PAGES

MISSING

Volume 26. Toronto, April 2, 1914 Contents of this issue on page 541

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

ROYAL BANK BUILDING FOUNDATION WORK

TALLEST BUILDING IN BRITISH EMPIRE UNDER CONSTRUCTION IN TORONTO — GENERAL FOUNDATION SCHEME DESCRIBED—NOTES ON PIERS, COLUMN BASES, GRILLAGES, ETC.

THE steel frame building which is now in the course of erection on the northeast corner of King and Yonge Streets, Toronto, is in every way an extremely interesting undertaking. The structure has been designed upon the most up-to-date and modern lines, as regards both engineering and architectural practice. The intention of this article at the outset was to deal with the engineering features of the entire structure, but owing to its size and the extremely large amount of important matter which a complete description of it would involve, beyond giving a few particulars of a general nature only the foundations will be dealt with in the present article.

The building, which is to be known as the Royal Bank Building, will be twenty stories in height, which will give it the distinction of being the tallest building in the British Empire. The over-all dimensions will be 81 ft. 2½ in. on King Street, 112 ft. 2⅝ in. on Yonge Street, and approximately 273 ft. from sidewalk to roof. Fig. 8 shows the progress which has been made on the building up to March 20th. The ground plan is practically rectangular, with the exception of a light court which is introduced near the elevator shaft on the eastern side.

Fig. 1.—Showing Stage of Work on January 15th, 1914.

The basement is divided into three sections, that on the front, or King Street, being 14 ft. 7 in., the central portion 18 ft. 10 in. and the northern section 23 ft. 10 in. below the level of the sidewalk. The ground floor level over the whole area of the building is 4 ft. below the sidewalk.

Excavation.—The soil on this site is composed of an upper layer of clay extending to a depth of about 30 ft., directly beneath which lies a deposit of moderately hard and shaly clay for a depth of from 2 to 3 ft. Upon sinking through this (or to about 33 ft. below sidewalk level) a very hard, dense shale is reached which, from borings that have been made in the vicinity, has not been found to change much in character in six hundred feet of depth, according to Professor Parks, of the department of geology, University of Toronto.

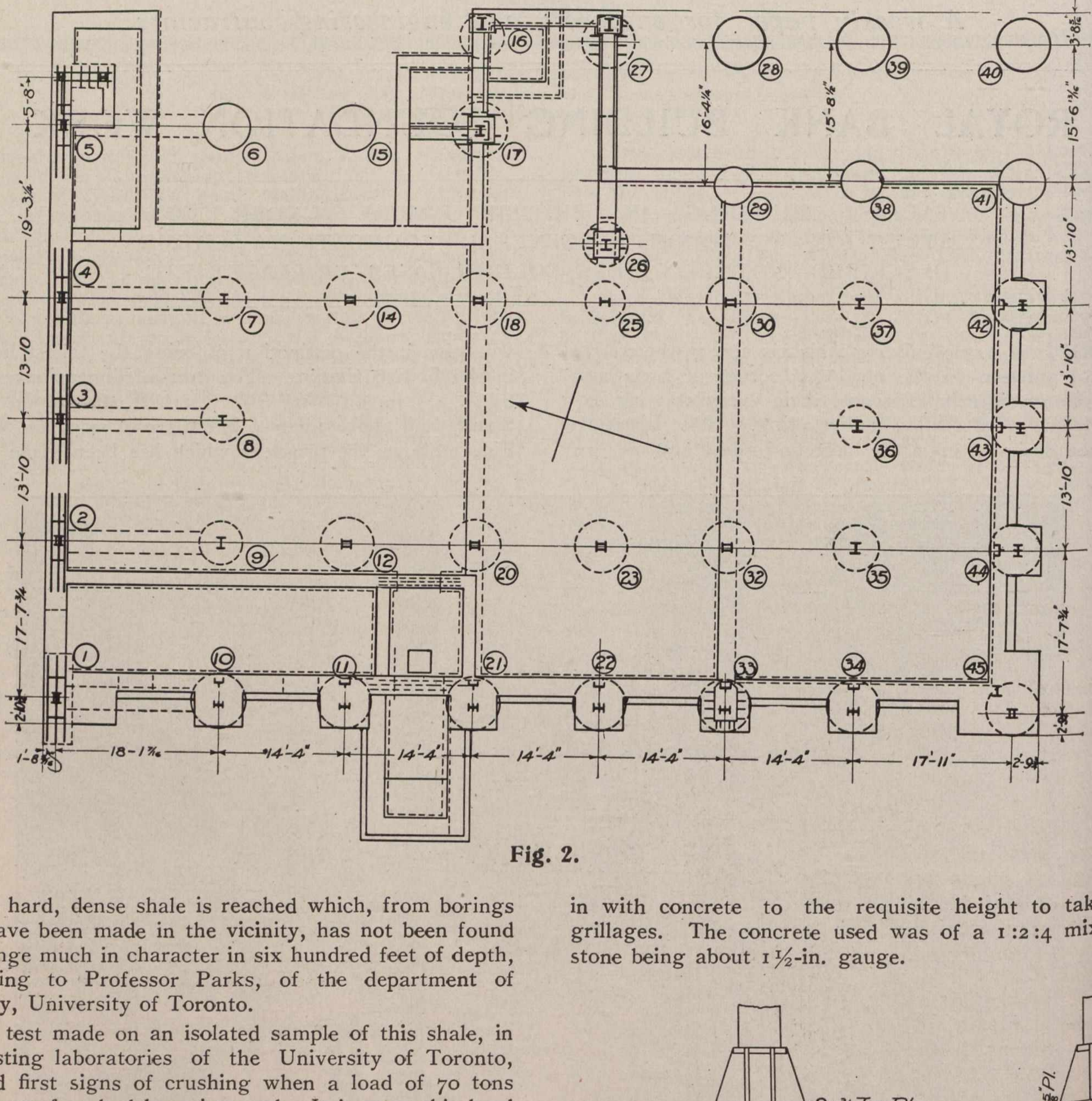

Fig. 2.

A test made on an isolated sample of this shale, in the testing laboratories of the University of Toronto, showed first signs of crushing when a load of 70 tons per square foot had been imposed. It is upon this hard shale of rock that the foundations of the building rest.

Caissons.—As no part of the basement is excavated down to the shale, caissons were sunk through the clay until bed rock was reached at each of the 41 points where a column foundation was required. Each column is carried upon a separate pier, with the exception of those which are carried on cantilever girders, or on plain girders, as shown on Fig. 2. All piers, with the exception of those along the extreme north end of the building, are circular in plan, and vary in diameter from 4 ft. 4 in. to 6 ft. 8 in. at the top, according to the proportion of the load that is transmitted to them.

These piers are increased in diameter at the bottom by an additional 2 feet in each case, the enlargement tapering through a height of 3 feet. On an average, each pier carries a load of about 14 tons per sq. ft. Owing to the nature of the soil, in sinking for piers it was found unnecessary to use any form of hollow caisson or piling as the clay walls were self-sustaining. Consequently these excavations were made exactly of the size and shape required, and on bottom being reached, were filled in with concrete to the requisite height to take the grillages. The concrete used was of a 1:2:4 mix, the stone being about 1½-in. gauge.

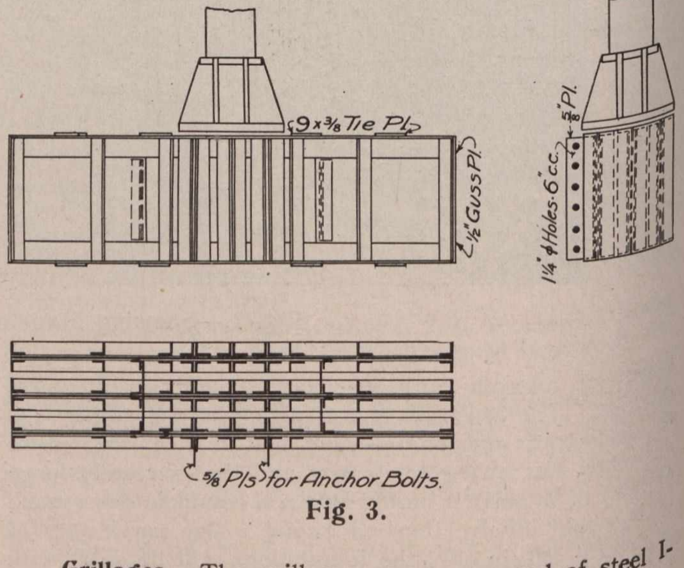

Fig. 3.

Grillages.—The grillages were composed of steel I-beams varying from 10 in. @ 30 lb. to 24 in. @ 100 lb., those for the main columns being composed of two sets of four 15-in. @ 50 lb. I's, and each set of 4 beams being connected by means of ¾-in. through-bolts with pipe separators between the beams. One set was placed at right angles to, and above the other upon the concrete piers. They were carefully levelled up and the whole then

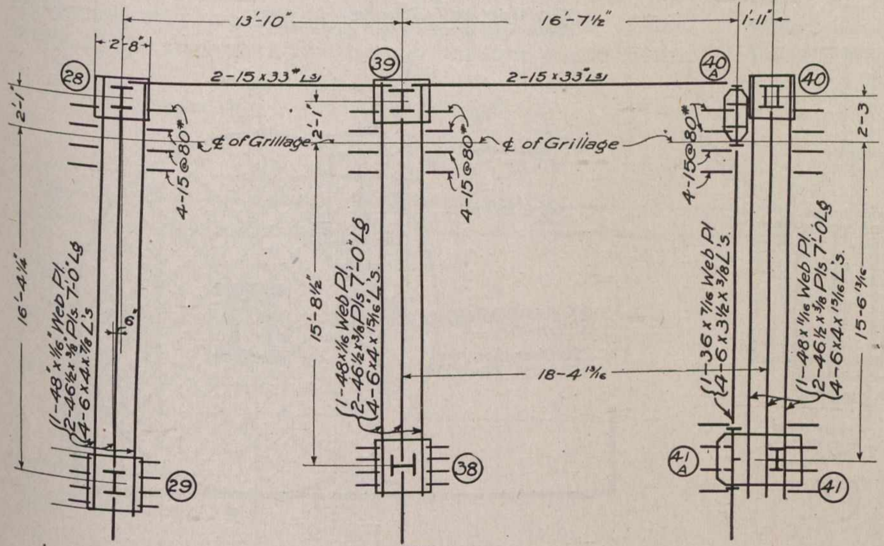

Fig. 4.

grouted in level with the top of the uppermost grillage. Section "A" of Fig. 5 illustrates the arrangement.

Column Bases.—Each of the piers constructed as above are capped with a heavy cast iron column base similar to those shown in Fig. 5. These bases were cast from tough grey iron. The actual test made on coupon bars one inch square in section and 12 in. long, loaded at the centre, gave on an average a breaking load of 30,000 lb. The upper surface of the cast iron bases is planed true and parallel to the lower surface, and holes are drilled for bolts to connect the columns to bases. In Fig. 1 several of these bases may be seen on the ground ready for placing. In designing these bases provision was made for 1 inch of grout between the base and the steel grillages. In setting, small wooden wedges were used under the corners of the castings, by which means the bases were set dead level, and raised or lowered to the exact elevation required. Grouting was then introduced through vertically cored holes at the centre of the casting, and by this means the space between grillage and base was thoroughly filled in. The wedges used in levelling were not removed, and, being of wood, will give under any compression to which they and the grouting may be subjected, thus insuring even distribution of the load over the whole surface without damage to the castings.

Type of Piers.—All piers are circular in plan with the exception of those under Columns 1, 2, 3, 4 and 5, along the north end of the building, and Columns 46 and 47, carrying a smoke stack at the north-east corner of the building. Columns 1 to 5 are each carried by four plate girders bolted together as one, and running parallel to and under the north wall. (See Figs. 2, 3 and 5.) It should be mentioned that in the City of Toronto all building foundations must be within the limits of the particular building lot; footings cannot be carried out under an adjoining lot. Consequently it is sometimes necessary to cantilever out to place the columns sufficiently close to an adjoining wall. Owing, however, to the depth of the basement at this end of the building, bed rock is not more than 10 and 11 ft. below the column bases, and it was not necessary to use cantilever girders to carry these five columns. Instead, a trench was cut along the extreme northern limit of the lot, extending inwards about three feet, and down-

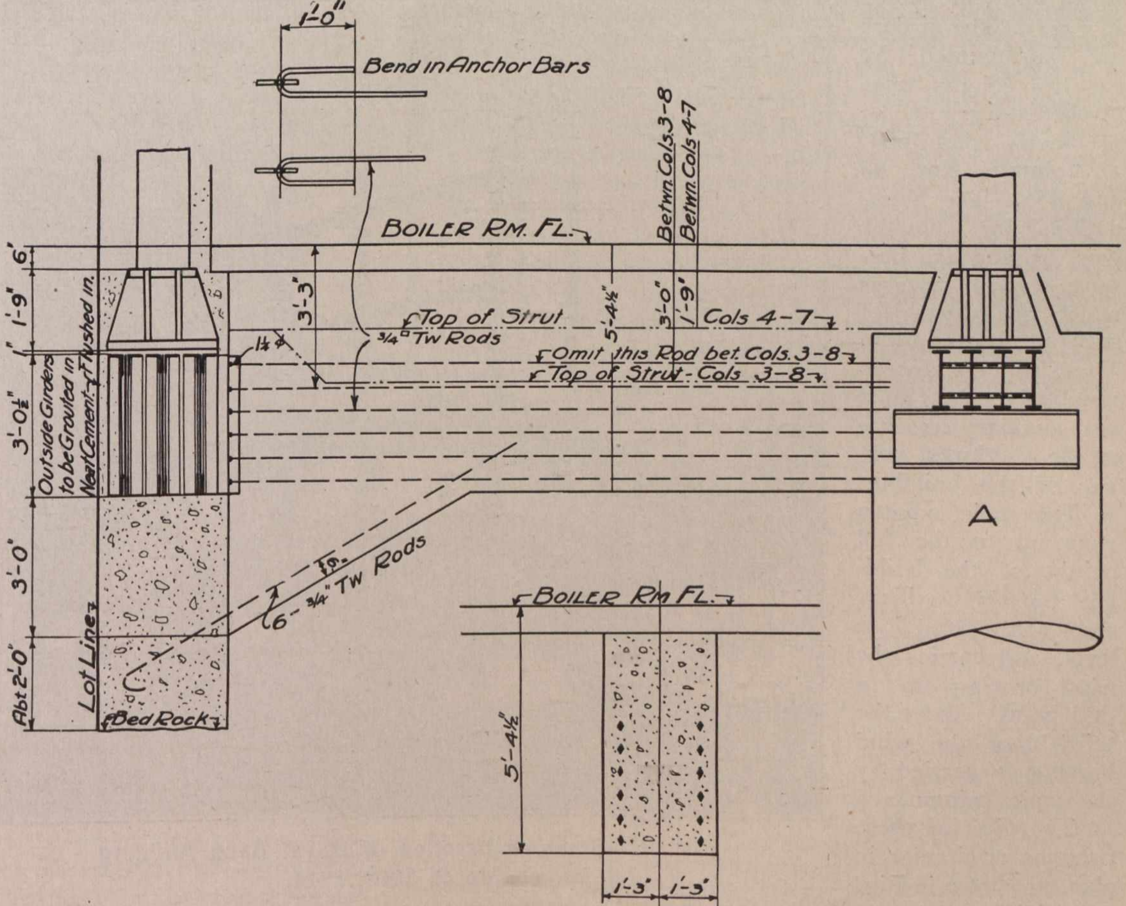

Fig. 5.

wards to bed rock. This trench was filled in with concrete to the requisite height, diagonal tie rods being inserted (as shown in Fig. 5) which later formed part of the horizontal reinforced concrete struts running at right angles to the girders. On this concrete wall were placed the plate girders already referred to. Twisted steel anchor rods were then hooked into the projecting plates provided on girders, and laid in a trench 2 ft. 6 in. wide by 5 ft. 0 in. deep, extending out at right angles to the girders and butting onto the caissons of the next row of columns. The girders, and trench with rods, were then filled in with concrete, the outer girder being grouted with neat cement flushed in to lot limit, as shown in Fig. 5. The girders are surmounted by cast iron column bases levelled and grouted as previously described.

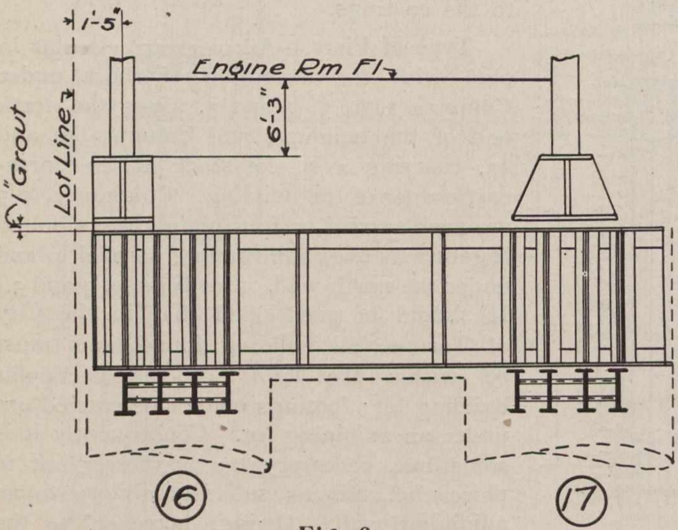

Fig. 6.

Columns Nos. 45 and 45a.—The foundations for columns Nos. 45 and 45a present several features which are worthy of special description. These columns are respectively the main and auxiliary columns at the southwest corner of the building.

The main column runs up to the full height of the building, but the auxiliary stops at the third floor level, and carries the wind bracing up to that point. Above the third floor the wind bracing is carried by the main column.

The pier for these columns is circular in plan, as shown in Fig. 9, and is surmounted by a special grillage composed of a bottom course of five and an upper course of six 12-in. @ 40 lb. I-beams, the latter course laid at right angles to the lower, as shown in Fig. 9. It will be noticed that the beams in the upper course are carried diagonally towards the centre of the building, to form a base for the auxiliary column. The weight thus applied would cause an eccentric loading upon the pier, the load centre approaching towards the inner wall of pier. To overcome this eccentricity of loading, the position of the pier has been moved diagonally inwards by 2¾ in., thus concentrating the combined load about the centre of the pier.

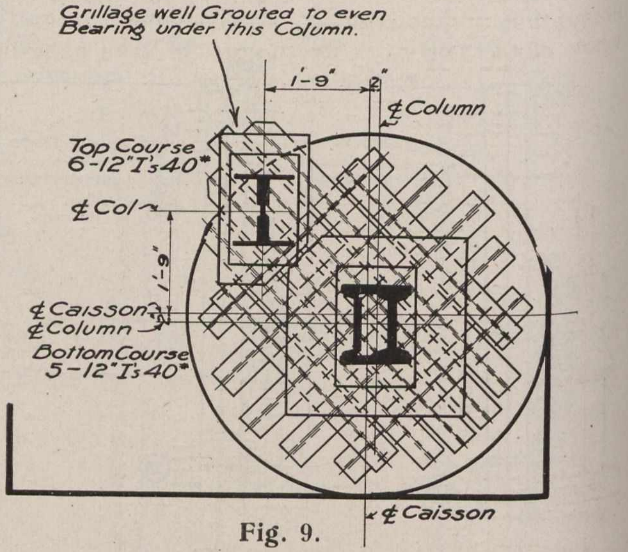

Fig. 9.

Cantilever Girders.—Columns 17, 27, 28, 39 and 40 on the east side of the building abut on an existing structure, and commence from a level considerably above the rock (as very little basement excavation was required under this portion of the building). They are carried upon cantilever girders. These girders are each carried in turn by two circular caissons which are surmounted by single grillages composed of four 15-in. I-beams. This is diagrammatically shown in Figs. 4, 6 and 7.

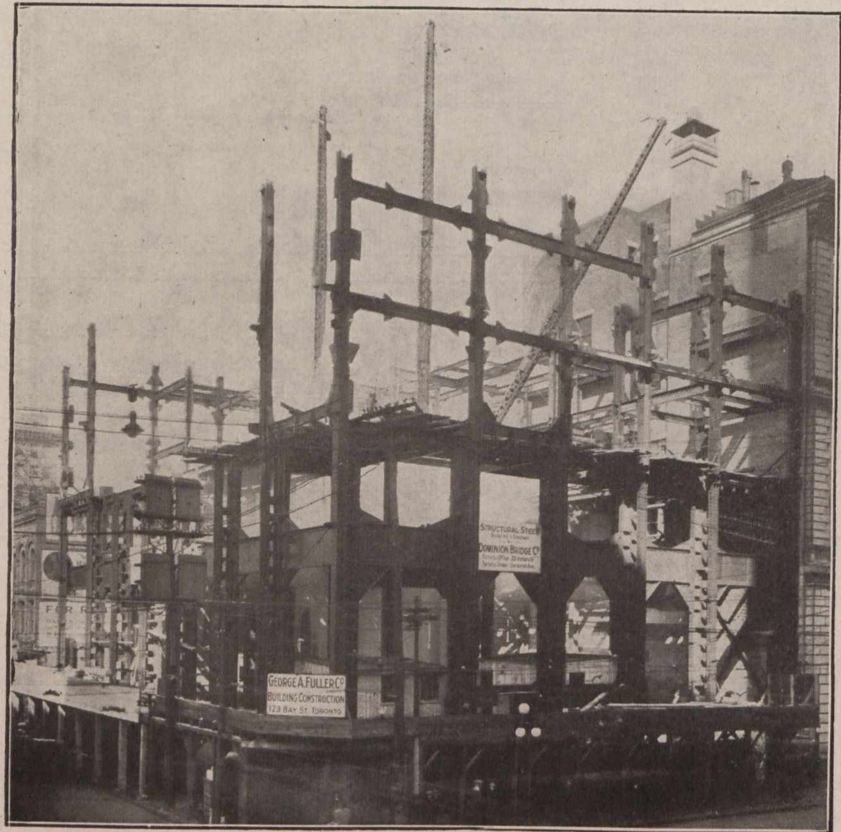

Fig. 8.—State of Erection of Royal Bank Building on March 20th, 1914.

The girders are each built in three longitudinal sections, as shown in Fig. 7, and are bolted together through diaphragms after being set in place. The spaces between the girders are filled with concrete, and they are also encased in the same material. A cast iron column base is set at both ends of each girder and grouted in, as shown in Fig. 6. This cut also shows the method of cantilevering.

The building is being erected for the Guardian Realty Company of Canada, Limited, at a cost of about

$1,250,000, including engineering and architectural fees and the carrying charges during construction. It will be managed and operated by Messrs. J. and L. M. Wood, Toronto, It is being built to the designs of Messrs. Ross and Macdonald, architects, Montreal and Toronto, to whom we are indebted for the photographs and drawings illustrating this description of foundation work. The whole of the steel-work for the building and foundations

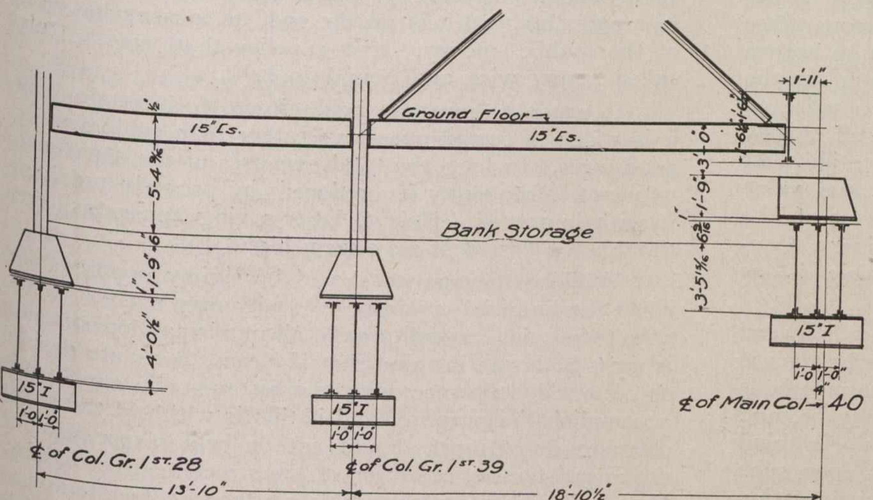

Fig. 7.

was designed by Messrs. Purdy and Henderson, Montreal. The steel is being supplied by the Dominion Bridge Company. Mill, shop and field inspection of all steel and testing of cement are being carried out by the Dominion Engineering and Inspection Company, Montreal and Toronto, to Mr. B. W. Seton of which firm we are indebted for much of the above information. The George A. Fuller Company, Limited, of New York, are the contractors and expect to have the building ready for occupancy in October next.

MOVING AN 8,000-TON BUILDING.

According to a recent article in the London Times an 8,000-ton three-story brick school building has been moved 1,650 ft. by placing it on a raft of timbers, cutting it loose from the supporting steel columns, hauling it across some sandy ground, four streets, and two street car lines, and turning it through an angle of nearly 180 deg.

The building rested on 60 steel columns, the heaviest load on an interior column being 135 tons and on an exterior column 160 tons. In preparing the building for the journey it was shored up on 12-in. by 12-in. timbers running under the floor-beams. The building is 142 ft. wide and 120 ft. deep. The columns are symmetrically spaced about the centre of the 142-ft. side, but are irregular in the other direction, which accounts for the uneven spacing of the 14-in. by 14-in. needles under the 12-in. by 12-in. cross timbers which were placed near the ends of each row of columns, even though there were only two columns in the row. Extra runs were placed near the end to take the extra wall load. As the footings for the steel columns extended below the ground surface into the basement the columns were cut off square about 4 ft. below the bottom of the floor-beams. Before removing the bases templets for the splices were applied and holes drilled in the portion above the cut, while prick marks were made on each footing. As the interior load was carried not by the cut-off columns, but by supports near it, 12-in. by 12-in. shores were placed on four sides of each column from the first floor to the second. On the shoring runways ½-in. by 6-in. steel plates were laid to receive the load from the 12-in. by 12-in. runners, 6-ft. long, under which were placed two similar steel plates turned up at the ends. There were 16 of these runners on each of the 19 runways and about 2,000 of the 3-in. steel rollers 2 ft. long. More than 1,500,000 ft. of 12-in. by 12-in. timber was used in the raft and shoring.

The blocking on the sandy ground rested on 6-in. by 8-in. ties laid close together with the material tamped under them as for a railway. Above these a blocking consisting of planed 4-in. by 10-in. timbers, and 6-in. by 8-in. or 6-in. by 6-in. cross-ties shimmed up to the bottom of the two 12-in. by 12-in. runway timbers, was used, the track plates being laid on the top of these last.

The pull was applied to six points at the rear of the building by 2-in. plough steel wire cables passed round the 14-in. by 14-in. timbers of the raft. Two loops in the centre permitted shackles to be attached at three points in the main cable. To these three shackles were attached triple blocks having seven strands of 1-in. wire rope leading 100-ft. away to the opposite blocks attached to a deadman. From the triple blocks a luff was made to double blocks, also attached to the same deadman, and a second luff, with a single block giving three strands of the 1-in. rope ending in a ⅝-in. cable, led to the drums of the hoisting engines used. The strain on the ⅝-in. cable was about one foot.

On the average the structure was moved 40 ft. each day, but the time actually spent each day in moving was only 30 minutes, the remainder of the time being taken up in carrying forward the runways and rigging the tackle and blocks. The building was moved a short distance and then turned slightly less than 90 deg. about the centre of the front wall as a pivot, after which the movement was in a diagonal line. It was again turned through almost a right angle, so that in its new position it faces in the same direction as before moving.

SLAG TAR MACADAM.

Slag tar macadam is a material very graphically described by its title. It consists of an improvement upon the early idea of tar macadam by the employment of a specially prepared furnace slag in the place of the usual road metal. In describing this product, it is stated that the metal consists of specially selected blast furnace slag, broken to standard gauges, mixed with selected tar and other ingredients, and specially treated for quick hardening by the company's own plant. The material is mixed hot by their own specially designed machinery, and stocked to mature. It is laid cold on the roads in one or more coats according to the nature and class of traffic, and the surface treated with fine chippings. As it sets very rapidly, there is no delay in opening the road to traffic. After a period of from one to three months when the surface has become completely solidified by traffic a dressing of specially prepared tar and chippings is applied. The initial cost is stated to be very little greater than that of an ordinary macadam road, whilst the life of the road is understood to be 80 per cent. longer. The surface of a slag tar macadam road is dustless and not slippery.

THE PROBLEM OF STREET CLEANING.

It is not possible for anyone to give intelligent advice about the cleaning of the streets of any city without a pretty full knowledge of all the local conditions involved. The kind and state of repair of the pavements, the traffic to which they are subjected, the facilities for disposing of street sweepings and rubbish, the climatic peculiarities, the degree of cleanliness it is desired or expected to maintain, as well as numerous other local circumstances, are all elements that must be known and carefully considered in outlining a program for the street cleaning department. One attempting to write on the broad subject must, therefore, confine himself largely to principles and practices of general application. As an article of this nature much of instruction and value is contained in a paper appearing in a recent issue of *The American City*, and written by Mr. S. Whinery, Consulting Engineer, New York City. The article is as follows:—

In most cities the data on street cleaning afforded by local past experience and results afford the best basis for future projects and programs. While the methods followed and results obtained in other cities may be, and should be, studied, it must be kept constantly in mind that it is not wise or safe to base conclusions upon such data without a full knowledge and careful consideration of all the facts and conditions affecting them. This is particularly true of reported cost data, for in addition to differing physical conditions it is, unfortunately, true that the present methods of accounting in many street cleaning departments make it next to impossible to ascertain the actual or relative unit cost of the various details of the work, and to compare intelligently results in one city with those in another.

Finances.—In a project for cleaning the streets of any municipality, the first important practical step is to provide the necessary funds for the support of the street cleaning department. Other things being equal, the cost of cleaning the streets is, roughly, in direct ratio to the degree of cleanliness attained, and the amount appropriated will, therefore, control the quality of the work that can be accomplished. However careful, efficient and economical a street cleaning department may be, the quantity and quality of the work accomplished will be limited by the amount of money available for the work. It is illogical and unreasonable to expect a street cleaning department to keep the streets ideally clean when the amount of money allowed for the work is wholly inadequate to accomplish that result. Therefore, in considering the sum to be appropriated, the standard of cleanliness it is desired to attain should be first determined and the appropriation figured accordingly.

Money is required by the street cleaning department for two general purposes—the proper equipment of the department and operating expenses. The former is as necessary and important as the latter. Satisfactory results cannot be expected if the department is compelled to do its work with insufficient, antiquated and dilapidated apparatus. Every citizen engaged in conducting a private business enterprise appreciates the importance of procuring the best and most efficient machinery and appliances if he hopes to succeed in these days of sharp competition. He must be prepared to conduct his business and turn out his product at the lowest possible cost, and to do this his equipment must be up to date and the best of its kind. It is not unusual in large and successful industrial and manufacturing establishments that a comparatively new and costly machine will be discarded and scrapped, and replaced by an improved one that will turn out work at a lower cost, and thus prove more economical in the end. Few will deny the wisdom of the same policy in conducting municipal public work, and yet many street cleaning departments are compelled to get along with old, dilapidated and inefficient apparatus, and often not enough of even this is on hand to do the required work properly. It is wholly unreasonable to expect a department to accomplish satisfactory results either as to quality or cost of work under such conditions. Not only this, but it is, in the end, an inexcusable waste of the public money. It is a policy that may be truly called penny wise and pound foolish.

If expenses must be held down to a certain limit, it is wiser to curtail operating rather than equipment expenditures. In fact, the total expenses of the department may not infrequently be reduced by properly providing it with improved, efficient, labor-saving apparatus, even though the first cost may seem high.

While extravagance should be rigidly opposed, and while the financial condition of a city may make it necessary to restrict expenditures in all municipal departments, it must be borne in mind that if clean streets are desired or expected, the necessary money must be supplied to accomplish the purpose, and if this is withheld the street cleaning department should not be held responsible for the unsatisfactory condition of the streets caused thereby. Emphasis is here given to this matter of adequate appropriations, because in many cities where economy is felt to be necessary the street cleaning department is among the first to be attacked and to have its appropriations restricted or reduced.

Method of Cleaning.—It is coming to be generally recognized that from both the sanitary and business point of view the most objectionable part of street dirt is the fine dust produced by the drying out and pulverization of the animal excreta and other matter that finds its way to the surface of the streets. The fresh, raw and usually damp excreta and rubbish are objectionable mainly to the sight, but when dried and ground the dust floats in the air when disturbed, and disease germs contained in it are breathed into the nose, mouth and lungs of those exposed to it, where it may develop specific diseases. This dust, carried by the winds, enters residences and business houses to the injury of delicate goods or furnishings, and by reagitation may thence be carried into the human system. Any system of street cleaning that does not provide for the prevention or allaying of street dust cannot, therefore, be regarded as satisfactory. The best remedy against dust is to forestall its formation by removing the fresh material from the street as quickly and completely as possible before it can be converted into dust. Where the street surfaces are of such a character as to admit of it, the most effective method of accomplishing this is prompt removal of the accumulations by the so-called patrol system, where a limited area of street is frequently passed over by a patrolling cleaner and the fresh accumulations removed.

Sweeping by power sweepers at intervals of one or more days, while less expensive, is far less efficient and satisfactory, though if properly done and supplemented by sprinkling with water or oil at intervals sufficiently near together to prevent dust-flying, it serves a good purpose. But whatever method for primary cleaning is adopted, the formation of more or less fine material cannot be wholly prevented, and it is important that the street surface shall be frequently washed by the use of hose, flushing wagons or power squeegees. On well-paved city streets the most efficient and satisfactory method of cleaning so far devised, with the apparatus now available, is hand cleaning by the patrol system during the day, followed by washing with hose or flushing wagons, or scrubbing squeegees during the night. While this is somewhat more expensive than plain machine sweeping, no other method yet devised will produce equally clean streets at a lower cost.

On macadam-surfaced streets this method is, of course, not applicable. With these, periodical removal of the loose material with hoes, brooms and shovels from street surface and gutters, and sprinkling in dry weather with water or oil to keep down the dust, is about the best that can be done.

Street Cleaning Apparatus.—The street cleaning apparatus now available and in general use is, as a rule, rather crude, inefficient and uneconomical. It may safely be said that street cleaning apparatus has not kept up with the march of improvement in other lines of work. The present machinery and devices may not admit of much further improvement, but there would seem to be a very promising field for the invention and introduction of new and perhaps novel devices that would do the work not only better, but more economically. The application of mechanical power to street cleaning machines and to conveyances for disposing of street waste has not made the progress that might reasonably be expected.

The disinclination of the average city council to supply the money to purchase and experiment with new and improved apparatus for the street cleaning department is doubtless largely responsible for present backward conditions. The wide-awake superintendent will keep his eyes open to possibilities in this direction, and the wise municipal government will give him authority and means to try out promising improvements.

The particular apparatus and devices most suitable for use in any city will depend materially on the local conditions, and must be selected with reference to these, and as the result of trial and experience.

Organization and Labor.—Assuming that the head of the street cleaning department is competent and knows from experience the local conditions and requirements, he should be given a free hand in the organization and manning of his department, unhampered by personal or political influence. This is a principle that has been discussed so thoroughly and is so universally accepted in theory that it need not be enlarged upon here. Unfortunately, it is too frequently ignored in practice. If the head of the department is to be held responsible for results, as he should be, he must be given full authority in the selection of subordinates down to the laborers on the street.

It is the custom in many cities to make the street department a sort of asylum for those requiring charitable help. Unfortunates who, because of age, decrepitude, disease or other causes are no longer able to obtain employment in private concerns and must be, partly at least, supported by the public, as well as those who have become old and infirm in the city service, are forced upon or retained in the street departments with the idea that they can thus earn something toward their support and to that extent relieve the public of their care. It is a mistaken policy. Not only are these disabled laborers unable to earn the full wages usually paid them, but they are a demoralizing element in the whole labor force. The average laborer, however strong and capable he may be, reasons that he should not be required to do more work than those around him who receive the same pay, and will too often gauge his efforts accordingly. A few decrepit men, who are physically unable to do a fair day's work, may set the pace for a whole gang.

Where it is not possible to wholly segregate to themselves these old and infirm laborers, it will usually be far better and more economical to send them to some retreat, and to retire deserving, worn-out employees on a pension. Street cleaning work requires able-bodied, energetic, active and alert labor, and if men of that kind only are employed the whole force may be held up to a reasonably high standard of performance.

Disposal of Street Sweepings and Waste.—In most cities the final disposal of the sweepings and waste collected from the streets is a more or less troublesome problem, and the cost is no small item in the expenses of the street cleaning department. A few cities are able to dispose of a part of the sweepings from paved streets to farmers and gardeners in the near vicinity on terms that repay at least a part of the cost that would otherwise have to be incurred. But the expense of handling and transporting the material to any considerable distance, and its great bulk compared with its commercial value as a fertilizer, place a limit on its disposal in this way. Nevertheless, it should be possible, in the smaller cities at least, to interest farmers and gardeners in the use of this material to a greater extent than is now common, and to thus dispose of sweepings at a price that would reduce the cost of disposal otherwise. While the percentages of fertilizing elements in the sweepings even from smooth pavements are small, the actual market value, measured by the total quantity of these elements in a ton of sweepings, is seldom less than two dollars, and there ought, and doubtless sometime will be, some way devised to utilize or recover at least a part of this value. Mine tailings containing much less value per ton are profitably worked over and the value recovered, and it would seem possible that the less difficult and refractory street sweepings might, if the proper process could be discovered, be treated with equal success. It is a problem that deserves more study than seems heretofore to have been devoted to it.

The use of street refuse for filling low ground or reclaiming areas of shallow water and marshes has not received the systematic attention it deserves. If, where such lands are available, the city would acquire them by purchase to be gradually filled in with city waste, their value would in time be so greatly increased that the profits from their sale would go far toward paying the entire cost of waste disposal. This is not a random statement; there are instances where private persons or corporations, having contracts for the disposal of city waste, have made enormous profits by the intelligent application of this plan.

Too often cities are satisfied to obtain permission for the free dumping of such waste on private lands, the owners of which, in time, reap large profits therefrom.

There is, it is true, a feeling in the minds of the public that extensive dumps of street waste in the vicinity of built-up sections is not only insanitary, but may result in a public nuisance. Experience in a number of cities seems to prove that this prejudice is without foundation in fact. Dumps of street sweepings, if properly and intelligently handled, may be neither insanitary nor offensive. When spread in comparatively thin layers and in that condition exposed to the oxidizing effect of sun and air, the purest and richest street sweepings (free from garbage) will not create a nuisance.

Cost-Keeping and Accounting.—Until quite recent years little attention was given to accurate accounting and detail cost-keeping in the street cleaning departments of American cities. It was difficult, if not impossible, to ascertain from the records and books the unit cost of any particular detail of the work. Discussion and agitation have of late years led to great improvement in this respect in many cities.

It is coming to be more and more appreciated that in the present developed state of the business of street cleaning, improvements and economies must be looked for in more careful attention to details, and in the possibilities of small reductions in the unit cost of these details. To do this successfully requires a careful study and analysis of these details, including their fully itemized cost, which in turn requires a full and complete recording and accounting system.

It is desirable for many reasons that a uniform system of accounting for street cleaning departments should be worked out and generally adopted, but even were this done there would remain many exceptional details in each city, not covered by the general account, that require special study because of local conditions. While, therefore, an adequate general system of accounts should be adopted and maintained, a program for the collection, recording and analysis of such particular details or features of the work as may seem to have a bearing upon problems and conditions peculiar to that city should be mapped out at the beginning of the year and put in force. Any additional expense that this may involve is almost sure to be many times repaid by the increased efficiency and economy that a study of the results may make possible. What is here suggested is the application to the street cleaning department of the special detail investigations upon which the modern "efficiency studies" have been based and from which such important results have been in many cases attained.

PRODUCTION OF ASBESTOS IN QUEBEC.

Returns received from eight producers show an appreciable increase in the shipments of asbestos from the producing centres of Thetford, Black Lake and Danville, Quebec.

None of the East-Broughton properties were re-opened during the year; at Robertson, only one mine was in operation. The fibre of the East Broughton rock is short and its market value is low, but, on the other hand, the percentage of fibre recovered from the rock is high. The quality of the rock at Robertson stands intermediate between that of Thetford and of East Broughton.

There has been a marked improvement in the asbestos market, and although the conditions are not yet ideal, they are more satisfactory than they have been for several years. The working margin of profits in the asbestos industry is narrow. Taking last year's figures, the production, i.e., the asbestos extracted from the rock, totalled to a value of $3,578,007. This is of course allowing the same prices for the stock on hand as for the shipments sold. This value of asbestos was extracted from 2,527,410 tons of rock. It is true that 25 per cent. of this rock goes direct to the dump and is not treated in the mill, but nevertheless, all of it has to be quarried and hoisted to the surface from depths reaching over 200 feet. Therefore, at that rate, each ton of rock yielded $1.42 of asbestos. In 1912, this figure was $1.38 and in 1911, it was $1.53.

IRON IN QUEBEC PROVINCE.

The iron ore and iron smelting industry has been dormant in the province for over two years. There has been no production recorded since 1911, and the prospect for a resumption of activity is not of the brightest. The Canada Iron Corporation, which operated charcoal furnaces at Radnor and at Drummondville to treat the local bog iron ores, has placed its affairs in the hands of a receiver, pending a reorganization. The abolition of the government bounties on iron and steel is said to have been one of the main causes of this state of affairs.

Titaniferous iron ore, of which there was an output of 4,981 tons in 1913, comes from St. Urbain and from Ivry. It is used as an ore of titanium, of which element it contains from 18 to 30 per cent.

MANAGEMENT ENGINEERING APPLIED TO A HIGHWAY CONTRACTOR'S ORGANIZATION.*

By Henry B. Drowne,
Instructor in Highway Engineering, Columbia University;
Engineer, Lane Construction Corporation.

THE fact that highway construction work looks simple and that only a relatively small amount of capital is required has led a large number of people to enter the field of highway contracting. Of this number some make a success, while others are a complete failure. Unfortunately, the law of the "survival of the fittest" does not always apply, because there are instances of those who survive through the medium of dishonest work. Competition in this line of work is very close. The big contractor with large plant equipment and heavy overhead charges must meet the competition of the small contractor who has plant enough to work only one job at a time and probably personally superintends the work. There is another class of contractors who make competition particularly discouraging at times by ignorantly bidding work at figures all out of proportion to the actual cost. This last class, however, is rapidly eliminated after trying to do work for which the bids have been too low. On account of the above conditions a contractor, who operates on a larger scale, must have a sound system of management or otherwise he will be forced out of business.

The writer believes that any man or association of men who desire to enter the field of contracting should first incorporate, as there are several advantages gained thereby. An incorporated company would usually have as officers a president, vice-president, treasurer, secretary and general manager. There might be a man for each office, or one man might occupy several of them, depending upon the size of the corporation.

No attempt will be made to outline in detail the duties of the individual officers of the corporation. Suffice it to say that at this point there should be two main divisions of duties into what might be called office work and field work. The office work would include all financial transactions of the company, such as obtaining credit, purchasing bonds, insurance, machinery and supplies and all accounting incident to the performance of the business of the company. The field work would include securing contracts and the planning and supervision of all construction work. The work pertaining to the first division is of a most important character and wise management and sound business in this department are in a large measure responsible for a company's success. On account of the brevity of this paper no further space will be devoted to this department. Consideration will be given to the management of the field work, that part of the work which is of more particular interest to engineers.

The generally recognized principles of good management are four in number and may be briefly stated as follows:—

1. The equal division of responsibility between the management and the workmen.

2. The development of a science for each element of the work.

*Presented before Section D of the American Association for the Advancement of Science at the Atlanta meeting, December, 1913.

3. The selection, training, teaching and developing of the workmen.

4. The co-operation of the management with the workmen.

Briefly stated, these rules may be applied as follows:

Usually the field work would be under the direct control of the general manager. A primary requisite to success is the ability to get contracts that will prove to be desirable work. It is difficult to make a poor job pay even under the best system of management, although an intelligent contractor will sometimes take one in order to keep his organization intact.

Second to securing desirable work would be the formation of the organization by means of which the construction work can be done. The building up of the field organization would be part of the duties of the general manager and its personnel is important. It is necessary to carry a permanent force that can be depended upon from year to year, this part of the organization comprising engineers, general superintendents, superintendents, foremen and skilled mechanics. The size of the permanent force would vary, depending upon the amount of work undertaken. In a progressive company the permanent force keeps growing proportionally to the increase in business.

The general manager should personally or through his immediate assistants, engineers or general superintendents, keep in close touch with each contract under construction. When a contract was secured, the machinery and tools necessary to do the work would be shipped to the job. Careful planning will save money that would otherwise have to be spent for new plant, as it frequently happens that some special machine can be worked to advantage on several jobs in the same season. The purchase of all material and supplies of any large amount would be done by those in charge of the office work, subject to the direction of those in charge of the field work. A superintendent, together with foremen and skilled mechanics would be selected to do the work and the approximate number of laborers necessary to start work would be determined upon. Questions arising relative to the interpretation of specifications, disputes with the party for whom the work is being done, estimating the amounts of work accomplished and the general planning of all the work would be attended to by either the general manager or his immediate assistants.

The foregoing shows to some extent the duties and responsibilities that would be assumed by the management. The superintendent who is assigned to carry out the plans on a contract would be selected on account of his fitness to do that particular job. Every man has his limitations, and it is the knowledge of these limitations that enables a successful manager to place a man where he will make good rather than to place him where he will be a failure. Besides being a man of energy and resource, a superintendent should be a man of good character. A contractor's reputation rests to a considerable extent in the hands of a superintendent and a reputable contractor values in no small degree his reputation for doing honest and thorough work. The superintendent would be responsible for carrying out the work pursuant to the plans laid down by his superiors. Delayed shipments, breakdowns, weather conditions, change of plans and labor troubles all combine to interfere with plans made in advance and the superintendent would often have to use his judgment in dealing with such occurrences until he can get in touch with those in charge of the field work. The co-operation of the superintendents, the foremen and skilled mechanics should always be sought in improvising methods to do the work in the most efficacious and economical manner.

The superintendent and his foreman should use considerable care in selecting laborers to perform different parts of the work and have considerable patience in training them to do it. An efficient gang can be developed only by a continual process of weeding out the poor laborers and the proper selection and training of those remaining. Fortunately many laborers consider highway construction as a sort of trade and they follow the same line of work year after year. If treated right they will seek employment with the same company each season, so there is generally a nucleus of experienced laborers available.

A good superintendent should always be cognizant of the cost of the work of each of his gangs and know whether the cost is out of proportion to the work that they are accomplishing. The gangs are never so large but that frequent inspection during the day and some mental calculation serves to show how work is progressing. Frequent visits by those in charge of field work would prevent slight errors on the part of the superintendent from becoming serious. Some companies require the superintendent to send to the office each night a daily report card showing the daily costs of doing the work. The writer believes that with a good class of superintendents who have the benefit of frequent conferences with those in charge of the field work the daily report card is not worth the trouble. The superintendent should, in any case, divide the work of the day under several classified heads which would be determined upon by those in charge. If a report of these classified costs for each day was sent into the office only weekly or even semi-monthly, it would prove to be efficient.

The fourth rule, that embodying the co-operation of the management and the workman, is particularly important to all highway contractors' organizations. Construction work of this kind only lasts two-thirds of a year, yet it is remarkable how a reputable contractor will maintain his permanent organization from year to year, even though his men are beyond his control for four months. The management must make the men feel that good and faithful work is appreciated and be quick to show it. Even the common laborer should not be forgotten. Although a bonus or other system of increased wages is rarely used by a highway contractor in dealing with his common laborers, the latter should be shown that those who excel gain the reward. Their efforts may be stimulated by seeing the cases of others of their class who are receiving increased pay or have been promoted to the position of foreman.

In concluding, the writer believes that the basic ideas contained in the principles of good management previously mentioned in this paper, are fully appreciated and are put into practice by the intelligent and successful contractors.

The greatest enterprise ever undertaken by British irrigation engineers, the Lower Bari Doab Canal, the third section of the "triple canal project" in the Punjab, has just been completed, and is described thus in the engineering supplement of "The Times," London, England:—"The Lower Bari Doab Canal is unusual in construction, for it actually crosses, upon a level, the important river Ravl. The new canal has cost about $7,500,000, and it is expected that it will irrigate over 871,000 acres of crops. The Chenab Canal, which is another section of the triple project, alone irrigates an area equivalent to two-fifths of the whole cultivable area of Egypt. The great Punjab canals have done more, for they have literally peopled the desert wastes."

DOUBLING THE LOAD CAPACITY OF AN OLD IRON RAILROAD VIADUCT.*

By W. T. Curtis,
Contracting Engineer, Wisconsin Bridge and Iron Co.

IN 1888 the Chicago and West Michigan Railway Company built a wrought iron single-track viaduct across the Manistee River, located about 100 miles north of the city of Grand Rapids, Mich., at a point now known as High Bridge, on the Pere Marquette Railroad, which system absorbed the old C. & W. M. Ry. some years ago. This viaduct is 1,170 ft. long, consisting in the main of 14 tower spans 75 ft. high by 30 ft. long, supporting 45-ft. spans between towers, and one 150-ft. river span across the main channel of the stream. The 30-ft. and the 45-ft. spans were, in the original construction, simple deck plate girders spaced 8 ft. on centres. The river span consisted of ordinary 150-ft. deck trusses spaced 14 ft. on centres. This structure as built 25 years ago, appeared as shown in Fig. 1.

During the winter of 1911-12, the structure was reinforced for heavier loading and stands to-day as appears in Fig. 2, taken from about the same point of view as Fig. 1. A comparison shows the reconstructed bridge to be somewhat more massive and substantial looking than the original. Fig. 3 is from a photograph taken at a little closer range after reconstruction, in order to bring out more clearly some of the details.

The original structure was designed for a loading about equal to Cooper's E-25. The rolling stock gradually became heavier and heavier, so that in later years the bridge was somewhat overloaded. In 1911 it was decided by the railway company to put still heavier loading (E-50) on the bridge, thus increasing it to an extent which would be unsafe for the old structure. It remained either to replace the structure with a new one, or to reinforce it, and the latter method was selected as being much more economical.

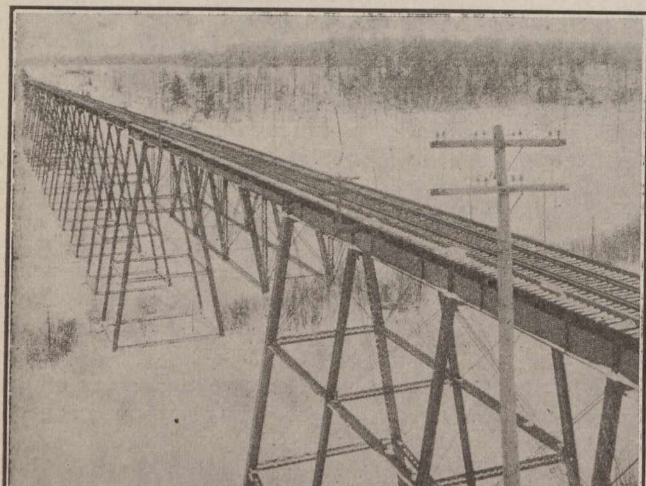

Fig. 1.—Viaduct Before Reinforcement.

Mr. J. F. Deimling, chief engineer, P. M. Ry., asked for competitive propositions for both cost and design on the reinforcement, submitting, by way of suggestive information, a solution which had been used some years ago on their Mill Creek trestle. This consisted of adding a new line of deck plate girders the entire length of the viaduct on the centre line of track, these girders being supported on new independent posts at the centre of each bent.

Some tenders were offered on this centre girder scheme of reinforcement for the entire Manistee viaduct, but were discarded, partly on account of greater cost but chiefly on account of uncertainty of distribution of load among the three girders, as the old girders of this Manistee viaduct are only 8 ft. centres, making the wood ties so short and stiff as to cause a marked degree of indeterminateness of the distribution of the load among the three girders. A further objection was the rocking or tipping effect over the new centre girder as a fulcrum under imperfectly adjusted or worn ties, the shortness of the ties magnifying this difficulty. (The girders of the old Mill Creek trestle were spaced further apart, which made the new middle girder idea less objectionable in that piece of work.) A still further objection to this centre girder scheme of reinforcement was the fact that the erection would seriously interfere with traffic during a long period of time.

Fig. 2.—Viaduct After Reinforcement.

Another scheme considered was to reinforce each of the old legs of the bents by adding another member parallel to it, surmounted with an additional new track girder placed closely along the side of the old girders, making a total of four girders with the old ones. This scheme was discarded as being prohibitively expensive, and somewhat unsightly as giving a pronounced appearance of being patched up.

The scheme finally adopted was proposed by the Wisconsin Bridge and Iron Company, being original with the writer, and is shown in Figs. 2 and 3, and also in diagram form, Fig. 4. The latter shows, in dotted lines, the old or original structure, and in full lines the newly added members.

This design was adopted for its economy, its lesser degree of indefiniteness of distribution of loads, its far greater general stiffness, its minimum interference with traffic during construction, and incidentally on account of its having a less patched-up and made-over appearance than either of the other schemes offered.

*From a paper to the Bridge and Structural Section of the Western Society of Civil Engineers, and appearing in the December Journal of the Society.

The governing or fundamental idea of the adopted scheme was to convert the upper or deck portion of the viaduct into a series of deep lattice trusses, of which the old girders would themselves constitute the top chords. This was done by adding a bottom chord about 12 ft. below the girders and introducing a Warren web system between the two chords thus formed. These old deck girders are, of course, stiff enough to resist the bending action of the load, and to deliver these local loads to the

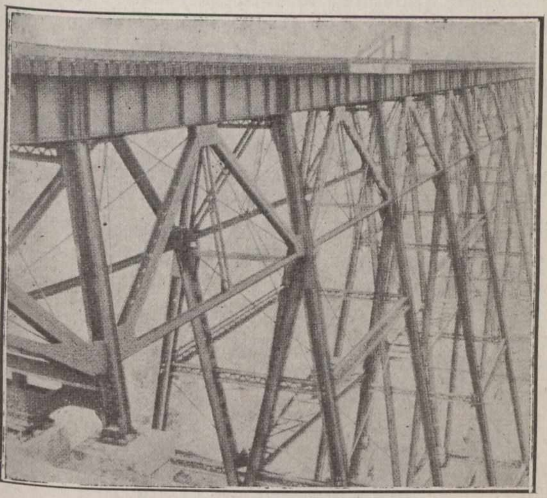

Fig. 3.—Detail of Reinforcement.

panel points of the newly formed truss. In calculation, for safety, the old girders were figured both as simple spans between new panel points, and as continuous girders, the worst result being used in all cases. Additional stiffeners were added and cross frames installed, as shown on Fig. 5.

pier built at the centre of each old bent. The two new columns thus form a V and make the remodelled bent consist of two A-frames, as shown in the typical cross-section sketch at the bottom of Fig. 4, and as shown quite clearly in perspective in Fig. 3.

This construction has the desired effect of virtually lessening the height of the trestle by about 12 ft., for the load is now delivered into the towers at the bottom chord of the newly formed trusses (Fig. 3). Furthermore, this system braces the structure longitudinally by virtue of the depth of the new trusses. Also, the new A-frame form of the bents stiffens the structure transversely. The scheme has the further advantage of being capable of field construction with practically no interference with traffic, as the old girders were not disturbed, except for the drilling of holes, etc., in them.

In this manner we preserved for the main length of the viaduct the original two-point bearing for the ties, which is undoubtedly the best, giving absolute definiteness of load delivery, and doing away with the tendency to tipping or teetering of the ties.

At the river span the system just described could, of course, not be followed, and here a new deck truss 150 ft. long was placed midway between the old trusses. The distance between the old trusses is 14 ft., being thus sufficiently far apart to give longer and consequently more limber ties, permitting of more definite proportioning of loads as delivered from the ties into the two old and the one new trusses, and also minimizing the tipping effect of the ties. In fact, this appeared to be the only reasonable solution of the river span problem, and was the one contemplated in all proposals offered.

The load from the new centre river truss is carried to the ground by a new independent straight column, as shown in Fig. 2.

The towers supporting the river span, and the three short spans of the north approach to the river span,

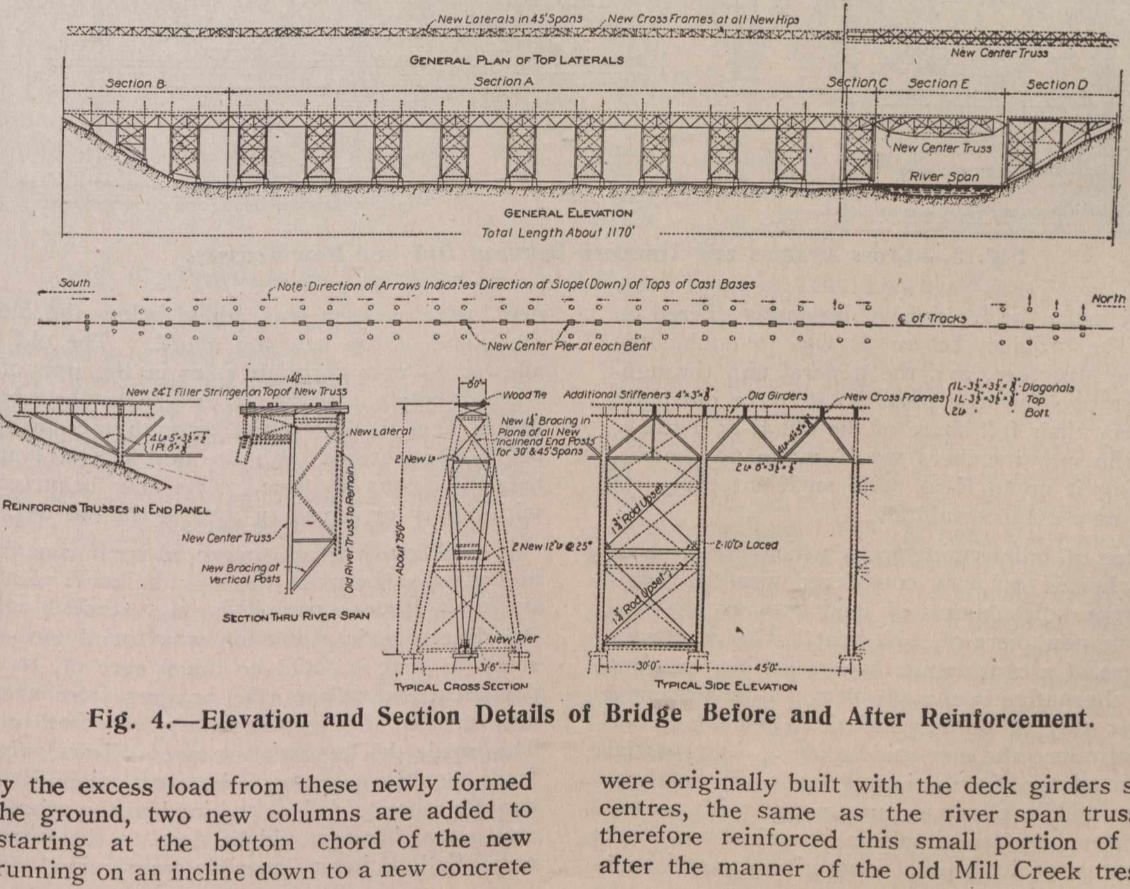

Fig. 4.—Elevation and Section Details of Bridge Before and After Reinforcement.

To carry the excess load from these newly formed trusses to the ground, two new columns are added to each bent, starting at the bottom chord of the new trusses and running on an incline down to a new concrete

were originally built with the deck girders spaced 14 ft. centres, the same as the river span trusses, and we therefore reinforced this small portion of the viaduct after the manner of the old Mill Creek trestle, i.e., by the introduction of a new girder midway between the two old ones, in line with the new river truss and, like the latter, supported by a single new independent straight column at the middle of the old bents.

The new steel was figured as closely as possible in accordance with the American Railway Engineering Association specifications. The old metal, which is of iron, was figured in general at 14,000 lb. per sq. in. in tension, and at 16,000 — 70 l/r in compression. Judgment had to be exercised at all times in the application of specifications, this particular piece of work being most highly susceptible for the practical adaptation of that familiar remark which appears on the front cover page of all of Mr. Theodore Cooper's specifications, reading as follows: "The most perfect system of rules to insure success must be interpreted upon the broad grounds of professional intelligence and common sense."

In a remodelling work of this kind it is impossible to escape entirely, indeterminate features, as the engineer is confronted and restricted by conditions as they exist. He necessarily lacks the freedom of ingenuity offered on new work. The problem before us was to double the capacity of the structure, and the general aim throughout was to arrange the new parts so that the old parts would still carry their full share of the old E-25 loading, and so that the new members would make up the difference to bring it up to E-50, with sufficient excess to insure taking care of uncertainties.

One source of indeterminateness which was true of both of the schemes seriously considered was the possibility of improper distribution of load between the two old and the one new piers of each bent. This is always true in the case of a continuous three-point bearing, but there was no alternative in this problem, as there seemed to be no other way of getting sufficient bearing in the soil than to introduce the new middle pier. As a partial insurance to a proper distribution of loads on the three piers, the new middle pier was surmounted with an adjustable cast iron base, so simple in its adjustment that a bridge inspector on his annual inspection can, without any assistance whatever, and with no other tools than a good-sized wrench, adjust this shoe to take care of any difference in shrinkage or settlement which may appear among the three piers. The sliding surfaces of these adjustable shoes were coated with a cheap and lasting form of lubricant. The wedges provide for a vertical movement of ⅛ in. for a horizontal movement of 3 in. and are controlled by ordinary machine bolts with double nuts. In erecting the wedges, they were set in pairs with the slopes in opposite directions so as to neutralize each other and prevent the entire structure from tending to drift or slide all in one direction.

In Fig. 5 is shown sectional views of the cross frames and hangers between the two old river trusses and the new truss, the latter being somewhat deeper than the old ones. The heavy I-beam shown at the top of the new centre truss does not constitute a part of the top chord section proper, it being merely a continuous filler and tie support, in order not to permanently disturb the old top lateral system which was left intact. An entirely new lateral system was added below the old system in the plane of the new top chord. The old laterals are allowed to pass through holes in the web of this 15-in. I-beam, only one of the old lateral members being disconnected at a time to insert through this beam, and none being disconnected until the new lateral system directly beneath it was in place. This filler beam was provided with shims for adjusting it to fit the old ties.

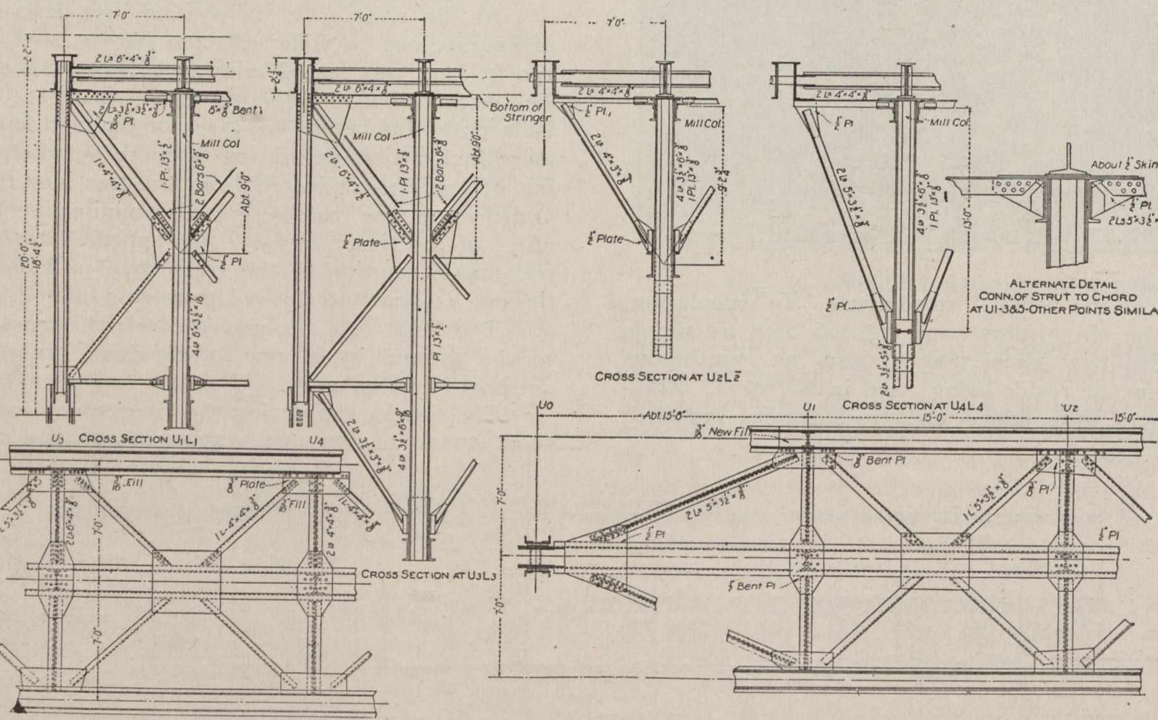

Fig. 5.—Cross Frames and Hangers Between Old and New Trusses.

A difficulty which presented itself was the difference in deflection between the old shallow river trusses and the new deeper one. This was studied carefully, and the difference in deflection was found to be sufficiently small so that it could be taken care of, to all practical purposes, by making the hangers from the old to the new trusses heavier than was theoretically required. This made the hangers act as equalizers, whereby if one truss should commence to be overstrained it would deflect enough more to deliver the load to the other truss before any actual harm would be done to the former. In this way, the load in any possibly overstrained member would still be so much below the elastic limit load that set deformation was out of the question. It was found that the percentage of overstrain necessary to demand equalization was very low, and that while perhaps this solution of the distribution of the loads would not be considered as the most desirable practice in new designing, it served as a safe and satisfactory solution of the problem at hand.

The expansion of this new centre river truss was taken care of by a link construction, shown on Fig. 6.

The structure being narrow and high, the matter of thoroughly bracing it was nearly as important as the direct loading feature, and while the general form of reinforcement provided for a marked general stiffening of the main run of the viaduct, additional bracing was added entirely independent of the old bracing system, the old system being allowed to remain intact so that both systems are now acting jointly to withstand wind and tractive forces.

and the tractive forces are carried from this point to the ground by an entirely new system of bracing in the longitudinal plane of the legs of these new V columns. (This is shown in typical side elevation, Fig. 4.)

The solution of the more general problems, while interesting, led incidentally to problems of more minute detail, which were in themselves fully as interesting as the larger problems, and in some instances were fully as important. The detail drawings for the reinforcement of this bridge covered some 35 sheets, and the scope of this paper will permit of touching upon only a few of the more interesting details.

The new V shaped columns in the tower bents are designed to go half on either side of the old bents straddle fashion, and were shipped "knock down," each leg of the V being in two parts for each of its sections. The lacing bars were shipped riveted to one side of each section, the other side being connected in the field. It

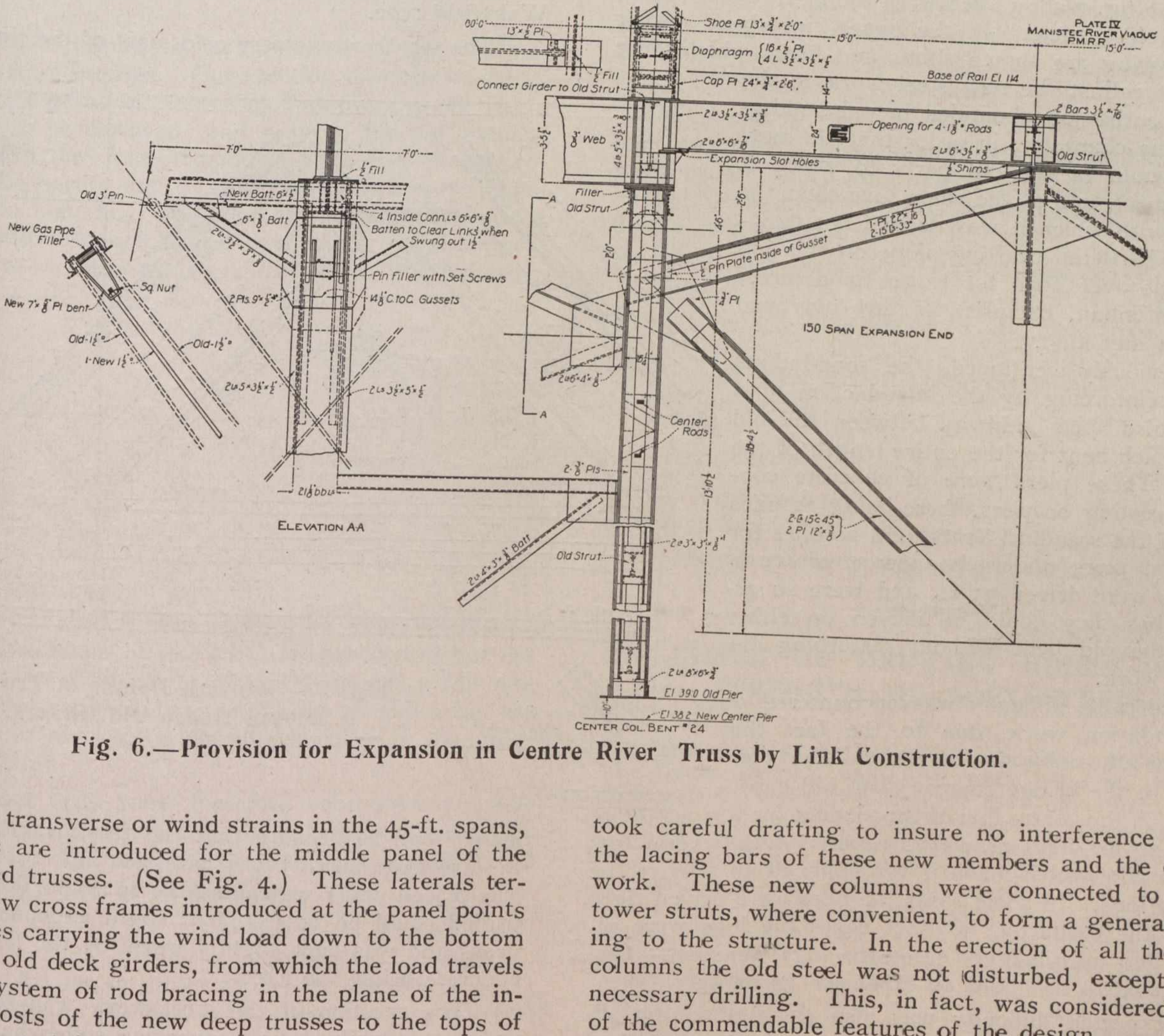

Fig. 6.—Provision for Expansion in Centre River Truss by Link Construction.

For the transverse or wind strains in the 45-ft. spans, new laterals are introduced for the middle panel of the newly formed trusses. (See Fig. 4.) These laterals terminate at new cross frames introduced at the panel points of the trusses carrying the wind load down to the bottom chord of the old deck girders, from which the load travels through a system of rod bracing in the plane of the inclined end posts of the new deep trusses to the tops of the newly formed A-frame columns. From this point to the ground the A-frames themselves constitute the additional wind or transverse bracing. The 30-ft. spans were similarly treated.

For the wind strain in the river and short approach spans which have the new independent straight centre column instead of the V shaped columns, no additional stiffness was afforded by the new column, and the old system of rods was therefore doubled.

For tractive force or longitudinal bracing the newly formed Warren side trusses formed sufficient bracing down to the tops of the newly added V shaped columns,

took careful drafting to insure no interference between the lacing bars of these new members and the old steel work. These new columns were connected to the old tower struts, where convenient, to form a general stiffening to the structure. In the erection of all these new columns the old steel was not disturbed, except for the necessary drilling. This, in fact, was considered as one of the commendable features of the design.

Connections for the rod bracing between the pairs of reinforcement trusses in the plane of the inclined end posts of these trusses presented a problem which was solved by the use of cast steel hitch brackets, which did away with what would otherwise have been clumsy and fussy detail. One of these hitch brackets is shown in position at the left-hand end of Fig. 7. In order to avoid the uncertainty of rivets in tension on these hitch brackets, bolts instead of rivets were used in the outermost holes. These hitch brackets were cut with right and left threads, permitting of direct adjustment of the tension rods.

Much trouble was experienced in finding suitable connections of the new wind-bracing rods to the old bents, which were not converted into the double A-frame form, on account of the old bracing being pin connected. Whenever possible, a connection was made, obviating the necessity of removing the old pins, but this was impossible in some cases.

Particular care was exercised to see that the loads from the new intermediate river truss were delivered properly into the columns, and a somewhat complicated detail resulted, as shown in Fig. 6, from which it will be observed that the details are so made, in nearly every case, that the old steel is not interfered with. This, in fact, was the aim of the detail work on the entire structure.

Extra eare was exercised in all the details to allow for inconsistencies in the old construction. This was done by providing numerous shims and doing a great deal of field drilling that would otherwise not have been necessary. Fig. 7 shows details of the 45-ft. deep trusses under the old girders. In the upper right-hand corner of this drawing are shown shims and fillers which were provided to adjust the new steel work to the old. The entire job abounded in painstaking work of this character, in order that the new member would fit the old parts to which it should connect, and at the same time clear the old parts with which it was desired not to interfere. The detail drafting alone on this job cost a little over $950 for wages paid direct to the draftsman, exclusive of any overhead expense of any kind.

As previously mentioned, the foundations required reinforcing by the introduction of a new or third pier midway between the old piers, at each bent for the entire length of the viaduct. These piers were of concrete construction resting on piles, there being 12 piles to each of the standard bents, and 20 piles for the special piers under the new river truss. The piles were driven 35 ft. and were so arranged that they could be driven on either side of the old bent without disturbing the old iron work.

Considerable difficulty was encountered on this foundation work, due to the fact that there existed, unknown to the railway company or to the bridge company, an old corduroy road in the centre line of the viaduct for its entire length. This road was covered with several feet of sandy silt, which made it very difficult to remove the corduroy logs. In some cases the piles were driven right through the corduroy, in other cases the logs were removed, and in still other cases the logs were cut. One way seemed to be about as expensive as another.

Unexpected difficulty was also encountered on account of the water rising some two feet higher than had been previously known. This upset our calculations for cofferdams, causing much delay and expense.

The method of handling the pile driver was quite interesting. It had to be moved many times to drive the small cluster of piles at each of the bents, each cluster being split into two groups as divided by the old iron bents which stood on the centre line of each pile cluster. The pile driver was handled from the deck of the structure 75 ft. above, and was placed at the various points of operation without removing any of the old bracing. This not only saved expense but was better for the structure. The driver was picked up near its centre of gravity, tilted over with its legs uppermost and its nose or top thrust between the bracing rods of the structure to the desired point of setting up. In this way it was moved along from point to point. Very little timber bracing was used at the foot of the driver, which was guyed to the old iron columns of which there were plenty near each set-up. The engine was handled separately from the driver, not being mounted on it. This avoided the necessity of moving the engine as frequently as the driver.

The concrete was mixed and placed in the winter without any unusual expense, aside from the excavation and cofferdam annoyance previously mentioned. Gravel was brought to the site in hopper bottom cars and run out onto the viaduct to a desired point. A few track ties beneath the car were then spread and the contents dropped 75 ft. to the ice below. From the stock piles thus formed the gravel was conveyed over the ice to the final point of deposit, the mixing being done in each case right at the forms. The cofferdams were of the Wakefield type.

The weather was very cold most of the time, but we merely had to be sure that the frost was taken out of the dry material to begin with, for most of the concrete was placed under water and the small portion which protruded could be protected at slight expense with marsh grass and was kept slightly warm by the larger mass of concrete below the ice.

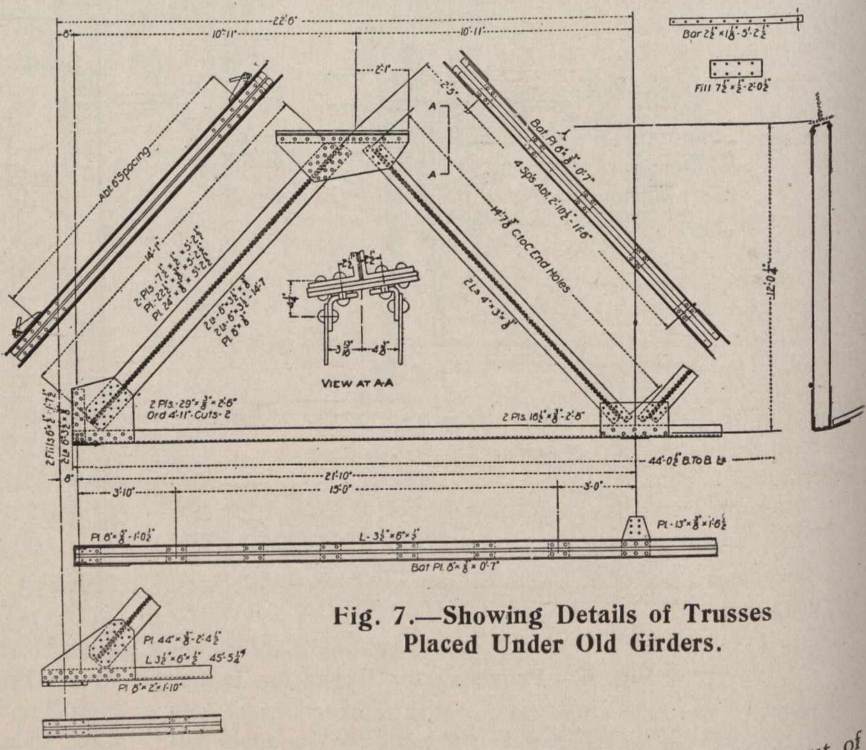

Fig. 7.—Showing Details of Trusses Placed Under Old Girders.

The erection of the steel work was somewhat unusual, and while at first appearing somewhat formidable, it worked out satisfactorily and with reasonable economy, barring delays due to foundation trouble.

The old work was mostly field bolted, which made the occasional temporary removing of old members less expensive. The field drilling and riveting was an expensive item, there being so much of it. There were about 7,000 holes to drill, about 2,000 old ¾-in. rivets to knock out and ream the old holes to 15/16 in., and about 28,700 rivets to drive on the job.

The new steel was handled by a derrick car at the beginning of the work, but this method did not prove entirely satisfactory, and the derrick car was later replaced by a locomotive crane which gave better results.

The river span was erected with very little falsework. The new steel columns were first erected at the ends of this span. Then the top chord was raised and suspended from the old structure with steamboat ratchets, the turnbuckles being placed so as not to interfere with railroad traffic. All new top chord bracing was then placed, this being connected to the old trusses, and all bottom chord bracing removed. The balance of the new truss was then placed with falsework consisting of but a single wood post at either end, and the truss was kept suspended and controlled with 24 turnbuckles until completely riveted.

The work abounded in opportunities for interferences and misfits between old and new parts, but very little trouble in this direction was actually encountered—so little, in fact, that we were agreeably surprised, and considered this piece of work as a demonstration of the feasibility of doing this class of reconstruction at reasonable cost.

A word in regard to the condition of the old iron work may be of interest. Our erection foremen reported, early in the operation, that they found some old rivets which had to be removed; and some of the old laterals, etc., to which they had occasion to hitch stay chains, appeared to be harder and more brittle than they were accustomed to handling. This led to investigation, and a chemical and mechanical test was made on the upset stub end of a broken lateral rod, with the following observations:—

	Sample A.
Manganese	0.05 %
Phosphorus	0.405%
Sulphur	0.020%
Silicon	0.289%
Area, sq. in.	0.1979
Elastic limit	not apparent
Ultimate strength, lb. per sq. in.	36,230
Elongation in 2 in.	3.5 %
Reduction of area	1.97 %
Fracture	Coarse crystalline

The above result of test was not satisfactory but the testing laboratory did not consider the sample a fair one as it appeared to have been subjected to abuse due to overloading in service, or possible burning in manufacture when upset.

Additional tests were therefore subsequently made of two samples cut elsewhere from load-carrying metal in the bridge, with the following observations, a mechanical test only being made in these cases:—

	Sample B.	Sample C.
Area, sq. in.	0.1979	0.1987
Elastic limit, lb. per sq. in.	41,230	42,300
Ultimate strength, lb. per sq. in.	56,500	57,520
Elongation in 2 in.	12%	16%
Reduction of area	12.2%	23.5%
Fracture	Fine granular	Half silky, half granular

While the metal in Sample B looked a little hard, the observations, taken as a whole, were such as to relieve suspicion as to the quality of fatigue of the iron in the old structure, and no further attention was paid to the matter other than a careful watching for defects, none of importance having been found.

As mentioned, the old structure was field-bolted (with the exception of buck and lateral bracing between the girders), a fact which was not discovered until after the field work of reconstruction had been begun. The owners, on becoming aware of this condition, at first seriously considered replacing all old field bolts with new rivets. Careful investigation showed the old structure to be in perfect alignment with none of the bolts loose in the slightest degree, although the structure had seen years of service and had been somewhat overloaded in its later years, so it was decided not to go to the extra expense of replacing the bolts with rivets. As a matter of fact, many of the buck and lateral connections which had been riveted originally, were found to be in bad shape on account of loose rivets, the vibration of passing trains having worn deeply into some of the rivets. While it was realized that the points which had been riveted in the old structure were points subject to more severe service than the points which had been bolted, the investigation satisfied all who participated in it that bolts are in reality much better than are generally considered in ordinary practice. Other observations we have had opportunity to make under somewhat similar circumstances have added evidence to this conclusion.

The cost of the reconstruction was, in round numbers, as follows; these figures including all extras on the work proper and a contractor's profit of 10%, the work having been undertaken on a percentage basis with a fixed maximum limit:—

Foundations in place (Ry. Co. furnished gravel free)	$10,200.00
New steel, 455 tons delivered at site (free freight)	22,400.00
Erection of steel (free transportation of men and equipment)	11,300.00
Total cost	$43,900.00

which, on a conservative guess, is only about half what a new structure would have cost.

The old structure weighed 496 tons.

INFLUENCE OF DRILLING HOLES ON THE STRENGTH OF SOFT STEELS.

Tests made at the Ecole Centrale, Paris, are reported in "Le Génie Civil" to show that when holes are drilled and then reamed in soft-steel bars the metal materially increases in strength, the average limit of elasticity improving 12.3 per cent. and the average tensile strength 9.2 per cent. This phenomenon is explained thus: In putting together the parts of a test piece broken under tension, it is found that the two ends do not coincide; and that, while the edges make a good contact, the central parts do not, thus indicating that the rupture begins at the centre, and that the edges have a higher tensile resistance than there is along the axis of the bar. Therefore, if several holes are drilled so as not to injure the material too much, as might be the case with punching, the average tensile strength of the section across the holes, per unit of metal, will be higher than before the holes were drilled, since each hole creates, so to speak, additional edges.

Westinghouse Church Kerr and Company, of Montreal and New York, have been retained by the Canadian Pacific Railway as engineers to investigate the matter of the proposed electrification of the new double-track, 5½-mile Selkirk Tunnel in British Columbia. The investigations will cover in general the type of system to be installed, the relative economies of steam and water power and the effect of the electrification upon operating conditions.

FLOW ON THE NORTH SASKATCHEWAN.

INQUIRIES received from some of our readers who are interested in the water power resources of the prairie provinces, respecting the stream flow on the North Saskatchewan River prompted us to apply to the Water Power Branch, Department of the Interior, for the information available at the present time.

It appears that there is a very meagre supply of data available as yet. In all, three gauging stations have been established upon the river. One of these was established in 1911 at Edmonton by the Irrigation Branch, Department of the Interior. It is stated that private interests have been taking records at Rocky Rapids, for which purpose a gauging station was established there last summer, but from this source no data are available at present. The records taken at Edmonton indicate fairly well the discharge to be expected at Rocky Rapids, as there are no streams of any magnitude entering the river between the two points; during the winter or low-water months the discharges of such streams would be negligible.

The low-water discharge has been known to fall as low as 1,200 cubic feet per second. The minimum recorded discharge is 1,073 cubic feet per second, which occurred Deember 4th, 1912, and is an actual metering. The maximum discharge recorded is 74,100 cubic feet per second, and occurred in July, 1912; though there is evidence upon which it is estimated that a maximum discharge of 180,000 cubic feet per second has occurred.

The following is the maximum, minimum and mean monthly flows recorded at Edmonton during 1911 and 1912:—

	Discharge in second-feet		
	Maximum.	Minimum.	Mean.
1911—May	21,755	6,568	9,238
June	27,930	10,600	17,412
July	51,442	15,520	28,094
August	46,692	15,320	24,600
September	18,668	8,024	11,502
October	8,024	4,887	6,597
November (1-10)	4,692	3,132	3,723
December (6-31)	1,750	1,380	1,638
1912—January	1,402	1,164	1,255
February	1,436	1,232	1,328
March	2,620	1,062	1,316
April	7,700	2,820	4,629
May	16,200	4,770	11,926
June	35,150	6,180	18,242
July	74,100	15,000	13,900
August	70,300	13,900	26,444
September	23,750	7,350	12,864
October	8,460	5,595	7,162
November	5,595	1,504	3,177
December	1,980	1,266	1,680

Some measurements taken in 1913 are given below:

	Discharge in sec.-ft.		Discharge in sec.-ft.
January 17-18	1,207	July 3	22,639
February 1	1,552	July 21	18,906
February 10	1,280	August 1	18,034
February 25	1,239	August 23	11,663
April 2	1,972	September 1	14,450
April 21	16,705	September 15	8,031
May 2	3,908	September 23	6,924
May 12	6,313	October 2	5,348
June 2-3	12,785	October 14	4,208
June 23	26,890	October 30	3,176

THE EXTENT OF MINERAL WASTE.

AN estimate of the present waste, in large measure unnecessary, of mineral resources in the country may be arrived at by a comparison with that of United States, which amounts to a loss of not less than $1,000,000 a day.

In one respect at least a consideration of the mineral wastes has a basis quite different from the consideration of agricultural wastes. Our crops represent an annual production from a reasonably permanent soil; our forests may grow again, though a much longer period of time is required; and the soils themselves may be reproduced from the subsoil and the rock beneath. But of our mineral resources we have only the one supply. This supply is to a considerable extent destroyed in use; and at the present increasing rate at which we are using and wasting it our one supply will be either exhausted or largely depleted while the country is yet in its youth.

The most urgent need for investigation and reform in the country to the south of us is in connection with the unnecessary waste of oil and natural gas. The United States Bureau of Mines reports that it has been able to stop a waste of natural gas during the past year valued at $10,000,000, with very limited facilities at its disposal. In many parts of the Oklahoma oil and gas fields the waste of natural gas that still continues is equivalent to $15,000,000 to $20,000,000 per annum, and this waste in all of the oil and gas fields of the country now aggregates more than $50,000,000 per annum. Of the total waste of gas in the different oil fields of the country more than 80 per cent. is believed to be easily preventable. As regards the remaining 20 per cent., it is believed that gasoline may be extracted from much of it and the gas itself burned for some useful purpose.

The need for enlarged investigation is further shown by the fact that in addition to this waste of gas the waste of petroleum, and especially the loss of the lighter oils, in pumping and storage is much greater than is ordinarily supposed. Moreover, the injury caused in a number of oil fields through the flooding of oil and gas strata by underground water is a separate phase of the subject calling urgently for inquiry and investigation.

The waste in coal mining is another drain which calls for serious inquiry and investigation. A preliminary estimate, based upon limited inquiry and examination, indicates an annual waste or loss of coal in mining and handling of not less than 250,000,000 tons per annum.

What is needed in connection with this loss is a thorough underground survey and examination at certain carefully selected areas in each of the important coal fields of the country, with a view to determining the exact conditions under which mining operations take place and the possibilities of adopting less wasteful methods.

There is a strong advocation of similar investigations looking to a reduction in the wastes or losses in the mining, preparation, and treatment of metalliferous ores and metals, which wastes and losses aggregate in different cases from 10 to 50 per cent. of the total yearly production of such minerals and metals.

Although the above figures apply to conditions in the United States, they sound a warning note everywhere against thoughtless waste in the eager regard for temporary gain on the part of individual operators. The saving already accomplished indicates the fruits awaiting similar methods to prevent the total and permanent losses which metal mining and metallurgical operations sometimes entail.

The Canadian Engineer

ESTABLISHED 1893.

ISSUED WEEKLY in the interests of CIVIL, STRUCTURAL, RAILROAD, MINING, MECHANICAL, MUNICIPAL, HYDRAULIC, HIGHWAY AND CONSULTING ENGINEERS, SURVEYORS, WATERWORKS SUPERINTENDENTS AND ENGINEERING-CONTRACTORS.

PRESENT TERMS OF SUBSCRIPTION
Postpaid to any address in the Postal Union:

One Year	Six Months	Three Months
$3.00	$1.75	$1.00

ADVERTISING RATES ON REQUEST.

JAMES J. SALMOND—MANAGING DIRECTOR.
HYNDMAN IRWIN, B.A.Sc., EDITOR.
A. E. JENNINGS, BUSINESS MANAGER.

HEAD OFFICE: 62 Church Street, and Court Street, Toronto, Ont. Telephone Main **7404**, **7405** or **7406**, branch exchange connecting all departments. Cable Address "ENGINEER, Toronto."
Montreal Office: Rooms 617 and 628 Transportation Building, T. C. Allum, Editorial Representative, Phone Main 8436.
Winnipeg Office: Room 1008, McArthur Building. Phone Main 2914. G. W. Goodall, Western Manager.
Address all communications to the Company and not to individuals.
Everything affecting the editorial department should be directed to the Editor.
The Canadian Engineer absorbed The Canadian Cement and Concrete Review in 1910.

SUBSCRIBERS PLEASE NOTE:

When changing your mailing instructions be sure to state fully *both* your old and your new address.

Published by the Monetary Times Printing Company of Canada, Limited, Toronto, Ontario.

Vol. 26. TORONTO, CANADA, APRIL 2, 1914. No. 14

CONTENTS OF THIS ISSUE.

FOR THE YOUNG ENGINEER.

The season is drawing to the stage when the portals of our universities will open for the young graduate to pass out into the field of engineering. In his eagerness for activity of a constructive nature he is not likely to pause for an invitation to lay aside his books. He should understand at the outset, however, that in spite of its qualified instructors, rigorous discipline, specialized courses and extensive equipment, the university does not turn him out a finished engineer. It has done well if it has fitted him with an understanding of how to acquire the technical knowledge which the problems of the profession will demand as they one by one present themselves.

At this time it is appropriate to bring before the young graduate some attributes of engineers and engineering that may not have appeared on the surface during the course of his academic work. One has only to observe a view of his surroundings in the course of the day to perceive what is being done and what is still to be done in the converting of forces and materials of nature to supply the needs of the world. The engineer is the man who leads and directs the doing of it. The work itself provides his best pay in the satisfaction of its successful accomplishment. Uniting the Atlantic and Pacific at Panama, throwing transcontinental railways across the Dominion, reclaiming vast areas through irrigation, developing water powers great and small, or driving tunnels through Mount Royal and the Rockies, exemplifies the efficient and capable manipulation of forces with which engineering has to do.

In his article on another page of this issue Mr. J. L. G. Stuart has paralleled the outstanding professions of the present day, with the result that the young engineer may be justly proud of his own selection. But it should be added that the unvarying forces and principles of the engineering profession require of him the same strict integrity and attention to business that spells success in any less advantageous choice of occupation. He will learn early that the engineering world has no place for other than the energetic man. His work is to get things done.

Further, he should aim to retrieve without delay the broadness of view which forced attention to special studies has required him for a certain lapse of time to forego.

Finally, as Mr. Stuart has intimated, engineering is a progressive profession, and the young engineer must resolve to keep up-to-date. A more intimate knowledge of his own particular branch of engineering should be his chief desire, but an equally important duty to himself is to keep posted upon what is being done in a general way along engineering lines. He will find that these requirements can be best attained by close relationship with men of his profession, through personal acquaintance, engineering societies and the engineering press.

ADVANCE IN ENGINEERING EDUCATION.

Next May the School of Mines of Columbia University will celebrate its 50th anniversary and it is stated that the curriculum which has been followed for a number of years without material change will then be discontinued. Under the new arrangement three years of specialized study in the various branches of engineering will be offered leading to the several technical degrees in the Schools of Mines, Engineering and Chemistry. The requirements for admission will be the completion of at least three years of a college or scientific school training.

The reason for this change is undoubtedly the outcome of prevalent opinion that in recent years something more has been necessary for the well equipped engineer than a sound technical knowledge of his subject. The engineering profession enters into almost every walk of life and the engineer should be a man not only well versed in his profession, but a man of affairs. He is called upon for advice in subjects connected with engineering to-day that were never associated with it until the past few years. Instead of being called into consultation on technical subjects alone he is now expected to give information upon matters connected with the business world in a way the engineer of a few years ago never imagined. Instead of adhering strictly to science he must now pass upon problems connected with economics, finance, and politics, and must always hold his own in the councils of men of business.

That a high school boy who comes to an engineering school is handicapped under these circumstances cannot be doubted, and the new order of things now being established at Columbia University promises a measure of relief.

It is a course which our universities with faculties of applied science and engineering should consider very thoroughly. If the engineering student could possess the basis of a general college education when he enters it is bound to help him to attain the position now demanded of the engineer and he will be better prepared to take up the harder tasks of graduate work with no necessity for apprentice work.

The completion of at least three years of a college or scientific school course as now required by Columbia for admission, this course to include thorough instruction in mathematics, physics and chemistry, and in addition, preparatory work in draughting, shop-work, mineralogy and surveying, places the student in a position to efficiently assimilate the education which there is to be derived from the demonstration and personal operation of the equipment with which our university laboratories endeavor to combine the practical with the theoretical.

EDITORIAL COMMENT.

The citizens of Ottawa have voted in favor of mechanically filtered water from the Ottawa River in preference to the 31-Mile Lake scheme advocated by Sir Alex. Binnie.

* * * *

Previous reference has frequently been made in these columns to the work of the International Joint Commission, and to the efficient methods which it followed for the consideration and solution of the variety of problems submitted to it by the governments of Canada and the United States. On April 7th the Commission will meet in Washington to resume its consideration of the applications of the Michigan Northern Power Company and the Algoma Steel Corporation for authority to divert water and to build compensating works in the St. Mary's River at Sault Ste. Marie.

Since its meeting in Detroit early in March a committee consisting of engineers representative of both countries and of the two applicant companies, have been engaged in drafting a schedule of conditions designed to provide such regulation of the dam in the St. Mary's River as will effectually safeguard the interests of the municipalities and others at the western end of Lake Superior.

ENGINEERING AMONG OTHER PROFESSIONS.

By J. L. G. Stuart, B.A.Sc.,
Assistant Engineer, Roadways Department, City of Toronto.

THE engineering profession is a very progressive one. It is always looking into the future, always trying for something a little better than it has already accomplished, always attacking new problems and doing new and bigger things. This is to some extent true of the medical profession, but it can hardly be said to be true of law, for the lawyer is always looking to the past and hunting up an old precedent to govern the administration of justice to-day. If past decisions were in accordance with the eternal verities, and had proved themselves just, beyond dispute, it would be all right, but such is not the case, for these laws and decisions were merely man-made, and the only thing that keeps a great many of the decisions standing is that they have not been carried to a higher court. In engineering, the fact that such a thing was done in such a way last year, last decade or last century, rather counts against that way of doing it to-day, for it is almost certain that there is a better way of doing it. The whole tendency of law and theology is conservative, that of engineering is progressive. In five years an engineer is almost out of date unless he has striven to keep abreast. Not so the clergyman, while a lawyer has simply to read up the last five years' statutes and decisions.

In engineering, probably more than in any other profession, a man has to stand on his own ability to do things. Fine words and fine manners do not count; it is his works that speak. In medicine, law and theology a man's personal appearance, address and general deportment count for a great deal, but in engineering the quality above all is the product of training and ability to put plans into material. Of course, if the engineer has men under him, he has to know how to handle them, but about all they require is just treatment and a knowledge on his part of what he is doing. An admirable feature is that the profession strikes such an even balance between theory and practice and gives such a scope for both inductive and deductive theory. An engineer works out his theory and translates it into material. If he does not get the results anticipated, it is up to him to discard his theory or find out what is the matter. He must keep the two together—that is to say, his theories must be practical or he is a failure in his profession. Unlike the lawyer who builds up a great deductive system of jurisprudence and frequently ends in making a travesty of justice, and unlike the theologian who also builds up a great system by deduction and arrives at a conclusion diametrically opposite to that of his brother theologian, the engineer never reaches such a *reductio ad absurdum*, for his theory is tested in practice at every step. He may make mistakes in details, but these soon show up and he need have no fear of his profession being torn asunder by the discovery that part of his understructure is false, for that understructure has already been tried and found true.

The engineer should have a good opinion of his profession. This is very easy, as it is rising in public estimation every year, and as its advantages far outweigh its disadvantages. Among the former might be mentioned its universality. Like art, its principles are independent of language, race, religion, locality and human laws. The principles which govern the boring of the Alps are the same which govern in the Rockies under similar conditions. A bridge over the Zambesi follows the same rules as one over the Niagara and may easily be designed by the same man. But a lawyer cannot go from even one province to another without having to study a new set of statutes. Not only are the principles universal as in medicine but, unlike medicine, the language is also universal; that is to say, the plans and drawings of our bridges and tunnels, etc., can be understood by any engineer be he Hungarian, French or of any nationality. In some large drawing offices in America there are many foreigners, some of whom speak very little English, but they are adept at design and draw good pay. This gives the engineer a wide field and limits him to no special country, climate or condition of men and things.

But an engineer has to take the consequences for his mistakes. If a lawyer looses a case through some oversight or poor work he has little trouble in making his client believe his case was rather weak, if indeed, his client ever questions the lawyer about his conduct of it. And if a doctor loses a case through imperfect diagnosis or wrong treatment it is very easy to leave the relatives under the impression that it was the inevitable. But not so the engineer. If his design is at fault and a train crashes through a weak bridge, the engineer has to take the consequences. He may not be hanged for murder, but he will lose his position and his reputation. It is not often that these accidents are traced to the engineer because his designs have been all tested step by step. He is well aware of the consequences of a mistake, and there can be no shuffling on his part. If President McKinley's death had been caused or even hastened by the explosion of a badly designed piece of apparatus in his sick room, instead of by giving him solid food too soon, the engineer or designer would not have gotten off with honor.

Deception has no place in engineering. Mother Nature will bring it to the surface sooner or later.

The profession, like trade and finance, is very materialistic. Every proposition has to answer the question, "Will it pay?" While nearly every one of them adds to the wealth resources, pleasure and other uses of mankind, still it is nearly always a materialistic advantage. Furthermore, the engineer deals entirely with materialistic force and matter, rarely with life, mind and spirit. To compensate for this, his recreation would follow other lines such as art, literature and sociology.

Another disadvantage is that it is apt to make one careless of the courtesies and amenities of life. However, this is very secondary compared with the first. A more serious one is that it is very difficult to get an independent position, or in other words, to have one's own business. There are a few consulting engineers, but most of them had to make their reputations as subordinates of big companies. An engineer is apt to devote all his time to technics and neglect the financial and executive side. This is the case in nearly every engineering office, the men are good engineers but they have not enough business to manage their own prospects to the best advantage. The result is they are simply tools of men who know less than they do but are good at business and draw bigger salaries. It would pay a young engineer in the long run to spend a vacation in a hustling real estate office, or at least selling engineering supplies. At any rate, he should seek a position where he will get business ideas and practise rubbing shoulders with his equals, rather than with his superiors, for then he will naturally fall into a secondary place and that should be avoided. A certain amount of office routine is necessary, but he should try to get a position where he will have field work along with it. This is a comparatively easy thing in civil, mining and hydraulic engineering, but very different in mechanical and electrical, and perhaps metallurgical and chemical.

All things considered, engineering is a fine profession and one which is rising in public estimation year by year because it delivers the goods. It has pierced the Alps and tracked the Andes; it has driven turbine boats at 40 miles per hour, steel railroad trams at 80, electric trams at 130 to 132. It has transmitted intelligence under the ocean and through the air, it has driven ships above the water, on the water and under the water; it has mapped the earth's surface, sounded the ocean's depths and has measured the winds in order to navigate three or more miles above the surface of the earth. It has gathered minerals from refractory rocks and transmitted water from mountains to desert and city. It has converted the refuse of great cities into valuable fuel and with it has raised the standard of health. It has built skyscrapers and cathedrals, raised hills and formed rivers. It has transmitted power more than two hundred miles over a small wire and may yet do it without the use of wire. Indeed, it would be hazardous to set any reasonable limit to the things the profession of engineering will accomplish.

AIR BRAKE TESTS ON THE PENNSYLVANIA RAILROAD.

IMPORTANT improvements in the braking of heavy passenger cars were described in a paper read before the American Society of Mechanical Engineers in New York, on February 10, by Mr. S. W. Dudley, of Pittsburg. These tests were conducted jointly by the Pennsylvania Railroad and the Westinghouse Air Brake Company. The results are considered the most important recent contribution to the subject of air brakes.

A train of 12 steel cars at 60 miles per hour stores up 224,000,000 foot-pounds of energy. This is sufficient to raise the entire train 120 feet. With prevailing brake equipment such a train would be stopped by an emergency application in a distance of 1,600 to 2,200 feet, according to the truck rigging and brake shoe design. These tests showed that this distance has actually been reduced to 1,000 ft., or to within the length of the train. This was the result of improvements in the truck brake design involving the clasp brake, having two shoes per wheel, and the location of the brake shoes with reference to the horizontal centre line of the wheels, in addition to improved methods of applying the air brakes quickly and simultaneously and at a high pressure. This concerns safety.

These tests emphasized, as has never been done before, the possibilities of improvement in efficiency and economy in regular service operation by proper attention to design and installation in order to permit the realization of the flexibility of improved air brake apparatus. These improvements centre in the electric control of the brakes, giving quick, simultaneous and responsive action. The electric control has opened the way for maximum effect in practice of improvements in practically all the factors involved in air brake apparatus, all of which were covered in the development represented by these tests. The tests constituted a progressive development of brake rigging and brake shoes in connection with the scientific study of the air brake as a whole.

Trains of 15 years ago were stopped in about half the distances prevailing in the practice of to-day. Increased size and weight of equipment brought an entirely new brake problem, which these tests have solved.

CONTRACTION AND EXPANSION OF CONCRETE ROADS—II.

ONE of the very important reports submitted at the National Conference on Concrete Road Building, Chicago, in February last was that of the committee on the contraction and expansion of concrete roads. The committee consisted of Messrs. R. J. Wig, N. H. Tunnicliff and W. A. McIntyre. *The Canadian Engineer* for March 19th, 1914, published the first portion of an abstract of the report. This portion dealt with the effects of changes in temperature and moisture content of the concrete, the effect of variation in the condition and character of the sub-base and the effect of traffic. The following sections, bearing upon the application of present knowledge to the prevention of cracks in concrete roads concludes our summary of the committee's report.

Cracks.—The committee expressed its belief that it is possible to prevent all cracking of concrete in roads, with a proper understanding of the physical phenomena affecting the expansion and contraction of concrete in roadways and a proper application of engineering principles.

Longitudinal cracks usually do not occur until seasonal changes. Transverse cracks may occur at any time, but the majority should occur during the first dry season.

Transverse cracks are probably due to a favorable combination of moisture content in the concrete and atmospheric temperature conditions, together with a restraint induced by the condition of the subgrade. They may, however, be caused by an unstable foundation.

Longitudinal cracks are probably in the majority of cases caused by an unstable condition of the sub-base, although they may be caused by a favorable combination of moisture content in the concrete and atmospheric temperature conditions, together with a restraint induced by the condition of the subgrade. The latter is particularly effective if the sub-base is crowned.

Diagonal cracks are probably most commonly caused by a combination of moisture content in the concrete and atmospheric temperature, together with a restraint induced by the condition of the sub-base. In rare cases they may be caused by the above combination and longitudinal restraint along one side when abutting a rough structure.

Effect of Quality on Cracking.—The best mixture is the one which is the most dense and which will reduce to a minimum the absorption of moisture, but it should also have a strength of at least 1,500 lb. per sq. in. at the end of 28 days. It should be mixed in such a way as to give a product of uniform quality. It should be placed in such a manner as to give a uniform quality of concrete in place and to prevent loss of water.

The sub-base should in all cases be thoroughly wet so as to prevent absorption of moisture from the concrete and thus cause a rapid drying out of the concrete.

The concrete should be cured in such a way that it will retain its own moisture and receive sufficient additional moisture until it is strong enough to resist the shrinkage stresses induced by drying out.

Relation of Slab Length to Cracking.—The maximum permissible length of slabs, of similar design, on a firm foundation, on a light or flat grade will vary with the climatic conditions. In localities where there is little rainfall, as in Arizona, or the San Joaquin Valley in California, the slab length probably should not exceed 25 ft. This length has been determined by an analysis of a report by A. B. Fletcher, State Highway Engineer, of California, on the cracking of a monolithic road, together with a knowledge of the results of measurements obtained by the Bureau of Standards.

In localities where the rainfall is intermittent and the ground water rises in cool seasons and lowers in warm seasons, similar to conditions which obtain east of the Mississippi River, the slab may vary in length from 30 ft. to a continuous slab. While the 30-ft. slab may be regarded as a minimum length, from economical considerations, the results of experiments indicate that cracks are quite likely to occur under certain conditions even in this length.

The data available would indicate that the length of the slab for the same sub-soil conditions does not affect longitudinal cracking. It is, however, interesting to note that in a report by A. N. Johnson, State Highway Engineer of Illinois, is to be found a statement that in roads constructed by him in 1912 with a total length of 2.3 miles he finds 9.1 slabs per mile, cracked longitudinally, transverse joints being spaced from 50 to 100 ft. apart, on roads 16 to 18 ft. in width. A report of F. F. Rogers, State Highway Commissioner of Michigan, on the Wayne County Roads, shows that on roads constructed in 1912 with a total of 9.6 miles, 9.5 slabs per mile, cracked longitudinally, transverse joints being spaced 25 ft. apart on roads 15 and 16 ft. in width.

The length of slab should vary with the quality of the concrete. In a short time a denser concrete will absorb less moisture and consequently will have less tendency to move; it will also have greater strength to resist stresses induced by restraint of the sub-base. A dense concrete is particularly of value where subjected to intermittent wetting and drying. In a dry climate where plenty of water is not available for curing the slab length should not exceed 20 ft.

The length of the slab should not be the same for all sub-soil conditions. If the sub-soil is of unstable material the length of the slab must be shorter than for a condition in which the sub-soil is stable.

If there is a distinct variation along the length of the road in the materials of which the sub-base is constructed a joint should be placed where the change takes place. This is necessary because of the change in the frictional restraint offered by different materials and also because of the difference in the porosity which changes the moisture conditions.

The length of the slab should vary with the condition of the sub-grade. If the sub-grade could be made very smooth so that a more or less uniform frictional resistance would be obtained throughout the length of the slab, it would perhaps be the most desirable condition, but as this is not obtainable it is believed that a more or less uniformly rough sub-grade is preferable to a so-called "smooth" sub-grade. This is explained by the fact that the rough sub-grade will make each small section in the slab care for its proportionate share of the stress induced by frictional restraint, while if the sub-grade is so-called "smooth" there will be rough places in it at intervals which will place upon certain sections undue stresses, which therefore will be more liable to cause cracks. If there is any decided change along the length of the road in the condition of smoothness of the sub-grade a joint should be placed at the point where this change occurs.

If the sub-grade is so-called "smooth" on a steep grade, the permissible length of slab would not be as long as a light grade, there being a tendency to slide down hill and thus add additional stress to that imposed by moisture and temperate change.

If the grade is steep the slab should be shorter in length than that used on a flat grade. A joint should be placed at all decided changes in grade.

It would appear that the slabs could be made longer if constructed during the fall or winter, in localities where not subjected to freezing, than if constructed in either the spring or summer, although there is not sufficient data available to determine whether this would permit of an appreciable change in length. Conditions indicate that concrete laid in the fall is probably not subjected to stress as much during the first few months, since the tendency to increase in length due to moisture is counteracted by the tendency to decrease in length due to temperature.

The experimental results indicate that there was greater movement of the concrete covered with a bituminous carpet than with concrete uncovered. This is indicated in Curves shown in Fig. 1 of covered and uncovered slabs. If, upon further investigation, this condition is found to hold true the slab length would probably have to be varied. The reason for the greater movement noted is probably to be explained by the fact that a dark surface absorbs more sun heat and the bituminous coating holds for a longer period any moisture which gets beneath it.

The length of the slab may be made greater for a greater thickness of slab. The increased friction caused by increased weight is proportionately less than the increased ability of the concrete to resist stress. Sufficient data are not available to give a relative figure.

It is not believed that traffic need be considered in determining the length of the slab.

There would tend to be a greater movement in a wide or elastic joint than in a narrow or unelastic one and since cracking occurs during contraction there would be less movement with a tight joint; a tight joint therefore would permit of a longer slab. It is not known, however, that this factor is sufficiently appreciable to be considered in determining the length of the slab.

Relation of Cross-Section of Slab to Cracking.—A concrete road laid on a crowned sub-base would be the most liable to crack longitudinally and on a dished sub-base the least liable to crack. The resistance offered to contraction of a slab with a crowned sub-base is greater than that offered by either a dished or flat sub-base, because the concrete must move against the effect of gravity. With the dished sub-base the concrete contracts with the effect of gravity and therefore is stressed the least.

The cross-section having the greatest thickness at the centre with a dished sub-base would offer the greatest resistance to longitudinal cracking; the cross-section having the least thickness at the centre with a crowned sub-base would offer the least resistance to longitudinal cracking.

It is not believed that transverse cracks are in any way affected by the width of the slab. The data available to the committee would indicate that the width of the slab for the same sub-soil conditions does not affect transverse cracking.

The slab should have its greatest thickness at the centre no matter where the longitudinal drain is placed.

Over an unstable sub-soil the slab should be made of greater thickness throughout the width than over a stable sub-soil, with the greatest thickness at the centre.

It is not necessary to vary the design of the cross-section of a slab with the condition of the sub-grade.

The dished is the preferable design under all climatic conditions, especially in arid regions.

The dished sub-base is the preferable cross-section for all seasons and especially so if the concrete is laid during the dry season.

The wider the road the thicker should be the slab.

It is not necessary to vary the design of the cross-section with the length of the slab.

A concrete road which must withstand heavy and concentrated traffic must be made thicker than for light traffic.

Value of Reinforcement in Preventing Cracking.—Reinforcement will be of value: (1) When the foundations are uncertain; (2) in regions where there is little rainfall and long or wide slabs are desired; (3) in regions where there is sufficient water for curing; (4) when it is necessary to have a thin slab; (5) when a decided change in grade occurs; (6) when the movement of the concrete is restrained at street intersections or on curves, if joints cannot be placed properly; (7) when the width of the slab is greater than 25 ft.; (8) when it is necessary to crown the sub-grade and the slab can not be made thicker at the crown than at the sides.

Only fabricated steel should be used and that form which will give the greatest distribution.

The quantity of reinforcement can only be determined by an analysis of the conditions affecting each specific case.

If uncertain sub-soil conditions tend to cause a settlement on the sides of the road, which is the most common condition, the reinforcement should be near the top. If settlement is apt to occur within the centre of the slab the reinforcement should be placed near the bottom, and where the whole of the sub-base is uncertain the reinforcement should be placed near both top and bottom. Reinforcement to resist stresses due to temperature and moisture changes should be placed near the bottom of the slab. The stresses set up by a change in temperature are insignificant, except in arid regions, compared with those set up by moisture changes, and ordinarily reinforcement to provide for temperature stresses is unnecessary.

The slab length may be anywhere from 20 ft. to continuous, depending upon the many elements entering into the problem.

The widest pavement without cracks within our knowledge is 40 feet. It is probable wider pavement can be constructed.

It would appear that if properly designed a thinner slab may be used if reinforced. Definite information, however, is lacking to exactly determine this fact.

The conditions of construction affecting cracking apply to plain concrete slabs as well as to reinforced slabs.

Effect of Joints on Cracking.—The purpose of joints is to relieve the stress which might be induced by a volumetric change in the concrete caused by change in moisture content or temperature and to care for unstable foundation conditions. The committee has no evidence of the failure of slabs in concrete roads due to buckling, crushing or spalling and therefore consider the joint as primarily for the purpose of taking care of contraction.

If a concrete road is constructed without considering the affecting factors, with the idea that nature will provide cracks, it will crack, but before doing so it will cause a weakening of the concrete for some distance on each side, which may result in a partial disintegration of the road. This is evidenced by short forked cracks appearing running off from the main crack. The cracks thus formed will gradually lengthen with time and will not only be irregular in alignment but they will not be vertical.

The width of the joint controls the longitudinal movement of the slab. A greater width will allow of greater movement, consequently the slab will be more liable to crack upon contracting.

A joint should be constructed as a contraction joint with little or no room provided for expansion, as all stresses in the concrete caused by expansion are compressive and may be absorbed by the concrete; later, upon contraction there will be little movement and therefore only small tensile stresses will be induced and there will be less liability of cracking.

Experimental results show that only the movements occurring near the ends of the slab are usually transmitted to the joints.

There are no available data to show the difference in effect of diagonal and square joints on expansion and contraction. Any joint, however, should be perpendicular so as to give proper bearing between adjoining slabs when they expand.

It is necessary to provide a longitudinal joint between the pavement and an adjoining structure if the adjoining structure is rough and will cause longitudinal restraint or if the abutting structure will not offer sufficient resistance to prevent being pushed out of place.

Joints should be placed at street intersections and at sharp curves so as to allow of free movement, wherever the concrete is restrained.

Effect of Character and Condition of Sub-Base on Cracking.—A rough sub-grade is preferable since a very smooth sub-grade is impracticable to construct.

The sub-base should be very dense, but not entirely impervious. Where a rich mixture is used in the construction of a road it would tend to dry out unduly, causing excessive contraction. If a smooth subgrade could be provided so that the friction would be reduced to a minimum it might be desirable to have an impervious sub-base, but this condition is very difficult to obtain.

It is desirable to have the sub-base uniformly and thoroughly compacted so as to prevent uneven settlement.

The sub-base should be dished.

Conclusion.—The committee observed that it had been fully established that the change in moisture content of the concrete was of much greater moment than the change in temperature under normal exposure; and that a proper combination of change in temperature, change in moisture content and friction have made possible the construction of long slabs which have remained free from cracks; while under an unfavorable combination of these factors, which is to be found in certain localities, long slabs have invariably cracked.

With a proper understanding of the physical phenomena, which are recommended for investigation, and with a proper application of engineering principles by competent highway engineers, it is believed by the committee that all expansion and contraction of concrete in roads can be so controlled as to permanently avoid cracking.

FORMS FOR CONCRETE WORK

We do not often hear of failures occurring in reinforced concrete buildings after their completion, but generally during their erection, and although all failures cannot be attributed to defective forms, yet the forms are to blame in a sufficient number of cases as to render the forms for concrete work an important element in securing efficiency in construction, and not merely in the utilitarian aspect. Although it is not the general practice for engineers to design their forms, that being generally left to the contractor, Mr. Allan Graham, in a paper which he read on March 12th before the Concrete Institute, expressed his belief that an engineer, for his own protection, should at least set out some typical portion of the forms for the contractor's guidance, thus doing all he can to circumvent failure in this direction at any rate. Of course, good forms alone will not ensure safety, and vigilance should likewise be used in detecting bad work, bad design, and bad material. For, as Lieut.-Colonel Winn has pithily put it, "a fool with a shovel may absolutely defeat the most elaborate calculation involving the calculus."

Formwork is a term embracing all kinds of moulds or centering set up to give shape to the concrete or similar plastic material. It is so employed in America. There is a consensus of opinion in favor of the definition "formwork" as an inclusive term, owing to the real meaning of the term "centering" having a more limited application than usually attributed to it. As the word "form" is the same, and has the same meaning in French, German, Italian and Spanish, the author believes it will be agreed we are on safe ground if we accept it for our purpose. The term has great merit, being superior to such terms as falsework or shuttering.

The contention that the engineer should prepare the design of formwork has much to recommend it. An engineer will generally have no hesitation in setting out the design of centering for a bridge or other equally important work, but for some reason or other the design of ordinary formwork which plays such an important part in the cost of reinforced concrete is never considered. There is no doubt that a thorough understanding of the principles underlying the everyday practice of concrete form design is one worthy of the best engineering talent. With this understood, the problem can be analyzed, the requirements realized, and the design decided upon that will be the most economical and efficient, giving due consideration to the salvage of materials.

It is not merely that a design is required for a specific case which will safely support a certain volume of concrete, it is rather the problem of designing a set of forms which can be erected, taken down, and many times re-used during the progress of work. The factors involved are many, such as the type of centering, the kind of timber, how much to centre at one time, and what clamps, bolts, nails, wire or strap steel should be used. These things properly considered will repay the trouble taken and result in better and more economical work.

Various authorities place the cost of formwork at anything from 20 per cent. to 60 per cent. of the total cost. The possibility of reducing this hindrance to the more general use of concrete ought to be sufficient inducement for us to give the matter close consideration. American constructional firms have struck out in many directions to reduce this cost to a minimum, and to this end the forms in most instances are designed in the drawing office, and this, it is reported, at a cost of 2 per cent. and a saving of 10 per cent.

In his paper Mr. Graham then dealt with the kinds of timber that are used for formwork, the desirability of giving a camber to the bottom of beam boxes, the desirability of carefully checking the measurements, to see that the concrete members are actually carried out as designed, the necessity of having joints close to prevent the mixture escaping, the remedying of cracks, the removal of forms, clamps and nails to hold the forms together, the repair and re-use of formwork, the number of sets required in order to get on fast enough with the work of building, the importance of carefully clearing forms of all sawdust, dirt and chips before filling with concrete, the wetting of timber to prevent sticking, the use of sheet metal, the time for striking forms and methods of determining the strength.

ELECTRIC RAILWAYS IN GREAT BRITAIN

In a report of the railway department of the Board of Trade it is shown that since 1878 the mileage of the tramways in Great Britain has increased from 269 miles to 2,662 miles, while the capital expenditures have grown from $20,447,721 to $385,688,425.

The number of passengers carried in 1878 was 146,000,000 and for the year ended June 30, 1913, 3,220,000,000 or about 71 times the entire population. Net receipts of the tramways in 1878 were $1,122,490, and in 1913, $27,158,268. Of the mileage 1,818 miles are operated by municipalities. Of the total mileage 2,637 are operated by electricity.

Of the 286 tramway enterprises 171 are municipal and 115 are owned by private parties. Included are 13 miles of trackless trolley, which as yet show a deficit in operation. The net receipts of the municipal tramways for the year were $19,905,445 and of this $6,314,840 were applied to reduction of tramway debts, $2,646,163 to reduction in tax rates and $3,629,200 were carried to surplus. In four municipal tramway enterprises cost of operation exceeded gross receipts and in 25 municipal enterprises it was necessary to raise additional revenue from taxes to meet some part of the charges for the year. The total amount thus raised was $315,840 in 1913, as compared with $301,960 in the preceding year, which seems to indicate that the deficits are growing.

The average receipts per passenger in 1913 was 2.13 cents, as compared with 2.158c. in 1912, 2.46c. in 1898, and 3.68c. in 1878. As practically all English tramways use a zone system of fares it is difficult to give a comparison between the rate of fare in English cities with those in this country, where generally a single fare is charged for a ride of any length.

FOURTH AMERICAN ROAD CONGRESS.

Mr. J. E. Pennybacker, secretary of the American Road Congress has announced that the Fourth American Road Congress will be held in Atlanta, Ga., during the week of November 9th, 1914.

At a meeting held in London, England, on March 12, the reconstruction of the Newfoundland Oil Fields Company, Limited, was approved. The proposal is for a new syndicate with Sir Henry Blake as president, and with a capital of $24,000.

MAXIMUM FLOOD DISCHARGES.*

It is sometimes important to obtain the maximum discharge or maximum gauge height which a given stream is liable to have. This has assumed increased importance lately because of the disastrous floods of the past year. Even in parts of the country where very serious floods have not yet occurred people have begun to realize that they may have such a visitation. Some rivers, like the Mississippi, because of their extreme importance, have been the object of special study, and there is much information on hand concerning them; but for many streams the engineer is at a loss how to estimate for the highest future flood. The common method is to take the greatest gauge height on record and assume that there are to be none higher in the future, a method which leads to bad results unless the records include an extraordinary flood, which they may not do, even if they extend over a considerable period. It is also dangerous if the unusual flood occurred some time since and conditions in the valley have changed in such a way as to cause higher water for the same discharge per second.

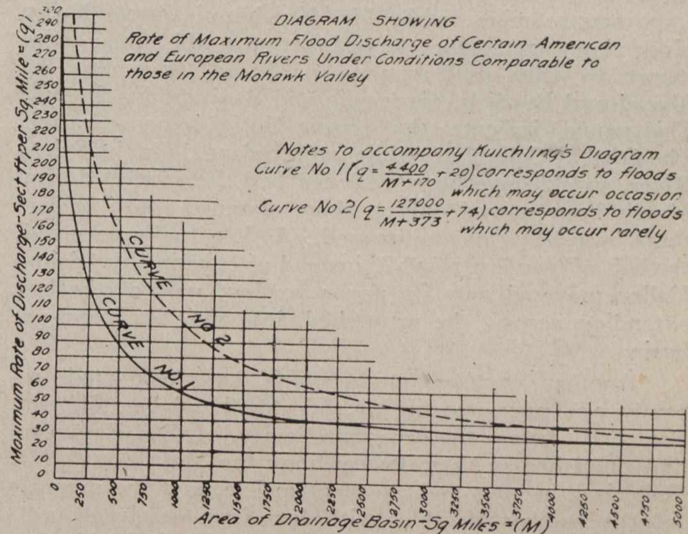

Fig. 1.

Another method of getting the maximum discharge is to look in encyclopedias, hand-books, text-books, etc., for information, and one is there met with all kinds of methods for getting the discharge. Some books will give the discharge in cubic feet per second per square mile for various kinds of country, from flat to very mountainous; some of them give the discharge as a function of the area, followed by a note saying that this formula applies to Northern India or Southern Italy, or some other place which the engineer is not interested in; and some books give the run-off from various classes of soil in terms of the rainfall. Then the engineer is as much at sea as ever, because the study of the rainfall is a complete problem in itself, and the flood may come from melting ice and snow or an ice gorge. The different results from the encyclopedia method do not seem to agree and the general result is more uncertainty.

Two studies on this subject have been made in recent years which seem to possess unusual merit. In connection with his report on the New York State Canal Survey, Mr. Emil Kuichling, M. Am. Soc. C.E., made an excellent study of flood flow on American and European streams. He obtained two equations which, with their

* From "Professional Memoirs" of the Engineer School, Washington Barracks, D.C., Vol. VI., No. 26.

corresponding curves, are shown on Fig. 1. It will be observed that the maximum rate of discharge is given per square mile in terms of the area of the basin in square miles, and small areas have a much larger unit flow. Curve No. 1 corresponds to floods which may occur occasionally, while curve No. 2 corresponds to floods which may occur rarely. The discharges indicated by curve No. 2 are larger than given by some authorities and much larger than are provided for in many places in this country. The reason of the latter is sometimes because people have not had that rare flood which may reach them any day, and against which many of them refuse to prepare until it has already occurred. The history of so many flood protection works is the story of a series of works with increased protection, the increased protection being added each time that a flood occurs larger than was expected. During the large flood which occurred in March, 1913, in the upper Scioto and Olentangy rivers, the discharge in each of these rivers at Columbus, Ohio, was, roughly, half way between the values given by the two curves. The Olentangy flows into the Scioto at Columbus. The discharge for the combined rivers is above the higher curve, or 90 second-feet per square mile with an area of 1,570 square miles, while Mr. Kuichling's curve No. 2 gives about 75 cubic second-feet for this area. (See report to City of Columbus on Flood Protection, by Alvord and Burdick, Hydraulic and Sanitary Engineers.) This would indicate that curve No. 2 is conservative. The flood at Columbus, while unprecedented for the Scioto River, would have been exceeded had the rainfall during March been moved only a short distance south or had there been snow on the ground. As it actually occurred, the belt of heaviest rainfall, instead of covering the Scioto Valley, covered only its upper portion, part of the belt extending across the watershed into the St. Lawrence basin.

Another excellent study which has been made recently was presented by Mr. Weston E. Fuller, M. Am. Soc. C.E., before the American Society of Civil Engineers and published in their Proceedings for May, 1913. Mr. Fuller's is a long and excellent article, and he presents a large number of tables with data from nearly all parts of the country, which are of great value in looking up the discharges that may occur in any particular section. Mr. Fuller does not compare floods by getting the maximum discharge, but compares the average flow for the day of maximum discharge, a method which has also been used by the United States Geological Survey. This average flow is obtained by dividing the total discharge in twenty-four hours by the number of seconds in a day. It will here be called the twenty-four hour flow, in counter-distinction to the momentary flow. Mr. Fuller compares the maximum twenty-four hour flow with maximum momentary flows, and also with what may be called average yearly flood flows.

Let Q (ave.) = average yearly flood flow obtained by getting the highest twenty-four hour flow for each year for a number of consecutive years and taking the mean expressed in second-feet.

Q = greatest twenty-four hour flow during a period of T years in second-feet.

Q (max.) = maximum momentary flow in second-feet.

T = the number of years in the period considered.

A = catchment area of the river in square miles.

For obtaining the relation between the flood to be expected in a series of years and the average yearly flood, he deduces the equation Q = Q (ave.) (1 + 0.8 log. T), from which he computes the following table:—

Table I.

Time in years.	Ratio of largest flood to average yearly flood.
1	1.00
5	1.56
10	1.80
25	2.12
50	2.36
100	2.60
500	3.16
1000	3.40

Mr. Fuller further, for getting the relation between the maximum momentary flow and the maximum twenty-four hour flow in the same flood, deducês the equation Q (max.) = Q (1 + 2A—0.3), from which he computes the following table:—

Table II.

Catchment area in square miles.	Ratio of maximum flood to average 24-hour flood.
0.1	5.0
1.0	3.0
5.0	2.23
10.0	2.0
50.0	1.62
100.0	1.5
500.0	1.31
1000.0	1.25
5000.0	1.15
10000.0	1.12
50000.0	1.08
100000.0	1.06

Frequently, gauge readings are available for a number of years, and if discharge observations are available a rating curve may be made, giving the relation between the discharge and the gauge height. Rating curves for many points have been made by the Geological Survey. With the gauge heights and the rating curve the value of Q (ave.) or the average yearly flood-flow may be determined, and by use of Table I. the largest flood against which it is desired to protect can be determined. The flood which occurs once in a thousand years will frequently be the proper one to protect against, as the thousand-year flood may be near at hand. With the greatest twenty-four hour flood so obtained you may proceed to Table II. and get the maximum momentary discharge, and by going to the rating curve translate this back into gauge heights if such is desired. Of course, one of the troubles with this method of Mr. Fuller's is in finding the value of Q, the average yearly flood-flow, as it is liable to be out badly unless the records for a long period of years are at hand; but, in any event, it is believed to be an excellent method of checking up results obtained by some other method, say, by Mr. Kuichling's curves. It has the great advantage of including all the peculiarities of the catchment basin, including rainfall and melting snow and ice characteristics. It is also of value where there are no discharge observations or rating curve, but otherwise sufficient gauge records available. This is probably a very common case. The discharge for each gauge height may be computed by use of Kutter's formulæ for the velocity $V = C\sqrt{RS}$ combined with the area of the hydraulic cross-section. The area of the cross-section, the hydraulic mean depth, R, and slope, S, can be measured without waiting for a flood and by assuming *n* the coefficient of roughness, the value of C may be obtained from Trautwine's handbook or elsewhere. The rating curve may then be constructed, which is liable to be much in error due principally to the value of n assumed, and by using Mr. Fuller's methods this error tends to come out "in the wash" by the time the results are translated back into gauge heights. Frequently it is the gauge heights rather than the actual discharge observations that are desired.

In their report, referred to above, Messrs. Alvord and Burdick used gauge records for sixteen years to find Q (ave.), the average yearly flood-flow for the upper Scioto, the Olentangy and the lower Scioto. Comparing these with the two highest floods on record the following ratios of Q (ave.) to Q are obtained:—

Table III.

	1913 Flood.	1898 Flood.
Upper Scioto	3.52	2.23
Olentangy	3.52	2.20
Lower Scioto	3.52	2.22

The value 3.52 is slightly greater than the ratio, 3.40, Mr. Fuller gets in Table I. for 1,000 years. 2.20 is between his ratios for 25 and 50 years.

Mr. Kuichling's studies naturally fall down when applied to some stream like the St. Joseph emptying into the Maumee at Fort Wayne, Indiana. This stream has a porous soil, and its maximum flood is only a fraction of that of the St. Marys River, the other tributary of the Maumee at Fort Wayne, although the St. Joseph has one-half larger drainage area. In such a case the methods of Mr. Fuller would naturally apply. But if there is nothing unusual in the basin of the St. Marys it would be safe to say it might have Mr. Kuichling's curve 2 discharge some day. The Scioto River, near at hand with its flood discharge, would indicate this.

Mr. Fuller's and Mr. Kuichling's studies seem to lend themselves to rivers the size of many of our navigable ones as well as small streams. In some cases other formulas or methods involving time and money for investigation give more accurate results, but the methods here presented give prompt results and often very valuable assistance. These methods, however, do not provide any factor of safety, they only give the maximum load. The levee or the bridge must be built a certain number of feet above the crest of the flood to provide this. It is desired only to call attention here to the factor of safety; it is too complicated a problem to be discussed in a few lines. It may be the best business risk to provide only against the ordinary flood without any factor of safety added. The land power-houses at the Ohio River Locks are being built with the idea that occasional floods will drown out the machinery.

PRELIMINARY STATEMENT OF MINERAL PRODUCTION OF QUEBEC, 1913.

The value of the products of the mineral industry of the province of Quebec in 1913 totalled $12,918,109. These figures are compiled from returns received by the Quebec Mines Branch direct from the producers. Although they are liable to change slightly, owing to additional dilatory returns, they are sufficiently near to give an accurate idea of the condition of the mining industry of the province. Annual mineral production since 1904 is shown by the following table:—

Year.	Value.
1904	$ 3,023,568
1905	3,750,300
1906	5,019,932
1907	5,391,368
1908	5,458,998
1909	5,552,062
1910	7,323,281
1911	8,679,786
1912	11,187,110
1913	12,918,109

COST OF LOCATION SURVEY FOR A SHORT RAILWAY LINE.

ENGINEERING AND CONTRACTING, of Chicago, recently published some cost data that will be found interesting and of value, compiled from accurate records made in relation to some location surveys run in 1912 for a railroad. The survey was for a branch 30.75 miles long, from an already established line to a manufacturing city; with a branch survey, to another city, 12 miles in length. Topographical considerations, aside from large bodies of water and high hills, were found to be of minor importance, the chief concern being so to approach the intersected streets that grade crossings might be cheeply avoided. Most of the distance was through a light growth of timber, requiring much chopping and trimming. No topography was taken, but all streets and water courses along the line were carefully surveyed and the boundaries of private lands were run out.

For three weeks the men were boarded in hotels in the two terminal cities; during nine weeks they were carried by team or railroad to the work from headquarters on the main line; and for twenty weeks and two days they lived in camp. From the camp, which occupied three different sites, about 26 miles of location were made, teams being kept with the camp for transportation.

Table I.—Distribution of Labor.

Description of work.	Cost.	Cost per mile.	Pct. of labor total.	Pct. of grand total.
Running the line finally adopted	$1,500	$35.10	39.7	20.8
Running lines afterwards abandoned	432	10.10	11.4	6.0
Surveys of intersected streets	666	15.60	17.6	9.3
Leveling on line finally adopted	156	3.65	4.1	2.2
Leveling on lines afterwards abandoned	65	1.52	1.7	0.9
Leveling on intersected streets	20	0.47	0.5	0.3
Meandering ponds and streams	57	1.33	1.5	0.8
Surveying private boundaries	382	8.95	10.0	5.3
Triangulation and traverse lines	146	3.42	3.9	2.0
Exploration	10	0.23	0.3	0.15
Check levels	10	0.23	0.3	0.15
Office work by field men	61	1.43	1.6	0.8
Holidays, absences and rainy days	279	6.55	7.4	3.8
Totals	$3,784	$88.58	100.0	52.50

Table I. of labor distribution does not include any general officers' salaries nor that of the chief engineer. The map drawing was done in the general office and does not figure in these tabulations.

Surveying instruments were supplied from those previously in use by the company, and interest on their cost is charged under "Field and Office Equipment." The camp equipment, consisting of seven tents, complete mess outfit, cot beds, blankets and quilts, was purchased second-hand at a discount of 50 per cent.

During the nine weeks above mentioned many days were lost on account of rain for which the men, being at home, were not paid. The pay of the party was as follows:—

Position—	Pay per day.
Assistant engineer in charge	$ 4.50
Transitman	3.33
Leveler	2.50
Axman and teamster, 7 days per week	2.25
Chainmen	2.00
Rodman	1.75
Axemen	1.50
Cook, per week	15.00

The total cost per mile given, $168.08 (Table II.) is the cost per mile of final location, and will be seen to include the cost of preliminary lines, and all the detail surveying necessary for complete land plans.

Table II.—Distribution of Expenses.

	Cost.	Cost per mile.	Pct. of exp. total.	Pct. of grand total.
Field and office equipment	$ 160.49	$ 3.75	4.7	2.2
Railroad and street car fares and expenses	453.73	10.60	13.3	6.4
Board and lodging	167.00	3.90	4.9	2.3
Team transportation	836.32	19.50	24.6	11.6
Camp equipment	209.16	4.90	6.2	2.9
Camp maintenance	1,488.92	34.82	43.9	20.7
Purchased information	81.38	1.90	2.4	1.4
Mail, telegraph and telephone	5.56	0.13	...	...
Totals	$3,402.56	$79.50	100.0	47.50
Grand totals	$7,186.56	$168.08	.....	100.00

Table III.—Analysis of Camp Maintenance.

Commodity.	Cost.	Cost per meal—4,047 meals.	Cost per man per day.	Pct. of total cost.
Meat, fresh and canned	$ 373.72	$0.092	$0.239	25.1
Fish, fresh and canned	51.93	0.013	0.033	3.5
Potatoes	29.84	0.007	0.019	2.0
Other vegetables	53.93	0.013	0.034	3.6
Fruit, fresh and canned	120.58	0.030	0.077	8.1
Groceries	108.56	0.027	0.069	7.3
Flour	31.92	0.008	0.020	2.1
Eggs	59.39	0.015	0.038	4.0
Sugar	27.49	0.007	0.018	1.9
Coffee	26.50	0.006	0.017	1.8
Tea	9.06	0.002	0.006	0.6
Butter	37.27	0.009	0.024	2.5
Milk	73.03	0.018	0.047	4.9
Ice	18.61	0.005	0.012	1.3
Fuel	36.23	0.009	0.023	2.4
Light	6.50	0.002	0.004	0.4
Water—6 weeks from city main	5.00	0.001	0.003	0.3
Land rentals	10.00	0.002	0.006	0.7
Cook's wages	305.34	0.076	0.196	20.5
Labor moving camp	104.02	0.026	0.067	7.0
Totals	$1,488.92	$0.368	$0.952	100.0

A study of the tables does not suggest much resemblance to similar ones previously published, the most marked difference appearing in the matter of camp maintenance, Table II. Much of the higher cost shown here is doubtless due to the high cost of living now prevailing. Also much may be due to the fact that all the men were accustomed to a pretty good table and an effort was made to provide them with home comforts.

SOME POINTS IN LAND SURVEY WORK.

By J. A. Macdonald, Ottawa, Ont.

IN surveying a field for the purpose of finding its area, the instruments and methods will be determined largely by the degree of accuracy required. If it is permissible to have an error of 0.5% the compass and chain are most conveniently used. If greater accuracy than this is required it will be necessary to use the transit and the steel tape. At the present time, however, in nearly all work except surveys of farms and woodlands, the transit is used even under conditions where the compass would give sufficient accuracy. In surveying a field, for example, all the angles and lengths of the sides are determined consecutively, the survey ending at the point from which it was started. By trigonometry the position of the final point, as of any other point with relation to the starting point, can be readily calculated. If the survey were absolutely correct the last point as calculated would coincide with the first, but this condition is never attained in practice. The calculated distance between the two, divided by the perimeter of the field is called the "error of closure." The term more properly applies to the actual distance by which the survey fails to close, and even when it actually closes in the field, it will not close in the plot. In surveying with a compass and chain the error of closure expected is about 1 part in 500.

In his own experience in land surveying, with both a transit and compass available, the writer has found little use for the transit in what is known as "custom work." Even when using the transit the magnetic needle on the transit must determine the meridian, and as all the surveying that had been done in Canada and elsewhere up to a few years ago was done by magnetic bearings, all work on old lines, such as retracing, re-surveys, subdivisions, etc., must necessarily be referred to the magnetic meridian; hence the absolute need of the compass.

If the transit is used in re-survey work in our old and settled provinces, it is of the greatest importance that the magnetic needle is of good length, and in good working condition, because one must ascertain his bearings by the needle. Even if he took the trouble to take an astronomical observation for azimuth the result would be of practically no value to the surveyor on such old work as retracements, re-surveys, etc. It is the writer's opinion that on the whole, for the surveyor who is doing "old work," a good compass will be found of more advantage than a transit. But if a transit can be obtained containing a reliable compass, with needle not less than 4½ inches long, there are added advantages in having a transit, though it is so much more cumbersome to carry about. As already stated, it all depends upon the nature of the work, but if errors are permissible of, say, 0.5%, or if much old work is to be done in the rural districts, then the compass is to be preferred. If the opposite condition prevails, and if much of the work is to be done in towns and cities, then the transit must in all cases be used. The land surveyor should, however, possess both the compass and transit if the nature of his work varies.

Surveying for Area.—In making a survey it is customary to begin at some convenient corner and to take the bearings and the distances in order around the field. As the measurements are made they are recorded in a field book. It is not always necessary to take the sides in order, but since they must be arranged in order for the purpose of computing the area it will be convenient to have them so arranged in the original notes. It is of the utmost importance in every survey that check measurements be taken. Even a few rough checks taken in the field, which will require only a little extra time, often prove to be of great value in detecting mistakes. Both a forward and a back, reversed, bearing should be taken at each corner. From them the angles at a corner can be obtained free from error due to any local attraction of the needle. With the compass it is often impossible to set the instrument up at the corners of the property, and in such cases assumed lines running parallel, or approximately so, to the property lines can be surveyed and the area determined. In some cases the instrument can be set on the property line at an intermediate point and the bearing obtained; but the surveyor must be sure that there is no local attraction of the needle at this point. All points where a compass-instrument is set should be marked and described so that they can be found again. If any instrument point is not otherwise defined it may be temporarily marked by a small stake and several reference measurements made from this stake to prominent objects nearby, so that the position can be determined if the stake is lost.

Division of a Property.—In order to divide a piece of land into two equal parts, the first thing the surveyor would do in most cases is to measure the width of the field on a course perpendicular to the sides. But in the case illustrated in Fig. 1 a river intervened, running in the direction of such a line and with its banks covered with a dense growth of alder and marsh, an almost impossible condition through which to cut a line. Another creek, with steep banks intervened further on, and the remainder of the area was covered with a dense growth of forest trees. By extending the outlines at (o) and (3) across the road and into the property to the east, a solution of the difficulty would seem apparent, but, to extend or prolong the line at (o) involved difficult cutting out of a line, while to the north of the river, and east of the road, was private property, most of which was under tillage, etc.

A simple method of overcoming these difficulties was devised by traversing the road from the post at (o) to the opposite side of the area at (3) and when completed calculating the latitudes. At Station (o) the instrument was set up and an angle or bearing of 18°00 (N,18°00′,E) turned, and the line measured to (1), 9.00 chains. At (1), the bearing was N,14°15′,W, and the line to (2), 3.10 chains. At (2), the angle was 35°00′, (N′, 35°00′, W) to (3). These courses, with their latitudes and departures, dotted, are shown in Fig. 1.

One might be inclined to think that to divide a piece of land with parallel sides would be an extremely simple matter. Were the property abutting upon a straight road at right angles to the side lines no doubt the finding of the centre would only be a matter of measurement; but running in a semi-circular form, as the road does in Fig. 1, renders the problem somewhat difficult, since to go to the labor of opening a line through the wood, at right angles to the sides, could not be done without an instrument.

Table I.—Traverse.

Station.	Bearings.	Distance.	Latitude.	Departure.	Total latitude.
(o)	18°00′	9.00	8.56	2.75	....
(1)	14°15′	3.10	3.00	.75	8.56
(2)	35°00′	3.20	2.62	1.83	11.56
(3)	....	...	...	...	14.18

The total width of the lot to be equally divided is therefore 14.18 chains, and the centre will be 7.09 chains from either side to make an equitable division. We now undertake to find the point 7.09 chains from Sta. 3. This will be a simple matter as we already know the distance from (3) to (2), and from (2) to (1) or 5.62 chains. The centre will then be 1.47 chains in latitude from Sta. (1) (7.09 — 562 = 1.47). Knowing the latitude and the angle from (1) to (o) (which is the same as the angle at

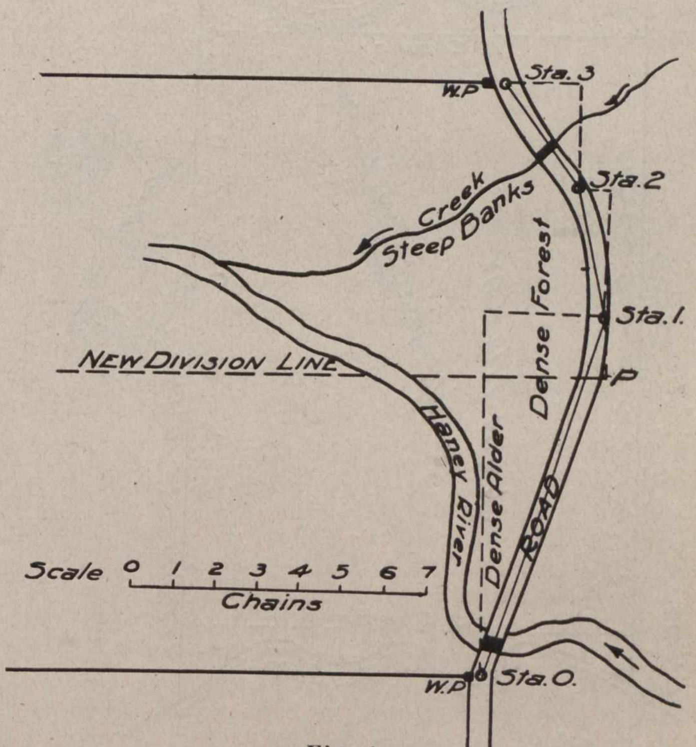

Fig. 1.

(o), viz., 18°00), divide the latitude, 1.47, by the natural cosine of 18°00′ to obtain the distance to the point, P, the centre. This is found to be 1.54. By measuring back on the road line 1.54 chains, we are at the precise centre, 7.09 chains. At this point, P, we set up and run the division line east, parallel to the side lines, or outlines of the lot. Thus, by a little ingenuity and trigonometry the precise division of the contained area was obtained without having to cut out a line or trespass on the adjoining private property.

Note Keeping.—All measurements should be recorded in a special note book as soon as they are made and not left to be filled in from memory. The notes should be neat and clear, so that there will be no doubt as to their meaning. Great care should be taken so that they will not be susceptible to any interpretation except the right one. They are generally recorded in pencil, but they should always be regarded as permanent records and not as temporary memoranda. As other persons who are not familiar with the locality will probably use the notes and will depend entirely on what is recorded, it is very important that the notes should contain all necessary data without any superfluous information. If the notekeeper will bear in mind constantly how the survey is to be calculated or plotted it will aid him greatly in judging what measurements should be taken and what are unnecessary. Clearness is of the utmost importance in note keeping, and to attain it the usual custom is not to attempt to sketch to scale. Yet, in surveys where considerable detail is desired, it is sometimes well to carry out the sketches in the note book approximately to scale. Care should be taken not to crowd the notes—paper is cheap—and an extra page of the note book devoted to a survey may save hours of time consumed in the office in trying to interpret a page of crowded data.

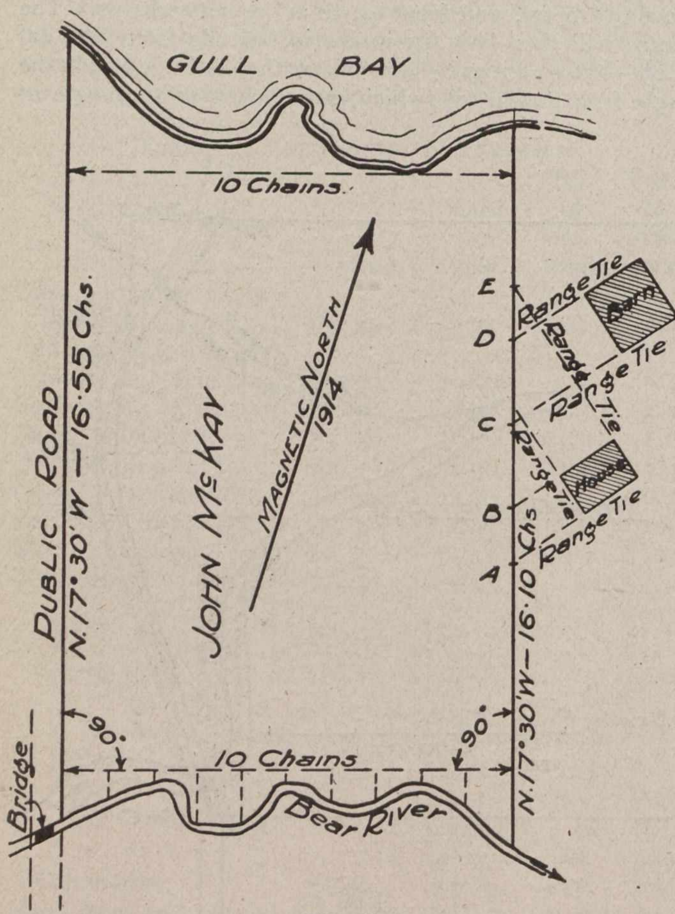

Fig. 2.

Where the work is of an intricate nature, the sketch should show roughly with pencil the various triangulations, etc., as in Fig. 1. This will greatly aid in the plotting.

Too much stress cannot be laid on the importance of being careful not to lose the note book, as not infrequently a note book contains data which thousands of dollars could not replace.

Although sufficient fullness to make the notes clear is desirable, it is customary to abbreviate the names of the features most commonly met with by the surveyor. To properly understand a set of notes one must be familiar with these abbreviations, as W.P., wooden post; I.P., iron post; I.P.M., iron post and mound; I.P.Pits, iron post and pits; Wit.I.P. or Wit.I.P.M., witness iron post—a monument placed some distance from the precise spot or true corner where a monument should be, but, owing to obstructions, cannot be made there; Temp. P., temporary post; etc. Distances should always be recorded in the note book in such a way as to indicate the precision with which they are taken. For example, if they were taken to 1/100 ft. and a measurement happened to be just 124 ft., it should be recorded 124.00. The two zeros are of as much consequence as any other two digits which might have come in their places. In addition to the measurements, every set of notes should contain the following information: Kind of work, locality, date, names of members of the field party, instruments used, etc. Where a survey is continued for several pages, the date may be placed at the top of every page, but the the other data need not be repeated.

Survey for a Deed.—In this case the lengths and bearings of all the boundaries are desired. The traverse lines should therefore follow the property lines, if possible. In case a true meridian is found by observation or by calculation, the bearings should be referred to this and marked "true bearings" by a note on the plan. This information should also be contained on the deed. More frequently, however, it is the magnetic bearing that is given. A plan which is to accompany a deed should show such features as watercourses, highways, buildings, and adjoining property lines, as well as stone mounds, stakes, fences, walls, or other artificial objects which mark the boundaries of the property. This plan should contain the following information:—

Lengths of all property lines together with their calculated bearings, or the angles at the corners; location and description of corner bounds; conventional sign or name on fences, walls, etc.; names of highways, streams or ponds, and of adjacent property owners; scale of drawing and direction of the meridian used. (It is better to refer all bearings to the true meridian when this is possible, and in such a case the direction of the magnetic needle should be shown in addition.)

The title should include a simple and complete statement giving the name of the owner, place, date and name of surveyor.

The written description of the property which is recorded in the deed should be given by bearings, or angles, and distances, stating in every case how the sides of the property are marked and whether bounded by a highway, stream or private property, giving the name of the present owner of the adjacent property.

It is customary with many surveyors to omit from the plan certain of the above enumerated data, so that while it may answer the purpose for which the survey was made, it does not contain all the data, and frequently not enough to enable another surveyor to relocate the property by means of it. This is done, of course, so that when the tract is to be re-surveyed, plotted, transferred or conveyed by deed to another party, it will be necessary to employ the same surveyor who has in his possession data for which the owner presumably has paid, and which the surveyor should have turned over to him on the completion of the survey. The plan and description of the survey should be so plain that any other surveyor could instantly interpret it, or that a lawyer could draw up the conveyance or transfer directly from the descriptive plot without confusion.

Judicial Functions of the Surveyor.—In running old and obliterated property lines, the surveyor is called upon to set aside temporarily his strict adherence to the mathematical side of surveying, and must endeavor to find, if possible, where the lines originally ran. He should, therefore, be familiar with the relative importance of evidence regarding the location of the property lines. It is his duty to find the position of the original boundaries of the property, and not attempt to correct the original survey, even though he may be sure that an error exists in it. This is the concensus of opinion among surveyors, and also of the courts, and should never be lost sight of. Very often it is true that, owing to the cheapness of land, the original survey was roughly made, with little thought of the effect it would have when the land became valuable.

The surveyor, therefore, must first of all acquire all physical evidence of the location of the boundaries. Failing in this, he will use his best judgment on any and all other reliable evidence, such as occupancy or possession or the word of competent witnesses. It must not be assumed that boundaries are missing because they are not at once visible. Stone mounds are often buried two or three feet deep, while the top of a stake soon rots off; but evidences of the existence of the stake are often found many years after the top has disappeared. The supposed location should be carefully dug over to find traces of the old stake.

A dispute between adjoining owners over the location of a boundary line presents a question which must be settled by the courts unless the parties can come to an agreement. In such cases the surveyor has to act simply as an expert judge as to where the line originally ran, and he has no power to establish a new line. He can, however, be employed as an arbitrator to decide on the equitable line, but they are not necessarily obliged to accept his judgment. If they come to an agreement, however, between themselves in the presence and with the concurrence of the surveyor, regarding the location of the line, and occupy to that line, this agreement is binding, even though no court has intervened in the matter.

It is to be assumed that the deed has been drawn by the grantor with honest intent to convey the property to the grantee. It is intended, then, that it shall be interpreted, if possible, so as to make it effectual. The deed should also be construed in the light of what was known at the time when the title was transferred. In this interpretation it is assumed that it was intended to convey property, the boundaries of which will form a closed traverse. It is then within the jurisdiction of the surveyor to reject any evident mistake in the description when running out the property line. Where artificial features are mentioned as boundaries, these always take precedence over the recorded measurements or angles, but these marks must be mentioned in the deed in order to have the force or authority of monuments. When the area does not agree with the boundaries as described in the deed, the boundaries control. All distances, unless otherwise specified, are to be taken as straight lines, but distances given as so many chains or feet along a highway or street are supposed to follow these lines, even if they are not straight. When a deed refers to a plan the dimensions on this plan become a part of the description of the property. When property is bounded by a highway, the abutters usually own to the centre line, but where it is an accepted street each abutter yields his portion of the street for public use, but if it happens that the street is abandoned the land reverts to the original owners. If a street has been opened and used for a long period, bounded by fences or walls, and there has been no protest regarding them, these lines hold as legal boundaries. In the case of a line between private owners acquiescence in the location of the boundary will usually make it the legal line. But if there is a mistake in its location and the question of its position has not been raised, occupancy for many years does not make it a legal line, though the rule or "law" of "21 years peaceable possession" make a strong legal claim. Where property is bounded by a non-navigable stream, as south boundary of Fig. 2, it extends to the thread of the stream., i.e., the centre of the channel. If the property is described as running to the bank of a river it is interpreted to mean to low-water mark, unless otherwise specifically stated. Where the ownership originally ran to the shore line of a navigable river and the water has since receded, each owner is entitled to his proportional share of the channel of the river.

Irregularly Curved Boundaries.—When a tract of land is bounded by an irregular curved line, such as a brook, as in Fig. 2, it is customary to run the traverse line near it, and may be sometimes crossing it several times, and to take perpendicular offsets to the brook. (These offsets are shown in Fig. 2.) If it is a winding brook with no distinct turns in it, offsets at regular intervals are measured from the transit line, as in the portion of the south boundary, Fig. 2. Since they are usually short, the right-angled offset lines are frequently laid off by the eye, or simply paced.

PERSONALS.

S. P. BENNETT has been appointed Municipal Engineer of South Vancouver municipality.

JAMES WOODRUFF has been appointed Road Commissioner for the township of Niagara.

R. PIERCEY has been appointed chief assistant and C. K. SAUNDERS assistant to W. J. Johnson, Engineer of Saanich Municipality, British Columbia.

PHELPS JOHNSON, president of the St. Lawrence and Dominion Bridge Companies and past president of the Canadian Society of Civil Engineers, is on a trip through Western Canada.

S. B. WASS, assistant chief engineer, St. John Quebec Railway, is chief engineer of the Quebec Extension Railroad, a proposed line 174 miles in length in Quebec and the State of Maine.

C. A. P. TURNER, consulting and contracting engineer, Minneapolis, advises us of the removal of his office in that city from the Phenix Building to the new Walker-Burton Building.

F. A. GABY, chief engineer of the Hydro-Electric Power Commission of Ontario, addressed the members of the Canadian Institute on March 21st. Mr. Gaby's lecture was a general treatment of the development and use of hydro-electric power.

VINCENT SIMPSON, secretary-treasurer of Gerald Lomer, Limited, Montreal, is making an extended business trip through the West in the interests of the Phœnix Steel Pipe Works, of Dusseldorf, and Deutsche Maschinenfabrik, A.G., of Duisburg, Germany.

R. F. HAYWARD, general manager of the Western Canada Power Company, addressed a recent meeting of the Manufacturers' Association of British Columbia on the subject of power. He outlined the increasing advantages and the utilitarian value of electrical power in a wide range of industries.

Several years ago, a scheme was advocated to construct a bridge across the gorge at Niagara Falls, N.Y., below the falls and close to the foot of Niagara Street. This project is being revived.

Coast to Coast

Edmonton, Alta.—The deficit of the Edmonton Street Railway department for 1913, which amounted to $190,000, has brought the actual deficit of that department, after six years' operation, to almost $400,000.

Toronto, Ont.—The Ontario Legislature has favored urging upon the Federal Government the importance oi granting a measure that will stimulate anew the iron industry of Canada, the form of assistance to be left to the discretion of the Federal Ministers.

Montreal, Que.—Improvements effected by the new Montreal Harbor Commission during its first year of office n 1913, necessitating an expenditure of $3,787,430 on capital account, and $1,325,636 on revenue account against which there were total revenue receipts of $1,361,964, are shown in the annual report of the commission recently issued.

Ottawa, Ont.—The powerful ice-breaker, for which the Ottawa Government has recently awarded a contract to the Canadian Vickers Company, will be of 8,000 h.p. The plan is to put the ice-breaker at work at the Cap Rouge ice bridge, prevent the accumulation of ice and afterwards to work between there and Montreal along with the Lady Gray and Montcalm. Not only will the opening of navigation be greatly advanced, but the spring floods along the St. Lawrence obviated.

Fredericton, N.B.—The C.P.R. has prepared plans for considerable work on the Atlantic Division for the present season; and while the work to be done will not be so extensive as during the past few years, it will be sufficient to maintain the efficiency of the line. Thirteen miles of new 85-pound rails will be laid on the main line between St. John and Megantic. On the main line, also, 40 wooden and dry stone culverts will be replaced by concrete, as well as a number of culverts on the branch lines. Twenty-five miles of ballasting will be done on the main line; while on the branch lines 61½ miles of light rails will be replaced by heavier rails, and 55 miles of ballasting will be done. A new loading siding will be built at St. Stephen; at Cardigan, at Burnside and Zealand on the Gibson branch loading sidings will be extended; and at Somerset Junction, in Maine, a new freight shed and two additional sidings will be built.

Vancouver, B.C.—The P.G.E. Railway Company has decided to proceed this year with the work on the establishment of docks and terminals at Squamish, and has estimated the expenditure for 1914 at $200,000. The company's plans for the year call for the reclamation of the tide flats of at least a mile in area, and also for dredging a considerable portion of the harbor. Also, it has been stated by Mr. J. W. Stewart, president of the company, that the company expects to award contracts by May 1st for the construction of the portion of the Peace River route; and it is expected to cover 100 miles of the new line this summer and to have grading on the entire section of 330 miles north-east from Fort George under way in the summer of 1915. The extension is to be finished and ready for operation right through to the Alberta boundary in 1916. Grading will be rushed on a section 150 miles from Fort George to connect with the portion now under construction north of Clinton, and on the other contracts to be let this season.

Victoria, B.C.—Dredging operations of the site of the new Marine and Fisheries depot have reached such a stage that the successful tenderers will be able to proceed with the construction of the Government wharf immediately the contract has been awarded. For the past three months the dipper dredge Mudlark has been confining its operations closely to the deepening of the channel in the immediate vicinity of the proposed wharves, until, at the present time there is a uniform depth of 18 feet at low water on the north side of the proposed wharf, while great progress has been made in digging out the hard-pan parallel with the channel. Already on the north side, running inshore to the Songhess Reserve, the Mudlark has taken out 52,000 cubic yards of material, and the dredge is now engaged in dredging out 35,000 cubic yards from the foreshore, running north and south. Upon the completion of this work during the next month, a total of 87,000 cubic yards will have been removed. When completed, the new Government wharf will be 450 feet in length, running north and south on the channel side, and will run inshore 210 feet, giving a depth of from 18 to 20 feet of water at low tide.

Victoria, B.C.—The Provincial Legislature has considered recently the estimates for the fiscal year, 1914-15. The estimated expenditure has been placed at $13,742,009.60, and the estimated revenue at $10,048,915.15. Among the votes affecting engineering projects at Victoria and in the immediate vicinity, are: $340,000 for Soughees Indian Reserve improvements; $315,000 for the extension and completion of the provincial parliament buildings; and $245,000 for the completion of the provincial Normal School. The total estimated expenditure on public works throughout the Province is $5,316,575. Of this amount $2,319,500 will be spent on works and buildings; $2,861,000 on roads, streets, bridges and wharves; $96,075 on subsidies to steamboats, ferries and bridges; and a balance of $40,000 on general contingencies. Other votes of important engineering interest coming under appropriations for other departments of the government are $500,000 for work upon the new provincial university; $150,000 for government buildings at Prince Rupert; a revote of $50,000 for the completion of the courthouse at Vernon; a conditional revote of $400,000 for the bridge across Second Narrows, Burrard Inlet; and a vote of $100,000 for development work at Strathcona Park. The appropriation for the Forestry branch showed an increase of $78,000; the Lands branch, a decrease of $124,000; the Surveyor-General's department, a decrease of $165,000; but the Water Rights branch, an increase of $67,000.

St. John, N.B.—The report of Mr. Monsarrat, chief engineer of the Quebec bridge construction, upon the most suitable site for a bridge on the St. John Valley Railway over the River St. John, stated that borings at Dunham's Wharf, one and a half miles above the Mistake, the point previously most favored, disclosed a deposit of sand 50 to 60 feet deep overlaying clay which would furnish a satisfactory formation for supporting piles upon which to build concrete or masonry piers. Towards the east shore he had located the 500-foot span which would provide for no interruption to logging operations, and on the west side near the deeper channel, a 25-foot swing span. He believed this to be the best of three projected sites. He would not recommend any earth or rock filling. He was satisfied a bridge could be constructed across the river at this location which would cost approximately $2,063,756, subdivided as follows:—superstructure, $543,715; substructure, $1,283,877; rock fill, $47,000; track and telegraph, $1,550; engineering and contingencies, $187,614. However, the Foundation Company, Limited, of Montreal, had been asked to make an examination and to give an estimate on the work. That company concurred in the desirability of the site recommended, and reported that it could build the substructure for the sum of $1,135,000, and have it completed by December 1st, 1915; and also could so arrange the construction of the piers that the steel work could be erected by December 31st, 1915.

NEWS OF THE ENGINEERING SOCIETIES

Brief items relating to the activities of associations for men in engineering and closely allied practice. THE CANADIAN ENGINEER publishes, on page 90, a directory of such societies and their chief officials.

D.L.S. EXAMINATIONS.

The result of the examinations held in February by the Dominion Land Surveyors' Association were announced last week. Examinations were held in the principal cities of the Dominion, and the number of candidates were 199. From the following results it will be noted that out of this number 15 candidates passed their final examinations, 37 passed the full preliminary and 3, the limited preliminary test. The list is as follows:—

Final.—F. Alport, Orillia; H. C. Bingham, Regina; L. E. S. Bolton, Listowel; R. F. Clarke, Kingston; H. J. Ewan, Yarmouth, N.S.; J. F. Fredrette, Ottawa; A. M. Grant, Ottawa; J. A. S. King, Ottawa; R. A. Logan, Middle Musquodoboit, N.S.; C. S. MacDonald, Ottawa; P. J. McGarry, Toronto; W. H. Norrish, Ottawa; B. C. Pierce, Kingston; G. P. Sharpe, Salmon Arm, B.C.; R. L. Squire, Ottawa; F. H. Wrong, Sandwich, Ont.

Full Preliminary.—C. H. Biddell, Regina; J. C. Bonham, Kingston; C. A. Buck, Edmonton; F. R. Burfield, Calgary; L. C. Calder, Bergen, Alberta; J. Carroll, Toronto; C. W. Cohoon, Ottawa; W. S. Cole, Kingston; C. W. Crowell, Yarmouth, N.S.; E. M. DesBrisay, Montreal; G. H. Donaldson, Ottawa; W. L. Frame, Montreal; J. T. Fullerton, Montreal; C. E. Joslyn, Kingston; K. Keeping, Montreal; G. L. Kezar, Britannia Heights, Ont.; A. M. Knight, Edmonton; C. A. R. Lawrence, Toronto; C. C. Lindsay, Montreal; J. E. Lyon, Ottawa; F. J. Martin, Winnipeg; A. H. Meitz, Toronto; T. S. Mills, Prince Albert; W. S. McDonald, Edmonton; M. D. McFarlane, Montreal; H. R. Mackenzie, Regina; H. A. Parker, Blairton, Ont.; J. M. Paul, Calgary; G. B. Patterson, Kingston; H. B. Pelletier, Montreal; C. E. Richer, Ottawa; J. Robertson, Lachine Locks, Que.; D. N. Sharpe, Winnipeg; G. J. Smith, Kingston; C. H. Tory, Edmonton; A. G. Wilkins, Ottawa; H. C. Wright, Roblin, Ont.

Limited Preliminary.—L. C. Prittle, Carleton Place, Ont.; J. H. Ramsay, Ottawa; G. A. Wall, Calgary.

CAN. SOC. C.E.—VANCOUVER.

The Vancouver branch of the Canadian Society of Civil Engineers had a meeting on March 18th, which was addressed by Mr. J. W. B. Blackman upon the subject of town planning. Mr. Blackman outlined the development of the idea of scientific planning of towns and cities since the days of Pompeii. His lecture was illustrated by lantern slides and the general trend of his treatment of the subject was the condemnation of the invasion of sky-scrapers into our cities.

CAN. SOC. C.E.—CALGARY.

On February 20th, the Calgary branch of the Canadian Society of Civil Engineers was addressed by F. H. Peters, C.E., Commissioner of Irrigation, the subject of his lecture being "The Georgian Bay Ship Canal." He summarized the advantages and disadvantages of the project now under investigation comparing its estimated value to Western Canada with that of the new Welland Ship Canal and the Hudson's Bay Railway. According to Mr. Peters, the basic principle underlying the advisability of constructing the Georgian Bay Canal was the cost of various kinds of transportation. He outlined the progress that was being made on the Welland Canal and on the Hudson's Bay Railway and explained the movement for the Georgian Bay Canal as being a third project in the interests of cheaper cost of transportation in shipping material in and out of Western Canada.

COMING MEETINGS.

AMERICAN WATERWORKS ASSOCIATION.—Thirty-fourth Annual Meeting to be held in Philadelphia, Pa., May 11-15, 1914. Secretary, J. M. Diven, 47 State Street, Troy, N.Y.

AMERICAN HIGHWAYS ASSOCIATION.—Fourth American Road Congress to be held in Atlanta, Ga., November 9-13, 1914. J. E. Pennybacker, Secretary, Colorado Building, Washington, D.C.

AMERICAN PEAT SOCIETY.—Eighth Annual Meeting will be held in Duluth, Minn., on August 20, 21 and 22, 1914. Secretary-Treasurer, Julius Bordollo, 17 Battery Place, New York, N.Y.

AMERICAN SOCIETY FOR TESTING MATERIALS.—Seventeenth Annual Meeting to be held in Atlantic City, N.J., June 30 to July 4, 1914. Edgar Marburg, Secretary-Treasurer, University of Pennsylvania, Philadelphia, Pa.

CANADIAN AND INTERNATIONAL GOOD ROADS CONGRESS.—To be held in Montreal, May 18th to 23rd, 1914. Mr. G. A. McNamee, 909 New Birks Building, Montreal, General Secretary.

OBITUARY.

We regret to record the death of Mr. FRANCIS S. CLEARY, a young engineer who died on March 24th at Monrovia, Cal. Mr. Cleary was born in Windsor, Ont., 27 years ago. He was educated at Windsor Collegiate Institute, St. Michael's College and Faculty of Applied Science and Engineering, University of Toronto, graduating with the class of 1911. During the past two years he has been employed as an electrical engineer with the Edison Illuminating Company of Detroit.

The death has been announced of F. D. FRIEND, resident engineer for the National Transcontinental Railway at Graham, Ont. Heart failure was the cause. Mr. Friend was a native of Devonshire, England and came to Canada about 10 years ago.

The death was announced on March 18th of DAVID-KEAY McLAREN, president of D. K. McLaren, Limited, Montreal. Deceased was 79 years of age.

B. W. FOLGER, president of the Kingston Street Railway, and well known in railway and steamship circles throughout Ontario, died in Toronto last week.

The Great Western Railway Company of England has just placed an order with Herbert Morris, Limited, for the supply of all chain blocks that they require during the year 1914. This is the 13th consecutive yearly repetition of the exclusive use of Morris chain blocks on the Great Western Railway.

ORDERS OF THE RAILWAY COMMISSIONERS OF CANADA

Each week on this page may be found summaries of orders passed by the Board of Railway Commissioners, to date. This will facilitate ready reference and easy filing. Copies of these orders may be secured from *The Canadian Engineer* for small fee.

21505—March 16—Approving revised location C.N.R. through Sec. 19-2-6, and Sec. 24-2-7, W. 2 M., Sask., mileage 0.00 to 1.43; and authorizing construction of revised line across road between Sec. 19-2-6, and Sec. 24-2-7, W. 2 M.

21506—March 16—Approving plans showing superstructure of eight (8) bridges on 13th Dist. of G.T.R., Province of Ontario.

21507—March 17—Directing that G.T.R., on or before June 15th, 1914, install gates at St. Clair Ave., Toronto, Ont., operates by day and night watchman; 20 per cent. of installing gates be paid by Ry. Grade Crossing Fund, remainder, 1-3 by city, and 2-3 by Ry. Company.

21508—March 14—Directing that G.T.P. Ry., at own expense, make certain changes in highway crossings in Tp. 34, Rgs. 1 and 2, W. 3 M., Sask.; work be completed by May 31st, 1914.

21509—March 16—Authorizing G.T.R. to construct siding into premises of the Chalmers Milling Co., west of Dawes Road, Toronto, Ont.

21510—March 16—Approving G.T.R. plan showing proposed arrangement for lighting vehicular and pedestrian roadways on Victoria Bridge, Montreal; work to be completed within 3 months from date of this Order.

21511—March 17—Authorizing C.N.R. to construct across and divert public road between N.E. ¼ Sec. 33-28-20, W. 3 M., and N.E. ¼ Sec. 4-29,20, W. 3 M., Sask., and divert highway between N.E. ¼ Sec. 33-28-20, W. 3 M., and N.W. ¼ Sec. 34-28-20, W. 3 M., to new crossing, in N.E. ¼ Sec. 33, at station 5684-20.2.

21512—March 17—Authorizing Cedars Rapids Manfg. and Power Co., Montreal, to take additional width of 25.9 ft. for right-of-way for transmission line, making in all a width of 125.9 ft. across Lot 338, Parish St. Joseph de Soulanges, County of Soulanges, Que., property of Archelas Clement.

21513—March 16—Authorizing London and Lake Erie Ry. to connect its tracks with Michigan Central R.R. Co., at west end of city of St. Thomas, Ontario.

21514—March 17—Authorizing G.T.R. to re-construct, subject to condition contained in consent on behalf of Tp. London, overhead bridge carrying highway, known as Westminster Road, between Lots 18 and 19, Con. 1, Tp. London, Co. Middlesex, Ont., over its railway, mileage 121.58 from Suspension Bridge.

21515—March 18—Approving Marconi Wireless Telegraph Co., of Canada's Tariff C.R.C. No. 8, covering new rates for cable letters and week-end letters; said tariff to be filed in form prescribed under Order No. 6679 (General Order No. 32), dated March 26th, 1909.

21516—March 17—Amending Order No. 21417, dated Feb. 27th, 1914, by striking out figures "18903.38" after word "File" wherever they occur in said Order and substituting therefor figures "18903.47"; and striking out figures "131" wherever they occur in said Order after work mileage and substituting therefor figures "161.1."

21517—March 16—Amending Order No. 17400 dated Aug. 30th, 1912, by striking out figures and words, "Lot 31, 0.14" in last line of operative part of Order and substituting therefor words and figures, "Lot 22, Concession 1, 0.72."

21518—March 18—Directing that, on or before April 1st, 1914, C.P.R. restore old clearance by raising under-side of top of culvert eleven inches (bridge over North Branch of the Clyde River, between mileages 24 and 25, just north of Flower Station, Ont.).

21519—March 19—Amending Order No. 21418, dated Feb. 14, 1914, by striking out figures "25" before word "August," where they occur in recital of Order, and substituting therefor figures "29," to read "29th August, 1913."

21520—March 16—Authorizing city of Montreal to construct 8 ft. diameter steel water pipe beneath tracks and across and along lands and right-of-way of G.T.R., upon Lot No. 3410 on Cadastral Plan of Mun. of Parish of Montreal, to be used as Emergency Supply in case of accident to regular water supply for city, subject to and upon certain conditions.

21521—March 19—Authorizing C.N.O.R. to construct trestle to carry its railway across Indian River, Tp. Fraser, Co. Renfrew, Ont., at mileage 101 from Ottawa.

21522—March 19—Directing that C.P.R. stop train No. 22 on flag, daily except Sunday, at St. Clet, Quebec.

21523—March 20—Authorizing C.P.R. to take certain lands situate in Lot 6, Con. 4, west of Hurontario St., Tp. Toronto, Co. Peel, Ont., for purpose of revising and enlarging its station yard at Streetsville Jct.

21524—February 26—Authorizing, subject to terms and conditions contained in agreement, dated June 14th, 1910, G.T.R. to construct siding into premises of Terminal Warehouse and Cartage Co., Limited, west of Common St., Montreal, Que.; and that the Order of Board No. 9859, dated March 9th, 1910, be rescinded.

General Order, No. 123—March 19—Approving form "Release of Responsibility," No. 981, respecting carriage of clothing, wearing apparel, and personal effects (all second-hand), in trunks, securely corded, submitted by C.N.R. That said Form of Release be made applicable to all railway companies under jurisdiction of the Board, until the Board orders otherwise.

21525—March 20—Authorizing G.T.R. to operate sixteen (16) bridges on its 30th District.

21526—March 20—Authorizing G.T.R. to operate trains over bridge carrying 16th District of its railway across Birch Ave., city of Hamilton, Ontario.

21527—March 23—Amending Order No. 19958 by inserting, after item No. 3, following words and figures: "No. 3a. 0.98, Pie LX Street, Railway to cross over highway by means of a bridge, having four openings instead of five, as shown on the said plan, dated 16th November, 1912." That Orders Nos. 16998, 17572, 19286, 19800, 19958, 21414, and this Order, be certified by Sec. of Board and endorsed as provided by Sec. 46 of Rly. Act., and transmitted to Prothonotary of Superior Court in and for Dist. of Montreal, Que.: Provided said Order be without prejudice to rights, if any, to city of Montreal.

21528—March 20—Authorizing C.N.O.R. to take portions of Lots 81 and 82, parish of Ste. Dorothee, Co. Laval, Que., property of Hormisdas Bibault and Onesime Lafontaine.

21529—March 21—Relieving C.P.R. from providing further protection at crossing of Government Road, west of station building at Mortlach, Sask.

21530—March 23—Authorizing G.T.R. to construct 2 bridges—namely, No. 138, mileage 91.90, 17th Dist., nearest Station Woodstock, Ont., and No. 7, mileage 6.15, 15th Dist., nearest station Weston, Ont.

21531—March 21—Authorizing C.P.R. to use and operate Bridge No. 2.65 on its Prescott Subdivision, Eastern Division.

21532—March 23—Amending Order No. 21508, dated March 14th, 1914, by adding following paragraph:—"And it is further ordered that after the completion of the work, the Railway Co., may close the old road allowances across its right of way; the road allowances according to the new survey to be substituted in lieu thereof."

21533—March 23—Approving proposed deviation of Essex Terminal Ry. Co.'s line, as already constructed, between a point near Bedford St., town of Sandwich, Ont., and Detroit River.