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Survey Monuments

Permanent Posts of Iron, Bronze and Concrete Now Supplanting Buried Tokens—Paper Read Before the Association of Ontario Land Surveyors

By J. W. PIERCE
Dominion and Ontario Land Surveyor

A MONUMENT has been defined as an object fixed in the soil, whether natural or artificial, and referred to in a document, and used as evidence for the delineation of boundaries or the situation of a particular plot of land.

Possibly too little attention has, in the past, been paid to this most important part of a surveyor's duty, and it is the purpose of this paper to discuss some of the more common types of monuments in use heretofore, with their advantages and disadvantages, and to describe some improvements that have been introduced.

Until comparatively recently, on ordinary land surveys in Ontario, the wooden post or a tree marked for a post has been used exclusively, due to the readiness with which posts of this material may be everywhere procured, and to the ease with which they may be set in place. Monuments of this class, when made of proper material and firmly planted, are without doubt very satisfactory for a short time after erection; they are readily located and easily interpreted, and if they were only more permanent, they would be ideal. Doubtless, the expectation of those responsible for the use of this type of monument was that it would remain in place until such time as the owners had entered into possession of their lands, after which it would naturally appear that the duty of preserving the monument would fall on those immediately interested. Unfortunately, landowners in this country pay little or no attention to the preservation of monuments, with the result that after a lapse of a few years, the great majority of our monuments are lost, in many cases beyond recovery. It is not necessary to point out to land surveyors the multitude of grave evils that are the direct result of lack of permanence of our early, and unfortunately to a great extent, our present type of monument.

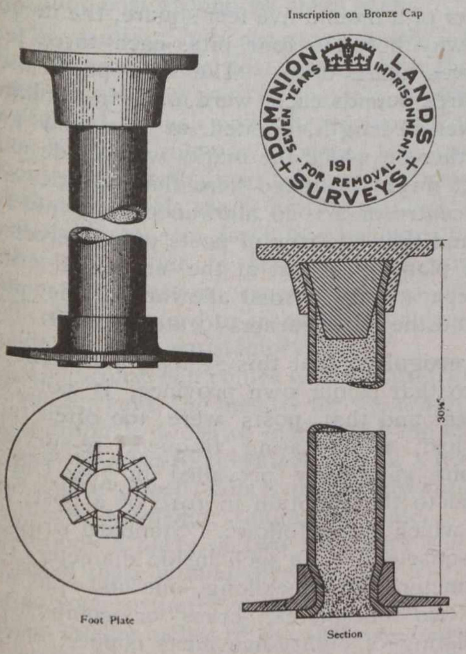


Fig. 1. Standard Survey Post.

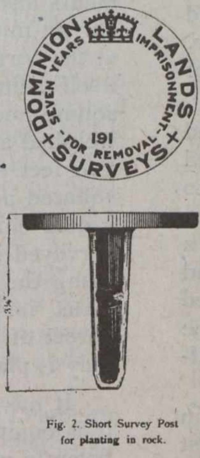


Fig. 2. Short Survey Post for planting in rock.

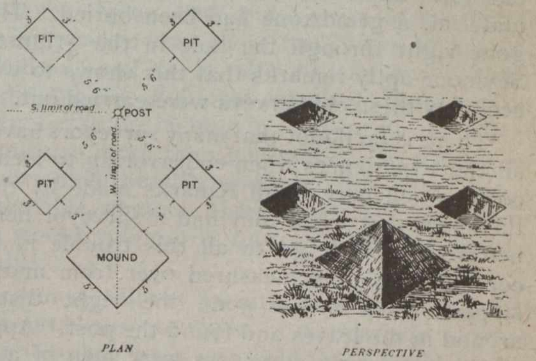


Fig. 3. Monument at township or section corner defining four sections

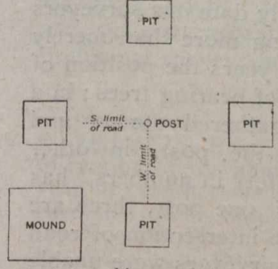


Fig. 4. Monument at township or section corner for south side of correction line.

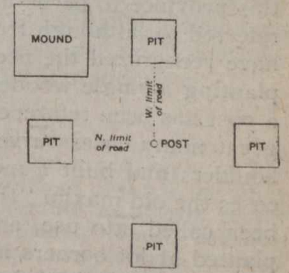


Fig. 5. Monument at township or section corner for north side of correction line.

There is apparently little room for doubt that it is not good practice to plant these very temporary monuments at the time of survey and leave their perpetuation to others in later years, and it is interesting to note the various departures from the plain wooden post that have from time to time been introduced with a view to making monuments more permanent.

In some of the foreign countries, and in fact in some of the earlier surveys in provinces in this country, it was customary to bury pieces of crockery, glass or other permanent material under the post, and in this connection we find the following instructions in the United States Manual of 1871: "Besides the charcoal, marked stone, or charred stake, one or the other of which must be lodged in the earth at the point of the corner, the deputy surveyor is recommended to plant midway between each pit and the trench, seeds of some tree (those of fruit trees adapted to the climate being always preferred), so that in course of time should such take root, a small clump of trees may possibly hereafter note the place of the corner. The fact of planting such seed and the kind thereof are matters to be truthfully noted in the field book."

In a very instructive paper prepared by Mr. Seymour on various forms of Dominion Lands Survey's monuments and read at the annual Dominion Land Surveyors' meeting a year ago, the following "true story" published in the Engineering News was quoted: "Called on to locate a certain corner that had been established many years ago, a surveyor of repute found that his nearest known starting point was some eleven miles away. The survey party commenced operations with every care, and at last, according to calculations, the desired corner was reached. The picket was jammed down into the earth with the expectation of coming into contact with the 'deposit,' but nothing seemed to be encountered. What could be wrong? The surveyor commenced to carefully check his calculations, but soon gave a joyous shout; the old notes explained that in the absence of other suitable material, a grindstone had been buried. The picket had gone right through the hole in the grindstone." Mr. Seymour aptly remarks that this shows to what degree of accuracy these old surveys were carried out.

There is no doubt that many surveyors have encountered similar experiences when endeavoring to locate obliterated corners and may recall remarks made by their clients to the effect that when they had a surveyor here forty years before, he didn't go to all this trouble in hunting up a corner; he simply measured over from another post and stopped when he had gone the right distance, kicked around in the leaves and found the post. Apparently some of our very early surveyors were men of an entirely different calibre to those of the present day.

So far as I am aware, it has never been the custom in this province to perpetuate monuments in the manner just referred to, although from a very early date our surveyors have recognized the necessity of doing more than merely planting a single wooden post. For years the position of a post has been referenced by means of bearing trees; in a great many cases surveyors have gathered stones and boulders and built a mound around the post, in other cases the old maxim "that there is safety in numbers" has been called into use, and instead of one post, three are planted at lot corners and five at the intersection of road allowances. Indeed, in some cases surveyors were unable to limit themselves to five posts. An examination of some of the original notes reveals the fact that in certain townships three rows of three posts, or nine in all, were planted at these intersections. In our present nine-mile township this system of posting is still in use, and in cases where the road allowance along a river or lake intersects the intersection of a concession and side road, you have your day's work right there. In many of these cases, our most experienced surveyors are unable to agree among themselves just where posting should be stopped and how some of these posts should be marked, and when we consider that these posts are often put in place by chainmen who are not always infallible, it is occasionally a source of speculation in camp as to whether this method of posting is the best and most efficient that could be evolved.

In after years, when one has occasion to work in this system of survey, it is not uncommon to be shown the position of one, only, of these posts with nothing to indicate which of the three, or five, or nine, as the case may be, it is. In cases such as this, it is only necessary to remark that the surveyor's troubles are often only commencing.

The disastrous effect of forest fires has been recognized to the extent that in our later surveys in Northern Ontario, surveyors have been supplied with supplementary iron posts which are planted at stated intervals throughout the township, such as the corners of a three-mile block, but no step, except a legal measure, has been taken to safeguard the post from loss through wilful removal or tampering through idle curiosity. It is common knowledge that in new country especially, survey lines are usually used as the first roads and consequently many persons who have otherwise no interest in monuments, are brought in contact with them, frequently to the detriment of the monument.

Until recently, subdivision surveys have been carried on in the provinces of Manitoba, Saskatchewan and Alberta under conditions entirely different to those obtaining in our own province, and the method of posting has necessarily also been different. Over a great portion of the West, it was impossible to obtain material to make wooden posts such as ours, and various types of monuments have been in use, the most common being the iron bar set midway between four pits; or in bush, the iron bar at the north corner of a mound five feet square, the mound itself being midway between four pits, each three feet square and eighteen inches deep. The iron posts used weighed about three pounds each, were made from piping two feet six inches in length, pointed at one end and squared at the other on which the marks were made with a cold chisel. It might be noted here that no lines are surveyed in the centre of a road allowance, but always along the side, and that one row of posts only is erected. Thus, instead of planting a post at the angle of every parcel of land separated by a road allowance, one post only is planted and the other corners located from it.

It has been recognized that this system, admirable as it is compared to that in our own province, is not sufficiently permanent and that posts were too often tampered with and lost, necessitating frequent re-surveys. Similar conditions apparently prevailed in the United States, which led to the adoption in 1910 of a post, the specifications of which are as follow: "Standard wrought iron pipe, three-quarters of an inch inside diameter, one inch outside diameter, three feet long, one end split and spread forming two foot plates, brass or composition metal cap, consisting of eighty-five parts copper, eleven and one-half parts zinc, two and one-half parts tin and one one part lead, five-sixteenths of an inch thick to lap three-quarters of an inch on pipe and flush on the end, so as to leave no space between cap and end of pipe and firmly riveted thereto; cap to be lettered as indicated, with cast letters indented. A space one inch in diameter to be burnished in order to show stamping of marks more clearly; inside of pipe to have concrete core and bottom of pipe to have rivet, bolt, or wire to secure core. Core to be of Portland cement and sand in equal parts; pipe to be coated, while hot, inside and out with mineral asphaltum rubber coating."

During the first year of the war the Surveyor-General of Dominion Lands carried on correspondence with the Commissioner of the General Land Office at Washington and also asked the various land surveyors then employed for their suggestions and criticisms, which has resulted in the adoption of a new model iron post for Dominion Land Surveys based on that used in surveys of the public lands of the United States, which has just been described.

This post consists of a standard wrought iron pipe one inch in diameter, thirty inches in length to the top of which is fastened a bronze cap three inches in diameter. The cap, instead of being riveted to the pipe, as in the United States model, has in the latest model a cast-iron cone inserted in it, and the end of the pipe is forced into the annular space between the cone and the cap, forming a very tight fit. The composition of the cap is ninety parts copper, five parts tin, four parts zinc and one part lead. A malleable iron foot-plate three and one-half inches in diameter with a hole smaller than the diameter of the pipe, is forced over the other end of the pipe, which has first received six equally spaced saw-cuts, after which the cut parts are bent down, thus insuring that the foot plate will neither move up nor down along the post. The whole post then receives a protective coating by being dipped into a vat of Mexican asphaltum, after which the pipe is compactly filled with a cement mortar consisting of equal parts of Portland cement and sand. After the cement is set, the face of the bronze cap is cleaned off with gasoline.

These posts weigh about eight pounds and are packed in basswood crates, ten to a crate, the total crate weighing eighty-five pounds. They cost the government last year $11.10 a crate f.o.b Winnipeg, or $1.11 each. Two years ago they cost around 70 cents each.

In planting, it is necessary to dig a hole thirty inches deep to receive the post, after which the earth is tamped back around the post so that the bronze cap only is exposed and is flush with the surface of the ground. The post is placed midway between four pits and in bush country the earth from the pits is formed into a mound. Various methods are in use for planting the post. In soil free from stone or frost, the ordinary post-hole augur is satisfactory, but in ordinary bush country where roots, stones and frost are encountered, in addition to greater difficulty in regard to transportation, an iron bar and the spade are most satisfactory.

The bronze cap comes with the inscription of Dominion Lands Surveys, the penalty for the removal and the crown in addition to a centre mark, and the chainmen are supplied with a set of seventeen dies in a leather belt, similar to a cartridge belt, which are used to stamp on the section numbers, township, range and date. Under ordinary conditions a party of two mounders will erect from four to six of these mounds per day.

In rocky country, where the rock is at the surface or within twelve inches of the surface, a special post is used. This post is entirely of bronze, the top being identical with that of the standard post from which a seven-eighths inch shank projects for three inches, the weight being under a pound. In planting this post a hole is drilled in the rock three inches in depth and filled with a paste composed of a mixture of Portland cement and water, into which the post is pressed. The necessary cement is supplied in small water-tight tins and special drills are used. The drills are well suited to the purpose; they are light and will stand for two or three holes in the very hardest of granite. When dull, they are returned to the head office for resharpening. A five-pound hammer has been found most suitable and the length of time necessary to plant a post in rock is seldom over twenty minutes, the average being nearer fifteen. It may be mentioned here that the rock posts are in great favor with the surveyors, who now would sooner make rock monuments than those in earth.

For use on townsite surveys, a post similar to the thirty-inch standard post but somewhat shorter and of less expensive construction is provided.

Surveys on which this method of posting is used are being carried on in the West under conditions identical with those in Northern Ontario, *viz.*, bush country through which the pack strap and canoe offer the only means of transport, and an ordinary subdivision party will, under these conditions during a season, survey four hundred miles of subdivision and plant six hundred of these posts.

The advantages of this type of monument are so apparent as to scarcely need enumeration, the principal points being increased permanence and greater uniformity of practice among surveyors in erecting monuments. After the post is in place, it is almost impossible to remove it, except by digging, and it is also inconspicous. It does not invite needless attention; in fact, nine out of ten persons in passing these monuments will, while they at once notice the pits and mound, pass the post, unless they have occasion to look for it in particular. When, however, it is necessary to locate the exact corner, one may approach the corner with every assurance that the post is in place.

When this model of post was first introduced, it occasioned serious misgivings in the minds of the Dominion Land Surveyors as to its practicability and considerable speculation was indulged in, particularly with regard to its weight, extra transportation necessary, difficulties likely to be encountered in its installation and increase in labor. Now, after three years of successful operation, it is apparent that these fears were to a great extent groundless, and it is safe to say that, under ordinary conditions, the additional extra help necessary on a survey party due to the change in the type of monument does not amount to more than one man. The Dominion Land Surveyors have heartily endorsed this post, and it is very questionable whether there are any among their number who would voluntarily return to the old type in use prior to this.

In this province, railway facilities are now such that transportation problems are slight in comparison to what they were as late as ten years ago, and there would appear little reason to prevent our following the lead of the United States General Land Office and of the Dominion Lands Surveys, and to investigate whether it would not be advisable to adapt posts of this nature suitable to our own use, on government surveys, as well as on townsites, municipal surveys and in general local practice.

An extract from an article published in the Year-book for 1916 of the Swedish Chamber of Commerce, says:—"The utilization of the abundant water power of Sweden has from year to year become of greater importance as a lever in the extension of its industry and development. Until, however, the Swedish Water Power Association was formed, towards the end of 1909, there was no uniformity in the methods adopted for dealing with the problem. One great drawback experienced was the over-rating of the water power as a direct source of income and subject for taxation, while another was a movement towards limiting the rights of strandowners to the disposal of the water, under cover of which the water-power utilization industry had up to then been developed. To increase the knowledge of the water power in Sweden, the association has compiled comprehensive statistics, and has issued special survey maps based thereon. It has also arranged water-power exhibitions, where the Swedish water-power technicalities and the progress of the Swedish water-power industry have been illustrated by numerous collections of drawings, photographs, statistical tables, etc. In recent years, the association, which now comprises 260 private members, 100 commercial undertakings, 12 societies and other corporations, and six foreign societies and corresponding members, has specially endeavored to prepare for an increased consumption of water power, with the view of lessening Sweden's dependence on fuel from abroad."

WATER SUPPLY AND SEWER SYSTEM FOR CAP DE LA MADELEINE, QUEBEC

By Romeo Morrissette
Three Rivers, Quebec.

DURING the past two or three years the village of Cap de la Madeleine, Quebec, has been favored with the establishment of several important industries, which has meant an increase in the population of the village of nearly 4,000 people. Up to the present time no water system had existed at all and the municipality was recently confronted with the necessity of going on with the work at a time when it was most difficult to secure money for that purpose. However, a franchise was granted to Mr. Alphonse Aubin to build such a plant, the company under agreement undertaking to construct the whole system at their own risk and expense, the municipality reserving for themselves the right of buying from the company within sixty days after its acceptance by the municipal council or at any time within five years.

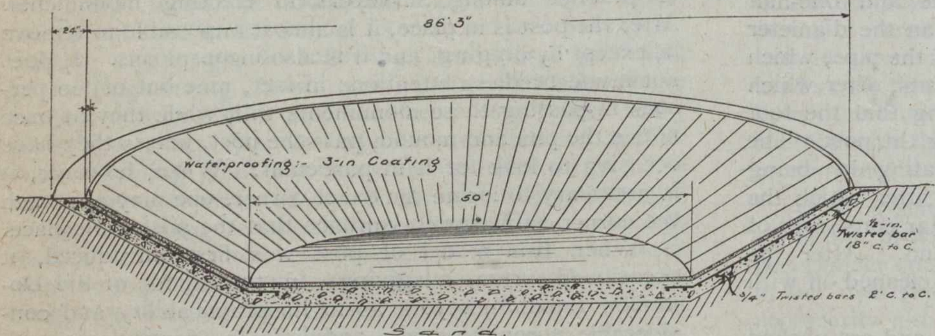


Fig. 1.—Section of Reservoir

If the municipality takes the plant over within sixty days, the specified price to be paid is the cost of the system of unit measurement. If, however, they do not exercise their option until after the sixty days have passed, but within the five years, the price to be paid is the capital represented by the revenue of the system at that time on a basis of 5 per cent. interest. The plant was designed by Mr. J. F. Greenan, of Chicoutimi, Que., who acted as engineer for the company, while the municipality engaged Mr. G. C. Bastien, of Three Rivers, to look after their interests.

A preliminary survey served to show that the geological conditions consisted of a stratum of sand on top of a stratum of blue clay. Borings were made with the following results: For two feet below the surface of the earth a stratum of gray sand exists; for the next ten feet, gravel; for the next two feet, fine sand; below this there is a deep stratum of blue clay.

It was decided to sink wells and pump the water from these wells into a water main, thence to a reservoir, the latter designed and placed so as to permit the return of the water by gravity. The water thus secured is soft, pure and cold, and is practically free from bacteria.

Pumping Plant

The pumping plant consists of a building 18 ft. x 24 ft., one story high with concrete floors 12 ins. thick except under the pumps, where the thickness is increased to 15 ins. The pump house is designed to accommodate two centrifugal pumps, with a capacity of 450 gallons a minute under a head of 125 feet. These pumps are to be connected to electric motors. Only one of the pumps is now in place, but the other one is to be installed at an early date. The pump has a 6-inch suction pipe and the inlet pipe extends eastward for a distance of approximately 125 feet. This pipe may be lengthened if necessary. Every 10 feet, pipe wells were driven into the soil along the inlet pipe, centre to centre on one side and alternating 2 feet on the other side. Water is found at about 7 feet below the ground. The discharge pipe is also 6 inches in diameter and is attached by a "T" to a 10-inch main and to an 8-inch pipe which leads to the reservoir. The system of valves is controlled directly from the pumping station. By closing the valve in the 10-inch main, and the valve in the outlet pipe near the pump, and leaving the other open, the reservoir can be emptied for purposes of cleaning or repairs. If the pump should need repairs the valve in the outlet pipe is closed and the reservoir supplies the water by gravitation. The reservoir is situated on a hill, 60 feet above the pumping station and 80 feet above the lowest level of the system and 6,300 feet from the village.

The Reservoir

The reservoir is of a circular type, having a diameter of 86 feet at the top and a diameter of 50 feet at the bottom, with a vertical height of 10 feet. The capacity is 235,000 gallons.

The sides and bottom are made of 1:2:4 concrete 24 inches thick covered by a 3-inch layer of waterproofing grout composed of the same preparation in the mixing of concrete as was used in the reservoir itself, to which was added 10% of Toch cement. Reinforcement in the sides consists of ½-inch steel bars on 18-inch centres, placed lengthwise, while twisted steel bars, 24 inches centre to centre, were placed circularly to the basin. No reinforcement was used in the bottom of the reservoir except with the side reinforcing extended 3 feet from the side. (See Fig. No. 1.)

Pipe Laying

The construction involved the placing of 12,080 feet of 8-inch pipe, 16,540 feet of 6-inch pipe, 821 feet of 4-inch pipe, and 3,956 feet of 2-inch pipe, making a total distance of open trench of 33,400 feet. The contract for the trench digging was awarded to Messrs. John Bouvin, W. Binette & Co., Pronovost, at 25 cents per cubic yard. The average depth of the trench was 6 feet with a width of 2 feet 5 inches at the bottom. For the laying of the pipe the price was 8 cents per lineal foot; the pipe itself cost approximately $60 per ton and was supplied by Messrs. Therreault & Racine, Quebec.

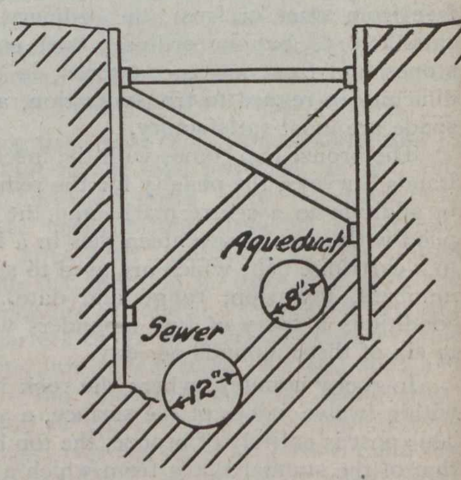


Fig. 2.—Showing Arrangement of Water and Sewer Pipes

About 20 pounds of lead were used for the joints, where the diameter was 8 inches; where the diameter was 6 inches, 15 pounds, and where the diameter was 4 inches, 10 pounds. Forty-six hydrants were placed along the system, the cost being about $75, while 45 valves were installed, costing approximately $40 each.

Wherever possible, advantage was taken of the work done for the water supply to place the sewer system. Vitrified clay pipes were placed alongside the water mains as per determined gradient from 20 per cent. to 2 per cent. and converging by gravity towards the outlets, two of which were in the River St. Maurice, and one in the St. Lawrence.

Manholes and Catch Basins

Forty-two manholes were placed. The bottoms of these manholes were 30 inches square and the upper part of elliptical form with radii 18 x 24 inches. They were built of concrete and cost about $45 each to construct. The catch basins, of which there were 15, consisted of 20-inch vitrified clay pipe placed vertically.

MANITOBA STEEL AND IRON CO., LIMITED

The organization meeting of the Manitoba Steel and Iron Company, Limited, was held in the city of Winnipeg last week and the following directors were elected: T. R. Deacon, H. B. Lyall, Sir Augustus Nanton, Geo. F. Galt, G. W. Allan, K.C., M.P., Sir Douglas Cameron, Chas. Pope, Capt. Wm. Robinson and W. H. Cross.

At a subsequent meeting of the directors, T. R. Deacon was elected as president; H. B. Lyall, vice-president; and Walter Stuart, secretary.

The company has been incorporated with a Dominion charter, with an authorized capital of $500,000, to take over the merchant end of the business of the Manitoba Bridge and Iron Works, which has grown to considerable dimensions.

The new company will carry on a general merchant business in heavy steel goods such as structural steel, plates and sheets, bar iron and steel, boiler-tubes, rivets, bolts, railway supplies, mining equipment, heavy forging billets and stock for shipbuilding. A block of land with suitable warehouse has been secured on Logan Avenue, Winnipeg, with railway siding facilities. Business will be commenced on March 1st.

The Manitoba Bridge and Iron Works intend to confine their business to purely manufacturing, for which this change will afford them more needed room on their present site. The latter company is also applying for a Dominion charter with an authorized capital of $1,000,000.

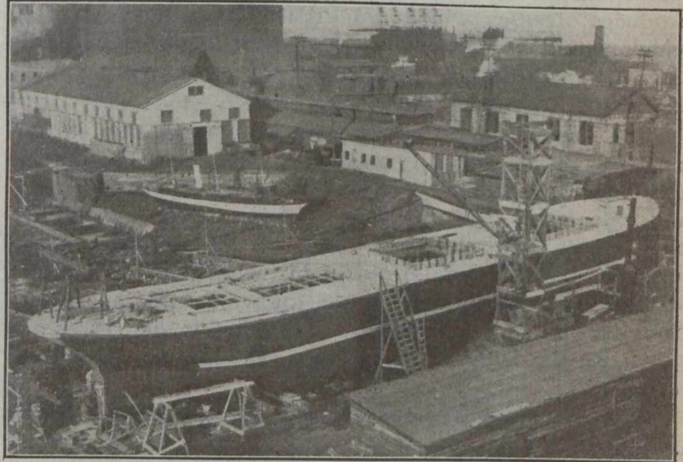
QUEBEC BRIDGE LECTURES

Two lectures on the Quebec Bridge were delivered recently in Toronto. A few weeks ago, Geo. H. Duggan, chief engineer of the St. Lawrence Bridge Co., addressed the Canadian Institute in the University School, Bloor Street, and last week Lieut.-Col. Chas. N. Monsarrat, chairman and chief engineer of the Board of Engineers, Quebec Bridge, addressed the Toronto Branch of the Canadian Society of Civil Engineers in the Chemistry and Mining Building of the University of Toronto. Both lectures were well illustrated with lantern slides. Col. Monsarrat said that error of only 1/64 inch in 50 feet was allowed in the fabrication, and that for such heavy work the accuracy obtained by the contractors was most remarkable. The greatest error found in the joints in the field was 25/1,000ths of an inch, and, when riveted complete, 4/1,000ths of an inch. The alignment of the bridge was found to be perfect.

CONCRETE BOAT AT MONTREAL

WORK on the equipment of the concrete boat at Montreal is progressing rapidly and it will be ready for a trial run early in the spring. The accompanying illustration gives an excellent idea of the size and outlines of the boat. It is being built by interests associated with the Atlas Construction Co., Limited.

The completion of the vessel was delayed by an accident last fall. When being launched, the ways collapsed at one end, leaving the boat half in water and half on land. A firm of experienced Montreal shipbuilders had contracted for the launching, but apparently there was some hidden weakness in one of the timbers forming the ways. The ground was excavated between the boat and the water,



Concrete Boat at Montreal, Before Launching

and jacks were used to force the vessel into the water. This jacking put the concrete under greater strain than any for which it was designed, and was an unusual test of the strength of the hull. No permanent damage resulted from the accident, as the builders state that there is not a crack. The boat is now afloat.

The concrete shell varies in thickness from 3 to 5 inches between the ribs, which are structural steel, spaced 27 inches apart. The keel is structural steel. The boat is 125 feet long, 22 feet beam and 13 feet deep. It is intended for service on the Great Lakes and was undertaken, it is said, chiefly as an experiment to determine the rapidity with which concrete hulls can be built and the cost of such construction.

The Chilean Government has placed an order for twenty engines with the Montreal Locomotive Works, a subsidiary of the American Locomotive Works. The Canadian company is now completing an order of twenty engines for the Union of South Africa.

The suit brought by Brennan & Hollingsworth, engineers and contractors, Hamilton, against the city of Hamilton for extras entailed in the construction of sewers for the Kenilworth Avenue subway drainage, has been settled by the city's paying $2,500 to the contractors and assuming all legal costs.

There are, at the present time, 32 Heroult electric furnaces in Canada and 22 of other types—in all 54 furnaces using the electric process. These furnaces have a capacity of 173,000 tons of iron and steel, 50,000 tons of ferro-silicon, and 8,000 tons of other ferro-alloys per annum. The British Forgings plant at Toronto has ten electric furnaces of the Heroult type and a total capacity of 60 tons per heat, or about 72,000 tons per annum, making it the largest electric-process steel plant in the world.—Official Bulletin of Commission of Conservation, Ottawa.

IMPACT—THE EFFECT OF MOVING LOADS ON RAILWAY BRIDGES*

By W. S. Kinne
Associate Professor of Structural Engineering, University of Wisconsin

MOST engineering structures must be designed to carry more or less moving, or "live" load in addition to a certain amount of immovable, or "dead" load. The calculation of stresses due to any set of immovable loads is a comparatively simple matter: as soon as the loads themselves have been determined, the principles of statics can be applied and the resulting stresses readily obtained. But the calculation of stresses caused by moving loads is not so simple. This is because the rapidity with which the live loads are usually applied produces stresses which are greater than the stresses which would be caused by equal dead loads. The additional stresses due to the effect of the velocity are known as impact stresses.

The usual method of calculating stresses due to live load is to divide them into two parts. One part is obtained by considering the moving loads as a set of fixed loads, and calculating the resulting static stresses. The other part, which represents the effect of the velocity of the moving loads, is determined by increasing the static stresses by a certain percentage, known as the impact percentage, or impact coefficient. Total live load stresses are given by the sum of the static and impact live load stresses.

In any class of structures where the stresses due to impact form any considerable part of the total stresses, it is necessary to know, within reasonable limits, the effect of rapidity of application of the loads, for the final results are uncertain to the extent that the impact stresses are uncertain. Railway bridges are a large and important class of structures which come under this head. This article will deal only with impact in this class of structures.

Unfortunately, no exact method has been devised which will give a general expression for the coefficient to be used in calculating impact stresses. The attempts made to determine the impact coefficient can be classed under three general heads, as follows: First, mathematical methods; second, empirical methods; and third, experimental methods. As a general observation on the results obtained by these methods, it can be said that the first method is not very satisfactory, because the mathematics involved becomes so complex that only the simplest cases can be treated. The second method also is unsatisfactory, as empirical formulas generally are based on the personal opinion of the designer. Probably the most satisfactory method is the third. If tests could be made on all classes of structures under all probable loading conditions, a very close estimate could be made of the maximum impact stresses which would have to be provided for. At present the greatest real progress has been made along this last-named line.

Direct observation on existing bridge structures has shown that the chief factors in causing impact are: (1) Rapidity of application of live load, (2) unbalanced locomotive drivers, (3) eccentric wheels, (4) deflection of beams and stringers, which gives rise to variations in the action of the vertical forces, (5) flat or irregular wheels, and (6) rough and uneven track. Of these causes of impact the last two give impact which is in the nature of a sudden blow upon the structure. The other causes are more in the nature of a varying load, or a series of impulses, acting on the structure.

The efforts of mathematicians to develop an expression for the impact coefficient have been confined largely to the first of the causes of impact mentioned above. A small amount of mathematical work has also been done on causes two, three, and four. As the conditions are complex, no very definite results have been obtained. Causes five and six, when considered to be similar to a suddenly applied load, can be shown to produce a maximum impact stress equal to the static stress. This conclusion holds only for very short spans, or for localized conditions, such as joint details.

In making the mathematical analysis for the first cause of impact given above, it has been necessary to assume very simple initial conditions. The assumptions made are that the track is perfectly smooth, the abutments rigid, and that the moving load is a single load with the rotating parts in perfect balance. If the straight beam AB of Fig. 1 be supposed to carry a rolling load, which moves slowly across the beam, the deflection, greatly exaggerated, will be somewhat as shown by the curved line ACB. The path of the moving load is then along a path ACB. If the load be considered as moving with great velocity, its motion in a curved path will cause a centrifugal force to be set up, which tends still further to increase the deflection. This added deflection is a measure of the impact effect due to the rapidity of application of the moving load. The resulting equations are rather complicated and they will not be given here. For a discussion of this subject the reader is referred to the discussion in "Secondary Stresses in Bridge Trusses," by C. R. Grimm. A similar discussion is given on page 525 of "Modern Framed Structures," Part II., where values for the impact coefficient have been worked out. The values given for a speed of 60 miles per hour are 8.7 per cent. for a 25-foot span, and 3.7 and 1.7 per cent. for spans of 50 and 100 feet respectively.

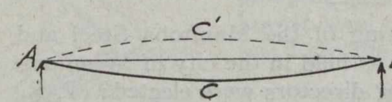


Fig. 1.—Deflection Under Moving Load

The percentages given above are relatively quite small. They are still further reduced by practical considerations, since in most cases bridge structures, when erected, are given a camber, that is, they are bowed upward, as shown by the dotted line AC'B of Fig. 1, to such an extent that under full live load the track is straight. The rolling load then moves along practically a straight line and little or no centrifugal force is set up, even at high speed.

When the impact is in the nature of a series of impulses, as in causes two to four given above, it is possible, in certain simple cases, to obtain some idea of the nature of the impact stresses. So many variables enter, however, even in a simple case, that the resulting expression is qualitative rather than quantitative in nature.

The case of unbalanced locomotive drivers is the most important of the impact-causing loads coming under this head, and the discussion will therefore refer to this cause of impact.

In order to transfer the power from the cylinders to the drive wheels of a locomotive, it is necessary to make use of a combination of rotating and reciprocating parts. It is possible to obtain a perfect balance for the rotating parts by means of properly placed counterweights. But in order to balance the reciprocating parts, it is necessary to add to the counterbalance certain weights over and above what is necessary to balance the rotating parts. This added weight is in the nature of an unbalanced force,

*Abstracted from article in the Wisconsin Engineer.

so far as the track is concerned. In most cases this added weight is about 300 pounds per axle, but may reach 900 pounds in extreme cases. Fig. 2 shows the path of such a counterweight during the forward motion of the drive wheel.

The vertical forces produced by centrifugal force, act according to the laws of simple harmonic motion. As a drive wheel 7 feet in diameter, travelling at 60 miles per hour, makes about 250 revolutions per minute, it can be seen that the vertical forces due to centrifugal effect may easily be a large percentage of the load on the driver.

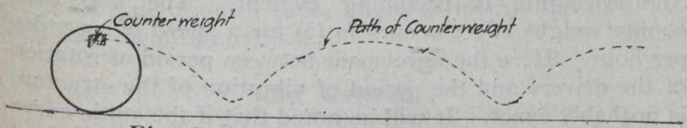


Fig. 2.—Path of the Counterweight

Such a varying force acting on a structure, first as a downward load, tending to deflect the structure downward and then as an upward force, tending to deflect the structure upward, will, if continued for any length of time, set the structure into vibration. A complete mathematical discussion of the subject will be found in Bulletin 125 of the American Railway Engineering Association, for July, 1910.

Fig. 3 shows, in a way, the sequence of events as a single unbalanced load passes over a structure at high speed. Sketch (a) shows the beam carrying the single unbalanced load. As mentioned earlier in this article, the static and impact live load effects can be considered separately and the two added to give total effect. On this assumption sketch (b) shows the static deflection of the centre point C as the load moves slowly over the span. This is called an influence line for deflection, and differs from the ordinary deflection diagram in that the deflection d, of sketch (b), shows the deflection of point C, sketch (a), for the load at point D. In the same way sketch (c) shows the effect of the centrifugal forces due to the rotating

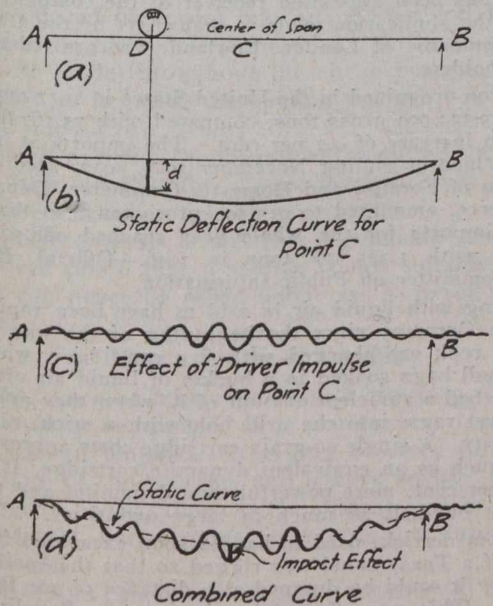


Fig. 3.—Effect of Centrifugal Force on Deflection

counterweight on the position of point C. As the load moves onto the span, the effect of the varying load is to set the beam into vibration. This vibration becomes a maximum as the load approaches the beam centre, after which it gradually dampens out. The curve is continued beyond the end of the span in order to show that the beam remains in vibration for a short time after the load has passed off the span. Finally, sketch (d) shows the combined curve.

The curves of Fig. 3 show ideal conditions, which occur when the period of rotation of the counterweights coincide with the period of vibration of the structure. Under such conditions the vibration is cumulative, and the maximum combined effect is obtained. At the centre of sketch (d) where the maximum effect is shown, the distance from the static curve, shown by dotted lines, to the combined curve, shows the effect of impact due to unbalanced drivers.

When the two periods of vibration do not coincide, the two effects may wholly or partially neutralize each other, in a manner similar to conditions studied in physics in the theory of sound waves. Where a locomotive is followed by a train load, the total weight of the train and structure is variable, as some loads pass off the span and others come onto it. This causes the period of vibration of the structure to be variable. It is then probable that the two periods coincide only for a short time. In any event, that speed of live load which produces maximum

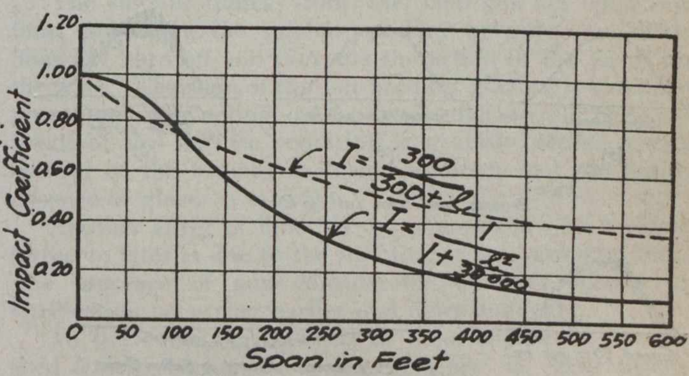


Fig. 4.—Impact Formula

cumulative vibration, and therefore maximum impact effect, is known as the critical speed.

In the theoretical discussion given in the bulletin above referred to, it has been shown that the coefficient for maximum impact which occurs at the critical speed can be expressed by the equation

$$I = k \frac{M}{p\,c\,l}$$

In this equation, I = impact coefficient; M = moment of rotation of the counterweights; p = live load per foot; c = circumference of drivers; l = span in feet; and k = a constant depending upon the design of the structure. The value of this constant must be determined by experiment. Stated in words, the equation says that the maximum impact coefficient, at critical speed, varies directly as the moment of the counterweights, and inversely as the live load, the circumference of the driver, and the span length.

The effect of eccentric wheels is somewhat similar to that of unbalanced drivers. If the speed is such that the period of rotation of the eccentric wheel coincides with the period of vibration of the structure and its load, cumulative vibrations are set up, which, in observed cases, have been equal to those produced by the locomotive.

The most important and extensive experimental attempt to determine the impact stresses in existing railway structures is that conducted by a sub-committee of the committee on Iron and Steel Structures of the American Railway Engineering Association. A complete record of the tests made will be found in the proceedings of the association (see Bulletin 125 A. R. E. A., July, 1910). The tests referred to were made under the personal direction of Dean F. E. Turneaure, of the College of Engineering of the University of Wisconsin, and the late Prof. C. L. Crandall, of Cornell University. These tests extended over a period of ten years, during which time tests were made on about 60 bridge spans which varied in length from 25 to 550 feet. In all, about 2,500 test runs were made, with test trains, and about 20,000 records were taken.

Based on a careful study of these tests, the sub-committee has proposed the following formula as representing in its judgment the probable maximum values of the impact coefficient.

$$I = \frac{1}{1 + \frac{l^2}{30,000}}$$

In this formula, l = span length in feet, and I = percentage of impact, or impact coefficient. The above equation is shown graphically in Fig. 4.

The determination of impact stresses by empirical formulas is usually based upon the personal experience of the author of the formula. A number of such formulas have been proposed. The formula which has met with the

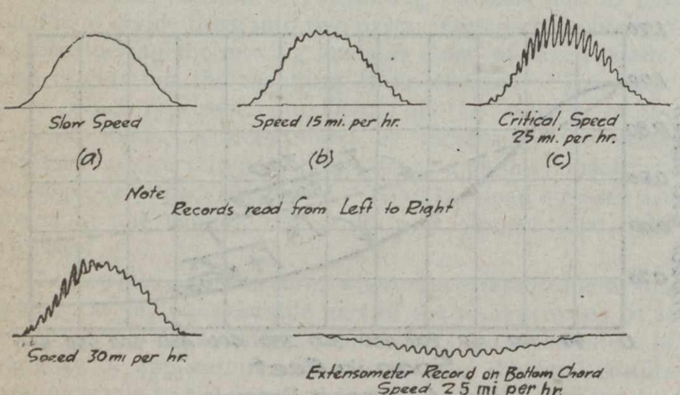


Fig. 5.—Records Taken With a Deflectometer

widest use is that given in the specifications of the American Bridge Company. This formula is

$$I = \frac{300}{300 + l}$$

The terms in this formula have the same meaning as those in the A. R. E. A. formula. It is shown in Fig. 4 plotted as a curve.

Comparing the two curves, it will be seen that the A. R. E. A. proposed formula gives much smaller values for spans over 100 feet in length. As the A. R. E. A. formula is derived from experiments, it probably more nearly represents actual conditions.

The object of the A. R. E. A. tests was the determination of the maximum impact coefficient. From the equation given for this coefficient, it can be seen that the desired coefficient depends upon the characteristics of the structure and the locomotive. The impact coefficient for a given structure may be different for two locomotives of different types, as for example, passenger engines, with large drivers, and freight engines with small drivers.

In order to determine the maximum impact coefficient by experiment, a given test train is run across the structure at varying speeds. The test is usually started with a slow run of about ten miles per hour. Due to the slow speed the rotating counterweights have practically no centrifugal effect, and the records are equivalent to static diagrams. Other runs are then made, gradually increasing the speed by small increments of about five miles per hour, until the record shows that the critical speed, and also the maximum impact, has been reached. By comparing the high speed records with the static or slow speed records, the amount of impact can be readily determined.

To illustrate the general process, the character of the records obtained during a test for maximum impact a few diagrams of actual test records are given in Fig. 5. Most of the records shown are from the deflectometer, as this shows best the action of the structure as a whole.

The records shown were taken on a 300-foot span. Sketch (a) was taken for a slow speed. The curve is fairly smooth and represents static effect. In (b) the curve becomes wavy, showing that the centrifugal effect of the counterweights is becoming evident. The maximum counterweight effect occurs in (c) for a speed of 25 miles per hour. Here the agreement between period of rotation of the drivers and the period of vibration of the structure is probably exact. It will be noted that if the static curve of (a) were sketched on the maximum combined curve of (c) it would cut an average line through the centre of the "saw teeth" of the latter curve. At a somewhat higher speed, shown in (d), the curve starts with well-defined saw teeth, but as the train advances onto the span, its period of vibration is decreased and the vibration becomes broken up, as shown by the irregular saw teeth. Sketch (e) is an extensometer record taken on the lower chord of the truss at the same time (c) was taken. Note the well-defined saw teeth on this record.

It is of interest to note that slow order sign boards at the ends of the bridge from which the records of Fig. 5 were taken called for a speed limit of 25 miles per hour. Sketch (c) shows that, for certain locomotives at least, this was the worst possible speed for the structure. In this case a speed of 40 miles per hour might have been better for the bridge than the slower speed.

Judgment has been rendered rejecting the petition of the directors of the Central Railway Company of Canada for confirmation of a scheme of arrangement between that company and its creditors. F. Stuart Williamson, M.Can.Soc.C.E., Montreal, has been appointed receiver of the company in response to the application made to that effect by the City Safe Deposit Company, of London, England, who are trustees for the bond holders.

The iron ore mined in the United States in 1917 amounted to about 75,324,000 gross tons, compared with 75,167,672 tons in 1916, an increase of 0.2 per cent. The imports of iron ore for the 11 months ending November 30th, 1917, according to the Bureau of Foreign and Domestic Commerce, Department of Commerce, amounted to 913,500 gross tons, so that probably the imports for the whole year reached 988,500 tons, compared with 1,325,736 tons in 1916.—Official Bulletin, U.S.A., Committee on Public Information.

Blasting with liquid air is said to have been rapidly developed in Germany since the beginning of the war. Holes drilled in rock are charged with five cartridges, which are simply small bags soaked in a bucket of liquid air after they have absorbed a sufficient amount of it, when they are jammed, like wet rags, into the drill hole with a stick, and fired by electricity. A single 90-grain cartridge costs approximately 6/10 as much as an equivalent dynamite cartridge. It is said to be 50 per cent. more powerful than dynamite, and the cost just about one-half as much in large quantities.

A boom derrick, used to handle spoil excavated from the lock pit of a Texas canal was rigged so that the spoil bucket handled by it could be dumped at a distance of 300 feet from the mast. This was effected by rigging a trolley line cable from the bottom of the mast to a sheave on the end of the boom, thence through the bottom block of the hoisting tackle, and to the top of the tail tower, where it was made fast. The boom was topped and the bucket hoisted, and was then allowed to move downward on the inclined trolley cable to the required point, where it was dumped and then returned for another load. It was found that for a distance of 300 feet a 12-foot drop was required, and that a load of 2,500 pounds was necessary for operation on this flat slope. In soft, wet ground a gang of seven men, including foremen and hoister, could handle 137 buckets in eight hours.

MANUFACTURE OF SEWER PIPE*

By Dr. Frank Coleman
Hamilton and Toronto Sewer Pipe Company, Limited

IN offering this association some remarks on the manufacture of sewer pipe, it is necessary to keep in mind the fact that but a few of its members are directly interested in this branch of clay working. An attempt will therefore be made to state some facts that may be of interest to all in some degree, and be sufficiently worthy of the consideration of those engaged in this business to elicit their helpful criticism.

Raw Material

In considering this question the presence of alumina and silica, the basic and essential constituents of clay substance, is assumed, and attention is turned to the other contents, which are more or less, incidental but of much importance, and to the necessary qualification of a suitable material.

We in Ontario make use of a deposit, usually called medina shale. The harder and more brittle shale, which is found rather abundantly, and from which such excellent dry pressed brick is made, and the surface clays used for the manufacture of common brick, are not suited for the purpose. In a general way the suitable material may be said to occupy an intermediate position. It is more plastic than the harder shales and differs in respect to chemical composition, while at the same time possesses a stronger body and different burning qualities than the lighter surface clays.

Any material to be suitable must possess sufficient plasticity to permit of its being pressed and moulded into forms. It must be of such a nature that it will pass through the dryer without excessive warping or cracking, and finally, it must burn until a vitrified body and salt glazed surface is produced.

Experienced observers may search for and find what appears to be the required material. A thorough test is then to be made throughout the entire process, and this may verify or negative the opinion formed. A favorable result of such a test is not, however, sufficient evidence upon which to make the investment required for a plant. It may turn out that the sample (even if large, which it should be) was only a pocket.

Chemical analysis is still less dependable; such a test may indeed prove that a sample is not suitable, but by itself it can never be relied upon as a proof that it is suitable.

Lime a Source of Trouble

Among various other contents of the clay, lime may be particularly mentioned, as it proves very troublesome in this part of Ontario. It is met at every turn and at every stage of the process, and always spells "trouble." Its presence is at times fairly evident and hence more easily avoided, but at other times your first intimation is spoiled ware.

Lime occurs chiefly in one of two forms: (1) Larger or smaller pieces of carbonate of lime—these may be colored red like the shale and may be quite soft, or hard and stony; (2) carbonate of lime in a very finely divided state mixed throughout the material; and solution of salts of lime. This division is made on account of the different defects produced rather than because of chemical differences in the two classes.

*Paper read before the Canadian Clay Products Association, Toronto.

The lumps may enter small enough or be ground fine enough to permit passage through the screen plates of the dry pans and not be specially or at all noticeable in the ware when pressed or while drying. When the goods are burned these pieces of carbonate of lime are converted into the oxide or quicklime. Upon removal from the kilns and exposure to rain or even to the moisture of the atmosphere, the pieces of lime become slacked. The pressure resulting from this change is sufficiently great to burst the surrounding material, and holes are produced of varying size in which is seen the lime.

Prevents Glazing Action on Tile

In the second form in which lime occurs, the trouble assumes a different character. Under these circumstances the lime is carried by the water through the pores of the ware to the surface; here evaporation takes place and the water leaves the lime behind as a whiteish more or less crystalline scum on the surface. This scum is added to as more water brings more lime to the surface during water-smoking until a more or less heavy coating results.

The sulphur fumes from the coal gas act upon this lime, producing the sulphate of lime or gypsum. This does not burn off and prevents the action of the gases on the ware. The soda of the salt used for glazing is similarly prevented from acting on the clay substance. The net result of this surface condition is grayish colored goods instead of the browns or black required, and the entire absence of glaze.

Another effect of lime to be mentioned now and referred to later is due to the fact that it is a powerful flux. The presence of any considerable quantity results in vitrification occurring earlier and more suddenly.

To overcome these effects of lime, chemicals may be used (chiefly barium carbonate) and are in some places where the percentage of lime is not too high. However, when the labor and other costs of overcoming the defects of raw material become multiplied, it becomes a question whether it would not be better to secure material from a less polluted source.

Effect of Carbon and Iron

The presence of carbon in material otherwise suitable, is perhaps, in this locality not of serious importance. It occurs chiefly in the form of larger or smaller roots, and some other vegetable substances. Much of this is to be screened out; the balance, of course, has to be burned out. The carbon present may be a cause of black coring, but this color is not simply charring—it is chiefly due to the fact that the iron present has been reduced by the carbon to the black oxide.

Of course, it is known that red shale contains iron. This important constituent is not only responsible for the color of the goods, but is also a powerful flux, safe and salutory under proper conditions, but disastrous if improperly managed.

The iron occurs chiefly in the form of ferric oxide, although some carbonate may be present, and, at times, sulphite. The latter two, however, sooner or later, lose the carbonic acid gas and sulphur respectively, and are changed into oxide. In the presence of sufficient oxygen, or under oxidizing conditions, the red ferric oxide results, under reducing conditions, in black or ferrous oxide. That there is an important difference between these two becomes apparent during burning.

Gathering and Preparing Material

The gathering of raw material offers little worthy of comment. The usual stripping to get rid of surface loam and vegetable materials is familiar to all, as is also the fact that a particularly strong clay may be the better for admixture with some of the lighter surface soils. Where such mixing is desirable, it is well to take together the full depth of the bank used.

At times it becomes necessary to shift or even to abandon a considerable area when the implacable lime menace is encountered. At other times a substantial bank peters out to an unprofitable shallowness.

It is fairly apparent why plants for the manufacture of sewer pipe in Ontario are centrally located and not erected upon the ground from which it is expected to secure raw materials. Insufficient quantities in a given location to last a number of years necessitates rather frequent shifting. It then becomes necessary to load material to railroad cars and to unload from same at the plant, and it then matters but little whether the haul is one mile or forty.

The preparation differs very little from that required for other clay products. The material should be ground in the dry state, usually by dry pans with screen bottoms. Further and finer screening is very desirable when possible. The material is then conveyed to hoppers, from which it is delivered by chutes to the wet pans for wet grinding or tempering. For the smaller sizes little further mixing is required, but for the larger, grog must be added to open the pores of the thicker body, that drying may be more rapid and more complete. For moulded ware more tempering and more careful selection of the material to be mixed is required.

Making the Ware

The machinery employed has not changed in essential features for many years. There is the steam press and the plaster moulds of our forefathers. Whether this fact indicated a want of inventiveness in this industry or an unusual wisdom on the part of the pioneers, must be left for others to judge.

The dies used require careful consideration, and must be adapted to the needs of the individual manufacturer and his material. Many of you are aware how great a difference a very slight change of variation in a die may make. Changes in raw material must also be met by necessary die changes. A die that will make a perfectly satisfactory pipe with some clays will not be at all suitable for others.

Drying

Drying is a very important step in the process. Just here it may not be amiss to suggest that in considering the requirements and difficulties of any part of the process of manufacture, it is necessary that all previous steps be appreciated and their influence appraised. One may say that certain defects resulted in drying. This may be true, but not be the fault of the drying process. Quite possibly that should be traced back to the raw material, or its treatment at any stage before reaching the dryer. This holds true for conditions until the pipe are entirely finished.

The floor space required for drying is rather considerable for as a rule each pipe has to stand alone. Means must be provided not only to supply the required heat and to distribute it evenly, but also to carry off the moisture-laden air.

We employ a steam heated concrete ground floor with spaced wooden upper floors, and a chamber of steam-heated pipe coils from which the warm air is distributed to all parts by means of a motor-driven fan and a system of galvanized conduits. In addition there has been recently installed overhead steam-heated pipe coils to increase the efficiency. Numerous and large ventilators in the roof provide the means for carrying off the moist air.

The temperature that the ware will stand has to be rather closely gauged at times and this may be checked by the use of recording thermometers.

Large pipe cannot be exposed, with safety, to temperatures that may cause no harm to smaller sizes. Too great a current of air, whether warm or cold, direct upon the pipe, must always be avoided.

To dry the ware as quickly as possible favors increased output and economy, but too much haste results in large wastage and defeats the object of low cost.

The pipe should remain in the dryer until bone dry, which takes from three to fourteen days, according to the size of the pipe and other conditions, such as the weather, etc. If set in the kilns in an under-dry state, some of the troubles resulting should be charged to this fact and not to the burner.

Kiln Practice

The kilns are of the usual round down-draft variety in which the pipe are set in circles. Those set nearest the bags are so arranged that they escape too direct action of the fires. The usual custom is to set several sizes in each kiln with the larger ones towards the centre, where they are placed in tiers four high. Nesting cannot be adopted to advantage, to any considerable extent, as the lessened draft between such pipe is likely to spoil both, but particularly the inside ones. In sizes of 16 inches and upwards small pipe may be set. Small pipe are also bunged in the spaces between the large ones. Traps, elbows, and other fittings are placed on top of pipe of suitable size from which they are separated by dry rings to avoid pressure effects.

The kiln floor should be as level as possible and under each bottom pipe is placed a ring of corresponding size. This helps to overcome any inequalities of the floor and permits the pipe when shrinking to creep more readily.

Burning

Burning involves four processes: (*a*) water-smoking, (*b*) dehydration and oxidation, (*c*) vitrification, (*d*) glazing.

It is our custom to commence firing immediately with coal, only sufficient wood for kindling purposes being used. The coal must be screened lump, long-flamed gas coal of good quality, and particularly, it must have a low sulphur content.

The early or water-smoking period is accomplished by firing lightly that the increase of heat may be slow and gradual.

Although appearing and feeling dry when set, there is much water in the ware to be disposed of. This water is not chemically combined, but is so closely joined to the clay substance that considerable heat is required for its removal, and it is probably not all removed until the coolest part of the kiln reaches a temperature above 400 degs. F. It is chiefly at this time that blistering and slabbing occurs, and this is usually found in the larger-sized pipe with thicker bodies.

This water must find its way from the deeper parts of the ware through the pores to the surface from which it escapes. Much of it must first be converted into steam and if steam is produced too rapidly or in too large a volume at any one time, the pores cannot contain it and internal pressure results, with separation of the laminae of the ware and swelling. Carried a little further this pressure will cause the outer layers to separate and the slabbing mentioned results. The degree of this defect varies from blisters of different sizes to a condition in which but little of the pipe remains standing.

To determine when water-smoking is completed, the cold-rod test is frequently relied upon, but this will not show whether the danger of the period has been avoided.

Pyrometer Makes Good Guide

It is of little value to know that the water is gone if in the going the ware has been spoiled. What is needed is a means of knowing that the process is being safely conducted, and for this purpose the writer is of the opinion that the pyrometer is the best guide. By this method the temperature may be known and regulated both as to the top and the bottom of the kiln, and having ascertained a safe rate of advance, the results will be constant for fairly constant starting conditions.

The heat may now be advanced more rapidly, as but little change occurs in the ware until the stages of dehydration and oxidation are reached. This is a period during which water is again liberated from the ware, but now it is the water of crystallization or that which was chemically combined with the clay substances.

At or about the same temperature required for this result, other changes in the chemical arrangement of the clay substances also occur. The carbonate gives off carbon dioxide, the sulphides liberate sulphur and the carbon is burned out.

Having reached the important period of oxidation, care must be taken to prevent the fires from being of too reducing a character. Of course, as fuel is supplied and then gradually burns we have alternating, reducing and oxidizing conditions. Up to a certain point or temperature, such alternation does no harm, but as the stage of vitrification is approached, oxidizing conditions must be maintained.

While the ware is still porous enough to permit of free interchange of gases, the black coring of ferrous oxide may be changed almost at will, but when the ware begins to assume a close, dense character, the black that is present remains for keeps. The kiln may still be finished and saved, but at great risk, and with an inferior product. The risk lies in the fact that vitrification occurs earlier and more suddenly in the presence of the black oxide than in the presence of the red oxide. As stated, the presence of lime also tends to early and rapid vitrification.

Vitrification

As a result of increased temperatures, further changes take place with the production of a more or less glassy condition of the ware. Dehydration and subsequent oxidation cause disintegration of various ingredients of the clay substances with opening up of the body of the ware. At that time the porosity is increased and the absorption high. Vitrification causes a fusion or union. The spaces are gradually filled and the ware shrinks. The substance becomes dense and darker in color, the strength is greatly increased, and the absorption of water reduced.

Such ware will absorb but little water and will not permit its passage. It is unaffected by corroding gases, acids or alkalis, and is for these reasons a safe and sure carrier for sewage, whether sanitary or industrial.

Salt Glazing

These qualities of the ware are enhanced by the final process of salt glazing. With the kiln ready for finishing and the fires all hot, a shovel full of salt is well scattered over each. The salt is split into chlorine gas, which passes off, and free sodium which combines with the surface forming the silicate of soda glass.

The heat is maintained by adding to each fire a bundle of wood and a small amount of coal. This is repeated from three to six times, according to results obtained, as shown by trial pieces. The process may have to be shortened if the appearance of the kiln indicates that the heat cannot be safely continued.

The burning may now be said to be completed, but unless the kiln is properly managed, much damage may yet result. Everyone with experience has seen trial pieces that when taken out during the burning showed a mirror-like glaze and yet when the pipe were removed from the kiln the beauty was gone. The glaze was still there, but not the gloss. This change occurred during the cooling, and is the result of the action of the gases in the kiln and of those coming from the fire boxes.

Remove Gases from Kiln

The remedy for this is to rapidly remove the gases from the kiln and to prevent the gas from the cooling fires from entering. The former may be accomplished by freely opening the kiln, completely closing the stack opening and thus producing a strong back draft. This is perfectly safe if not too long continued. To avoid gases from the fires, the latter may be drawn.

Opinions vary as to the best methods of cooling kilns. The object, of course, is that this may be accomplished as quickly as possible and yet that air checking of the ware may be avoided. It has been advocated that the kiln openings be closed and the hot air gradually withdrawn through the flues and stack. Others claim that such a method favors air checking and recommend that the kiln be cooled without the aid of the stack draft. Our experience would suggest the latter method as being the safer one. As in other stages, time-saving must not unduly risk pipe loss, and air checked goods are of no value.

We employ as aids in the control of burning, pyrometric system, trial pieces of ware, pyrometric cones, and in addition to these such skill as the burner may possess from observation and experience.

A discussion of methods and merits of the pyrometer would be out of place at this time, but we believe it to be very helpful, particularly in the early stages of burning.

The trial pieces are a necessity. They are placed on top and bottom pipes in various parts of the kiln, within reach of hooks. From these, the condition of the ware from time to time may best be judged, and especially the important stage of oxidation.

Pyrometric cones furnish valuable information as to the period of finishing. These, like the ware, are affected both by the degree and the amount of heat and fluxing conditions.

Cement was first put on the market in England. In 1875 the use of Portland cement in the United States came into commercial prominence. When the product was first placed on the market in competition with that which was being imported from England and Germany, a good price was demanded. However, production in excess of demand soon resulted and it proved a big factor in the price cutting that followed. The second and most important reason for declining prices was due to an improvement in the methods of manufacture. From 1890 up to the present time there have been constant improvements, the use of more economical fuel, the invention of better and more efficient machinery. In a period of 15 years the cement output in the United States has increased over 600 per cent.

COST-KEEPING AND CONSTRUCTION ACCOUNTING*

By G. Ed. Ross
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IN preparing this paper, I had in mind cost-keeping on a force-account basis from the contractor's standpoint, or else from that of the State on projects being handled directly by State forces. When the contractor's force-account is kept by the State as a check on his costs, the method varies from that outlined only in a few details.

Cost-keeping should start with the first survey and be a comprehensive continuous record extending to completion of construction. Maintenance-cost records are then started and continue from year to year. Uniformity in construction accounting is possible only to the extent of adoption of a theory or principle sufficiently elastic to be adaptable to a wide range of conditions, suitable for the largest as well as the smallest job. The method of procedure is then uniform, and the data gathered will be uniform for similar conditions on the various projects, or units of projects. The divisions on the average construction job made to insure proper supervision of the forces employed are the logical units for cost records. When segregated in this manner, it matters little whether the cost of the project is a few thousand dollars or a million; the principle involved and method of securing data by units are identical.

If the division happens to be a gang of 50 men on one mile of earth excavation, accomplishment per man per day, week, or month may be compared item by item with a rival gang of 165 men on a three-mile division, or another with 200 men on a ten-station unit, all doing similar work. All the items may not necessarily be identical, if a sufficient number are similar to make possible a fair comparison of the relative degrees of efficiency. By this comparison the accomplishment per man as well as the weak points of the less efficient gangs are apparent. It will also determine to some extent whether or not large crews are handled as economically, from the standpoint of accomplishment per man, as smaller gangs. The man-day performance-test frequently results in surprises as to the real value of foremen and superintendents, as well as those in less important positions. With this definite record at hand, those who are not accomplishing an average day's work may be detected and either "speeded up" or dropped. When men are graded and rewarded by a fair test of efficiency, increased effort and results are insured.

Many of the items of cost develop with the work. Washing out false-work and piers on bridge construction, earth-slides on road construction, and similar accidents are likely to occur. For this reason, it is practically impossible to determine in advance just what form the final statement of costs will have. Considerable detail is necessary, and by keeping the data in small items during the construction period, they may be finally assembled in the desired form. As a supporting narrative for charges against the various account-numbers, and for historical purposes, the cost-keeper should keep a diary of important events during construction. Another necessary permanent record in keeping costs is a comprehensive narrative statement covering such items as wages paid the various classes of labor, cost of materials and supplies on the job, rental and purchase prices of equipment, the kind of equipment used, with information regarding the good or weak points and the methods employed to improve the service of the equipment, weather conditions, the condition of the labor market, distance from the project to the nearest shipping point, and any other data that have a direct bearing on the work performed. The value of the cost record as a basis in subsequent years for other estimates will depend largely on the fullness and accuracy of this narrative statement. Cost records of two years ago are of little value to-day as a basis for estimates without such a narrative as above outlined, because of the fluctuation in prices of material, supplies, and labor.

The time-book used in our work has spaces for account-numbers. Usually two spaces with eight sub-divisions for account-numbers are allotted each man, although as a rule he will work under only one or two account-numbers during the entire month. This record is made by the time-keeper in the field twice each day, or as many more times as the nature of the work may require. While the large number of items in the account-number book may seem confusing at first, each project (unless it be a very large one) is required to handle at the most not over thirty numbers during one month for labor costs, and a few more numbers for materials and supplies. The number is inserted in the proper place and the time-keeper is soon sufficiently familiar with them to carry them in his mind. In segregating costs an "x" or the number of hours, if less than a whole day, is placed opposite the proper number. If the timekeeper is reasonably careful, there is no excuse for error. At the close of the month, the time-book is totalled by pages and a summary by account-numbers is made. This is a good check on the accuracy of the timekeeper's work. If the gross amount in both cases by pages and by account numbers is the same, the timekeeper can feel pretty sure that he has not made any errors, provided he has counted the number of days properly. This is the one possibility of error that should have careful attention, as the remainder of the book checks itself. The invoices are received by the time-keeper, the goods checked and the bills approved, if correct. The account-numbers are then entered opposite each item and the record mailed to the general office. The items from all projects under way are then summarized in the general office and the record on the cost-ledger sheet is the result. Every feature bears its share of administrative cost. When the books are finally closed, a total of the cost-ledger features, together with the appraised value of equipment and supplies left, should balance with the gross expenditures on each project. A record of actual costs is the result of this manner of procedure.

Contractors have been known to finish a job with the firm conviction during its progress that they were making a profit. Their method of checking unit costs indicated a safe margin over the contract price, but they found on their final settlement a loss on the completed job. The overhead and incidental charges, always to be found on construction work, had been entirely overlooked. There was no check on these expenses during the progress of the the work and the revelation of the loss was a decided shock.

The numerical system of cost-keeping and accounting is adaptable to any work consisting of numerous items, departments, or divisions, on which detailed unit costs are desired. It is simple in its operation, after once the principle is thoroughly understood, and is intended to meet all emergencies that arise on construction work. Costs on divisions are assembled in such form that it may be known at all times just what units are within the estimated cost, and those running higher on which special

*Address delivered at meeting of Northwest Society of Highway Engineers.

study is required. The forms necessary in its operation are few and inexpensive. The record that is kept by the department segregates the cost-keeping record into 24 distinct "features." These "features" are then subdivided into 1,030 items. There are more items on our work than would ordinarily be used by the average contractor. On public work every one seems to feel that he has a right to ask questions and have records produced for his scrutiny. A number of people entirely unfamiliar with construction work request the department for data which could not be furnished except for the large number of items that we carry. As a matter of fact there is little more work required in gathering the original costs segregated in this way than would be needed if fewer numbers were used, and we are able, by assembling various items, to give the costs in any manner that may be desired.

At the close of the job, practically the only cost that is required is the "feature-cost" of the work. During the progress of the work, however, the items are important. These should be assembled frequently by the timekeeper for the superintendent. Daily costs are good things on a new job until the work is well under way and the superintendent is assured that his organization is keeping within or below the estimate. After that, summarizing costs for estimating purposes should be done two or three times a week so that the work cannot "get away" from him. After the timekeeper becomes familiar with this method of handling his costs, it should take him but a few minutes each evening (not over half an hour, for a crew of 250 men or less) to compute his daily costs. A wide-awake timekeeper should know the approximate cost of materials used on the work every day. He should be able to compute the labor cost and make a safe estimate as to the cost of the work done that day. This, of course, cannot be done with absolute accuracy, as it is a matter of estimation throughout. He gets his estimated yardage moved by timing the slip-scrapers, fresnos, or wheelers for a given period, knowing the capacity of each of these. He should know the exact labor-cost and the approximate material-cost. Some allowance should be made for variations. If the costs are near the estimate or above it, he should make an effort to get absolutely accurate costs and thus determine the proper procedure.

This is the real value of any cost-keeping system, namely, being able to check the costs of the work during its progress, and to give the engineer or superintendent daily costs sufficiently accurate for him to keep a close grip on that work, insuring a profit for the contractor. It is always pleasing to the clerical man to have a neat set of records at the end of a job, but contractors and contractors' employees cannot live on paper records. What they want and what they must have, if they are to continue in the business, is a sufficiently accurate check on their unit costs, while the costs are being produced, to insure their making a profit, or if they are not making a profit to be able to put their finger on the weak point in time to remedy any defect that might not have occurred to them had the fact that they were losing money remained undiscovered until the work was completed.

The cost of operation is to be considered as well as the efficiency of the system itself. A system may be thorough and accomplish everything required of it, but if its operation is too costly for the average contractor, it is in the same class as merchandise which is too expensive for the consumer. We have given careful attention to the operation of this method of gathering costs, with a view to eliminating every possible expense without impairing its general usefulness. Good forms on cost-keeping work, when carefully prepared and intelligently used, are a decided asset. As a rule, however, there is a tendency to run too much to forms, without any definite idea as to their real use and value. Frequently employees in the organization are allowed to express their spasmodic inspirations in the shape of a new cost-keeping form, although they have but little knowledge of the real requirements, except perhaps from a narrow viewpoint that they have obtained from their connection with one unit of a large project.

We use few forms. In fact, a good summary of costs can be prepared on a blank sheet of paper. This is another advantage of the numerical system of accounting, as it makes it unnecessary to carry a multitude of forms in order to summarize the data desired. We have found also that there is no good reason why the forms should be large. Our forms are practically all pocket-size to fit the books that are ordinarily carried by engineers, and we do not find that by reducing the size of the form any of its efficiency or value is lost. There are many advantages in this aside from the convenience. We find that the forms used for the collecting of cost data in the auditing department do not cost one-tenth as much as those formerly used, not to mention the far better record secured with the smaller form. The cost-ledger sheets are thin and the record is made with India ink. Blue-prints may be made any time a reproduction is desired. This ensures a reproduction of the first record without possibility of error. In the assembling of engineering data, such as monthly-estimate reports, we do require a few larger forms, but we endeavor to have these as few as possible. When a form is prepared, a careful study is made to see if with a little variation it can be made to fit several purposes just as well as the original purpose for which it was prepared.

During the few years that the State Highway Commission has been organized, there has been ample opportunity for studying the legal requirements in public records. The only record a court will consider, in case of difference of opinion between contractors and the engineer, is the original record taken in the field. While we hope there will be no more law-suits or difficulties of that nature, it is to the advantage of the department always to keep its records in such a manner as to meet the requirements of any court, and especially in view of the fact that, when this is kept in mind from the beginning, the cost of such records is not greater than the haphazard records that frequently are gathered. We have, therefore, insisted that the timekeeper carry the time-book in the field and make his original record as he goes. This soils the time-book somewhat in rainy weather, but to offset that there is much less liability of error when the time is taken in the field and kept in the permanent record, than when it is re-copied in the evening after the time-keeper has done a day's work and is tired. There is where the errors are usually made and there are plenty of other important matters on which the timekeeper can spend his time rather than to be copying and re-copying unnecessarily. These records are sent to the general office each month, carefully labelled, vouchers prepared, and originals filed away to form a part of the permanent record of the department.

Methods of accounting for field work differ materially in almost every respect from those employed in the average mercantile business. This is a fact that is frequently overlooked by accountants when preparing cost-keeping systems for construction work. In the first place, the system should not be made simply for the use of experienced accountants or office-men. The man who is the most valuable on construction work and who must do the detail work in connection with the gathering of costs is frequently a man who has had little office experience.

Our experience has been that as a rule the man with long years spent in an office does not make as good a construction accountant as the man who has had just enough office experience to be fairly familiar with the rudiments of office work. For the office man with long training at a desk where everything is brought to him, it is difficult to develop the "go-out-and-get-it" spirit that is necessary for the field accountant to have if he is to make good. The man who makes good in field accounting must be alive and alert, have plenty of initiative, a fairly well-balanced judgment, and must consider no job on the project as beneath him. The time-keeper on construction work should be a man of sufficiently broad experience to be capable of handling a large amount of detail. He should take his time twice a day or as many more times as the nature of the work justifies, and he should take it at a different hour every day. He should be acquainted with the detail plans of the engineer or superintendent. He should have a fair knowledge of grading work, and of contractors' equipment, and he should know where every piece of equipment on the job is every day. He should know what every man is doing, and he should not pester the superintendent with unnecessary questions. He should know enough about mess-operation to determine the cause when a poor meal is furnished and to correct the trouble, and he should know when an economical meal is not being served in time to correct it before the cook has run the mess too far into debt. The timekeeper should also have enough backbone to face an "ugly" cook and discharge him if he finds that cook cannot make good. The timekeeper, if he is made of the right material, should be the right-hand man of the superintendent or engineer, and at the same time the errand-boy. He should look after the camp carefully, taking measures to keep the sanitary conditions good, he should know when men are sick and see that they are properly attended. In short, the timekeeper is the handy man around the camp. If his work is efficiently handled, there will usually be a well-satisfied crew, provided the superintendent is equally efficient. If the camp conditions are poor and the mess unsatisfactory, the best of superintendents will find it difficult, if not impossible, to get results. The timekeeper should know enough about accounting to handle the details thoroughly, but more important than this is the need of being active, energetic, and of having plenty of initiative.

Handling equipment charges is sometimes a difficult problem. There are several ways in which this may be done. We have finally decided that the most satisfactory way on our work is to segregate the equipment into two classes, "heavy equipment" and "small equipment." The small equipment is charged directly to the work as it is purchased. This charge is carried under "Purchase of Equipment." A list of this equipment is kept by the timekeeper, who checks it from time to time to make sure that the equipment is still on the job. The general office, however, carries it as a charge against the work until the completion of the project, when it is gathered and stored or else shipped to another unit or project. A physical valuation is made at this time, one project being credited and the other charged with what is considered to be a fair value. Heavy equipment is listed in an equipment-record book at the time of purchase, together with fully descriptive data as to its cost and other particulars. The project on which this equipment is used stands all the ordinary repairs and replacements during its service on that work. These charges are carried under the item of "Repairs to Equipment." The last item in each feature is "Depreciation on Equipment" and this carries a charge for the use of this equipment during the period it is on the project. The depreciation charge is determined as follows:

When new equipment is purchased, the probable length of its usefulness is estimated, taking into consideration the repairs that will be made from time to time, and periods when it will be idle. On this estimated period, the proper depreciation cost per month is based. For instance, we may assume that a road-grader costing $525 will last through three seasons. It probably will be in use only nine months each season, making 27 months as the time it will be used before it is valueless. This gives a depreciation charge per month of approximately $19.50. If at the end of 27 months we found that replacements and repairs still left the grader in fairly workable condition, the equipment as a whole would be credited with its value at that time. This would probably be offset by some other piece of equipment which we had estimated would last for a certain period and was entirely worthless before that time. At the end of each job, a physical valuation is made on the equipment. If there is any material difference between the price charged the work for the use of this equipment by monthly depreciation charges and the price that the physical valuation indicates should have been charged, an adjustment is made to correct the records.

The State Highway Commission has authorized the Department to assist any counties that might wish to improve their cost methods on road work by the installation of a simplified cost-keeping system. This is without cost to the counties. With the county work we do not endeavor to go into detail as with our own department, inasmuch as the work must be directed in most cases by the various road-masters. We have, therefore, outlined a simple method of handling the cost records by counties, consisting of one number for each "feature" without any other segregation, which gives them between 25 and 30 account-numbers to handle.

For instance, our "feature" for bridges is composed of 90 items. With the County Courts, we give the "feature" one number; that is, all work connected with bridge-building is designated by one certain number, perhaps 25. The principle of the system is retained, but it is simplified to such an extent as to remove all fear in the minds of those operating it that they are getting into a mass of "red tape." As interest grows the items are developed and enlarged along suggestions made by interested officials with special attention to the ability and capacity of the various officers through whose hands this record must pass. Before installing the system, we insisted that some one man be responsible for its operation and that this man be given access to every charge made against the work. It is preferable for bills to come through his hands before being paid, to ensure his getting all charges against a certain project. In most cases, we have taken one supervisor's district as a trial project. The practice will spread over other districts as the officials realize the value of definite records. Lane county and Wasco county have been leaders in this work. These counties have now adopted practically the entire system of the State Highway Commission on nearly as elaborate a basis as is used in the general office, and we are well pleased with the results they have obtained.

The civil engineers and land surveyors of British Columbia are applying to the legislature for incorporation under the title, Engineering and Technical Institute of British Columbia. The institute will also admit to membership architects and others engaged in purely technical occupations.

HOW TO LAY OUT AND JUSTIFY A PROGRAM FOR WAR ROADS*

By Geo. C. Diehl
County Engineer, Erie County, New York.

TO justify any construction program it is necessary to affirmatively answer the inquiry, "Will such construction help win the war?"

Road construction at this time might be divided into three classes: 1st, those which assist in the war program; 2nd, those which retard the war program; 3rd, those which do not interfere with the war program. There are so many ways in which roads are of value that in order to simplify this discussion only the viewpoint will be considered wherein highways assist the railroads. The present difficulties in railroad transportation are well understood, and the problem as it is now directly presented is that haulage over highways should release locomotives and cars and relieve congestion at terminals and freight houses.

Road advocates emphatically and enthusiastically favor construction of roads which will help win the war, and by a like token they must resolutely oppose the construction of those roads which retard the war, but also urge the construction of roads which do not interfere with the war but result in considerable economic advantage.

The roads in the first class might be sub-divided into roads which radiate from railroad shipping points and those which parallel railroad lines. As railroads are now overcrowded, radiating roads are not so urgent. The principal effort should be concentrated on roads which approximately parallel railroads. Consideration should also be given to a far greater extent to those roads which have heretofore been improved.

To illustrate what a small percentage have been used, attention might be called to the statement made by Fourth Assistant Postmaster-General Blakeslee that out of 156,000 miles of improved highways in the United States there was no mail service carried over 121,000 miles.

It is necessary to fix the approximate length of motor vehicle haul. This has been variously stated from 50 miles upwards. The daily distance for motor vehicle delivery parcel post is 135 miles, and it is likely that 150 miles daily would be a safe figure on which to base calculations. War roads, therefore, would not be continuously improved across the country, but by overlapping of zones of local service there would be improved stretches for four or five hundred miles. Of course, there might be some special roads of greater length.

There will be a sufficiently large supply of gasoline, permitting a maximum use of motor vehicles.

The elements which enter into this problem include availability of local material, time required for construction, ability to provide suitable detours, and the number of cars and locomotives which would be released. It is apparent that if two roads were of equal length and other conditions were equal that the road built of local material, without using railroad haulage, would be the most desirable. Likewise a road that could be built in the shorter time would be preferred.

In order to preserve a continuous line of traffic, it would be necessary to prepare detours to carry traffic during the construction of the war roads.

In considering the various forms of traffic, it may be assumed that through travel cannot generally be carried on the highways, and that the construction is primarily for the purpose of moving local travel. This might be divided: 1st, into passenger; 2nd, freight; 3rd, express; and 4th, mail. The possibilities of moving passengers by motor vehicles are almost unlimited, providing suitable roads are furnished, as there are in this country to-day over 4,000,000 passenger cars, and these have a greater capacity of passenger miles than all of the coaches on the steam and electric railroads combined.

The railroads can be relieved to a greater extent where the centres of population, production and distribution are close together. An examination of a railroad map of the country would show that such locations are to be found largely in the New England, Eastern and Atlantic seaboard states, and the largest expenditures for war roads would be in those sections.

Between the neighboring cities in many sections of the east it is even now possible to motorize local passenger business. This would eliminate there a very large percentage—possible 75 per cent. or more—of local passenger trains, and if through passenger trains refused to carry local passengers, a considerable percentage of through trains would be eliminated. The pleasure-seeking passenger business which is carried to the White Mountains, the Adirondacks, Atlantic City and other resorts, which even in war times are much frequented, can in a large measure be transported by motor vehicles over existing improved highways, particularly from points on main railroad trunk lines.

Local freight, especially the smaller units, would be likewise transported by motor. Local express and mail packages could be carried over the highways and all of these combined would bring great relief to the railroads. This problem is very complicated and many elements must be considered to determine which roads would give the greatest amount of railroad relief for the sum expended and the time involved. The element of time is of especial importance during war.

In passing, it is pointed out that much time is given to surveys, principally for the purpose of computing the amount of earth work. If, for the purpose of these war roads such earth work is estimated instead of accurately calculated, much time would be saved. Preliminary surveys could be simplified, particularly in districts where the roads are comparatively level, final grades being frequently established just before the time of construction.

Motor vehicle passenger cars have increased in number by leaps and bounds, already arriving at figures a few years ago thought impossible. Motor truck travel over the highways is certain to increase amazingly, particularly at the close of the war, when business will expand to the maximum and the steam railroads will carry an ever-increasing tonnage. In spite of this fact it will not be surprising if an even greater tonnage is carried by motor trucks over the highways than is transported over the railroads.

It is important also to consider the width of the highways, as with the ever-increasing traffic, widths heretofore adopted will prove inadequate. To illustrate this by a concrete example: If we assume an improved 16-foot highway, generally considered a double road, and operate 3-ton motor trucks at a speed of 15 miles an hour, or a half-minute headway, that is, about 600 feet apart, 120 trucks or 360 tons could be transported in either direction every hour. In a 10-hour day, 3,600 tons in one direction, or 7,200 tons if fully loaded in both directions, could be conveyed. This would mean only the amount carried by one or two modern freight trains. Thus it will be seen when the tonnage exceeds this, unless there is operation by

*Abstracted from paper read before the Convention of American Road Builders' Association.

night and day, that the roads must be wider than 16 feet. If passenger traffic is carried over the roads, they must be much wider.

To intelligently design highways and bridges, maximum loadings must be adopted. The railroads of the country have been reconstructed several times by reason of increasing weight of rolling stock. To design a railroad bridge it is necessary to have not only the maximum load, but the wheel concentrations and distance between such concentrations. A similar plan should be adopted in highway construction. Motor vehicle manufacturers could construct cars consistent with such loading.

Political sub-divisions would be warranted in forbidding travel over highways and bridges which would not conform to the rules laid down. There must not only be a maximum weight allowed for each tire, but there must be a maximum per wheel and space between wheels. On this plan it would make no difference whether a 3-ton, 5-ton or 10-ton load were carried, as the maximum strain on roadway, bridges or other structures would be fixed.

The cost of highway construction bears a definite relation to tonnage. Assuming that the enormous contemplated increase occurs, then the public must be prepared for highway expenditures far in excess of the amounts heretofore appropriated, particularly with reference to main trunk lines, as the lateral roads can economically be constructed of the less expensive types.

Economic theories of railroad construction have been developed so that it is possible for the railroads to determine the exact expenditure which would be justified to eliminate a foot of rise and fall or a degree of curvature, and if the highways are to carry the enormous motor vehicle travel which is anticipated, then similar economic theories should be developed for highways. To illustrate, on a highway which carries 2,000 3-ton trucks daily, at a rate of 6 cents a ton-mile, the cost of haulage would amount to $360 for each mile per day. If the highway were lengthened one mile, the increased cost would amount to upwards of $125,000 a year, which, capitalized at 8 per cent., which might be a reasonable allowance for sinking fund and interest charges, would justify an expenditure of one and one-half million dollars.

Before fixing a maximum grade, it would be necessary to determine whether trailers were to be used, and if so, the total weight of the trailers and load as compared with the hauling engine. On the railroads, grades are frequently reduced to six inches to the one hundred feet, while on the highway 6 per cent. and upwards is not found objectionable when properly improved, the difference being that the locomotive forms but a small percentage of the entire weight hauled, which is not the case at present with motor vehicles. The advantage, of course, rests with the motor vehicle travel, as great distances are saved thereby. As an illustration, the distance from Albany, N.Y., to Pittsfield, Mass., is 50 miles by rail and but 38 miles by highway.

Every highway department should have a traffic engineer, as the problems of traffic are so intimately connected with construction and maintenance that the problems must be worked out jointly. The traffic department should take a frequent traffic census, as a controlling factor in many cases will be the cost of moving a ton a mile, and in order to determine this accurately, data must be kept, which will be invaluable after a period of a year or two. After a period of 8 or 10 years, it would be indispensable.

Charts can be prepared showing the relation and classes of traffic in proportion to population and amounts of production. The curves on charts prepared in states where improved highways are most prevalent would indicate to a considerable extent the type of construction, width, grades, alignment, etc.

With such a highway program there would be greatly stimulated the amount of production and territory not now available for agriculture would be opened up and the economic conditions bettered along many lines.

ROAD DRAINAGE*

By J. L. Harrison

THAT water, in one way or another, is the cause of an enormous amount of damage to highways is too generally admitted to necessitate any presentation of facts to justify a statement that the problems which arise in dealing with it are among the most serious, and at the same time among the most obscure with which the highway engineer must deal.

These problems are usually grouped under the heading "Road Drainage," and discussions of them are very likely to be limited to the presentation of generalizations in regard to the simpler aspects of the problem of freeing the right-of-way of what is obviously surplus water. However, the obvious is not always the most important, and so it happens that though of no less importance than formerly, the consideration of the problem of dealing with surface water may properly give place to the consideration of the more illusive as well as the more important problem of dealing with wet subgrades.

Thus, as this paper is presented for the consideration of gentlemen who have a considerable knowledge of highway problems, there is no need to amplify or to discuss such trite statements as that road ditches should be large enough to carry off the surface water or that they should always be kept open, etc. Neither is it necessary to caution the gentlemen here present that openings should be kept clear and that all structures should be frequently inspected, in order to preserve the proper freedom of surface flow and prevent the damage which is sure to follow when obstructions force flowing water to find and to enlarge new paths. These are matters of such common knowledge that they may be dismissed with the observation that all carefully supervised highway organizations now give them constant consideration.

When, however, the problem becomes one of dealing with sub-surface rather than with surface water, the question is obscured and the phenomena concerned are correspondingly less understood. However, it is here that the surprises are found and that the field for study and for improvement in highway design is almost untouched.

As a clear understanding of the facts is essential to a proper appreciation both of the problems which must be met and of any progress toward their solution, it may be well to note that, except perhaps in the most extreme desert regions, the sub-strata are saturated at no great depth below the surface of the ground. The level of complete saturation is known as the water table and will be found to occur at from somewhat above the surface where there are lakes, and swamps which become lakes during wet seasons, to considerable distances below the surface as in the arid regions where the water table may be many feet below the surface, if not absent entirely.

Next in importance to the fact that the water table is usually near to the surface is the fact that the water table

*Abstracted from paper read before the Indiana Road School moves up and down with the seasons. Heavy rainfall causes the accumulation of water in the ground with a consequent elevation of the water table, and long periods of drought lower the water table both because there is a gradual sub-surface drift of the ground water from the upper elevations toward the sea, and because capillary attraction is constantly raising water from the saturated subsoil to the surface where it is carried away by evaporation. Of necessity, if the total of the loss by sub-surface movement and by evaporation exceeds the supply, the water table will be lowered. Such a condition now prevails in some sections of Nebraska where the soil survey records show that the moisture content of the soil is at the lowest point ever recorded. This is a case of a gradual lowering of the water table over a period of some years. The condition more often met with by highway engineers, and of more importance in highway design, is the relatively wide seasonal variation in the elevation of the water table, a variation which may have a range of a good many feet and which, in extreme cases, may convert areas that are dry and solid during the drier months, into almost impassable marshes during the periods when the rainfall is heavy.

The level of the water table at any given point may be raised either by the absorption of local rainfall or by an increase in the rate of the drift of the ground water which has been caused by heavy rainfall in other regions. To illustrate this point one has only to refer to so common a phenomenon as the flooding of cellars, a most annoying matter which almost every careful observer has had occasion to deal with when the local rainfall by no means justified the pronounced rise in the elevation of the water table which has brought it a foot or two above the cellar floor.

The simple raising of the water table often causes highway troubles. "Keep the subgrade dry," is an old-time admonition which was frankly based on the assumption that a good highway surface would "shed water like a roof." The dry subgrade is as much to be desired as ever, but no matter how well tne "roof" acts, the subgrade will not remain dry unless water can be kept from rising into it from below. Herein lies much of the trouble which highway engineers experience in preserving smooth pavement surfaces during the spring months. At this season more moisture is supplied than evaporates or is carried off in the ground water drifts. As a result, the water table often rises to such an extent that in low areas lakes are formed, and if a highway chances to be built over an area where this rise in the water table has brought the pavement foundation into the region of complete saturation, a marked lessening of the supporting power of the foundation necessarily results.

Tile drainage is the usually accepted remedy for this condition of affairs, but tile drains have, very generally, proved to be of less usefulness than had been expected. One reason for this is that the water table does not have to rise into the foundation of a road to make it the source of trouble. All that is necessary is that it rise enough so that capillary attraction can keep the foundation wet. Just how near to the surface this may be has not yet been determined, but as extensive studies of the effect of capillary attraction in raising the water needed to support plant life, show that capillary attraction will raise water through some soils as much as six feet or more, the problem of escaping the results of capillary attraction at once appears to be a serious one. And herein lies the trouble with many of the systems of tile drainage which have been installed. Tile drains lower the water table; that is, the level of complete saturation, but they do not affect the action of capillary attraction. As such drains are seldom placed more than three or four feet below the surface, they do not at all prevent the wetting of the subgrade, for in almost all soils capillary attraction will raise enough water to keep a subgrade wet at even greater distances than this above the water table. This difficulty with tile drainage systems is entirely aside from positive errors of installation, such as the use of tiles of too short a diameter, the use of tiles without bells, the use of gradients which are too light, etc., and is an elemental difficulty which, in our present knowledge of this subject, must be admitted as existing, but which is as yet unsolved.

As illustrating to what an extent capillary attraction may affect the moisture content in the soil under a pavement, it will be interesting to many to know that one sample of soil taken just below a pavement in the business section of Washington, D.C., an asphalt pavement on a heavy concrete base, showed 12.23 per cent. of moisture by weight, which is approximately 32 per cent. by volume. The cut which had been made in the street where this sample was taken, was about ten feet deep but had not yet reached a level at which free water collected in the trench. In view of the nature of this pavement and of the fact that all of the ground for considerable distances in all directions from the point where this sample was taken is covered either by buildings or by sidewalks and pavements, it must be assumed that whatever water was found in the soil under it had come to that level by being raised from below. Here is a case, therefore, where capillary attraction had raised water enough to practically saturate a pavement foundation which is at least ten feet above the water table. In this particular case the soil under the pavement is clay. In its nearly saturated condition this clay is as plastic as good putty. Just what loads it will support has not been determined, but that if the water content in it could be reduced, its carrying capacity would be materially increased, can hardly be doubted. This case has been cited because it shows very clearly the range over which capillary attraction may act, and the amount of moisture which may be involved. It is not, however, an isolated case for the writer has found a good many pavement footings which contained even more moisture than this.

As has been pointed out, tile drainage does not solve this problem. Tile drainage will remove any water subject to the action of gravity, but in heavy clay soils the percentage of water so affected is so small that the actual level of complete saturation—the water table—is often hard to determine. The converse of this fact is that in heavy soils the percentage of water which may be raised by capillary attraction is very high and the distance through which the water may be raised is correspondingly great. Where the soil is subject to the direct action of the sun and the wind, the moisture raised by capillary attraction is evaporated and so the large amount raised each season and dissipated through evaporation is unnoticed, but where the surface is covered by an impervious layer, as by a hard pavement or even by a board, the constantly rising moisture fails to escape as it does in the open country. In fact, examinations of the water content in the soil under numerous hard pavements show that even when the soil in the surrounding fields is so dry that plant life has withered, 30 to 40 per cent. (by volume) of water may be found in the soil immediately under the pavement. This would seem to make it clear that a pavement may so shield the subgrade that a high water content is preserved even during the drier months, so high a moisture content, in fact, that it would seem fair to conclude that the muchtalked-of "dry subgrade" is, for ordinarily humid regions, purely a myth.

The significance of this condition of the subgrade composed of heavy material, even at elevations of ten feet or more above underlying water tables, is far-reaching. In the first place, it suggests a lower carrying capacity for subgrades than is usually assumed. But more in line with the subject matter of this discussion, it suggests a very cogent reason why so-called "well-drained, dry" subgrades freeze during cold weather, namely, that they are neither "well-drained" nor "dry." It may be, in fact it often is, true that they are "drained" in the approved fashion, but that they are "dry" is to be doubted, both from the fact that repeated examinations show that the soil under the pavements in the eastern half of the United States are almost never "dry," no matter how well they have been "drained" and because, had they been dry, they most certainly could not have frozen.

As affecting hard surface roads, another matter of drainage deserves consideration, namely, the relation of water in the subgrade to the cracking of these pavements. It has been shown that capillary attraction supplies so much moisture that the soils under hard surface pavements are seldom dry. During cold weather the moisture in the soil freezes, solidifying the ground into a block often a number of feet thick. This process proceeds under a pavement just as it does in other places. However, this freezing causes little or no trouble. In fact it is practically the uniform statement of engineers familiar with this matter that hard pavements go through the early winter without trouble. This is due to the fact that the freezing proceeds from the top downward and that the underlying soft earth takes up all of the expansion caused by the freezing.

As the winter proceeds, the surface of the ground now being a layer of icebound soil, winter thaws occur which melt the snow that is on the ground and perhaps also a few inches of the soil. When this occurs a wholly different problem in road drainage is presented, for the water which is taken up by the melted soil on the surface cannot percolate into the lower strata because of the intervening layer of frozen ground. Under these conditions it may, and in fact often does, happen that the top of the ground becomes completely saturated. The pavement, of course, protects the subgrade from the direct admission of water at such times as this, but this is by no means an adequate protection, not to mention a complete protection, for the complete saturation of the surface of the ground really amounts to nothing less than raising the water table to this level. Under such conditions, if the subgrade is level with or cut below the surrounding country, there is a distinct tendency for the plans of complete saturation to work its way under a pavement just as it does, for instance, under a house when the cellar fills with water from below. More or less of the water in the soil at such times is in excess of what could be retained there by capillary attraction and so is subject to comparatively rapid influence by the forces of gravity. Hence the distinct tendency of this surplus water to move rapidly into such places as the soil in a pavement footing, in response to the general principle that water will seek a level.

Even when the pavement rests on an embankment it is subject to immediate effect under such conditions as this. As stated before, the saturation of the surface of the ground, under conditions which prevent the percolation of surface water into the lower strata is, for all practical purposes, equivalent to the elevation of the water table to the level of the surface of the ground. Repeated experiments made by those who are investigating the movement of soil moisture as affecting plant life, have shown that the rate of movement by capillary attraction may be very high where the lift is short. Under the conditions here assumed, therefore,—that is, comparatively low embankments have been constructed over flat lands,—the saturation of the top soil on the flat land will produce a condition almost exactly equivalent to that which would be produced if this land were actually flooded with water, and the effect on all of the subgrade which is thawed out, even if only a few inches of the surface and a few inches under the pavement have been thawed out will, for all practical purposes, be the same. This is because capillary attraction will raise water even in a comparatively thin layer of thawed-out soil covering the surface of an embankment, just as water is raised by a wick, and will distribute it horizontally through the shoulders and under the pavement within the space of a very few days or, if the shoulders and slopes are already wet, even within a few hours. Of course, the rapidity with which a subgrade is wetted in this way depends both on its height and on the material of which it is composed, but as the subgrades usually used in highway construction are comparatively low, they are almost always within the range of capillary action.

In passing, it might be noted that the major reason for objecting to free running water in ditches, and to standing water on or near the right-of-way, is based on this same general fact, namely, that capillary attraction will very promptly bring this water into the subgrade, where it acts to lessen the supporting power of the ground on which the pavement rests.

As for hard-surface pavements, much breaking is, no doubt, due to positive overload during periods when these conditions have rendered the subgrades so wet as to be abnormally plastic, and consequently of low supporting power. The major part of the breaking of these pavements is, however, due to re-freezing after the conditions above discussed have practically saturated any thawed-out portion of the subgrade. When the re-freeze comes, conditions are different from those which prevailed at the time of the year when the subgrade was first frozen in this one particular, namely, that now the water which freezes is contained in a space between the pavement and the still un-thawed portion of the originally frozen ground mass. It is not necessary to go into a long discussion of the phenomena of freezing. Suffice it to say that in freezing, the water caught between the pavement and the frozen ground exerts a tremendous positive force which is ample not only to crack heavy pavements but to lift them considerably out of line. Moreover, the force developed in freezing is not usually relieved by a uniform movement in the overlying slab. If it was so relieved, all of a pavement block would be moved a small fraction of an inch and no great harm would be done. This does sometimes happen, but if it chances that conditions in the pavement initiate failure at some one point all of the pressure is relieved at this point, in which case the distortion at this point may be considerable. This is very similar to the process by which a boiler explodes. As long as the boiler holds, the pressure is equal on all parts of the interior. But when the stray bolts fail the front plate may be blown clear out of the building. This, by the way, explains why one corner, or one edge, or one end, etc., of a pavement block may be raised a number of inches when the total expansion due to the freezing of a good many feet of water would not equal this amount. Of course, relief has occurred at a point rather than by a general elevation of the block and the excessive distortion is the result.

For the relief of this general condition the writer recommends the use of broken stone or Telford bases, unfilled with fine material and consequently containing voids so large that capillary action will not fill them with water. These footings should be deep enough to extend below the reach of late winter and early spring thaws and should be so drained to the ditches that no ordinary percolation, no matter from whatever source, can fill them with water. Such a system will be expensive, but it can hardly be doubted that it will be valuable enough in protecting pavements during spring weather to more than justify the necessary expense of its installation.

In closing, it is desired to point out that the careful consideration of the actual condition of pavement subgrades is becoming of more and more importance. Loadings are increasing rapidly and the highway engineer must either provide for these heavier loadings or definitely prove that they are not economically feasible. To do either, he must be able to tell pretty definitely what his subgrades can be depended on to carry, and in order to arrive at this fact he must know how his footings are going to be affected both by the water which falls on the right-of-way and by that which comes to it in other ways. The notes which have been here presented outline the problem. They do not solve it. However, they are presented with the feeling that the longest step toward the solution of a problem has been taken when the problem itself is clearly stated. The solution will come in time, but pending the solution it will be well to act on the assumption that the greatest problems in land drainage lie under the ground and are often most a factor where their presence has at first been least suspected.

MONTREAL BRANCH, CAN.SOC.C.E.

Upon formal application of sixteen Montreal members of the Canadian Society of Civil Engineers, the council of that society has authorized the formation of a Montreal Branch along the lines indicated by the new by-laws recently adopted.

The first meeting of the branch was held in the society's rooms last Thursday evening, when it was decided that a nominating committee be appointed to select at least two candidates for each of the branch offices. There will be a chairman, vice-chairman, secretary-treasurer and six committeemen. The committeemen are to be elected for two years, the others for one year. In the first election, the three committeemen receiving the largest number of votes are to remain in office for two years and the other three are to retire at the end of one year, and thereafter three committeemen are to be elected each year for a two-year term.

The nominating committee are to add to their list of nominees for any office, the names of any candidates submitted in writing by at least five corporate members. The nominations are to be made before February 28th, when letter ballots will be sent to all corporate members resident within twenty-five miles of headquarters, the ballots to be returned by March 14th. The result of the election will be announced at a meeting to be held that evening.

The members of the nominating committee are R. M. Hannaford, Frederick B. Brown, L. G. Papineau, J. Duchastel, W. Chase Thomson, M. Brodie Atkinson and H. G. Hunter.

The Vancouver Island Pile Driving Co. has just finished making extensive repairs to the wharf of the Canadian Kelp Products, Ltd., at Sidney, subsequently proceeding to the railway company's wharf which they repaired. They are now at James Island putting in a new float for the wharf there. Their next work will be at the Quarantine Station.

THE FUELS AND WATERPOWERS OF CANADA A CONSIDERATION OF THEIR PROPER SPHERES OF USEFULNESS

By A. S. L. Barnes, A.M.I.E.E.

ALTHOUGH a considerable number of technical men have taken this matter seriously for some years now, popular opinion is very hard to influence, unless some very abnormal conditions arise which draw everyone's attention to them; in other words, there is a tremendous amount of inertia in the said "opinion." This mental inertia, like its physical counterpart, absorbs a great deal of energy before any results, in the form of motion, or action, are manifested, and as a rule the losses are great, for, usually, the larger portion of this absorbed energy is dissipated in the form of heat (-ed debate) instead of appearing in the form of useful work as it would if the mental machinery of the public (taken en masse) were reasonably efficient.

In regard to the fuel question, the abnormal circumstances referred to above are certainly with us now, and people generally are in the mood to take some notice of the warnings and advice to which technical men everywhere are giving expression.

The Commission of Conservation, the Bureau of Mines, the universities, and other bodies have been recently giving publicity to the need for thorough investigation of the whole problem.

It is for the public to take heed and see to it that the governments, Dominion and Provincial alike, are vested with full powers to take such action as, based on the best available advice, seems to be necessary.

Development work, in endeavoring to get the greatest amount of energy out of all classes of fuel, together with all possible by-products, is not only warranted by what is being done in England, Germany (especially the latter) and other countries, but is essential to Canada, and of paramount importance to the Province of Ontario on account of the peculiar and unenviable position which this province occupies in respect of coal resources.

There will be a tendency, as a daily paper recently stated, for the public to forget all about its coal troubles of the present time as soon as the warm weather comes. This will be especially true probably this year when everybody's thoughts will be focussed on food production, but the technical men who know the gravity of the situation must lead the people in this matter, for no one else is in a position to do so. Lawyers, politicians, doctors, schoolmasters, financial men and others may know that there is a difficulty ahead, but who can give the right guidance except the engineers and chemists? Without their expert knowledge millions of money might be spent, all to no purpose.

Dr. Haanel, director of the Bureau of Mines, recently stated, in referring to the utilization of peat, that it is essential, in order to prevent the waste of capital inevitably connected with misdirected effort, to employ only men with proper technical training for such work, or words to that effect, in order that the many mistakes made in the past by persons lacking such training, may be avoided.

There are two main uses to which fuels may be put:—

(1) For the generation of mechanical power.
(2) For the production of heat, to be used as such.

In some instances, in fact many, the use of fuels for the first-named purpose is unavoidable because power is needed and there is no other source available. This is the case in all localities lacking water power and at sea.

The primary object of this article is to lay down two principles which seem to the writer to be fundamental and to form the true basis of the proper conservation and use of two great natural resources of Canada, *viz.*, fuels and water power.

These principles are as follow:—

(*a*) All fuel should, as far as possible, be utilized solely for the direct production of heat, to be used as such, and not for the generation of mechanical power.

(*b*) All water power should, as far as possible, be used for the generation of mechanical power, either directly or through the medium of electricity; and all electric energy generated therefrom should also, except for special processes such as welding, electric furnace work, cooking, etc., be so utilized.

Dealing with the first of these principles, and keeping in mind the fact that the utilization of fuel for the generation of mechanical power cannot be altogether avoided, it is, nevertheless, true that such a use is wasteful and always will be so, as compared with employing it for heating purposes.

The correctness of this statement is not altered, even if all possible by-products be extracted from fuel before it is made use of as a fuel.

Take, for example, coal. It may be fired directly into boiler furnaces, which every man with technical knowledge is ready to admit is an extremely wasteful way in which to use it, or, after having had taken from it all of the many by-products which it is capable of yielding, the residual coke may be fired under the boilers, but in either case, what is the result?

Probably in a good sized modern generating station the result will be about as shown below:—

Energy in coal or coke	100%
Energy lost in boilers	25
Theoretical loss in converting energy in steam to mechanical energy in the turbine, about	52
Other losses, up to the switchboard	10
Total losses	87%
Actual energy utilized (= per cent. efficiency)	13%
Total energy as above	100%

The very largest stations, with a good load factor approaching 50%, may improve on this 13% efficiency by a matter of 2 or 3 per cent. perhaps, but not more.

If gas be obtained from the coal and used in a gas engine, a somewhat higher efficiency will be obtained, but at the best it could hardly exceed 25% and the same is true of oil or any other fuel when used for the generation of mechanical power.

Where no other source of power is available there is, of course, nothing to do but make the best of it by gaining every possible advantage in manufacturing by-products and by utilizing the most efficient plant. If, however, we turn to the use of fuel for heating, it is found that an ordinary house furnace will show an efficiency, even in the hands of the average householder, of twice, or even three or more times, that of the most up-to-date and largest electric generating stations handled by the best experts.

Technical Paper No. 97, of the U.S. Bureau of Mines, gives records of tests made by a university professor during the winter 1912-13, in his own house, he himself and his family being the only ones attending to the furnace, which show an average efficiency for the whole season of 65%. Careful records were kept of all the essential factors and there is no reason to doubt the reliability of the figures.

The foregoing sets forth the reasons why fuel should not be used for the generation of mechanical power if it can be avoided, since the quantity of fuel which will generate one horse-power of mechanical energy can easily be made to yield at least double or treble as much energy for heating purposes.

The fuel administrator of the United States, Dr. H. A. Garfield, where the use of coal for mechanical power purposes is unavoidable to a great extent, is anxious that all the energy in the coal that can possibly be made use of should be utilized, as the following extract from the "Electrical World" of January 8th, 1918, shows, and if it be right to conserve fuel in this manner, it is right to try to conserve it to a still greater extent by substituting the energy of water power.

Dr. Garfield says: "The coal consumption in the large electric plants, per kilowatt hour, is less than half that of the average small plant of less than 500 kw. rating.

"Everything possible, therefore, should be done by the large stations to cause the voluntary closing of the small isolated plant.

"The way to do this is to reduce the charges for power service as far as a reasonable return on the invested capital will permit. A general overhauling of prices charged for energy should be made, reducing the figures for power to encourage the abandonment of the small isolated plant, saving half the coal used by the latter, and recouping the loss of revenue by raising the figures for light, thus encouraging customers to be less wasteful in its use.

"It is a recognized fact that there is an enormous waste of coal due to the extravagant and luxurious use of electric light."

Taking up the second of the principles enumerated above as fundamental, *viz.*, that water powers should be utilized as far as possible for the generation of mechanical power and not for the production of heat, consideration of this matter shows that there are two excellent reasons why this should be done.

In the first place, think of the cost of electric energy throughout, say, the Province of Ontario, as compared with that of energy in coal.

Anthracite at $10 per ton, having a calorific value which may be assumed as 14,000 B.t.u. per lb., costs one-half cent per lb., or one cent will purchase 28,000 B.t.u.

In an ordinary house furnace, if 50% efficiency be obtained, as it can readily be, then 14,000 B.t.u. cost one cent, but where can electricity be purchased at such a rate, seeing that one kilowatt hour is only equal to 3,412 B.t.u. For domestic use, one cent per kw.h. is a cheap rate, yet at this price, assuming 100% efficiency for electric heating, electric energy is more than four times as expensive. From this it is evident that electricity is not at present a serious competitor of coal for heating and possibly never will be, because, supposing the price were reduced until it could compete with that of coal at $10 per ton, the coal would probably come down in price leaving electricity stranded high and dry until some further considerable reduction could be made; even if the price of coal were not lowered materially, improved methods of using it would be developed which would still enable it to leave electricity behind in the race.

The foregoing must not be taken as arguments against the use of electric energy as an auxiliary heating agent to supplement coal, oil or gas heating. For warming up a rather cold room in severe weather, which cannot otherwise be easily kept at a reasonable temperature, and for use at the beginning and end of the cold season, electric heaters have a wide field of usefulness which ought not to be denied them.

Also, it may be remarked that in order that electric energy might become a competitor of coal for heating the actual cost would not need to be brought to an equality with that of coal as the cleanliness, convenience and elimination of disagreeable work which would accompany the adoption of electric energy would be considered by most people as well worth paying a little extra for. Further, it is conceivable that if ashes and their removal were eliminated from the expenses of a city some reduction in the rates would be possible which would be a gain in favor of electricity.

In the second place, it is necessary to consider the quantity of energy required for heating houses, etc., on a large scale.

Assume, for example, that an eight-roomed house requires 9 tons of anthracite during the winter season of $6 \times 30 = 180$ days. The average rate of coal consumption will be $\frac{9 \times 2{,}000}{180} = 100$ lbs. per day.

This is equivalent to $\frac{100 \times 14{,}000}{3{,}412} = 410$ kilowatt hours, which means an average load of $\frac{410}{24} = 17$ kilowatts (= 23 h.p.).

As, however, the furnace efficiency is only, say, 50% and the efficiency of electric heating is 100%, then the electric equivalent of the coal will be one-half of the foregoing or 8.5 kilowatts.

The load factor of the furnace, *i.e.*, the ratio of the average load to the maximum load, will be about 66% (this figure is borne out by the U.S. Bureau of Mines Bulletin already quoted), hence the equivalent maximum electrical load will be $\frac{8.5 \times 100}{66} = 13$ kilowatts. A generating station supplying electricity for heating would, therefore, have to be prepared to handle a 13-kw. load, approximately, as an average, for every house served. According to the 1911 census there were rather more than two and a half million people in Ontario at that time, time which means, probably, 500,000 homes.

If an average maximum load of only 12 kw. had to be supplied to all these homes it would account for a maximum load of 6,000,000 kw. (= 7,440,000 h.p.). Seeing that the total possible development of Ontario water powers has been estimated at under 6,000,000 horsepower, where is the power to come from to furnish even a considerable proportion of the homes of Ontario (exclusive of the requirements of factories, office buildings, etc.) with electric energy for heating, quite apart from the great requirements for power, lighting, electric traction, etc.?

This second consideration, aside altogether from questions of cost, should effectually dispose of the popular notion which has been growing a good deal within the past few years, and has even been fostered in some quarters by those who might have known better had they taken the trouble to make a few simple calculations, that electricity is destined to become a great, in fact *the* great, agent for heating.

True conservation, therefore, lies in utilizing the water powers of the country to the fullest practicable extent for mechanical power for factories, railways, metallurgical and other purposes for which they are specially adapted, through the medium of electric energy, and in using the fuels, in the most economical manner possible for heating and *not* for the generation of mechanical power.

As showing whether, from the standpoint of conservation, it would be wise to operate railways by electric power instead of with coal or other fuel, it may be stated that figures, which appeared in the Electric Railway Journal last year for one of the United States lines are as follows:

Freight service—
 39.4 kw.h. per 1,000 ton-miles.
 276 lbs. coal per 1,000 ton-miles.

Passenger service—
 29.1 kw.h. per train mile.
 188 lbs. coal per train mile.

Assuming the use of coal having a calorific value of 12,000 B.t.u. per lb., the foregoing figures mean that the efficiency of conversion of the energy in the coal to mechanical power on the rails is, for the two services, 4% and 4.6% respectively, or an average of 4.3%.

Were the railways of Canada to be operated by electricity the 9,000,000 tons of coal used annually by them could be released for the production of heat at an efficiency of 50% or more instead of being used for power at less than one-tenth of that figure.

Nine million tons of coal could heat about 1,000,000 homes per season. Similarly, if it were possible to use the 10,000,000 or so tons of coal at present employed annually in the production of mechanical power another million homes could be kept warm and, as there were only, according to the 1911 census, about 1½ million occupied dwellings in the country at that time, there would be enough coal left over to heat a goodly number of business and manufacturing establishments as well.

Returning to the railway problem, if the consumption of coal on the various lines be 9,000,000 tons per annum, then, assuming an efficiency of 5%, this means (with 12,000 B.t.u. coal) an average load of about 1,600,000 kw. and possibly, owing to load factor, a maximum of three times this figure. This is easily within the capacity of Canada's available water powers, even allowing for other requirements on a large scale.

Assumptions of this kind are, of course, not capable of being acted on in their entirety for many reasons, but the relations between the figures given hold good for isolated cases equally as for the country considered as a whole.

The preceding assumptions, arguments and deductions take no notice of the financial aspect of the problems considered; they are concerned only with the question of the truest economy—that of making the country's resources last as long as possible.

Also, no consideration has been given to the use of exhaust steam for heating, which modifies the situation to some extent in many cases, but only has effect during winter, except where such steam is used in the manufacturing processes being carried out.

Among the Canadian patents recently issued through the agency of Ridout & Maybee, Toronto, are prevention of pitting and corrosion in steam boilers, Charles Haythorpe; dust and waterproof floors, Lewis S. Yolles; key bolts, Universal Tool Steel Company, Limited; internal combustion engine, Harry C. W. Neighbour; sections for sectional boilers, Anders B. Reck.

A summary of the Quebec Bill to protect public buildings in the province against fire may interest electrical engineers. The bill provides that no electric installation in a public building in the province, for the transmission of light, motive power, or heat, shall be put in or altered except by a person or under the immediate supervision of a person duly authorized and holding a license to that effect. The word "public building" in this Statute has a far-reaching effect, extending from churches and court-houses, etc.

SHIPBUILDING ON VANCOUVER ISLAND

These and other interesting facts are recited in the annual report of the Inner Harbor Association, Victoria, B.C., just published:—

When the great need for ships became apparent the Cameron Lumber Company, Limited, operating a saw mill on the Upper Harbor of Victoria, and the Genoa Bay Lumber Company, operating a mill on Cowichan Bay, Vancouver Island, organized a shipbuilding company under the title of Cameron-Genoa Mills Shipbuilders, Limited, and established a shipyard on the western shore of the Inner Harbor of the city of Victoria. Work was started thereon about the first of June, 1916. After the necessary buildings had been erected and the machinery installed, the keels for three ships were laid down in rapid succession, and work thereon pushed with all possible speed. The first ship was launched about February 1st, 1917. So far there have been launched by that company six five-masted wooden schooners. These ships are 256 feet long over all, 43 feet breadth of beam and 21 feet depth of hold, with a carrying capacity of from 1,500,000 to 1,750,000 feet of lumber, or 2,500 tons dead weight, equipped with auxiliary power of the Bolinder type of engine, developing 350 horse-power, with a normal speed of 7 knots when engine-driven, using oil fuel, and carrying a crew of 15 men.

They have proved themselves to be excellent lumber carriers, loaded with lumber for overseas markets as they have been completed and ready to be put into commission. These ships are classed A1 at Lloyds for 12 years. This shipyard has now on the ways and under construction four steam schooners, which are being built for the Imperial Munitions Board of the British government.

Work With All Speed

The Foundation Company's yards were established during the summer of 1917, and five wooden steamers are now on order at these yards by the Imperial Munitions Board, four of which are in various states of progress, and one will probably be launched in a short time, the others following at short intervals.

These steamers are 250 feet long, 42 feet 6 inches molded breadth and 25 feet molded depth, with a dead weight carrying capacity of about 2,800 tons. The steamers are of the well-decked type; have four extra large hatchways with five winches for rapid loading and discharging cargo. They have ample accommodation for officers and crew, and equipped with two class A lifeboats to British Board of Trade requirements, each capable of taking the whole crew. The engines are triple expansion, developing 1,000 indicated horse-power, two marine boilers of the Howden water tube type, three furnaces with forced draught for either coal or oil complete. All parts of the vessel's hull and machinery and fittings are standardized, designed with the idea of providing a good commercial, fairly speedy type of cargo carrier capable of being built in the shortest possible time (in this case less than six months) at a minimum cost. These two shipyards employ about 1,300 men and have a monthly pay roll of about $100,000.

Altogether the shipbuilding programme of the province comprises 41 wooden ships distributed amongst the various shipyards along the coast. Twelve of these are auxiliary schooners and constitute the fleet of the Canada West Coast Navigation Company. Two are for the Dominion government and 27 are for the Imperial Munitions Board. The Canada West Navigation Company's ships and the two schooners for the Dominion government are of the same type and require about 1,100,000 feet of lumber apiece. The average price of lumber has been about $36.50 a thousand feet. In British Columbia there is an inexhaustible supply of the finest timber, admirably adapted for shipbuilding purposes, with a constant demand in the foreign market.

Quality of Wood Excellent

The Douglas fir is one of the best woods for spars frequently squaring 45 inches for a length of 90 feet. It is exceptionally strong for its weight, a fact more important in the shipbuilding industry than almost any other business requires. It is important that the material be as light as the desired strength will permit, since all surplus weight increases the cost of transportation. It is one of the few woods whose strength is above the value set by the well established law of weight vs. strength.

In addition to the large timbers and planks obtainable from Douglas fir trees, the stumps yield the finest and largest ship knees in the world. The knees used in the construction of the local vessels were obtained at Cobble Hill and experts who have seen them declare they are the very best known. Cedar, spruce and hemlock abound of great size. The best timber areas are as yet, however, untouched as the mills have hitherto limited their operations to coast districts with direct water carriage. The area further inland will be reached later by railroads as the country is more developed.

Facilities for Ship Repairing

As having a direct bearing upon port interests, attention may be called to facilities for shipbuilding and general repairing directly connected with the harbor.

In the Upper Harbor or Basin, are situated the works of the Victoria Machinery Depot, having a frontage of about 360 feet, the marine ways are fitted with a cradle 280 feet long by 60 feet beam, providing dry dockage for repairing, cleaning, etc., for vessels up to 3,000 tons displacement. Larger vessels are docked by the firm at the Esquimalt drydock. At the plant are situated up-to-date machine shops, boiler shops, blacksmith shop, foundry and pattern shops, and a large wharf for receiving and storage of goods.

Supplies and Equipment Ready

Contracts have been obtained for the manufacture of the Howden marine boilers for the Imperial Munitions Board for installation in wooden steamers under construction on this coast. Hutcheson Brothers and Company, Limited, Bay Street, electrical and mechanical engineers, iron and brass founders, manufacturers of marine and stationary engines, anchor and cargo winches. This firm has a contract for the supply of winches and other deck machinery for the Imperial Munitions Board.

The Robertson Iron Works, Store Street, supply most of the heavy forgings for the steering engines and other machinery, for which they are fully equipped with steam hammers and complete appliances. The Ramsay Machine Shop, machinists and engineers, Store Street, are supplying winches for use on these steamers for the Imperial Munitions Board, together with the under-water and other special fittings and steering engines, and the Lemon Gonnason Company, Limited, capital planing mills, Orchard Street, have supplied a large proportion of the finished framing, doors, windows and house finishings for the vessels recently launched and are completing similar work for the steamers building for the Imperial Munitions Board.

Messrs. Moore and Whittington, of Pleasant Street, have supplied to both the shipyards a considerable amount of the heavy timbering for the ribs and ceilings, as well as the decking and house framing used in the various ships under construction. Messrs. Jas. Leigh and Sons are supplying to the shipyards of the Foundation Company and the Cameron-Genoa Company a proportion of the heavy timbering and decking and house work used in the various ships that have been and are now under construction.

Obtain Work of Noted Company

The firm of Yarrows, Limited (associated with the firm of Yarrows and Company, Limited, of Glasgow), builders of shallow draft vessels, have extensive shipyards at Lang Cove, Esquimalt Harbor, contiguous to the present government drydock. Their marine railway is capable of accommodating vessels up to 300 feet in length by 55 foot beam, and has a hauling capacity of 2,500 tons deadweight. Larger vessels are docked by the firm at the adjacent government drydock. Their wharf is over 600 feet in length and has shearlegs with a lifting capacity of 60 tons. Also a floating crane with a 95 feet boom capable of liting 10 tons.

The firm is at present working on a contract for propellers for the Imperial Munitions Board, for the wooden steamers under construction, and also for five sternwheelers for river service in India, 185 feet long and 30 foot beam; two have been finished and put into service, while the other two (and a third 185 feet by 35 feet by 7 feet) are under construction. After being fully assembled at the Esquimalt Yards and placed in readiness for the water, the vessels, which are of extremely light draught (about 3 feet) and practically flat bottomed, are "knocked-down" and the parts shipped to the Orient, where they are re-assembled and put in running order. They carry both passengers and freight and make about 10 knots a hour. Contiguous to the above is the government graving dock, 480 feet in length by 90 feet in width at coping level and 65 feet wide at the entrance, with a depth of water of 26½ feet. This dock is available for general ship repairing when not required by the government.

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Principal Contents of this Issue

	PAGE
Survey Monuments, by J. W. Pierce	147
Water Supply and Sewer System for Cap de la Madeleine, Quebec, by Roméo Morrissette	150
Quebec Bridge Lectures	151
Concrete Boat at Montreal	151
Impact—The Effect of Moving Loads on Railway Bridges, by W. S. Kinne	152
Manufacture of Sewer Pipe, by Dr. Frank Coleman	155
Cost-Keeping and Construction Accounting, by G. Ed. Ross	158
How to Lay Out and Justify a Programme for War Roads, by Geo. C. Diehl	161
Road Drainage, by J. L. Harrison	162
The Fuels and Waterpowers of Canada, by A. S. L. Barnes	165
Shipbuilding on Vancouver Island	168
Construction News	48

STOP THE WATER WASTE!

Many Canadian cities are wasting water which, if saved, would increase pressure, reduce operating costs, save fuel or electrical power, and in many instances would postpone costly extensions to plant.

Every city and town engineer should make certain that none of the water which he is pumping is running to waste through leaks in his mains. Water-waste surveys will nearly always pay for themselves, even where the water-works are in good condition, as there are invariably some small leaks which can be found and stopped. As a general rule such surveys will save large sums.

No extensions to waterworks plants are warranted in war time until it has been made certain that water is not being wasted. In Montreal, for instance, the city is being urged to finish the aqueduct sufficiently for it to be used as a source of additional water supply, or to build another conduit at a cost of hundreds of thousands of dollars. The daily capacity of the existing single conduit is about 75,000,000 gallons. The average consumption last month was over 66,000,000 gallons and went as high as 70,000,000 gallons on two days. As the consumption is increasing at the rate of about 10,000,000 gallons per annum, the civic authorities are alarmed at the urgency of the situation.

It is probable that a duplicate conduit or some other alternative source of supply should be available at Montreal, but, aside from standby capacity to meet accident requirements, it can be fairly assumed that Montreal's 75,000,000-gallon conduit would supply that city for some time to come, aided as it is by the private company which supplies part of the city, if thorough water-waste surveys were vigorously prosecuted and all leaks stopped, and if meters were more widely used.

In a recent editorial, Engineering News-Record, of New York, said: "Besides cutting down useless and harmful waste, meters afford the only just means of apportioning the cost of a public water supply among the consumers, which alone is convincing argument for their use in these times when every man's burden should not only be kept to a minimum but should also be as equitable as possible."

The Bureau of Municipal Research, of New York, in a recent report on conditions in Montreal, says: "The present schedule of water rates is inequitable and discriminatory, and should be discontinued in its entirety. Water tax is in effect a flat rate for service, and is open to criticisms that have been applied to flat rates in all forms of utility service, and which has led to their general discontinuance. The city should adopt a policy looking to the universal metering of the service. No further flat rate customers should be accepted, and the metering should be installed first on the premises of customers whose use and abuse of water is known to be the greatest, and the metering of the domestic consumers postponed to the last."

AFTER-THE-WAR PROGRAMS

English cities and towns are preparing comprehensive programs of work to be done after the war. Ideal plans are drawn, and schedules of work are prepared which will obviate local difficulties in finding employment for returned soldiers.

Such well-conceived plans of growth are long steps toward municipal efficiency and are highly desirable apart entirely from the war and its problems. Their need was emphasized last week in the report of the New York Bureau of Municipal Research to the board of control of Montreal.

"The distribution of public improvements throughout the city of Montreal," says the Bureau, "has not been in accordance with any well-conceived plan based on a comprehensive study of the city's needs. In fact, in many cases the controlling elements in securing appropriations for public works appear to have been political expediency. As a natural result of this ill-advised policy, particularly in regard to street improvements, there has been extensive construction of permanent pavements in sections of the city where the need in no way justified the expenditure.

"The seriousness of this matter would be far less were it not for the fact that the city has paid the entire cost of street improvements, no assessment being made against the property benefited. Expenditures of this character during the past decade have aggregated millions of dollars for which the city has received no direct return. This practice has contributed materially to the present financial embarrassment of the city and cannot be too severely criticized. It is imperative that the city government of Montreal without delay take appropriate action to make mandatory the levying of special assessments against the abutting property for street improvements, including resurfacing.

"The present street paving problem is one of resurfacing and construction, rather than maintenance. It is urged that immediate action be taken to organize a maintenance force, adequate to keep in repair those pavements which have recently been constructed and have not yet fallen into that condition of disrepair which is so common in many parts of the city."

The most important defects in Montreal's civic government, says the Bureau, are the general policy followed in respect to public improvements and the lack of an adequate plan of work. Under present conditions, authorizations of public improvements such as streets and sewers are made by council and the board of control. The chief engineer of the city has no voice in the matter other than to advise those bodies upon request. This same complaint could be laid against the government of many other Canadian cities and towns, and is one of the matters requiring adjustment when preparing after-the-war programs.

Other effects of the lack of proper planning for the future are reflected in the following paragraph from the Bureau's report:—

"Two other defects in the present improvement policy of the city which have hampered the effects of administration of the department of public works are (1) authorizing the execution, irrespective of season and without providing sufficient time and adequate funds for the study of these improvements, and (2) authorizing the execution of public improvements by city forces without competitive bids. The net result of No. 1, particularly in the cost of sewer improvements, has been the excessive cost of construction."

PERSONALS

Lieut.-Col. C. N. Monsarrat, chairman of the Board of Engineers, Quebec Bridge, has been elected a director of Canada Foundries & Forgings, Limited.

William Storrie, chief engineer of the John verMehr Engineering Company, Limited, Toronto, is on his way to England to spend two months with Mr. verMehr.

Lieut. Stanley M. Sproule, of St. Lambert, P.Q., a graduate of McGill in both civil engineering and architecture, has been awarded the Military Cross for "special work in Flanders."

Lloyd Harris, president of the Russell Motor Co., who has been associated with the British War Mission in Washington for several months, has been appointed chairman of the Canadian War Mission in that city.

A. H. Harkness, consulting engineer, Toronto, has been elected by the Toronto Branch of the Canadian Society of Civil Engineers as the representative of the branch on the nominating committee of the society.

Lieut.-Col. Geo. A. Walkem, R.E., formerly of Kingston, Ont., has been placed in charge of all British railway construction work in Palestine. He is a graduate of McGill and spent some years as a civil engineer in British Columbia.

Lieut. Herbert D. Brydone-Jack, a graduate of McGill, and formerly engaged in the surveying department of the Canadian Pacific Railway, has won the Military Cross. He is attached to headquarters staff, 31st Brigade, as reconnoitring officer.

Captain Maurice Pope, of the Canadian Engineers, has won the Military Cross for gallantry in action. Captain Pope is the son of Sir Joseph and Lady Pope, of Ottawa. He attended McGill University, later entering the service of the Canadian Pacific Railway.

Major F. J. Mulqueen, graduate in science, Toronto, '13, O.C. in the 182nd Field Company, Canadian Engineers, has been mentioned in despatches and awarded the Military Cross. He enlisted from Brazil in the Royal Naval Motor Boat patrol service.

F. L. McPherson, former engineer of Burnaby municipality, and more recently filling the position of government district engineer in Nelson district, has been recalled to Victoria, B.C., to become assistant to A. E. Foreman, provincial engineer of public works.

Captain Wm. M. Everall, A.M.Can.Soc.C.E., who has seen more than two years of service in France, has been appointed assistant engineer with the Dominion Public Works Department at Victoria, B.C. Previous to joining the army he was Dominion engineer at Port Arthur, Ont.

Prof. Watson Bain, of the University of Toronto staff, has been granted leave of absence for the duration of the war. Prof. Bain, who is a professor in applied chemistry, is going to Washington, where he will be associated with Mr. Lloyd Harris on the Canadian mission there.

Sergt. A. W. Youell, of Aylmer, Ont., B.A.Sc. '11, Toronto, has received the Military Medal for services at Passchendaele. A brother, Lieut. Leonard Youell, a student in applied science, Toronto, class '16, was awarded the Military Cross for work as field observation officer at Hill 20, last August.

T. J. Wrennick, who has been in charge of the Grand Trunk terminals at Hamilton, has been made terminal superintendent for the district including the International Bridge, the Fort Erie and Bridgeburg yards in Canada, and the Black Rock and River Street yards in Buffalo. He succeeds T. W. Saunders, who has held the position since its creation six years ago. The position involves management of the bridge and a measure of control over the seven railroads which use it for freight and passenger traffic.

Arthur Surveyer and R. DeL. French have formed a partnership as Arthur Surveyer & Co., consulting engineers, with offices at 274 Beaver Hall Hill, Montreal. Mr. Surveyer, who is a member of the Honorary Advisory Council for Scientific and Industrial Research, has been engaged in consulting practice for many years past. Since 1911 Mr. French has been principal assistant engineer with R. S. and W. S. Lea, consulting engineers, Montreal, and at the same time served on the staff of McGill University as lecturer in civil engineering, in charge of the courses in municipal and sanitary engineering.

OBITUARIES

Howard C. Stone, a well-known Montreal architect, died on February 14th, from pneumonia. Mr. Stone, who was a native of Northampton, Mass., went to Montreal twenty years ago, after practicing architecture in New York City. He designed the head office of the Royal Bank of Canada, the Coristine and the Commercial Union buildings in Montreal, and the Maisonneuve factory of the United Shoe Machinery Co., of Boston, Mass., and had charge of the remodelling of the head office of the Molsons Bank, and the Canada Steamship Company's office on Victoria Square, Montreal.

H. A. Bayfield, B.A.Sc., A.M.Can.Soc.C.E., engineer in charge of the building of the government's big assembling plant at Ogden Point, where all the Imperial Munition Board's ships are to be outfitted, died at Victoria, B.C., February 13th. He was formerly superintendent of dredges for British Columbia under the Federal Government, and before that was in charge of extensive wharf construction at St. John, N.B., and other eastern seaports.