatures. These are the views of Sir Robert Hadfield as recalled by Mr. C. R. Darling in a recent paper in The Engineer (London) on radiation pyrometers and their calibration.

In blasting operations one often encounters difficulty in loading holes that occur in soft rock. Where trouble is experienced by material falling into a hole from soft, loose strata near the top, if dynamite is the explosive in use, the hole may be filled with water before loading. This prevents the choking of the hole from falling earth and rock, as the pressure from the water either cements the fine material in place or prevents it from falling out.

COAL-TAR PRODUCTS USED IN MAKING EXPLOSIVES.

IN *The Canadian Engineer* for August 12th, an article appeared outlining the use of coal-tar products in various industries, including timber preservation, road making, power production and explosives. With respect to the last-mentioned product the following notes from a technical paper of the U.S. Bureau of Mines, prepared by C. G. Storm, will be found of interest:—

The coal-tar products of greatest importance as raw materials in the explosives industry of the United States are benzene, toluene, naphthalene, and phenol (carbolic acid). These materials are employed in the manufacture of the various nitrosubstitution products which have gradually found such wide application either as explosives or as ingredients of explosive mixtures.

As explosives the nitrosubstitution products of coal-tar derivatives are used as bursting charges for explosive projectiles, torpedoes and mines, and also for detonators and primers. As ingredients of explosive mixtures they are used (1) in various low-freezing or non-freezing mining explosives to lower the freezing point of such mixtures; (2) in certain colloidal or gelatinized explosive mixtures, where their property of forming colloids with the so-called "soluble nitrocellulose" is utilized to produce explosives that are plastic; and (3) in various other types of explosives for the purpose of imparting some desired characteristic. The most commonly known blasting explosives used in America, black blasting powder and "straight" nitroglycerine dynamite, contain no coal-tar derivatives.

In order to avoid the formation of products having inferior stability, it is generally essential that the benzene, toluene, or other raw material used in the preparation of the nitroderivatives should be of a high degree of purity.

Nitrobenzenes.—Mononitrobenzene, commonly known as "oil of mirbane," is little used in the explosives industry because of its volatility, although it is sometimes used as a minor constituent of certain low-freezing dynamites and other types of explosives. It is used much more extensively in soaps, lubricating greases, etc., mainly for the purpose of imparting a more or less agreeable odor. Furthermore, it forms an intermediate product in the preparation of aniline and its many derivatives.

Among the aniline derivatives of importance are tetranitroaniline and tetranitromethylaniline, both of which have in the past few years assumed prominence as detonating explosives for projectiles, mines, and torpedoes. Many other derivatives of aniline have been found to be applicable as stabilizers or as gelatinizing agents in nitrocellulose smokeless powders. Among such substances are methyl or ethyl phenyl urea, phenyl benzyl ether, phenylacetanilide, formanilide, and diphenylamine. The latter is, however, the only one which has been used in the States.

Nitrotoluenes.—The nitrotoluenes are more extensively used in the explosives industry than any other nitrosubstitution compounds, being employed chiefly for sensitizing certain types of ammonium-nitrate explosives and for lowering the freezing point of the low-freezing dynamites.

In the absence of exact statistics, a rough estimate places the amount of the various grades of nitrotoluenes used in the low-freezing dynamites manufactured in America in 1913, at about 2,000,000 lbs., while in the "permissible" explosives employed in coal mining probably 250,000 lbs. of the same materials were used during the same year.

Pure crystalline trinitrotoluene has proved one of the most efficient explosives for use in explosive shells, torpedoes, and mines, and is extensively used by almost every important military service, including that of the United States. In recent years it has also come into use as a substitute for a large proportion of the mercury fulminate in detonators (blasting caps) and as a charge for detonating fuse.

Nitronaphthalenes.—The nitronaphthalenes are used to some extent, chiefly as sensitizers in the "short-flame" permissible explosives of the ammoniumnitrate type. Certain derivatives of these compounds, the alkaline salts of nitronaphthalene sulphonic acids, produce, when mixed with sodium nitrate and other ingredients, explosives suitable for coal mining.

Picric Acid and Picrates.—Picric acid (trinitropheno) and certain of the picrates are highly important as military shell explosives; the acid is also employed in surgical dressings for burns and wounds. The manufacture of these compounds depends entirely on phenol (carbolic acid) as a raw material.

The possibilities of the use of the nitroderivatives of coal-tar products in explosives are far greater than is indicated by the above brief summary. Much investigative work on such compounds is being carried on.

URBAN AND SUBURBAN ROADS

THESE roads were briefly discussed by Mr. J. S. Brodie at a recent meeting of the Institution of Municipal and County Engineers of Great Britain as follows:—

Road Improvements.—The improvements of existing highways may be conveniently considered under the following headings: Foundations and wearing surfaces; Widenings; Diversions; Gradients; Corners and road junctions; Cutting hedges and trees.

Foundations and Wearing Surfaces.—It has frequently appeared from discussions on this subject in the press, and even at conferences of road engineers and road users such as the last International Road Congress, that there were no settled questions in regard to road foundations and surfaces. This view cannot be seriously maintained, however, as, on the contrary, we have agreed on points like the following:—

(1) All roads, whatever the amount of traffic may be upon them, must be properly drained, and must have adequate foundations, either of hand-pitched rubble or Portland cement concrete.

(2) The strength of the foundation must be fixed in relation to the amount of traffic it is likely to carry.

(3) Wearing surfaces must bear a proper relation both to the amount and nature of the anticipated traffic.

(4) Waterbound macadam under modern traffic conditions is unsatisfactory from any point of view.

(5) The use of any and every "local" stone for road making or mending solely on the score of cheapness of first cost is financially unsound and that only suitable material for roadmaking should be used.

(6) To make or maintain a road above or below the requirements of its traffic conditions is equally unsound financially.

Road Widenings.—It has recently been laid down by a high authority that, except in the immediate vicinity of towns, a metalled width of 18 feet of carriageway is generally adequate for traffic purposes.

Now, in urban or suburban areas, an 18-ft. width of carriageway between curbs is absolutely inadequate.

The writer's own practice is a minimum of 32 ft. 6 ins. between curbs for roads upon which there is any possibility of through traffic, and a minimum of 21 ft. for what may be considered merely as roads for access to residential property. The width of 32 ft. 6 ins. allows for a possible double line of tramways, and also for width of heavy motor cars, two very important advantages.

Larger widths are, of course, necessary for greater volumes of traffic; the ideal width providing for (*a*) two standing vehicles one on each side of the carriageway and immediately opposite each other; (*b*) two lines of slow traffic; and (*c*) two lines of fast traffic; or a total width between curbs of 54 ft.

Road widening improvements in built-up areas must always be very costly. Some interesting figures have recently been collected by Mr. W. T. Lancashire, city engineer of Leeds, and published by him, in regard to eight of the largest English towns, exclusive of London, who have collectively spent over 16½ million pounds sterling on road widening at an average cost of nearly one shilling in the £ on their rates.

The obvious moral is, therefore, that road widenings should be made (and made on a liberal scale) well in advance of building operations, when the cost will be quite insignificant and the future benefits very great.

Road Diversions.—Road diversions are generally made (*a*) in order to shorten the road or (*b*) to avoid excessive gradients by making a detour. In both cases the diversions can often be shown to be justified on grounds of economy alone. In a proposed diversion of a main road partly within (but chiefly outside) the writer's district, the length of the present road is 2 miles 80 lineal yards, while the length of the road when diverted in a nearly straight line will be 1 mile 5 furlongs 113 yards. It will thus be shortened by 627 lineal yards, or less than 83 per cent. of the present length. The gradients will be considerably improved in the new road, so that the annual saving in maintenance will be upwards of 17 per cent., which will be a very good return on the capital outlay for carrying out the scheme, and a permanent saving both as regards maintenance and use for all time.

On the other hand, the writer has made diversions where the horizontal length has been increased, but the reduction of gradient has been so considerable that both in regard to the user and also the cost of maintenance the advantages of the diversion have been amply proved.

Easier Gradients.—The writer considers there will be general agreement as to the three classes of ruling gradients in urban roads, *viz.*: For fast traffic, not exceeding 1 in 50; for mixed traffic, not exceeding 1 in 30; for purely local traffic, not exceeding 1 in 20.

In hilly districts, however, it will often be impracticable to obtain gradients even distantly approaching those given above.

Curves at Corners, Crossings and Junctions.—At all corners or turnings, the curves should not be less than 100 feet radius, and the convex side of the road having solid fence walls or close hedges should be removed and replaced with open railing, so as to be as free as possible from obstructions to sight for at least 100 feet forward.

Road junctions and cross roads should be properly bell-mouthed, when both sides of the road will, of course, be convex, and the same remarks apply.

Super-elevation, while it may be successfully adopted in simple turnings, should not be used at all in junctions or cross roads, but the cross road or junction should "mitre" into the main road, so as to avoid all "bumping" of fast traffic in both of the roads crossing each other.

Secondary roads joining or crossing main roads should have warning or cautionary notices fixed, to slow down, as fast traffic on main roads should always have precedence over traffic on secondary or district roads.

Cutting Hedges and Trees.—However picturesque they may appear, nothing will cause more harm to carriageway surfaces than overgrown and overhanging hedges and trees, which, by excluding the sun and wind from the surface of the road, prevent its being kept clean and dry. Hedges should be kept down by trimming at the proper time of the year, so as not to exceed 4 feet in height above the surface of the road, except at turnings, crossings and junctions, where, as already stated, they should be replaced by open fencing.

Road Maintenance.—The writer must reiterate that the most important factor in successful road maintenance is a staff of properly trained workmen, and especially reliable foremen, and also that such well-trained foremen and workmen should be adequately remunerated, proportionate to the experience and skill required for the work entrusted to them. No other outlay in connection with road work will make such a handsome return as a sufficient and well-trained, well-organized and well-paid staff of workmen.

Then, only materials of the best quality should be used, both in construction, repairs and renewals. A frequent cause of excessive costs in road renewals and repairs is due to the use of local material of low first cost, but which turns out to be terribly expensive in the long run. The temptation to use unsuitable material for road work because of its apparent "cheapness" should always be resisted.

It is also of supreme importance that any signs of weakness in any part of the road surface should be at once investigated, the cause of it clearly ascertained, the proper remedy applied and repairs effected without delay.

It is further of importance, not merely for the sake of good sanitation, but primarily in the interests of the road itself, that all dirt and filth should be cleansed from the road before it has time to be trodden in by the traffic.

The writer inserts herewith in a tabulated form the cost of maintenance of all the roads in the area for which he is the engineer, *viz.*, the County Borough of Blackpool:—

Comparison of Cost of Road Maintenance for the Last 10 Years.

Year ending March 31st.	Length of Roads. Miles dec.	Cost of Maintenance. Total cost. £	Cost per mile. £ dec.
1906	89.00	6,669	74.83
1907	91.33	5,036	55.14
1908	93.33	6,832	73.2
1909	94.16	4,929	52.33
1910	96.25	4,415	45.87
1911	97.75	4,917	50.3
1912	100.00	5,597	45.97
1913	100.75	5,395	53.54
1914	102.75	4,786	48.5
1915	104.14	4,485	43.06

It will be seen from this table that although the mileage of the roads has increased during the last ten years by about 17 per cent., the annual cost of maintenance has decreased about 32 per cent., the cost per mile showing a decrease of about 42 per cent.

The writer attributes this gratifying result entirely to insisting on all new roads being made on those principles which experience has shown to be the best; and in providing funds for practically reconstructing all existing roads so as to make them sufficient to meet all reasonable modern traffic conditions.

Editorial

ENGINEERS AND CITY GOVERNMENT.

There is a tendency on the part of the public to consider the function of an engineer is that of an official or civic servant, but that the prerogative of administering the departments belongs to the municipal politician who perchance might know something of the duties of the office he is seeking to fill, but usually has but a hazy idea of what he is elected to perform.

The fact that the engineer occupies such a retired position in the estimation of the public is one for which he is alone to blame. Engineers, as a rule, are silent yet ceaseless workers; they are not given to flag-wagging or stumping with abundant supply of rhetorics, but it would nevertheless be an advantage if engineers were to assert themselves more prominently in city affairs and, indeed, in all public affairs.

It is, of course, highly essential that the executive offices should be occupied by capable, experienced and tactful engineers, but it does not appear reasonable that their capacity, efficiency and tact should often be circumscribed by men elected by the public to administer and control such departments. We must acknowledge that there have been instances where such men have had the ability of applying good sound commercial experience. Still, these are exceptions and only emphasize the need for public men of technical, commercial and financial training to undertake public duties.

City government, as is well known, is largely an aggregation of engineering problems—water supply, sewerage, sewage disposal, refuse disposal, streets and roads, street railway, lighting buildings, bridges, and so on. It is an anomalous situation when the public elect men to represent them in the administration of city business who have often paid the minimum of attention to the problems which they are expected to solve. Of course, it will be urged that the officials are appointed for that purpose and the elected representatives have only to decide on the adoption or rejection of the schemes submitted. It is here where the city government is lacking in strength and foresight. Laymen are called upon to decide on technical matter, and sometimes outside influences are brought to bear on the projects with the object of frustrating the advice of the technical advisers.

The engineer's training should be of value to the public. The nature of his work calls for foresight, preparation for the future, stability, surmounting difficulties, co-ordinating the work of different classes given for one united object, administration, developing schemes with due regard to economy, efficiency and utility.

It is often asserted that it would be an advantage if the engineer was endowed with some measure of estheticism. The foregoing qualities are recognized in the construction and administration of the Panama Canal. Lord Kitchener and General Joffre—two engineers—are allotted stupendous tasks. These examples might be multiplied. Can it be denied that the training of these men have had their value in the minds of the publics they represent?

Engineers, however, like other men, are reluctant to enter a field where the recompense—if it can be so termed—is abuse and criticism. Engineers are not more sensitive to abuse and criticism but they have not gone through a schooling of casehardening and expect that public service merits something better. Public service calls forth the highest qualities of citizenship and this should be the key-note of city government.

A RAILWAY CONSTRUCTION PROBLEM FOR THE GOVERNMENT TO SOLVE.

Awarding railway construction jobs to other than Canadian contractors has occasioned at odd times a voice of protest here and there in Canada. There has been, perhaps, some measure of justification for local feelings of dissatisfaction, but in the great majority of instances matters of superior equipment, more stable organization, besides lower prices, have figured largely in the awards.

One of our readers has informed us that in the case of the recent award for the work of construction of a new line in the Hope Mountains, in British Columbia, there seems to be ground for controversy, however. Objection is raised by British Columbia men on the ground that as so much of the country's money is bound up in subsidies the work should go to the country's men. During the past few years a very large amount of railway construction has been going on in British Columbia, but almost without exception the work has been done by Seattle, Spokane, Portland or St. Paul firms. When the province guarantees the money borrowed by a railway company, or when the federal government grants big subsidies, it is contended that they should have some say in the awarding of the contracts; at least they should ask that Canadians be given some show if not some preference." It may be stated that the men employed are generally citizens of Canada, but on the other hand, "all the big salaries and all the profis go to men from the other side of the line, and the money goes to build up foreign cities and foreign institutions.

"In the case of the Hope Mountain contract there seems to have been some double-crossing done for the benefit of the United States contractors. Either that or the lumber to be used will come from the other side of the line. If the latter is the case, it seems odd that the government should subsidize big works and millions of dollars worth of material should be imported to complete the job. This may not be the case, but the fact is that the American firm was able to get its lumber supply at $1.50 per thousand feet less than local men, the one quotation being $7 and the other $8.50. If these figures were given by local mills, then they did not play fair, with the result that the work goes to a firm from the United States.

"In this connection the question has been asked how it is that non-Canadians can constantly get large works in this country which have been subsidized by the government. On the face of it, it seems odd that foreigners should directly profit from the taxes paid by Canadian citizens, while the man who helps to pay the impost whistles for work."

PAN-AMERICAN ROAD CONGRESS.

The programme of the Pan-American Road Congress, to be held at Oakland, Cal., September 13-17, under the joint auspices of the American Road Builders' Association, American Highway Association and the Tri-State Good Roads Association, contains the following list of papers to be presented at the technical sessions:—

(1) "The History and Future of Highway Improvement." L. W. Page, director, Office of Public Roads, U.S. Department of Agriculture.

(2) "The Relation of the Road to Rail and Water Transportation."

(3) "The Benefits and Burdens of Better Roads." S. E. Bradt, secretary, State Highway Commission, Illinois.

(4) "Roadside Improvement." Paper by Henry S. Graves, Chief, Bureau of Forestry, U.S. Department of Agriculture.

(5) "The Essentials of Proper Laws for Highway Work." Col. E. A. Stevens, State Highway Commissioner, New Jersey. A. N. Johnson, Highway Engineer, Bureau of Municipal Research, New York City.

(6) "National, State and Local Responsibility for Road Conditions and Ways of Securing Improvements." Judge J. T. Ronald, Seattle, Washington.

(7) "Proper Road Location: Its Importance and Effects." Paper by William R. Roy, State Highway Commissioner, Washington. Discussion opened by Paul D. Sargent, Chief Engineer, State Highway Commission, Maine, and by W. F. McClure, State Engineer, California.

(8) "Road Drainage and Foundation." Paper by Geo. W. Cooley, State Highway Commissioner, Minnesota. Discussion opened by R. K. Compton, Chairman, Paving Commission, Baltimore, Maryland.

(9) "Highway Bridges and Structures." Paper by W. S. Gearhart, State Highway Commissioner, Kansas. Discussion opened by Clifford Older, Bridge Engineer, State Highway Department, Illinois.

(10) "Highway Indebtedness: Its Limitation and Regulation." Paper by Nelson P. Lewis, Chief Engineer, Board of Estimate and Apportionment, New York City. Discussion opened by J. F. Witt, Dallas, Texas, by W. I. Vawter, Medford, Oregon, and by B. A. Towne, Lodi, California.

(11) "Organization and System in Highway Work." Paper by A. B. Fletcher, Chief Engineer, State Highway Commission, California. Discussion opened by H. R. Carter, State Highway Engineer, Arkansas, and by C. D. Blaney, chairman, State Highway Commission, California.

(12) "The Educational Field for Highway Departments." Paper by Prof. L. S. Smith, Department of Highway Engineering, University of Wisconsin. Discussion opened by A. D. Williams, Chief Road Engineer, West Virginia.

(13) "Roadway Surfacings." Paper by F. F. Rogers, State Highway Commissioner, Michigan. Discussion opened by E. R. Morgan, Roads Engineer, State Road Commission, Utah.

(14) "Resurfacing Old Roads." Paper by W. D. Uhler, Chief Engineer, State Highway Department, Pennsylvania.

(15) "Street Pavements." Paper by Curtis Hill, City Engineer, Kansas City, Mo. Discussion opened by M. M. O'Shaughnessy, City Engineer, San Francisco, California.

(16) "System in Highway Accounting." Paper by S. D. Gilbert, Auditor, State Highway Commission, New York. Discussion opened by A. R. Hirst, Highway Engineer, State Highway Department, Wisconsin.

(17) "Uniformity for Highway Statistics and Data." Paper by H. E. Breed, First Deputy, State Highway Commission, New York.

(18) "Engineering Supervision for Highway Work." Paper by T. W. MacDonald, State Highway Commissioner, Iowa. Discussion opened by Lamar Cobb, State Engineer, Arizona, and by Prevost Hubbard, Chief, Division of Road Material Tests and Research, U.S. Department of Agriculture.

(19) "The Merit System in Highway Work." Paper by Richard Henry Dana, President U.S. Civil Service Reform League. Discussion opened by Dr. J. H. Pratt, State Geologist, North Carolina.

(20) "The Determination of the Justifiable Outlay for Specific Cases of Highway Improvement." Paper by Clifford Richardson, New York City. Discussion opened by Henry Wells Durham, formerly Highway Engineer, Borough of Manhattan, New York City.

(21) "Convict Labor for Highway Work." Paper by G. P. Coleman, State Highway Commissioner, Virginia. Discussion opened by J. E. Maloney, Secy.-Engr., State Highway Commission, Colorado.

(22) "Motor Traffic: Its Development, Trend and Effects." Paper by Elmer Thompson, Secretary, Automobile Club of America. Discussion opened by Warren Gould, Chairman, Automobile Club, Seattle, Washington, and by W. G. Chanslor, San Francisco.

(23) "Equipment for Highway." Paper by Prof. A. H. Blanchard, Department of Highway Engineering, Columbia University. Discussion opened by H. J. Kuelling, County Highway Commissioner, Wisconsin.

(24) "Load and Tire Effect and Regulation." Paper by F. H. Joyner, Road Commissioner, Los Angeles California. Discussion opened by Prof. T. R. Agg, University of Iowa.

(25) "Comparisons of Traffic and Their Economic Value."

(26) "Maintenance, Materials and Methods." Paper by A. W. Dean, Chief Engineer, State Highway Commission, Massachusetts.

(27) "Dust Suppression and Street Cleaning." Paper by W. H. Connell, Chief Highway Bureau, Philadelphia, Pa. Discussion opened by Perry Brown, City Engineer, Oakland.

(Closing) "Lessons of the Congress." Paper by Charles F. Stern, Member State Highway Commission, California.

VALLEY ROAD TAKEN OVER.

The Government of New Brunswick has taken over the stock of the St. John and Quebec Railway Company and has named new officers for the company. The officers are: President, Irving R. Todd, St. Stephen; secretary, Edouard Girouard, Moncton; treasurer, John D. Palmer, Fredericton. Other directors are: W. S. Fisher, St. John and Richard O'Leary, Richibucto.

The Steel Company of Canada has closed a contract with the Dominion Gas Company, a subsidiary of Cities Service Company, covering the delivery to the Hamilton plants of the steel company of 6,000,000 cubic feet of natural gas daily.

The Engineer's Library

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

CONTENTS.

BOOK REVIEWS.

Surveying and Field Work. By James Williamson, A.M.I.C.E. Published by Constable & Company, London. First edition, 1915. 363 pp.; 271 figures; size, 6x9 ins.; cloth.

This work is prepared for the guidance of the student of surveying. It is principally a record of problems which have arisen in the author's experience and are of a type similar to those met with by every surveyor. For the beginner, however, his work covers a wide range; he first develops a conception of the subject generally, following with the more elementary surveying problems, the use of hand instruments, and the location of buildings and boundaries by tape alone, such as might be attempted by the student in the early stages of his career. Proceeding to the preliminary operations of a more advanced survey, he calls attention to the importance of fixing a general outline of the work in land, before commencing a survey, so that the result may be obtained in the easiest and most efficient manner, and with the least liability to error.

The author then takes up surveying instruments, the sextant, the compass and the transit, their construction and limitations, followed by a discussion on their use in problems in field work. Levelling occupies several chapters of both field work and note keeping. His chapter on contours, and their application to design, contains some very practical ideas. He uses a sewerage project to illustrate his argument. The chapter is well worth the attention of both the graduate and student. The closing chapters on the layout of curves, and mensuration tables are to be found in any field book in more convenient forms.

The arrangement of the work is open to improvement, and there is some repetition which might have been avoided and would add to the clearness. The solution of some problems are begun in one chapter and completed in a succeeding. On the whole, the book contains little information not already found in text books on this subject.

Water Purification Plants and Their Operation. By Milton F. Stein, Assistant Engineer of Design, Cleveland Filtration Plant. Published by John Wiley & Sons, New York. 250 pp.; size, 6x9 ins.; illustrated. Price, $2.50 net.

Mr. Stein, who is assistant engineer in charge of the Cleveland filtration plant, gives in a simple and concise manner instructions for the operation of water purification plants. The author has succeeded in treating the subject in a manner that will appeal to the non-technical operator, although certain phases of the subject have been treated very elaborately and these chapters will be of especial value to the chemist in charge of such plants.

For the operator of a purification plant the author gives full information and data on such subjects as standard solutions; making bacterial and chemical tests of water; handling coagulants; washing filters; keeping records.

In Chapter I., Water and Its Impurities, the author deals with the various types of purification that are common to domestic water supplies.

Chapter II., Types of Purification Plants, there is a very complete description of the various types of filters now in use in America. In several instances the author has dealt with the efficiency of the plant.

Chapters III. and IV. deal with the physical, chemical, and bacterial tests. These particular chapters will appeal especially to the chemists and the technical men responsible for the work of the plant.

Chapter V., Interpretation of Tests, is a chapter which is complete, yet not too full of detail.

Chapter VI., Coagulation and Sterilization. This is a very practical chapter and one very valuable to those in charge of the actual operation of the plant.

Chapter VII., Water Softening; Chapter VIII., Sedimentation; Chapter IX., Filtration and General Operation.

The book is well supplied with illustrations and diagrams and is altogether one of the most useful publications that has come to our notice in connection with the operation of filtration plants.

PUBLICATIONS RECEIVED.

Geology of Cranbrook District.—Memoir 76, No. 62, Geological Series of the publications of the Geological Survey, Ottawa, deals with the geology of Cranbrook map area, British Columbia. It is written by Stewart J Schofield.

Coal Fields of British Columbia.—Memoir 69, No. 57, Geological Series, published by the Geological Survey, Department of Mines, Ottawa, is a history and analysis of the coal fields of British Columbia, compiled by D. B. Dowling.

British Columbia's Mines.—Annual report of the Minister of Mines for the year ended December 31st, 1914, being an account of the mining operations for gold, coal, etc., in British Columbia; illustrated with charts and photographs.

Wind Stresses in Steel Frames.—Bulletin No. 80 of the Engineering Experiment Station, University of Illinois. It deals with wind stresses in the steel frames of office buildings and is written by W. M. Wilson and G. A. Maney, and published by the University of Illinois, Urbana, Ill.

Topographical Surveys.—Annual report of the Topographical Surveys Branch, 1913-1914, of the Department of the Interior. This contains a report of the surveyor-general of the Dominion lands; the reports of surveyors, and various schedules and statements. It is illustrated with photographs, maps and profiles.

Dust Prevention and Road Preservation.—Bulletin No. 257 of the United States Department of Agriculture, Washington, D.C., is a contribution from the Office of Public Roads, of which Mr. L. W. Page is director. It summarizes progress reports of experiments in dust prevention and road preservation, 1914.

Products and By-products of Coal.—This bulletin, published by the Mines Branch of the Department of Mines, Ottawa, has been written by Edgar Stansfield, M.Sc., in collaboration with Dr. F. E. Carter, B.Sc., Dr. Ing., under instructions received from Mr. B. F. Haanel, chief of division of fuel and fuel testing.

Forestry and Irrigation.—The annual report of the Department of the Interior, Ottawa, (Vol. 2) for the fiscal year ended March 31st, 1914, contains an interesting report on irrigation by the superintendent of irrigation, and also a report on small water powers. The volume is well illustrated with charts and photographs.

Buying and Selling of Ores and Metallurgical Products.—By Charles H. Fulton. In this paper an attempt is made to outline clearly the underlying principles, the subject-matter being based on personal experience and investigation. This is technical paper No. 83, containing 44 pages, published by the Department of the Interior, Bureau of Mines, Washington, D.C.

Production of Explosives.—The production of explosives in the United States during 1914 with notes on coal mine accidents due to explosives, compiled by Albert H. Fay, is a subject of technical paper No. 107 of the Bureau of Mines, Department of the Interior, Washington. The total production of explosives in the United States in 1914 was 450,251,489 pounds.

Ontario Good Roads Association.—Proceedings of the 13th annual meeting of the Ontario Good Roads Association, being also the proceedings of the second Canadian and International Good Roads Congress and exhibition held at Convocation Hall, Toronto, March, 1915, appended to the annual report of the Provincial Engineer of Highways, Parliament Buildings, Toronto.

Explosions in Coal Mines.—Methods of preventing and limiting explosions in coal mines are discussed in technical paper 84, Bureau of Mines, Department of the Interior, Washington, by George S. Rice and L. M. Jones. Although advance in the knowledge of mine explosions, particularly coal dust explosions, has been slow, yet since investigations were begun in 1908 by the testing stations of various countries, progress has been steady, each station contributing to the general fund of knowledge.

State Management of Public Roads.—The development and trend of the state management of public roads, a report by Mr. J. E. Pennybacker, chief of road economics, office of public roads, Washington, D.C., has been reprinted in pamphlet form from the year book of the Department of Agriculture for 1914. The whole development of state road management in the neighboring republic has been towards a larger measure of participation by the state through increased appropriations and more comprehensive state supervision.

Oil Mixed Concrete.—In Bulletin No. 230 of the United States Department of Agriculture appears a contribution by Logan W. Page, director of the Office of Public Roads, on the subject of Oil-Mixed Portland cement concrete. While experimenting in his office in an attempt to develop a non-absorbant, resilient and dustless road material, one capable of withstanding the severe shearing and raveling action of automobile traffic, the writer's investigations lead him into a very promising discovery. He found that when a heavy mineral residue oil was mixed with Portland cement paste, it entirely disappeared in the mixture and, furthermore, did not separate from the other ingredients after the cement had become hard.

CATALOGUES RECEIVED.

Centrifugal Pumps and Centrifugal Pumping Units.—Bulletin No. 1632 of Canadian Allis-Chalmers, Limited, Toronto, describing the different types of their centrifugal pumps, with illustrations of same.

Civil Engineering Instruments.—An illustrated catalogue of 223 pages, issued by W. and L. E. Gurley, Troy, N.Y., describing a complete line of instruments used in civil, mining and hydraulic engineering and land surveying.

Directory of Piston Ring Sizes.—A new catalogue published by the Burd High Compression Ring Co., Rockford, Ill., describing their piston rings for automobiles, motorcycles, cycle cars, trucks, tractors and engines. Price, 50c.

Chlorine Control Apparatus for Water and Sewage Purification.—A 36-page illustrated catalogue, published by the Wallace & Tiernan Company, Inc., New York, describing their automatic control and manual control chlorinators.

An Unusual Exhibit.—An illustrated pamphlet, issued by the Des Moines Steel Co., Pittsburgh, Pa., describing their exhibit at the Panama-Pacific International Exposition, San Francisco, and giving a list of elevated steel tanks and standpipes erected by them previous to 1915.

Lumina Solid Steel Windows, Doors and Partitions.—A 48-page, well-illustrated catalogue, issued by the Detroit Steel Products Co., Detroit, Mich., describing the utility of these constructional necessities, together with important installations made by this manufacturing firm in Canada.

GOVERNMENT BOUNTIES FOR ZINC.

Bounties on a sliding scale, not exceeding two cents per pound, will be granted by the Dominion government upon production in Canada from Canadian ores of zinc, containing not more than 2 per cent. impurities, when the standard price of zinc in London, England, falls below £33 per ton of 2,000 pounds, provided that bounties shall not be payable on zinc produced before the expiration of the war or after the 31st day of July, 1917, or on zinc contracted for the Shell Committee at a price of 8 cents or over per pound, total amount of bounty to be paid not to exceed $400,000.

As a result of this action on the part of the Government the Canadian shell committee, on behalf of the Imperial War Office, has been able to contract for several thousand tons of zinc at very reasonable rates with a further reduced rate for further deliveries.

The object of the bounty is to insure the producers against too great a fall in price in the period between the end of the war and the 31st July, 1917. The bounty will give an impetus to the refinement of zinc in Canada and serve the purpose of ensuring a certain supply of brass to the shell committee.

IMPORTANCE OF WATER STORAGE.

The problem of properly conserving and utilizing the water resources of a country is neither new nor novel. The great hydro-electric development in Canada requires strict control and present conditions cannot be adequately dealt with by the legislation and the ideas of twenty years ago. The water-power wealth of Canada is one of the principal assets of the country and it is most urgent that not only the governments but also individuals interested in water-power schemes should recognize the importance of expert regulation and control of our streams. Water conservation and storage has ceased to be looked upon as a sentimental idea only, and its immediate economic value has become clearly recognized.

Every cubic foot of water, as it passes over falls and rapids in large and small streams on its journey to the sea, has an element of power which is lost forever if not used at the time of its passage. All have noted the difference between the enormous volume of water rushing down our streams during the spring floods and the much diminished flow at the end of summer, which in the majority of our streams, is further reduced during the winter months. Most water-power enterprises have been planned to utilize only this low, winter flow and allow the large additional volume available at other times to pass without obtaining a single horse-power of useful work from it, thus utilizing the full amount of power only during four months in the year. For comparison and to furnish an idea of the amount of power going to waste during the remaining eight months, it may be stated that one cubic foot of water per second passing over a ten-foot fall during the remaining period represents 14 tons of coal during that period.

A similar illustration is given by considering the waste at points where water-power is being used. With the exception of Niagara and the St. Lawrence River, whose flow is exceptionally well regulated by nature, the average yearly flow of our streams is from two to ten times their minimum flow. As, in most cases, developments provide only for the minimum flow of streams, it follows that the water wasted is from one to nine times that used. Taking the lowest figure, that is, assuming that the power wasted is equal to the power used, and taking the total power developed in Canada exclusive of Niagara and the St. Lawrence as 1,000,000 h.p., we find a yearly non-use of water-power in Canada equivalent to 12,000,000 tons of coal due to non-storage of water.

RAILROAD EARNINGS.

The following are the railroad earnings for the month of July:—

Canadian Pacific Railway.

	1915.	1914.	
July 7	$1,666,000	$2,343,000	— $677,000
July 14	1,635,000	2,285.000	— 650,000
July 21	1,670,000	2,232,000	— 562,000
July 31	2,476,000	3,181,000	— 705,000

Grand Trunk Railway.

July 7	$ 990,278	$1,048,006	— $ 57,728
July 14	989,629	1,072,872	— 83,243
July 21	980,898	1,010,895	— 29,997
July 31	1,537,141	1,592,244	— 55,103

Canadian Northern Railway.

July 7	$ 258,800	$ 362,000	— $103,200
July 14	279,100	375,000	— 95,000
July 21	277,100	378.000	— 101,800
July 31	391.100	478.400	— 87,300

COAST TO COAST

Calgary, Alta.—It is expected that the new elevator which has been completed will be opened shortly.

North Bay, Ont.—The new government trunk road between North Bay and Sturgeon Falls is now open for traffic. The new road extends a distance of 23 miles and has taken over a year and a half to complete.

Quebec, Que.—The foundation stone of the new Union Station at the Palais has been laid by His Worship Mayor Drouin, and it is expected that by the New Year the new station will be in use.

Vancouver, B.C.—The new $80,000 addition to the provincial courthouse in this city has now been completed and is ready for use. The architects were Messrs. Gardiner & Mercer, and the contractors, the Dominion Construction Co.

Regina, Sask.—With this year's construction programme completed last week, the city now has 67¾ miles of sewers laid within the city limits, including storm sewers and 73¼ miles of water mains, including the supply mains from Boggy Creek.

Ottawa, Ont.—So far this year 4.6 miles of concrete sidewalks have been laid in this city. Already passed by the council and yet to be constructed are 1.8 miles. It is estimated that this year's sidewalks will cost about 22 cents per square foot. Ottawa now has a total of 201 miles of concrete sidewalk.

Vancouver, B.C.—The contractors for the government jetty at the North Arm of the Fraser River expect to complete their contract this week and will then concentrate their efforts on the second unit of the main channel jetty, on which favorable progress has been made on account of the weather conditions.

New Westminster, B.C.—The city's new five-million-gallon storage reservoir, located adjacent to the present high level track, is now practically completed, and will provide an added safeguard against shortage on the upper levels of the city for fire protection purposes. The two reservoirs situated at the top of Eighth Avenue will have a storage capacity of over seven million gallons. These storage receptacles are fed from a 14-inch main, which delivers in the neighborhood of a million gallons every 24 hours, making the storage capacity equivalent to seven days' supply.

London, Ont.—The new syphon chamber on Riverside Avenue, where the city sewage is elevated on its way to the disposal plant, has been completed. The work was commenced about three months ago, and during the period of construction the sewage flowed into the river. The syphon is provided with a necessary valve for flow regulation and is expected to be the means of entirely eliminating a long-termed nuisance. Mr. Willis Chipman, Toronto, was consulting engineer to the city in connection with the installation.

Toronto, Ont.—Operations at the Don Valley section of the Bloor Street viaduct continue rapidly. The contractors state that they are now considerably ahead of schedule time. Concrete footings are now completed at pier "A," and also at pier "B." The first lift on concrete above the footing has been finished at pier "C," whilst at pier "D" the work is 20 feet above ground level. Excavating is going on in full swing at pier "E," and men are busily driving steel sheeting. At pier "F" the first lift above the footing is being erected, and will stand about 12 feet high. At pier "G" excavation is still in progress. At the main abutment at Danforth Avenue the grading is almost completed.

Quebec, Que.—The contractors in charge of the work being done on the St. Charles River harbor improvements, Messrs. Quinlan and Robertson, have made great progress within the last four months, so much so, in fact, that by the close of navigation the dam above the locks will be completed. At present there are in the neighborhood of some three hundred men employed on the works. Vast improvements are to be made on the Louise Embankment along the bank of the river in order to meet the requirements of traffic which will necessarily result from the completion of the locks and dam. The area southeast of the locks, nearest the embankment, and below the C.N.R. bridge, is to be filled in, and used as a freight yard. A highway bridge will be started next summer, of the bascule type, with telephone wires and cables running beneath the locks, so that the work now under way on the St. Charles River is a stupendous undertaking.

PERSONAL

HARRY WALSHAW has been appointed temporary building inspector of Calgary.

W. J. DOHERTY has resigned the position of general sales manager of the Northern Electric Company, Limited, Montreal, to go into business in Chicago.

A. D. SMITH, electrical inspector for Fort William, has been recalled to Ottawa by the hydro-electric commission. He will be succeeded by Mr. E. G. Jaffray, of Port Arthur.

R. W. FORD, superintendent of the Vancouver Gas Company, has resigned in order that he may devote all his time to military affairs. Mr. G. Porter, electrical engineer for the B.C.E.R., succeeds him.

R. H. MURRAY, A.M.Inst.C.E., resident sanitary engineer for the province of Saskatchewan, has received an appointment with the overseas forces under the British Army Medical Corps. He sails for England on August 28th.

Major C. N. MONSARRAT, who is chief engineer of the board of engineers of the Quebec bridge, has succeeded Lieut.-Col. J. G. Ross as officer commanding the 5th Royal Highlanders of Canada. Col. Ross is leaving for England where he will be attached to the staff of Brigadier General Carson in charge of Canadian troops.

GEORGE HENDERSON has been appointed to the vacant positions of president and general manager of Brandram-Henderson, Limited, Montreal. The new head is a son of the late Joseph R. Henderson, who was president and general manager for many years. He has been a director for some years, having had charge of the Maritime branch of the business.

OBITUARY.

The death occurred on August 20th, at Peterborough, Ont., of John E. Belcher, C.E., aged 80, who for many years filled the positions of county engineer and city engineer.

Second Lieut. D. Hook, a Canadian civil engineer, son of Allan J. Hook, Vancouver Island, has been killed in action. He went to England on the outbreak of the war and after a course of training obtained a commission in the Lancashire Fusiliers and went out to France early in July.

On August 17th an explosion occurred in the match factory at St. Casimir, Que., killing Nicholas Murphy, a well-known inventor and electrical engineer, aged 23.

The death occurred at St. Lambert, Que., of L. A. Roberge, a veteran railway contractor, at the age of 77. The late Mr. Roberge was promotor, builder and president of the famous railway that used to run on the ice from Montreal to Longueuil.

COMING MEETINGS.

PROVINCIAL ASSOCIATION OF FIRE CHIEFS.—Annual Convention to be held in Ottawa, Ont., August 24th to 27th, 1915. Secretary, Chief James Armstrong, Kingston, Ont.

NEW ENGLAND WATERWORKS ASSOCIATION.—Annual Convention to be held in New York City September 7th to 9th, 1915. Secretary, Williard Kent, 715 Tremont Temple, Boston, Mass.

AMERICAN ROAD BUILDERS' ASSOCIATION and AMERICAN HIGHWAY ASSOCIATION.—Pan American Road Congress to be held in Oakland, Cal., September 13th to 17th, 1915. Secretary, American Road Builders' Association, E. L. Powers, 150 Nassau Street, New York, N.Y. Executive Secretary, American Highway Association, I. S. Pennybacker, Colorado Building, Washington, D.C.

AMERICAN ELECTRO-CHEMICAL SOCIETY.—Twenty-eighth annual general meeting to be held in San Francisco, Cal., September 16th to 18th, 1915. J. M. Muir, 239 West 39th Street, New York City, Chairman of Transportation Committee.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—Convention to be held in San Francisco, Cal., September 16th to 18th, 1915. Secretary, Calvin W. Rice, 29 West 39th Street, New York City.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—Convention to be held in San Francisco, Cal., September 16th to 18th, 1915. Secretary, F. L. Hutchinson, 29 West 39th Street, New York City.

AMERICAN SOCIETY OF CIVIL ENGINEERS.—Annual convention to be held in San Francisco, Cal., September 16th to 18th, 1915. Secretary, Charles Warren Hunt, 220 West 57th Street, New York.

INTERNATIONAL ENGINEERING CONGRESS.—To be held in San Francisco, Cal., September 20th to 25th, 1915. Secretary, W. A. Catell, Foxcroft Building, San Francisco, Cal.

AMERICAN ELECTRIC RAILWAY ASSOCIATION.—Annual convention to be held in San Francisco, Cal., October 4th to 8th, 1915. Secretary, E. B. Burritt, 29 West 39th Street, New York.

NATIONAL PAVING BRICK MANUFACTURERS' ASSOCIATION.—Annual convention to be held in Dayton, O., October 11th and 12th, 1915. Secretary, Will P. Blair, B. of L. E. Building, Cleveland, O.