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CONDITIONS FOR MAXIMUM LIVE-LOAD STRESSES IN THE PRATT TRUSS WITH CURVED TOP CHORD

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Main Diagonals

By reason of the inclination of the top chord of a truss of this type the shear in any panel is not resisted wholly by the diagonal in that panel, but a certain portion of it is borne by the top chord. It may, therefore, happen that the maximum stress in the diagonal will arise when the shear in the panel is *not* at its maximum.

Let it be required to determine the loading condition for the maximum stress in the diagonal *Cd* of the truss shown in Fig. 1. The loading to the left of the panel under consideration, *cd*, is as-

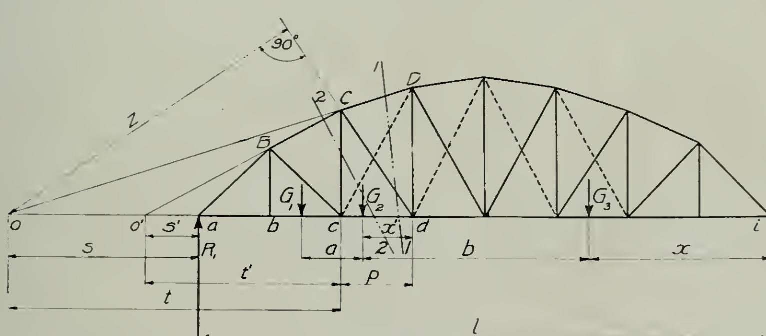

Fig. 1.

sumed to be either a single load G_1 or a series of loads of which G_1 is the resultant and which therefore acts at their center of gravity, G_2 represents the loading in the panel *cd* and G_3 the loading to the right of the panel. These three loads are separated by two fixed spaces *a* and *b*, G_3 is situated a variable distance *x* from *i* and G_2 a variable distance x' from *d*.

Producing *DC* till it intersects *iao* at *o*, and imagining a section plane 1—1 passed through the panel *cd*, it is seen that the stress in Cd is equal to the moment at o divided by the arm z. The stress in Cd will, therefore, be a maximum when this moment is a maximum. The moment about o of the forces acting on the part of the truss to the left of the section is $M = -R_1 s + G_1 (s + l - a - b - x) + \frac{G_2 x'}{p} \times t$, only the portion of G_2 which is transferred by the stringers to c having the effect of an applied force acting on the part of the truss to the left of the section 1 — 1.

Taking moments about i,

$$R_1 = \frac{G_1 (a + b + x) + G_2 (b + x) + G_3 x}{l}$$

and inserting this in the above equation for moment, we obtain

$$M = -\frac{G_1 (a + b + x) + G_2 (b + x) + G_3 x}{l} \times s$$

$$+ G_1 (s + l - a - b - x) + \frac{G_2 x'}{p} \times t$$

Differentiating with respect to x, and remembering that $dx' = dx$, we obtain as a condition for maximum moment.

$$\frac{dM}{dx} = -\frac{G_1 + G_2 + G_3}{l} \times s - G_1 + \frac{G_2}{p} \times t = 0,$$

Now $G_1 + G_2 + G_3$ is the total load on the span and may be represented by the single symbol G. Also, letting $l = np$, where n is the number of panels, and re-arranging,

$$G_2 = \frac{G}{n} \times \frac{s}{t} + G_1 \times \frac{p}{t} \tag{1}$$

For ordinary rolling loads which are likely to pass over a bridge, such as locomotives and cars, the equality indicated by the last equation cannot be realized unless $G_1 = o$. In other words, **for a maximum stress in a main diagonal, there must be no load to the left of the panel under consideration.** A special loading composed of several very light loads followed by a series of very heavy ones, might need to be so placed that one or more loads would lie to the left of the panel under consideration, but for any system of loads to which bridges are ordinarily subjected this would not be true. Equation (1) may then be simplified for ordinary use by omitting the last term, thus becoming

$$G_2 = \frac{G}{n} \times \frac{s}{t} \tag{2}$$

For the truss with parallel chords, s and t become infinite, $\frac{s}{t}$ approaches unity and (2) becomes

$$G_2 = \frac{G}{n}. \tag{3}$$

From the above it is evident that for a maximum stress in a main diagonal, there must be a *less load* in the panel than that required for a maximum shear in the panel or for a maximum stress in a main diagonal of a truss of the same span and number of panels and having parallel chords.

Vertical Posts

Consider the vertical post Cc, Fig. 1. Pass a section plane 2 — 2 through the truss cutting three stressed numbers, BC, Cc and cd. The counter cD will carry no stress when Cd is stressed. For the stress in Cc the moment center is o' and the arm is t'. The criterion of equation (2) may thus be made to apply to vertical posts by substituting s' for s, and t' for t, becoming

$$G_2 = \frac{G}{n} \times \frac{s'}{t'}. \tag{4}$$

The loading conditions for maximum stresses in the diagonal and the vertical post meeting at an upper chord panel-point are therefore generally different, **but if the top chord has the same slope on the two sides of the panel-point,** $s' = s$ and the criterion of equation (2) will apply to both members.

Counters

Consider the counter Fg, Fig. 2. The loading is assumed to not extend to the left of the panel fg, since, as has already been pointed

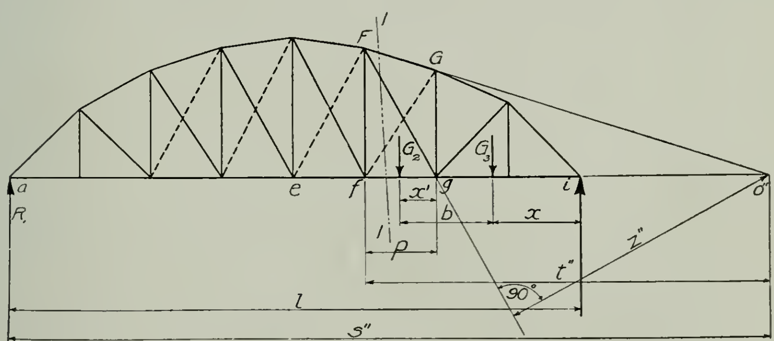

Fig. 2

out, the condition for a maximum stress in a diagonal cannot be realized, except in rare instances, with loading to the left of the panel in question. For a maximum stress in Fg, the moment about o'' must be maximum, since the stress is this member is the moment about o'' divided by z''. Considering the moment of the forces acting on the part of the truss to the *left* of the section 1—1, we obtain,

$$M = R_1 s'' - G_2 \frac{x'}{p} \times t''$$

$$\text{But, } R_1 = \frac{G_2\,(b + x) + G_3\,x}{l}$$

and therefore

$$M = \frac{G_2\,(b + x) + G_3 x}{l} \times s'' - G_2 \frac{x'}{p} \times t''$$

Differentiating with respect to x and making $dx' = dx$, we obtain as a condition for a maximum

$$\frac{dM}{dx} = \frac{G_2 + G_3}{l} \times s'' - G_2 \times \frac{t''}{p} = 0$$

Now in this case $G_2 + G_3$ is the total load on the span and may be represented by G. Also, letting $l = np$, and simplifying,

$$G_2 = \frac{G}{n} \times \frac{s''}{t''} \qquad (5)$$

This is precisely the same criterion as that contained in equation (2), the distances from the moment centre being in both of the measured to the *left* support and to the panel-point to the *left* cases panel in question. The value of s''/t'' being greater than unity, it follows that for a maximum stress in the counters of a truss with curved top chord, the load in the panel must be *greater than* the load accompanying a maximum shear in the panel or a maximum diagonal stress in the similar truss with parallel chords. This relation is the reverse of that already noted for the main diagonals.

Chords

Since the moment centre for the stress in any chord member is an opposite panel-point, whether the chord be curved or straight, the condition for maximum stress in any such member will be the same as for maximum moment at the opposite panel point. This is the same for trusses with parallel or curved chords and may be written

$$\frac{G_1}{m} = \frac{G}{n}$$

in which

G_1 = the total load to the left of the panel point in question.
m = number of panels to the left of the panel point.
G = total load on the span.
n = total number of panels on the span.

In words, **the moment at any panel-point will be a maximum when the load per panel to the left of the panel-point is equal to the load per panel for the entire span** and it may be shown as a further condition that the maximum moment can arise only when this equality is brought about by **the load per panel to the left of the panel-point changing from being less than to being greater than the load per panel for the entire span.**

Effect of Varying Curvature of Top Chord

In many Pratt truss spans the curvature of the top chord is not great enough to require the application of the special criteria derived above. For less than a certain curvature, therefore, the rules for maximum web stresses will be the same as for trusses with parallel chords. Some indication of the value of the limiting inclination of chord segments is afforded by the fact that for a truss of the type shown in Figures 1 and 2, having 8 panels of 25 feet each, a hip depth of 30 feet, and subjected to any of the steam railway loadings of the Dominion Government specification the special rule for maximum diagonal stresses contained in equation (2) first becomes necessary for the successive panels when the slopes of the top chord segments are as follows:

Chord Segment	Slope, Vertical to Horizontal
BC	5½ in 12
CD	3 in 12
DE	1½ in 12

To render the application of equation (2) necessary for the diagonals in *all* panels up to the centre, the truss under consideration would require to have a depth of 51 feet at the centre, or slightly over one-quarter of the span. A truss of such proportions would, for several reasons be undesirable, in general. While the top chord segments in the end panels may be inclined with sufficient steepness to bring into operation the special criterion of equation (2), the rapid reduction of this slope near the centre soon renders possible the application of the simple rule for parallel chord trusses. Since the values of s and t are independent of the truss depth, the less the depth at the hip, the less the slope of the chord segments at which equation (2) becomes necessary. Its application will be most frequently required when the top chord panel-points are on a regular curve passing through the end supports, that is for the bowstring truss.

In case of doubt whether the curvature of the top chord is great enough to require the application of the special criteria derived above, it is best to employ them, since they are perfectly general and apply to trusses with any degree of top chord curvature. As has already been shown, the rules for parallel chord trusses are merely particular cases of the general ones herein established.

References

References—For a more extensive treatment of the subject, the student is referred to the following works:
Edgar Marburg—Framed Structures and Girders; Vol. 1, Stresses; Part 1.
Burr & Falk—Design and Construction of Metallic Bridges.
Johnson, Bryan & Turneaure—Theory and Practice of Modern Framed Structures; Part 1, Simple Structures

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LITERATURE AND MINING

By J. C. Murray, B.A., B.Sc.*

Samuel Pepys was an official in the Navy Department in the reigns of Charles II. and James II. He was, also, an amazingly candid diarist. His diary, obviously never intended for publication, was written in a short-hand of Pepys' own devising. It covered the period 1660-1669. By accident it was not destroyed and it was included in the gift of books that Pepys bequeathed to Magdalene College, Oxford. Not until early last century was the shorthand deciphered.

Frequent illuminating allusions to mining matters occur in the

*Editor of *The Canadian Mining Journal*," in an address to the Engineering Society the first part of which appeared in "Applied Science" for October.

diary. Nova Scotia figures in several of these. In an entry for May 13th, 1667, we find this: "This morning comes Sir. H. Cholmly to me for a tally or two; and tells me that he hears that we are by agreement to give the King of France Nova Scotia, which he do not like: but I do not know the importance of it." A few months later, however, Pepys received more light, for he complains of the matter again, and characterizes as shameful the giving away of Nova Scotia, "which hath a river 300 miles up the country, with copper mines more than Swedeland, and Newcastle coals, the only place in America that hath coals that we know of." A river 300 miles long would, if crowded into Nova Scotia, assume roughly the shape of a closely coiled serpent. Also rumours of coal have come from other parts of the continent; but Mr. Pepys was not a stickler for trifles.

During the year of the great fire of London, 1666, Pepys notes the extraordinarily high price of coal in the city. The price per chaldron (25½ hundredweight) was £3 3s., and it must be remembered that the purchasing power of money was thrice as great then as it is now. But early in 1667 worse befell. Pepys, in the act of purchasing some newsbooks at Westminster Hall "did hear everybody complain of the dearness of coals, being at £4 per chaldron, the weather, too, being become most bitter cold, the King saying to-day, that it was the coldest day he ever knew in England." The next day, sad to relate, was still colder. "This day," groans the excellent Samuel, "was reckoned by all people the coldest day that ever was remembered in England; and God knows! coal's at a very great price!" Harried as the coastwise colliers were by the Dutch fleet, it is not surprising to read that coal went up to £5 10s. in the following June.

A few sentences from his description of the methods used at the Royal Mint, and we shall have done with Mr. Pepys.

On the morning of May 19th, 1663, Pepys, to use his own good phrase, was "up pretty betimes." With a few friends he was shown over the Mint by the controller, and he takes pains to set down his impressions. He tells, among other things, how he "saw the manner of assaying of gold and silver, and how silver melted down with gold do part, just being put into aqua-fortis, the silver turning into water, and the gold lying whole in the very form it was put in . . . . which is a miracle; and to see no silver at all, but turned into water, which they can bring again into itself out of the water, " Discussing all these things afterwards at dinner, the controller told his guests of one dishonest laborer who clipped coins and swallowed the clippings "down into his belly,and so they could not find him out." The thief was later induced to confess. His thievings amounted to £7. Another artisan made dies that produced facsimiles of old, worn coins, and thus gained 50 per cent. on his investment.

It is not inappropriate here to glance for a moment at Lord Macaulay's vivid description of the condition of the mineral industry of England just about the period to which we have been referring. Tin was one of the most valuable products of the mine, the output from Cornwall being about 1,600 tons annually. Copper, however was altogether neglected. Rock salt was not worked. "The salt which was obtained by a rude process from brine pits was held in no high estimation. The pans in which the manufacture was carried on exhaled a sulphurous stench." In fact, the residue was hardly fit for human consumption, and, as it was supposed to induce scorbutic maladies, it was used only by those who could not afford to buy the more expensive French product.

Since the manufacture of iron implied the wholesale destruction of forests wherefrom to obtain the necessary charcoal, the industry was not encouraged. In fact, nearly all the iron used was imported, not more than ten thousand tons being made in Great Britain annually, a quantity equal to the output of one large modern furnace in less than a month. The art of using coal or coke had not, of course, been thought of.

Coal, the most important of all minerals, was very little used in manufacture. Few mines were worked that were not easily accessible by water, and London, so Lord Macaulay believes, consumed at least half of all the coal mined. As the capital is credited with requiring about 350,000 tons annually in the reign of Charles II. (and this quantity was thought to be fabulously large) one can compute the total without a ready reckoner.

It would be pleasant, of course, to continue multiplying such citations and quotations. Standard English literature, both prose and poetry, abounds in facts, fancies, and metaphors drawn from mining and metallurgy. Our vocabulary has drawn many cogent phrases and words from the mine. The whole course of history has been colored by man's desire for the products of the mine. The arts and the industries are based upon the miner's labor. Our remotest ancestors, shortly after they outgrew their tails, took to smiting each other with roughly smelted weapons of iron and copper. At the same time—I have to ask you to take my word for this—the female of the species recognized the decorative value of polished metals. And I doubt if this made for peace.

It is, I take it, quite superfluous to quote from Holy Writ. You all know of that first artificer, Tubalcain, of the metallic embelishments of the Temple; of that oft misquoted and magnificent chapter in the Book of Job; and last, of the specifically mineralogical terms in which both places of future abode are described in the last book of the accepted canon.

All this, I doubt not, would be a work of supererogation. It will suffice for me to assure you that there are equally available and more modern works that can be used with profit. The assays of T. Sterry Hunt, the volumes of Sir William Dawson, many of the pamphlets of Dr. Henry Youle Hind, not to mention other noted Canadian scientists are pre-eminently worth while to the mining man. Moreover, when he wishes other stimulation, he can turn with profit to the pages of Parkman, who is to my mind the best of historians; or to Prescott, who deals with more southerly latitudes. In both, particularly in the latter, he will find that the romance of mining plays a considerable part.

The broad truth that I wish to impress upon you is that general reading is vitually necessary through all stages of our mental development. I fear that I have succeeded in submerging this truth in a flood of extraneous matter. Nevertheless it is a truth that cannot be ignored. The mining man who reads wisely and well is a better citizen than the mere technologist. He is also the better technologist.

THE BUSINESS SIDE OF CENTRAL STATION WORK

By Wills Maclachlan, B.A.Sc.*

The profession of engineering is divided into a number of different parts. The work of the civil engineer, the mining engineer and the architect, is well known, but the exact work of the electrical engineer is not so well defined. First, I will try to give some idea of the work that an electrical engineer is called upon to do. Electrical engineering naturally divides itself into two main branches. First, the design, manufacture, construction and sale of electrical appliances. By this I mean any appliance that is used in the handling of electricity whether it be a transmission line, a large generator, or a flat iron. The second division of electrical engineering is the generation, transmission, distribution, and sale of electricity. If you purpose following the profession of electrical engineering, your energies in later years will be confined to one or more of the sub-divisions that have been mentioned, but it is the intention to dwell here on the latter of these divisions, namely, central station work.

The work of the central station is divided into pure engineering and business. Under the branch of pure engineering we find the work of the general superintendent and all who are responsible to him, and in large central stations we also have the experimental side under the engineering department. Then we come to the business side of the central station. There is a great tendency among students and young engineers to belittle the office work and spend their energies on the practical side of their training. This is a great mistake, and to show some of the objects of the office work of a central station is the aim of this paper.

Let us examine briefly the accounting system of a modern central station. The line department, meter department, office staff, sub-station and power-house are doing work every month. It is costing a certain amount of money to operate the central station. Its modern accounting system tries to sub-divide the cost of these different operations and this is obtained by using what are called accounting numbers. In the central station with which the writer is connected, we use 61 account numbers. These numbers cover the wages of the power plant, the fuel used in the power plant, the water used for power, the oil and waste in the power plant, etc. Again there are pole rentals, maintenance of poles, maintenance of overhead lines, maintenance of underground circuits, the rental of underground conduits, maintenance of transformers, maintenance of meters, etc. Further classification involves new business salaries, canvassing, advertising, salaries of head office, salaries of local office,

* In an address to the Engineering Society, Oct. 20th, 1912.

printing and stationery, head office expense. etc. By thus keeping the expense of each of the different operations entirely separate on pay rolls, invoices, stores reports, we are able at any time during the year to tell exactly how much each of the different divisions is costing. For instance, if the cost of maintenance of the overhead lines is excessive, we are able to put our finger on the specific item, that requires readjustment, enabling the management to proceed at once to bring this expense down to a reasonable amount. Then these different operating expenses are grouped together under the main divisions: Total Expense Power Plant, Total Maintenance Power Plant, Total Expense Transmission, Total Expense Distribution, Total Utilization Expense, Total New Business Expense, and Total General Expense.

By grouping all these expenses for the month and placing them in total on a form, we are able to compare, for example, October expense with that of September, August or July of this year, or with the expenses of corresponding months last year. If it is evident that a certain expense this year is entirely out of proportion with the corresponding expense last year, we immediately seek the reason. This may be uniquely recorded on cross section paper, plotting dollars and cents as ordinates and the months of the year as abscissas. At the beginning of each year curves are plotted showing the last year's expense and then on this same cross section paper the expense of the current year is plotted from month to month. In this way it may be seen at a glance how each expense is running.

It is expedient now to explain the capital charges and the manner in which this part of the business is operated. You will recognize that, if you have to extend your system into a new part of the town, for instance into a new manufacturing plant needing power, and into the workmen's houses near the plant, if your lines are not near at the time, it is hardly fair to build these lines and charge them to operating expense. In a case like this, we make out an estimate of the cost of building the new lines. At the beginning of each year we send in all the estimates for building lines that we think will be necessary during the year. The executive office passes on these estimates, and appropriates money to do this work. This appropriation is given a number and each of the estimates under this appropriation is given a job number. For a certain central station you might have an appropriation number 100, covering all your capital expenses for the year. Under this appropriation there will be jobs 1, 2, 3, 4, 5, 6 and as far as your different divisions go. Under these divisions you have itemized work, such as the extension of your system for a block that will cost about $80.00 or $90.00, which will be designated, say No. 4A. An extension of the system in another part of the town will be called 4B., and so on. In this way, as in the case of the account numbers, we keep each separate extension by itself, and can readily tell how much it is costing. This gives us data to work on for future estimates, and also affords a check on whether the work is being carried on satisfactorily or not.

The manner in which the consumers' ledger is handled is also interesting. In this ledger we carry the accounts that we have against all our different consumers. This ledger is ruled horizontally about 45 lines to the page, each line representing a different consumer. Vertically for each month we have, columns for Electric Metered, Electric Non-Metered, Power, Street Lighting, Property Rents, Total Earnings, etc. Then on the cash side, we have Cash Received, a column for the Date of Receipt, Discounts and Delinquents. The accountant in making out the bills for the month takes the meter reader's book. This is a loose leaf book, containing all the readings of the meters on the consumers' premises, each consumer having a page. He works out from the meter readings, the amount of power the consumer has used during the month. He then multiplies this by the rate charged and places it in the consumer's ledger and on the bills. On the bill he also marks the discount allowed and the net bill. Then when this bill is paid he marks in the amount paid on the correct column noting the date and also noting the discount allowed. These two columns should equal the earnings shown when the bill was made out, so to balance this ledger, we take the total out-standing for the previous month, less cash and discounts, to equal the delinquents, Then delinquents plus all earnings should equal the total outstanding for the present month. This shows a very simple ledger, but the simpler the ledger, the better it is as there are so many different accounts to be kept in it.

Taking up now some of the work that is carried on in the office, let us look into who should constitute the office force. First there is the *cashier*. This is the man who has charge of the office. He is responsible for all moneys received and for the keeping of the books. He is also responsible for the filing of all records, etc. Then we have an *office assistant*, whose duty it is to aid the cashier in all work possible, to look after the stores' reports, and to act as a general utility man in the office. These two men in the average size central station will look after all complaints, signing of contracts, and the sale of appliances, etc., to the consumer. Third, the *stenographer*, who writes out all correspondence, keeping track of filing system, making out reports regularly for the executive office, typing and addressing the consumers' bills. Fourth the *meter-reader*, whose duties it is to read the consumers' meters once a month, and to install new meters. The average meter-reader can read about 150 meters a day, and hence may be expected to have considerable spare time, and in this time he is usually required to act as a clerk to the line foreman. Fifth, the *manager*. His duties are to keep a general supervision over all work, and to act in an advisory capacity between the office staff and line force. He is the representative of the company in all dealings with the public.

This in a short way will give an idea of the office staff of an average sized central station. All the records in the central station should be kept on file so that they are accessible at all times. This is very important, as in filing duplicates, etc., it is often found necessary to refer to a record that is perhaps a month or a year old. We find that by using card system, Shannon files, and vertical files, we can keep things in good shape.

Let us investigate the events that occur when a consumer enters the office and asks to be connected to the line. First he is required to sign a contract for the supply of electricity. This contract is made out on a regular form by one of the office staff and the consumer's signature is witnessed by him. After the contract is made out, an instruction order is made out instructing the line department to do the work. This contract being made out in duplicate accompanied by the instruction order is submitted to the manager for his consideration. The manager then signs the contract for the Company, and approves the instruction order, placing on the latter the accounting number to which the work is to be charged. A copy of this instruction order is kept on file in the manager's office, the original along with the contracts, being placed on the line foreman's desk. The line foreman on receiving the order, checks it with the contract, has his men run the service and has the meter-reader install the meter. At the time the meter is installed the meter-reader examines the house, estimating the number of lights and getting every detail with regard to the service. When the work is completed, the line foreman places on the instruction order the amount of material used to do the work, and amount of time used in doing it, the meter number and reading, number of lamps in the house, and number of transformer to which the house service is connected. He then initials the order and returns order and contract to the manager's desk. The manager then checks completed order and contract, and if everything is in right form he takes off his file the copy of this order and destroys it. He then returns the contracts and order to the office. The office assistant then takes the instruction order, works out what the material costs and files the order for the monthly return. A meter reading sheet is then made out from the contract and instruction order, and is placed in its right place in the meter reader's book and the name of the consumer is entered in the consumers' ledger. The contract is then filed in the contract file, and a copy mailed to the consumer. At the end of the month all the instruction orders are grouped together and on a stores' report the cost of the work is returned to the executive office showing the cost of material used in different jobs during the month. I do not think it is necessary to go into all the details of the different forms that are required in the office. We use some 34 different forms at the present time, and I will simply mention that there are separate forms for ordering material, returning invoices, petty cash reports, consumers' ledger reports, stores reports, pay rolls and a number of other forms to the executive office. These forms go through a regular set routine, and in this way we save a great deal of time in being able to do the work quickly and at the same time without any mistakes.

We will next touch on the new business side of the central station work. It is very important before starting in a campaign or canvass for new business, to know your territory. This is first done by having a card system made out, having one card for every house in town. On this place different details that are required, with regard to the house. It is well to have one color card for the consumers and another for non-consumers. If the central station is large enough a solicitor is employed to go out and interview prospective consumers. Let me touch for a minute or two on the training and work of the solicitor. I do not know of any position in the central station that would give better training in central station work than the work of the solicitor. This man should be able to meet people, talk to them in an ordinary gentlemanly way, explain all the details that are required in a way that they will understand, leaving out all technical language. He should be able to go into a store, lay out that store for lighting and tell the prospective consumer about what this average bill will be for a year. You will think I am asking a great deal of a solicitor, but it is not a hard proposition to lay out an average store for lighting and most of the data can be obtained from tables. Above all things, the solicitor should remember that he is the employee of the central station that is soliciting business from the public, and the public judges the central station by the employees that they see. Hence just so much as the solicitor gives a good impression, so much will the public have a good impression of the central station. This work of soliciting develops a man in meeting the public, in telling his story in a concise and convincing way, and trains him in that most important study, namely the study of human nature.

The advertising of the central station is a very important detail. In good advertising the most important thing to remember is to tell one thing at a time, have your advertising a little bit different from that of everybody else, and educate the public in the many uses of electricity.

Let me now touch briefly a subject that is just beginning to be recognized as a very important one. Namely the collection and analysis of statistics. By collecting the statistics of your central station, I mean as follows:—Take the total revenue for a period say six years, working out a curve showing the growth of revenue from year to year, take your total revenue for a year, find you what per cent. each month's revenue is of the total and plot a curve showing variation from month to month. Take from the sub-station or power-house reports the total K.W-hours used each month and plot them, and on the same cross section paper plot the monthly peaks. Take the revenue from your lighting consumers, and the revenue from your power consumers, and plot them from month to month. Then from the previous year's records plot the per cent. that each month is of the total revenue under meter, power, and flat. From these and other curves that might be mentioned, you will be able to analyse from an engineer's standpoint the workings of the central station. These curves give you an insight into the real workings of the central station that you can get in no other way and with these curves and these statistics as a basis, if you will give the question of rates and forms of contract the study that it should get, the knowledge of rates in the future should be on a far better basis than it is at the present time.

Before closing, let me outline the duties of the central station manager. First, what should his duties be to the staff? He should try to know the details of the duties of every member of the staff, so that he can lend help and advice at any time. He should gain the confidence of his staff in such a way as to bring about that ideal of working, namely, *esprit de corps*, and team work, that is absolutely necessary in modern business.

Second, in regard to his duties to the executive office, he should see that all orders from the executive office are carried out in detail. If he does not understand these orders he should find out the why and wherefore immediately, and he should be loyal to the executive staff and try to instill into his staff that loyalty that is necessary. In regard to his duties to his consumers, the position of the modern central station has changed greatly in the last few years. The old motto of Cornelius Vanderbilt of "Public be Damned," has long since passed away and the modern motto of "We Serve," is coming to the front. If the consumer comes in with a complaint, investigate that complaint and take the consumer's word that he is telling the truth. After careful investigation, if there is a doubt in the case give the consumer the benefit of the doubt and you will find that by acting fairly with your consumers, you will get better results than by antagonizing them.

The duty of the manager to the community might be broadened out to refer, not only to the central station manager, but to engineers in general. At the present time the engineer is of too quiet a disposition. The professional men in other branches, namely the doctor, the lawyer, the minister, etc., are taking their places as good citizens and are helping the community as a whole. Up to the present time the engineer has not come forward as a broad minded man and as a citizen. He has received his training in looking at things with a critical eye, and from the more practical standpoint. Do you not think that his advice in matters pertaining to engineering works would not be acceptable to the community? We find hundreds of thousands of dollars wasted on work that has been abandoned due to the fact that good sound engineering advice was not obtained in the first place. You say that the community by paying for it, can obtain good engineering advice, but in municipal councils and on our legislatures and in parliament, we find doctors, lawyers and business men working for the community, but to find an engineer in any one of these capacities, is a very rare thing. Why should the engineer as a professional man, as a business man and as a good citizen, not come forward and lend his help in the governing of the municipalities of the country. If you will, as I hope some of you will, go into central station work and become managers or local managers of central stations, you will find that you will gain a great deal of good for yourself, for your company, and for your community, if you will go into the Board of Trade or Chamber of Commerce, and lend your aid to assist movements in your town and help in moulding and educating the public mind up to good ,sound, broad-minded, principles.

You must remember that the profession that you are now entering is just in its infancy. Thirty years ago the profession of electrical engineering was practically unknown, and electricity was confined to the laboratory. You must remember that the great stride that has been made in this profession in the last three decades will be surpassed by the stride that will be made in the next three, and it rests upon you and other men who are entering upon this profession to see that these wonderful developments are carried out. Remember, that Canada's strength lies in the value of the enormous water powers that are scattered over the whole country. The old motto was "We have iron and fire, the hand cannot go back on the dial of time." But the new motto is "We have iron and fire and power, the hand of time cannot go back on the dial of time," and hence we have the united trinity to aid in making Canada one of the nations of the world." We are ancients of the days, but in the morning of the times in regard to electricity." In taking up your statistics, you should remember that it is not only the purely technical work to which you should devote your attention—and I would not belittle th. technical work, for I well understand and appreciate the enormou amount of labor required to perfect the design of electrical apparatus in the future and to operate the large transmission lines in a more efficient way than they are at the present time—but you must be able to see clearly the value of the office work and the value of the field work, and if you can combine the detail information that you can get from the statistics of the office with the knowledge of the right way of designing and the right way of operating and add to these that very important element, the human touch, you will do a great deal to elevate the profession of electrical engineering, to enrich and strengthen the position of your country and to have the personal satisfaction of doing something worth while.

In this paper I have simply tried to open up different lines of thought regarding central station work so that you will have some conception of the work of the engineer in the business side of the central station.

IRRIGATION*

By H. M. Goodman, '13

Irrigation may be defined as the systematic application of water to land with the object of promoting present or prospective growth. The artificial watering of crops in which the farmer and the engineer unite in the employment of methods whereby water may be applied in the easiest, least expensive and most surely uniform manner, i. e., by the action of gravity and natural flow, is the result. Ditches are constructed which lead water from the source of supply, and are so aligned and graded that the water flows through and from them into minor channels, and from them in turn to distributary channels, leading finally to the fields by means of ploughed furrows or otherwise. Agriculture by irrigation produces the most luxuriant and abundant crops, since in the arid and semi-arid regions, where artificial watering is essential, sunshine is ever present, and water is applied only when needed, and always in exactly the amount desired. The notable difference between a dry-land farmer and an irrigator

* With references to the Dominion Government Irrigation Belt in Saskatchewan.

is that the former relies on Nature for his entire supply of moisture, while the latter buys and pays for the requisite amount.

Hydrographical investigations have to be undertaken in order to find out whether sufficient water can be acquired for irrigation purposes. These operations consist of obtaining full information regarding precipitation, run-off and stream flow.

Precipitation

Where climate and soil are favorable to the growing of crops, it is evident that the necessity for irrigation depends on the available amount of precipitation. For this reason it is necessary to examine carefully the records of precipitation in the district, extending over a number of years in order to arrive at a conservative estimate of probable precipitation. In practice it is always prudent to base the estimate on minimum values, since precipitation is known to vary perceptibly from year to year. It is also necessary to approximate the maximum precipitation which may occur, in order to make the design sufficiently strong to withstand it.

Run-off

The name is applied to the quantity of water which flows in a given time from the catchment basin of a stream. It includes rain-

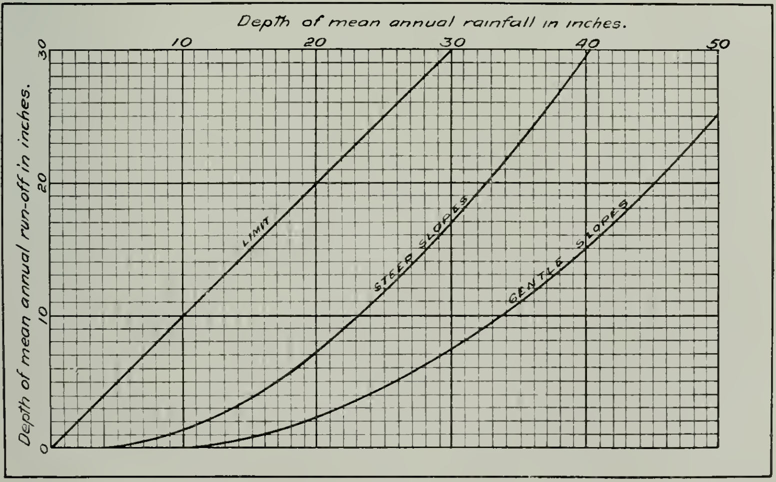

Fig. 1—Relation of Run-off to Rainfall

fall, springs, etc. Run-off from a catchment area may be expressed either as the number of second-feet of water in the stream draining that area, or as the number of inches in depth of a sheet of water spread over the entire catchment. As run-off bears a direct relation to precipitation it would appear that, knowing the amount of rainfall and the area of catchment basin, the amount of run-off can be directly ascertained.

This is not the case, however, for the amount of run-off is effected by varying climatic and topographic factors. The climatic influences bearing most upon run-off are, the total amount of precipitation, its rate of fall, and the temperature of the earth and air. Within a given drainage basin the rates of run-off vary on its different portions: thus, in a large drainage basin the rates of run-off for the entire area may be low if the greater portion of the basin is nearly level, but at headwaters of the streams where the slopes are steep, the rate of run-off will be greater.

For consideration of the above the curve of Mr. F. H. Newell, shown in Fig. 1, gives graphically, an excellent means of obtaining the average run-off due to average precipitation.

In irrigation reconnaissance surveys this curve is very useful and is at present used by Dominion Government parties in their work.

Stream Flow

Where the catchment basin is comparatively level, well covered with timber and grass, and the soil deep, the rate of run-off is consequently low and the streams are nearly constant in their discharge, being subject to few and not excessive flood rises. This occurs where, as in most cases, the larger portion of water reaches the streams by seepage. Where the catchment basin is precipitous and barren the regimen of the stream is the reverse of the above—very little water soaks into the soil, and after a heavy storm most of the water runs off in a very short period, resulting in great floods.

Mean Discharge of Streams

When definite data of the annual discharge of a stream are not available they may be obtained approximately by multiplying the depth of run-off in inches by the area in square miles of the catchment basin. While these quantities will furnish valuable information regarding the mean annual discharge of the stream they fail to indicate the mean discharge during different months and especially during the irrigation period. For this purpose a discharge curve is important, and if there be none for the stream in hand, it will be necessary to make a few gaugings at different stages of water.

Theory and Practice of Measuring Discharge

There are three distinct methods of determining the surface flow of streams.

(1) By measurement of slope and cross-section and the use of Chezy and Kutter's formulæ. This method is very rough and is made use of only in special cases, such as in obtaining an idea of discharge during flood time where the high water marks can be easily determined, or arriving at an estimate of discharge of a spring creek when no water is flowing.

(2) By means of weirs, which include any device or structure that by measuring its depth on a crest, or sill, of known length

and form gives the flow of water by the use of the well known Francis' formula.

This method is used when the stream is small, and when the depth of water in the stream is too small for measurement with a current meter. If the conditions of Francis' formula are observed this method is very accurate.

(3) By measuring the velocity of the current and its cross section. For this method a current meter is chiefly used. In making a measurement with a current meter, a number of points, called measuring points, are located in the plane of the measuring section, at which points observations of depth and velocity are noted. The measuring points divide the total cross-section into elementary strips at each end of which these observations of depth and velocity are made. The discharge of any elementary strip is the product of the average of the depths at the ends, the width of the strip, and the average of the mean velocities at the two ends of the strip. The sum of the discharges of the elementary strips is the total discharge of the stream. If the instrument is kept in good repair the results are considered fairly accurate.

For stations with permanent beds it is possible to prepare from the data collected, station-rating tables, each of which gives for its station the discharge corresponding to any stage of the stream and also, when applied to the daily gauge heights, gives the daily discharge.

The basis for a station-rating table is a rating curve which shows graphically the discharge corresponding to any stage of the stream, and is usually constructed by plotting the results of the various discharge measurements, with gauge heights as ordinates and discharges as abscissas. These points define the curve which can then be drawn in. Since the discharge is the product of two factors, area and mean velocity, any change in either factor will produce a corresponding change in the discharge. The curves of area and mean velocity thus furnish valuable assistance in studying the accuracy of the measurements, and determining the true location of the rating curve. These curves are defined by plotting gauge heights as ordinates and areas and mean velocities as abscissas.

Now, by the use of the discharge curve, as shown in Fig. 2, and accurate gauge height readings, a fair idea of the water flowing through daily is arrived at, and hence the amount of water available for irrigation purposes is determined.

For the engineer investigating the feasibility of an irrigation scheme as regards available water he can secure most of the information up to the present from the Hydrographic Service.

In cases where the data gathered by the Hydrographic Service do not cover the source of supply from which diversion is proposed, the engineer should ascertain the approximate drainage area above the point of diversion, the nature of the land composing it, i. e., whether the slopes are steep or flat, timbered or bare, the kind of soil, whether likely to absorb a large proportion of precipitation. He should obtain all information possible regarding precipitations, more particularly concerning its physical division into rain and snow. Then the peculiarities of flow in the source of supply should be carefully considered, it should be accurately determined whether or not the stream has a constant flow and what is the nature of the feeders that maintain it. In case the flow is periodic an effort should be made to ascertain the average duration of the periods each year, and calculations as to the quantity of water at flood stages should be made by means of the Kutter & Chezy formulae from water marks observed.

Similar observations relative to the size and slope of the channel, erosion due to flood water, and the nature of the bed and banks, are often of value in estimating the water supply in a stream with which the engineer is unfamiliar.

Irrigable Area

In reporting upon the area it is proposed to irrigate careful consideration should be given to the nature of the land with relation

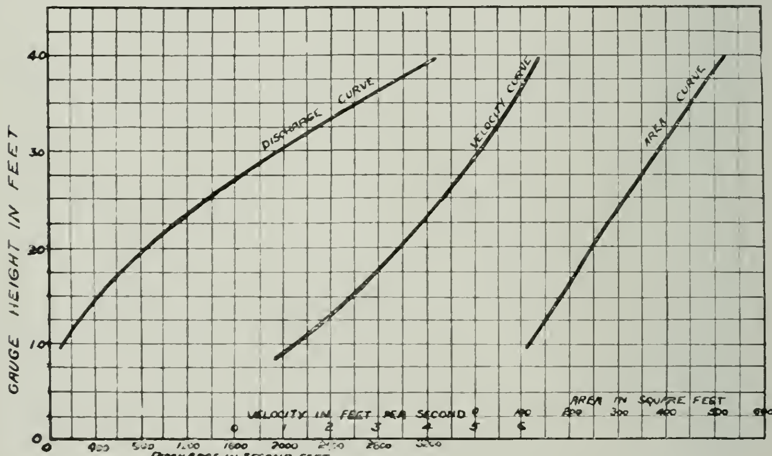

Fig. 2—Discharge, Area and Velocity Curves

to its slope, ascertaining the approximate fall in feet per mile, together with other characteristics of the surface; and likewise with relation to the composition of the soil together with the abundance and quality of the vegetation found thereon, and the kinds of growths best adapted to it under irrigation.

These data are essential to the engineer in determining the system of irrigation most suitable to the particular case, together with the probable cost per acre of constructing a satisfactory scheme.

Reservoiring Facilities

In the province of Saskatchewan (Dominion Government irrigation belt) in the majority of cases at the present time the source of supply is a stream or coulee having a periodic flow only, or one in which all the low water flow has been previously granted. This makes the inclusion of some system of reservoiring necessary if the scheme is to be fully successful. In such cases it is necessary for the engineer to look carefully into the storage facilities on or in the vicinity of the land to be irrigated.

The different methods of reservoiring in Saskatchewan are:

1. Dyking System.—This is the least expensive and least efficient method of reservoiring since the land that it is actually intended to irrigate is completely under water during long periods. It is frequently the only method available, however, without very expensive outlay. It is applicable to comparatively smooth flats, having a fall of not more than 10 or 15 feet to the mile, and succeeds very well when used in connection with the irrigation for hay. The dykes are most successfully constructed on contours so that the high water mark on one reaches the bottom of that next higher. With this system of irrigation a thorough system of drainage ditches is required.

(2) Reservoirs Within the Stream Bed.—These are obtained by damming the stream valley, and are consequently more expensive than dyking systems. The principal difficulties to be overcome are in the provision of dams sufficiently strong to resist freshets and of such construction as to permit of the safe passage of excessive flood water through suitable wasteways. This method is used when reservoiring is not practicable in the vicinity. When the fall of the stream valley is slight it is possible to hold back quite a large amount of water by the construction of a dam.

(3) Storage Basins Outside the Stream.—These make the most satisfactory system wherever they are feasible at a moderate expense. The difficulties in the way of construction are usually much greater than in either of the other cases, owing to the cost of dams, intake ditches and proper outlets arising from the fact that a sufficient elevation must be obtained for the reservoirs to deliver water on the highest point of the irrigable land, making it necessary to have the intake higher up the stream with a resulting longer ditch. Furthermore, the intakes must be of large capacity if they are to utilize flood water to the best advantage, as they should be able to fill the reservoir within the usual flood period of each year.

The reservoir problem is one of great importance in determining the probable success of any such irrigation system and should be carefully investigated before an opinion is formed as to the feasibility of the proposed scheme.

Duty of Water

Duty of water is a term used by irrigation engineers to express the amount of work that water does or may be expected to do in irrigating crops, and is one of the first items of importance in designing an irrigation system.

On this duty of water for a given soil and region oftentimes depends the financial success of an irrigation enterprise. As water becomes scarce its value increases. The estimated cost of an irrigation project therefore depends on the amount of water the land will require. The dimensions to be given the canals and reservoirs depend likewise on this factor. The duty of water varies primarily with the crop; it varies also with the temperature of the locality and conditions of the ditches. The period of time during which water is applied to the land for irrigation from the time of first watering until the last is known as the irrigating period.

Units of Measurement

The duty of water is expressed usually in either of the following ways:

(1) By the number of acres of land that a second-foot of water will irrigate; and,

(2) By the number of acre-feet of water required to irrigate an acre of land. In considering the duty of water it should be noted whether it is computed from the quantity entering at the head of the canal or the quantity applied to the land, since the losses by seepage, evaporation, etc., in the passage of water through the canal are considerable.

The duty of water in Saskatchewan is a matter of extreme doubt, but at present it is estimated that one second-foot during irrigating period at the head will irrigate 150 acres. These figures have no doubt been acquired by experiment in parts of the province where the water is chiefly used in the ranching district for raising hay. The duty would, of course, be different were the soil required to grow other classes of vegetation. The irrigating period in Saskatchewan is from about May 1st to Sept. 1st, the service periods varying with the kind of crop. To handle water economically a head must be carried sufficient to furnish the requisite velocity of flow to the most remote points.

If irrigation were in progress at the same time along all points of the same canal sufficient water would not reach the lower portions to properly water the bed of the ditches. In the operation of a canal system, therefore, it is customary to divide the laterals into sections and to permit of the irrigation of one or several sections only at a time. This is done by establishing a system of rotation, giving each section a definite service period under different heads.

Classes of Irrigation Works

Irrigation works may be divided into two classes: gravity and lift irrigation. The former includes all systems by which the water is conducted to the land by the aid of gravity or natural flow. Among them are, perennial canals, periodical and intermittent canals, inundation canals, and storage works.

Lift irrigation includes those forms in which the water reaches the land, not by natural flow, but by mechanical means. This method of supplying water is seldom made use of on account of high cost, and is therefore used only when the supply of water is known to be ample and the soil to be covered warrants it. There are at present no schemes in Saskatchewan where water is pumped.

Irrigation Canals

The conditions required to develop an irrigation canal are these: It shall be carried at as high an elevation as possible to provide sufficient fall for the irrigation of land to a considerable distance. It should be fed by some source of supply as would render it a running stream. It should also have such a slope and velocity as to reduce to a minimum the deposition of sediment and the growth of weeds. Finally, its velocity should be the greatest possible in order that cross-section may be reduced to a minimum for a given discharge.

Where the precipitation is small, occurring during a short period of the year, resulting in intermittent or periodic flow of streams, canals of this class, or storage works must be employed. This is largely the case in Saskatchewan, and the works constructed are mainly for diverting water from such sources. Intermittent and periodical canals are usually small in dimensions, commanding relatively small areas of land, and are generally employed by individual farmers for the utilization of the waters of some stream which may be safely relied upon for continuous supply, occurring through spring storms and melting of mountain snows.

Storage works receive their supply from intermittent streams carrying sufficient volumes of water in times of flood.

Inundation Canals

These might also be called flood-height canals, as they are dependent for their water supply on the height of flood rise in the river or stream. There are numerous schemes in Saskatchewan where the water is brought to the land by these canals. This type of canal rarely requires permanent headworks for the control and admission of water to its channels, its head consisting of a simple cut through the river-bank or the ridge which separates the stream from the low-lying surrounding lands. As they depend upon flood rises for their supply the beds of these canals are generally at some height above the beds of the rivers from which they receive their supply, and usually at the level of mean or low water, so that when these streams are not in flood they do not receive any water. Although many of the schemes in Saskatchewan are of this nature they have not proved very satisfactory for frequently the flood does not rise high enough to give a sufficient head with which the low-lying lands may be irrigated, especially so when the ditch is of some length. If, however, some sort of a dam be thrown across the stream the irrigator may then be more certain of his water supply. However, as this means extra cost for the installation, its construction is frequently not warranted since the area to be irrigated may be small and the cost per acre high.

Perennial Canals

These canals derive their supply from perennial streams or from storage reservoirs. They are divided into two classes, according to the location of their headworks, viz., high line canals and low service canals. The former are usually of moderate size and are designed to irrigate lands of limited area which lie adjacent to the foot of the higher hills. They are generally given the least possible slope in order that their grades may remain high. In such canals it is necessary to locate the headworks high up in the stream.

There are many schemes in which the type above mentioned is made use of in Saskatchewan and which are now working most satisfactorily.

Parts of An Irrigation Canal System

(1) Source of water supply.
(2) Irrigable lands.
(3) Main canals.
(4) Headworks and regulating works.
(5) Control and drainage works.
(6) Laterals.

The source of the water is the first consideration in designing an irrigation scheme. The relation of this to the extent of irrigable lands must then be considered.

The headworks usually consist of a diversion dam or weir with regulating gates to control the amount of water to the canal entrance, and of a wasteway for discharging surplus water. Control works are built along the canal line for the regulation of the amount of water admitted to the laterals (or branch canals), for the wasting through spillways of superfluous water including that received from side drainage. Falls, or drops, may be constructed to neutralize any excessive slope of the country.

The laterals are the channels which receive supply from the main canal and which in turn supply the plow furrows through the land proper.

Alignment of Canals

Having determined the source of water supply and its relation to irrigable lands, the next question is the alignment of the canal. To get the best alignment there should be made a careful contour topographical map of the center irrigable area, as well as all possible routes for the diversion of water. On this trial line locations may be laid down. The more direct the location the shorter the line, the less the cost of construction and the losses by absorption. The line should not necessarily follow grade contours, for ofttimes by the inserting of occasional drops as shown in Fig. 3, and which must be well protected from washing, a more economical location may be obtained.

It is recognized by engineers that effective drainage of low-lying lands must go hand-in-hand with irrigation if it is to be carried on most satisfactorily. For this purpose also the contour map is of good service. Faulty alignment of canals results in obstructions of the natural drainage outfalls. and the use of natural drainages as irrigation channels has often been shown to be the principal cause of evil.

Grades

A steep slope may bring the canal to the irrigable lands at too low an elevation, while too great a cross-section in the diversion line will increase the cost of construction. Care is therefore necessary in proportioning the relation of cross-section to slope in order that the most suitable velocity may be maintained and the amount of material necessary to be moved be a minimum.

In different soils different slopes are necessary to produce a

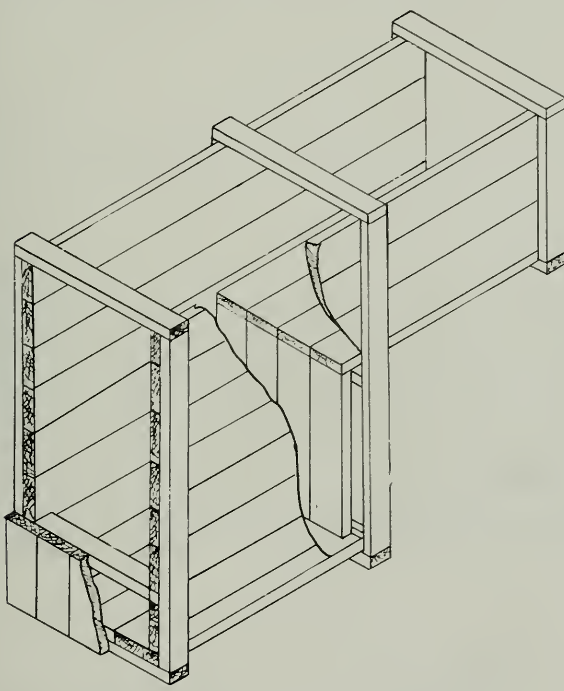

Fig. 3—Sketch of Drop, made of timber

velocity which will not cause a deposition of silt on the one han or cause bank erosion on the other.

The irrigation surveys in Saskatchewan employ the following method:

For firm gravel, rock or hardpan a velocity of from 5 to 7 feet per second.

For ordinary soil or firm loam a velocity of from 3 to 3.5 feet per second.

For light sandy loam a velocity of from 2 to 2.5 feet per second.

The grades necessary to produce these velocities depend upon the cross section. The required velocity being known, the grade may be ascertained from the Chezy & Kutter formulæ for a given discharge.

The Department have computed most useful tables by the use of the above mentioned formulæ and curves. These are used in the field. When grades and sections that are not mentioned in these tables are required they can easily be computed by plotting special curves and interpolating.

Cross-Section

The most economical sections are those with vertical sides, but these are applicable only to the firmest rock. The *best* section is of trapezoidal form.

The inner slopes of the banks may vary from 1 : 1, to as low

Fig. 4

as 4 : 1 according to the character of the soil. In ordinary firm soil a slope of 1½ : 1 is sufficient.

The cross-section of the canal may be so designed that the water may be carried wholly in excavation, wholly in embankment, or partly in either, depending primarily on the alignment of the canal and secondarily on the character of the soil.

It is clear that when half is in cut and the other in fill the amount of material moved is a minimum. But this does not necessarily give the best service. This must be carefully investigated, for if the canal is in embankment losses from leakage are liable to occur. (This can be overcome by the placing of flumes on the fill, as can be seen on several of the working schemes in Saskatchewan, and when wholly in excavation the character of the soil should be carefully studied, as a sandy soil will cause excessive seepage losses unless the canal is properly lined, for which purpose concrete is frequently used.

The headworks of the canal system consist principally of:—

(1) Diversion dam, or weir.
(2) Sluiceways.
(3) Regulators at the head of the canal for its control.
(4) Wasteways for the relief of the canal below that point.

Diversion Dam or Weir

When irrigation is affected by means of a canal drawing its supply from a stream, it is necessary to have some means of raising

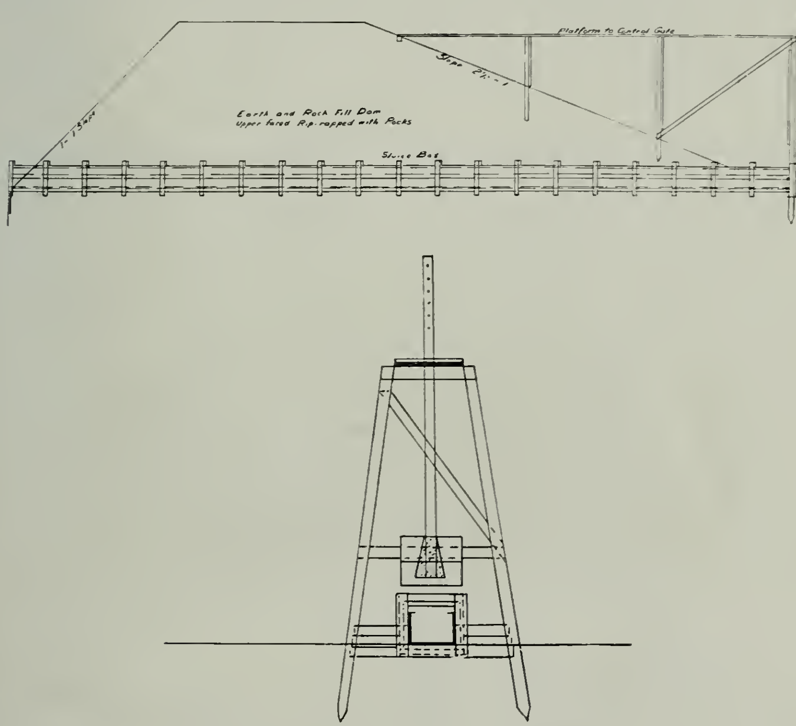

Fig. 5—Section through centre Sluice Box

the low-water level to a height sufficient to maintain the required supply in the canal. The method adopted is to build a barrier across the stream, and such barriers are of various types depending in the general way on the local conditions affecting the site selected and the materials available for construction.

It is beyond this paper to go into the theory and design of dams, but several photographs and sketches of dams and weirs in actual service in Saskatchewan are shown. The irrigation belt in that province is for the most part too far from the railroad to allow the construction of permanent structures, owing to the excessive cost, and it is therefore for this reason that the structures now in use are of timber, earth and rock which can be obtained at a reasonable price, and are near at hand.

The stream shown in Fig. 4 is one which flows only in the spring of the year and by constructing the dyke shown the irrigator

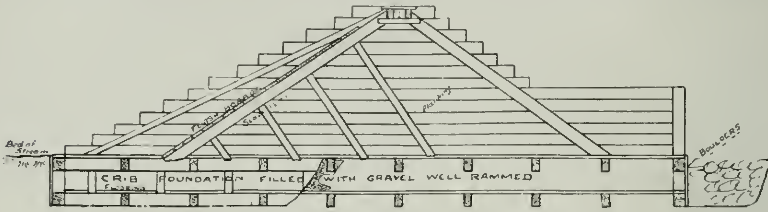

Fig. 6—Cross Section through Wasteway

can hold back considerable water, especially so in the case of where the fall in the bed is slight. The water into the ditch is controlled by means of the headgate at the end of the dyke or dam.

Fig. 5 shows a dam used to hold the water flowing down a dry coulee from spring freshets due to the melting of mountain snows

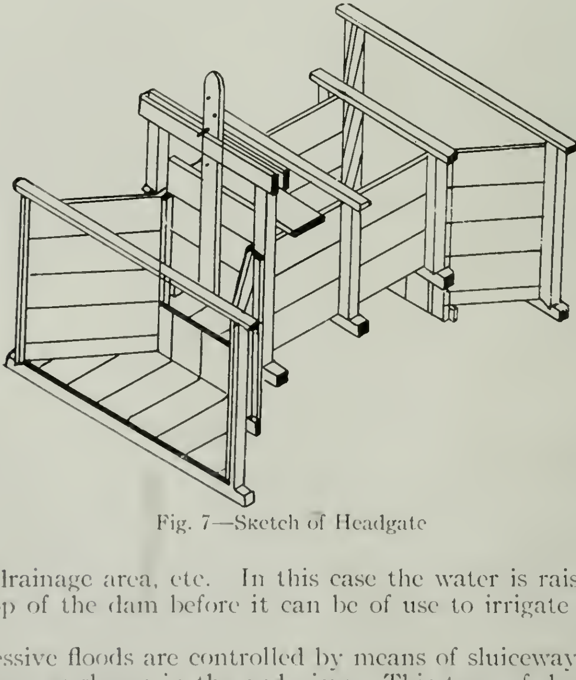

Fig. 7—Sketch of Headgate

over its drainage area, etc. In this case the water is raised nearly to the top of the dam before it can be of use to irrigate the lands desired.

Excessive floods are controlled by means of sluiceways through the bottom, as shown in the end view. This type of dam is often used where the stream valley is used as a reservoir, placing a sluice box at the point where the surplus water not required may be allowed to flow into stream bed below, and one or more at the inlets to the canal, since when damming up a valley there can be sluice-boxes on each end.

Fig. 6 shows a dam with open sluiceway as used in perennial streams. The height of the water level is controlled by flash boards which can be placed in or taken out with little difficulty. When the water is not required it is allowed to follow its course, but when required for irrigation purposes the water level can be raised to the height necessary for it to flow naturally into the canal which is usually at one side of the dam.

Sluiceways

Sluiceways are placed in the bottom of most well constructed dams. Their object is to remove by the errosive action of the water

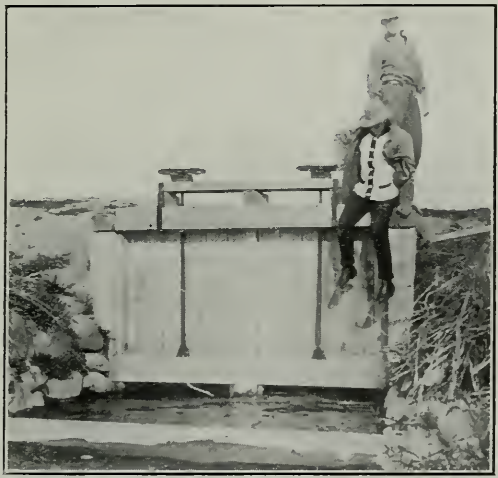

Fig. 8

any sediment which may be deposited in front of the regulator. There are two classes—the open sluiceway and the undersluice. The open sluice is practically identical with the open weir. Where the weir forms a solid barrier to the channel and is only open for a short portion of its length, the latter is spoken of as a sluiceway. Undersluices are more generally constructed where the dam is of considerable height, and are commonly applied to dams which close storage reservoirs.

Canal Regulating Gates

The regulator should be so located with relation to the dam that the water held up by the latter will pass at once into the canal. This is most successfully effected by placing the canal head immediately adjacent to the dam and building it as a part of that structure. The amount of water admitted by the regulator should be easily controllable at any stage of the stream. This can be best effected by having gates of such dimensions that they can be quickly opened or closed.

A sketch of one of the types of headgates in use on schemes in Saskatchewan is shown in Fig. 7, and also a photograph of one of

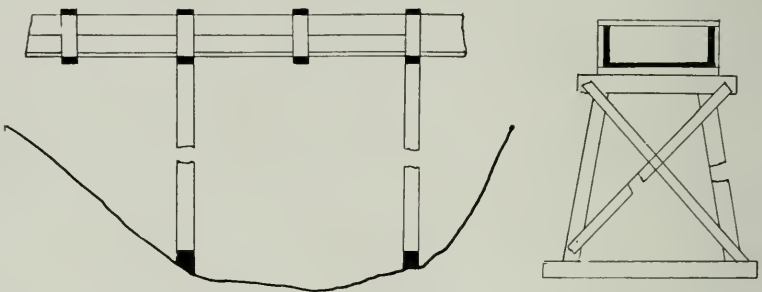

Fig. 9—Elevation and End View of Flume and Bent made of Timber, crossing a Coulee.

the best working headgates in the district mentioned is illustrated in Fig. 8.

Wasteways

The function of the wasteway is to relieve the dam and canal in times when floods are beyond its capacity, or when the water is not required. The methods used in the construction of wasteways

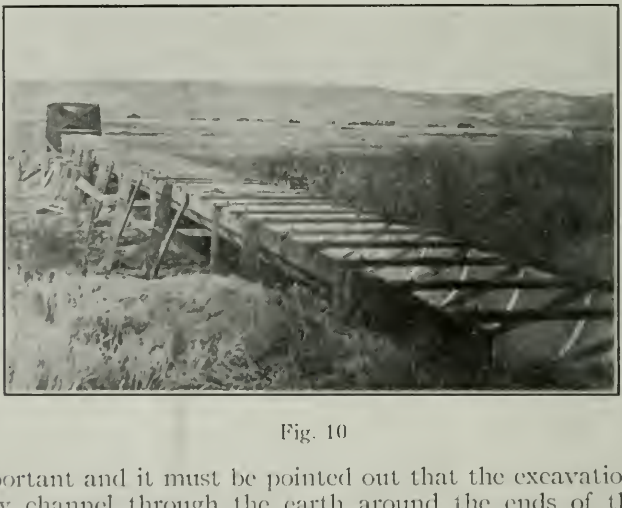

Fig. 10

are important and it must be pointed out that the excavation of an overflow channel through the earth around the ends of the dam is an unwise procedure, especially where the dam is high or the excess of flow large, unless absolute provision is made by means of sheet piling or otherwise to prevent the bottom or sides of this channel from cutting out. In the majority of cases such spillways, constructed on various works in Saskatchewan are inadequately protected, and will, sooner or later, cut out, leaving the dam completely out of the stream channel.

Frequently the site of the dam is so located that there exists a natural overflow channel which acts as a wasteway when floods reach to nearly the height of the dam.

Flumes

Flumes on bents, as shown in Fig. 9, are made use of when it saves the cost of construction of the canal system as it would in the case where it was necessary to get across a coulee.

They are also made use of when it is necessary to cross an earth fill as already described.

When the canal encounters a steep sidehill a flume will save in the cost of construction, since a more permanent wasteway is attained.

Flumes are used where the canal crosses a stream. Flumes can be either of timber or metal.

When they cross gaps they can be supported either by bents or laid on a bridge.

Fig. 10 shows a metal flume in use on a scheme in Saskatchewan where it crosses a river and is supported by a bridge.

Reservoirs

This phase of irrigation is of ever-increasing importance in districts where the stream flow is periodic, and the engineer must realize the necessity for some such system when considering the feasibility of a scheme on any source of supply of this nature. It is quite unnecessary to take up the advantages of reservoirs where the flow in the source of supply is only spring run-off, as they are self-evident, but seen in cases where the stream has a constant low water flow the irrigator who reservoirs has a decided advantage, in the fact that he has absolute control of his methods of irrigation, i. e., he can turn a larger irrigating head into his ditches and avoid heavy seepage losses found in small streams, while the land is covered more quickly.

References

References—To the student desirous of a thorough treatment of the subject of Irrigation, the writer recommends the following:—

Wilson—Irrigation.
Engineering—Refer to Index for Articles.
Hoyt and Grever—Hydrographic Manual.
Dominion Government Reports—Progress of Stream Measurements.
R. J. Burley, '04—Instructions to Irrigation Engineers.

On Nov. 7th, T. Kennard Thomson, '86, of New York, addressed the Canadian Club of Niagara Falls, Ont., on "Bridges of the Past and Future."

BITUMEN IN MODERN PAVEMENTS

By J. B. Temple, B.A.Sc.

The importance of a suitable pavement in roadway construction is quite apparent without tabulating the obvious reasons here, and one will see that the many advantages may be summed up in the following headings:

(1) Lessening of tractive power.

(2) Cleanliness and sanitation.

(3) Establishment of permanent grade.

(4) Appearance.

The reasons that follow from the above will at once suggest themselves.

With the exception of railroad construction, there is no branch of engineering on which so much time, research and money have been spent. It is estimated that the annual expenditure for pavements in cities of thirty thousand population or more, is $1.91 per capita; or varying from $2.16 in the largest cities to $1.52 in the smaller, and that the total cost of pavements in all cities of 8,000 population and over is $500,000,000.

Now, no one kind of pavement is equally well suited for all roads; local conditions, whether it be in city, town, or rural highway, will determine the pavement, and it is obvious that even different streets in the same city will require different treatment regulated by traffic, cost, and, as mentioned above, local conditions.

Engineers have long sought for some substance that would be versatile enough to meet all these conditions, and although the pavement question is not solved, yet the substance that seemed to offer itself as a "binder" (or cement) through a great range of pavements was bitumen.

Bitumen—Its Nature and Occurrence

The name is of Latin origin applied to hydro-carbons. In its widest sense it embraces the whole range of these substances, including natural gas, petroleum, and the solid forms of asphalt, albutite, gilsonite, elaterite, ozokerite and halcheterite.

The bitumens of chief commercial importance may be grouped under the three headings: (1) Natural gas, (2) Petroleum, (3) Asphalt, and it is with the latter group that we shall chiefly deal. To the roadway engineer a "bitumen" is a hydrocarbon of tarry nature and containing little or no paraffin.

Asphalt is widely distributed throughout the world and is found in a great many rocks of different geological periods. There are differences of opinion for accounting for the presence of hydro-carbons in these rocks, but it is generally conceded that asphalt itself is formed by the evaporation and oxidization of liquid petroleum which has escaped through the outcropping strata.

Asphalt occurs in workable deposits in three types. The first type embraces the beds of nearly pure separated-out bitumen. The second type embraces occurrences of asphalt bound up in limestone or sandstone. The third type, though not as distinct, deals with the occurrence of commercial quantities in petroleum and oil shale deposits and exudations therefrom.

One of the best known deposits of the first type is the "Trinidad Pitch Lake," although the more recently developed deposits of Venezuela are said to exceed this world famous "Bitumen Reservoir." Immense deposits that may yet outclass all others are reported from, Fort McMurray, Alberta Canada.

As an example of an asphalt deposit we will take the "Trinidad Lake." In area this lake covers 99.3 acres, and the depth, while sometimes placed at twenty feet, is uncertain, and may be a great deal more. The deposits are dug out to a depth of one or two feet and transported to the refinery by means of a small railway which is laid on a corduroy of palm branches.

The excavations are quickly filled in by a plastic material which oozes up from the bottom and hardens in the hole. The surface of the lake is not level, but is made up of irregular masses separated by water and subject to independent motions. The New Trinidad Asphalt Co. export annually about 150,000 tons, and although up to the present over 2,000,000 tons have been removed, there is little evidence of the reduction in the quantity. The before-mentioned "Venezuela" deposits, which occur in the State of Bermudez, are said to be the largest yet worked, covering an area over 1,000 acres. Asphalt belonging to the first type is found in very pure quality in Cuba, principally at Cardenas, Vuelta, and Pinas del Pio. The product from Vuelta ranks among the purest natural asphalt. There are also some very old deposits of this type around the Red Sea.

For the best examples of our second type of asphalt (i.e. asphalt in linestone) we must look to Europe, as the Simmer pits in Hanover, Vorwhole in Brunswick, Travers in Switzerland, Sicily, Volga district in Russia, Canton of Neuchatel, and the neighborhood of Scyssel.

The bituminous material present in this rock ranges from 7 to 20 per cent., but for roadway material the rocks containing about 10 or 11 per cent. were found the best, so the lower grades are mixed with the high grade to bring to this constituency. From the richer rock is made a sort of asphalt "mastic," which is used for footpaths, floor, roofs, etc.

The third type of asphalt embraces the exudations of the oil shale deposits, such as are found in the petroleum fields of California. They are really semi-asphaltic oils in which the more volatile hydro-carbons (of the paraffin series) and the "burning oils" have been removed, leaving a heavy "tarry" asphaltic petroleum containing a minimum of paraffin wax.

These asphalts are sometimes produced artificially, being the residuals in the process of distillation of crude asphaltic and semi-asphaltic oil. They are then called "artificial bitumens," but it is in reality a duplication of nature's process.

There is another "bitumen" used a great deal of late in place of asphaltum, and which can hardly belong to any of the foregoing types, but is closely related to the latter. It is what we commonly call "tar," and is in itself of several types, namely, coken oven tars, coal gas tars, water gas tars, combination of water gas and coal gas tars, and asphaltic materials and tars.

We will not go into the different refining processes necessary for these different types, but might state that when the first type of asphalts is taken from the 'pitch lake" they undergo a preliminary treatment to drive off most of the water and a large percentage of the vegetable matter, clay, sand, etc., that is present.

To the refined "bitumen" is added a small quantity of residuum oil of petroleum, which makes the substance more plastic, less liable to crack, and more easier to work. This mixture is called "asphaltic cement," and is the asphalt of commerce. In appearance it is almost indistinguishable from common coal tar. It is run into barrels and shipped to the various plants and corporations all over the world, and whose chief uses in roadway constructions we shall presently take up.

Tests for Bituminous Materials

One of the first things to find in a bituminous road material under analysis is the "determination of soluble bitumen." This is done by drying the powdered specimen to be analyzed by heating it to 125 degrees centigrade for one hour. A small quantity is then dissolved in carbon bi-sulphide by intermittent decantation and the residue finally caught in an asbestos filter.

The filtrate containing bitumen is evaporated, the bituminous residue burnt and the weight of the ash obtained plus that of the residue deducted from the total weight of the substance taken gives the weight of soluble bitumen present. (Note: This is the experiment in brief, the operation being somewhat more complex.)

In somewhat similar manner the portion of the whole bitumen soluble in alcohol and ether is found. Another test is to find the loss by application of heat. This consists of enclosing the material in a box and heating at a known temperature for five hours to find the volatilization that takes place.

In connection with the "penetration," the American Society for Testing Materials has drawn up a rather concise test, which it recommends in its report of 1911. It is as follows:

"The Penetration Determination"

"The penetration of bitumen shall be the distance expressed in .01 cm. that a No. 2 needle will penetrate into it vertically without friction at 25 degrees C. under a stated weight applied for stated length of time, as follows:—

"First test of duration five seconds, weight 100 grams, if penetration is less than 10; a weight of 200 grams applied for one minute, if between 10 and 300; a weight of 100 grams applied 5 seconds, if greater than 300; penetration shall be determined under a weight of 50 grams applied to 5 seconds.

"Temperatures recommended, 0 degrees C. (32 degrees F.) and 46 degrees C. (114.8 degrees F.) and 25 degrees C. (77 degrees F.)."

One of the most important tests now in use to find the melting point consists in suspending a half-inch cube by means of a hook one inch above the bottom of a beaker filled with water at a temperature of 60 degrees F. Heat is applied in such a manner that the temperature of the water is raised 9 degrees F. each minute. The temperature recorded by the thermometer at the instant the cube of bitumen touches the bottom of the beaker is considered the melting point.

Bituminous Highway Construction

Although of only recent introduction the simplest manner that bitumen is applied to our roads is in the use of the "light" oils for the purpose of laying the dust, thus preventing a nuisance, and to some extent preserving the top of the road by keeping it from blowing away. These light oils are applied cold in much the same way as water is applied to the streets. Two applications a season will keep the road dustless and in good condition and make the highway infinitely better than if the same amount of money was spent on frequent watering. This oil sprinkling is particularly applicable to macadam and gravel roads, although every year sees more oil and less water used on all kinds of surfaces. The total cost of oil-sprinkling a road several times a season is not very much more than the old system of watering, and the results are far more satisfactory and permanent. Another way of applying these oils is in an emulsion, which mixes with the water in an ordinary watercart and is sprinkled therefrom.

There is also the more important process of applying a hot tar or asphaltic oil to act not only as a dust layer, but also as a binder for the surface of the road, making it waterproof, and thus forming a bituminous carpet or roof over it. The different oils used in this work are divided in St. Louis city specifications into four grades, arranged according to specific gravity and the use to which they are put.

The grades are as follows:—

No. 1. Residuum oil, having a gravity of 10 deg. Be., is applied cold, and is used on cinder roads and for the purpose of giving life to the surface of a road that has previously been treated with a heavier product and is becoming dusty. Being merely a dust layer it should not be considered as having any binding properties.

No. 2. Residuum oil having a gravity of 20 deg. Be. is applied hot, and is recommended for park roads and for roads that are not main arteries of travel.

No. 3. Residuum oil having a gravity of 16 deg. Be. is applied hot, and is used on the main thoroughfares having a mixed traffic and acts as a temporary binder for the mineral matter.

No. 4. An oil asphalt compound having a gravity of 12 deg. Be. is applied hot, and is recommended for any type of road, since it simply forms a binder for the mineral matter which actually bears the traffic.

The simplest method of applying these asphaltic oils to a macadam or gravel road is as follows:

The road is first graded and drained, after which a layer of sandy gravel is laid and rolled; on this is spread hot asphaltic oil, using about ¾ gallon per square yard. There is then a quantity of sand or stone chips spread over the road. The work of treating a road surface is not complete for several weeks. As soon as the road is open to traffic it is necessary to give attention to the "wet" spots that appear and apply more sand or stone chips to them.

Here are a few essential points extracted from "Gravel Surfacing and Bituminous Wearing Course Specifications of Massachusetts Highway Commission." Section 10:—

"On a sub-grade prepared as hereinbefore specified, selected gravel should be placed to the depth of 5 inches at the centre, 4 inches at the sides............

"This course shall be thoroughly watered and rolled....... so that entire surface shall conform to the cross-section......... On the surface thus prepared bituminous binder shall be applied for a width of 15 feet.........It shall be heated to specified (180 deg. F.) temperature and distributed evenly by a controllable machine. A thin layer of sand shall be then spread to such a depth that after rolling no surplus binder shall appear upon the surface."

The chief points in these specifications for asphaltic oil are:

"(a) It shall not froth when heated to 100 degrees C....... Specific gravity of at least 0.97. It shall not contain more than 1 per cent. of matter insoluble in carbon bi-sulphide.

"When 20 grams are heated in a flat bottomed dish 3 inches in diameter for 24 hours in a well ventilated oven (at 250 deg. C.) the loss in weight shall not be greater than 15 per cent., etc."

Superficial Tarring and Tar Macadam

In 1903 some French engineers carried on extensive experiments in the application of asphaltic cements, oils, pitches, and of chief importance, common tars. The simplest methods employed were much the same as described by the Massachusetts Highway Commission.

In the use of "tar" the following fundamental principles were laid down by them*:—

"1st. Superficial tarring should be done only during dry and warm weather, in order to obtain efficient and economical results.

"2nd. Road must have a dry, smooth, durable surface.

"3rd. All dust must be brushed off in order to facilitate the adherence of the tar.

"4th. After the distribution of the coat of tar it is necessary, in order to avoid a slippery surface, to apply a dressing of sand, gravel or stone chips."

All sorts of tars and pitches have been used in this work, but, according to City Engineer Rust, of Victoria, B.C., distilled tar is better than common coke oven tar. There are also many excellent patent compounds on the market. Some of these are done up in a liquid form, which may be applied cold, and which contains a volatile substance that quickly evaporates, leaving the more tarry material behind, which possesses more binding properties than an ordinary liquid "cold application" oil.

The two chief methods for "tar macadam" (or gravel) construction are, firstly, applying the bitumen by "penetration," and, secondly, by previously "mixing" the stone and tar before they are laid.

One of the very successful ways of making a bituminous-bound road by the "penetration" method is described as follows: The road is prepared as for any good water-bound macadam, special attention being given to drainage. Stone to the depth of at least four inches at the crown and three inches at the sides is spread and thoroughly rolled. Over this may be spread a thin layer of sand (not always done): then hot bitumen is applied from a sprinkler or by hand (at least one gallon per square yard). Another layer of coarse stone is applied to the depth of $2\frac{1}{2}$ inches and rolled as before, and to this is applied more hot bitumen, about 2 gallons per square yard. Over this is spread from $\frac{1}{2}$ to 1 inch of stone chips (or sand) and if after roller any "wet spots" appear, more chips are added. Sometimes the whole thing is finished off by a sprinkling of a light dust-laying oil.

There are many modifications of the above treatment, but in general the method is the same. It would be good engineering practice to make the road a trifle thicker than described

* Professor A. H. Blanchard, C.E., *Canadian Engineer*, April 13, 1911, p. 566.

above, particularly in the centre where the wheel traffic occurs. A total thickness of nine inches in the centre and six inches at the sides has been recommended.

To "bituminize" an old macadam road the method is quite similar. The road is scarified, graded, and about 1 inch of new stone added, which is rolled and tarred. The rest of the operation is as above described.

In the mixing method the top course of stone is tarred before it goes into the road. In this process the stone is heated to drive off all the moisture, then the hot tar applied to it and thoroughly mixed, either by hand or machine. It is then spread (to about the depth of 2 inches) to the previously prepared macadam road. It is covered with a slight coating of chips or sand and rolled. More will be said about this when we come to "bitulithic." This method gives a better road for town purposes because it is more homogeneous, the voids are filled up, and the tar is rightly proportioned; in fact, these (mixed) roads give by far the best and most satisfactory results

A first class pitch for road work is given as follows: Coal tar, 1,100 pounds; refined tar (heavy bodied), 800 pounds; creosote oil, 100 pounds; total, 2,000 pounds.

By way of comparison it might be mentioned that the cost of tar macadam road is from 15 to 20 cents per square more than the water-bound macadam, but from what has been said the many advantages (including the lessened maintenance) are apparent.

Bitulithic

Bitulithic has many recognized advantages over the sheet asphalt for city pavements, but also has the disadvantage, that the price is somewhat high; for example, in Toronto, it costs $2.00 per square yard to lay asphalt pavement on 5 in. concrete and 1 inch binder, while 2 in. of bitulithic on the same depth of concrete and no binder costs $2.23 per square yard. However, bitulithic is an excellent pavement, and there are over one thousand miles of it in use. It has proved equally satisfactory in climates of Texas and Florida to northern climates of Manitoba and Saskatchewan.

Bitulithic is a compound of crushed stone mixed with hot bitumen in proportion necessary to fill the voids. On account of being nearly as compact as solid stone and at the same time possessing greater elasticity, it presents a surface that is very durable to destructive traffic, and being of a coarse nature it provides a good foothold and has been used with success on streets in Toronto having a steep grade.

The method of manufacture of this compound is, in brief, as follows:—

The proportions of the different sized stones that will give

* Mr. F. S. Eppele, Co. Engineer of Mercer Co., N.J., in a paper read on January 20, 1911, before American Society of Civil Engineers, at a Road Meeting in New York City

the best results are determined by laboratory test. Crushed stone is heated (250 deg. F.) and screened in a rotary screener, the different sizes of stone being deposited in different bins. The proportion of each of these found to be the best is weighed and if there are not enough fine-grained particles to make the best mixture, pulverized stone, sand or hydraulic cement up to 25 per cent. (but not over) is added. This is then mixed with hot bitumen and laid on a concrete foundation to the depth of 2 inches. It is then thoroughly rolled and, while still warm, a thin coating of "Warren's Quick-Drying Bituminous Flush Coat Compound" is applied. On this is spread a layer of stone chips which are immediately thoroughly rolled into the surface until it has become cool. On grades a mineral flush coat may be used in place of the liquid flush coat.

Sheet Asphalt

Sheet asphalt, for "surfacing" on city streets, was the first bituminous pavement to come into general use and favor, and although it has lost some of its popularity, owing to recent developments, yet there is still no pavement that is used so extensively the world over, and when laid by modern methods it is (just a question of argument) under a great many conditions equal to any pavement yet thoroughly tested. It possesses (with bitulithic) the advantages of being elastic and not too noisy, sanitary, easy to clean, light resistance to traffic, etc. It is also easy to repair.

Its chief faults appear to be slipperiness and liability to crack if not properly laid, and as it is generally constructed with a low crown (4½ inches up, in Toronto, for 24-ft. street), water is liable to stand in any depression in the surface, and this deteriorates the pavement in that spot, which crumbles and necessitates patching. Therefore every care is necessary to see that the finished road conforms as nearly as possible to the cross section plan, and that none of these depressions exist.

The water could be carried off successfully by using an extra high crown, but this is not practical in cities like Toronto, for in frosty and wet weather the pavement would be slippery. The tendency has been of late to reduce the crown. At one time crowns of over six inches on a twenty-four foot street were common. During the summer of 1911 new pavements were laid with four and a half inch crown. It might be stated that where two streets of different crowns meet it is necessary to strike a mean and shape the intersection so as to throw the water as evenly as possible in all directions, and in no case to let it run over the top of the road, but to lead it to the nearest culvert in the most expedient manner.

Sheet asphalt was first used in Paris in 1854 and in London in 1869. At that time it was made by grinding up the bituminous limestone (before mentioned) proportioning them so as to give about 10 p.c. bitumen. This was heated and spread on the road and formed a "mastic asphalt." Later, a compressed asphalt replaced this (rolled asphalt), which method with modification exists to-day. The first asphalts of America were made up of Trinidad asphalt, sand and stone dust, and these are the ones now in general use. The exact composition for asphalt pavement varying with the locality, climate, etc., mixtures that were found successful in America did not meet with satisfaction in Europe and vice versa.

It is necessary that the material have the most efficient ductility and stability to meet the requirements. Our climate conditions here in Toronto are exceedingly troublesome to contend with, for the heat of summer is often hovering around 100 deg. F. (which would mean a pavement temperature of possibly 130 deg.), and in winter we have registered below 20 deg. F. Mr. Clifford Richardson, in his book "Modern Asphalt Paving," states that the contraction of a pavement having a range of temperature extremes of 150 deg., would amount approximately to one inch in every one hundred feet; however the compressive effect of the traffic will compensate for some of this. It has also been shown that the contraction of an asphalt surface is less at high temperatures and greater at low temperatures. Some bitumens become brittle at above 32 deg. and some not until below zero, and after this brittle point is reached they will fracture before elongating if put into a ductility machine. This simply means that during the time when the contraction is putting the greatest strain upon the pavement, the asphaltic bitumen is rapidly reaching a point where it is incapable of further elongation in accommodating itself to the contraction effect of the decreasing temperatures. Where an asphaltic bitumen collapses readily on heat and hardens readily when subjected to cold, it is obvious that it will reach this condition in paving work before the asphaltic bitumen which has a long range between its melting and brittle points.

The above remarks apply more or less to all bituminous pavements, but are magnified in a sheet asphalt on account of its homogeneous nature and the amount of bitumen present, etc.

(*To be continued*)

E. D. MacFarlane, '09, is with the Houston Electric Railway Co., at Houston, Texas.

R. E. C. Chadwick, '06, has been appointed manager in charge of the Montreal office of the Foundation Company, Limited. Mr. Chadwick's connection with the firm has been of eighteen months' duration, although he was previously engaged with the Foundation Company, New York, as superintendent on the Woolworth Building. During 1909-10 he was bridge engineer for the city of Toronto.

APPLIED SCIENCE

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EDITORIAL

GRADUATE ASSOCIATIONS

With this issue the seventh volume of Applied Science begins. No more appropriate time or place could be chosen to endorse the spirit of organization among School men, more particularly as official bodies of men vitally interested in the Faculty of Applied Science and Engineering. Elsewhere in this issue appear accounts of annual reunions of three such associations, a fourth is shortly to be held in Toronto, and in all probability similar news from a fifth, in Vancouver, will soon be received.

At these reunions the graduates are familiarized with conditions as they exist at the University, and in the graduate body in general. They hear with pride and satisfaction the accomplishments of one kind and another in the School "family"; they discuss with concern the various needs which may have made themselves evident to them as engineers in the practical field. And, too, they meet, rub shoulders again, partake of, and thoroughly enjoy the School atmosphere which invades the gathering. It only requires the inauguration meeting to insure a revival of the old S.P.S spirit.

With a graduate body comprising considerably over 1,200 members, the time is ripe for a few more branches being formed. The Montreal branch has some fifty graduates in Quebec province in line. The Association in Timiskaming has a membership of over 60 School men. In Pittsburg about 30 reside. Vancouver is headquarters for over 50 men in British Columbia, while the branch in Toronto is accessible to over 350 graduates.

Branches do not exist in Ottawa, where 40 of our men are situated; in Winnipeg, where there are 40 more; in Calgary, where the 70 School men in Alberta might muster; or in Regina where the Regina Engineering Society has set a good example for 60 School men in Saskatchewan to follow. Hamilton is not too close to this city to have a branch organization of its own. It could include 45 resident members, and with those in Welland, Brantford, St. Catharines and adjacent towns could swell its membership to 80 or more. Chicago also has 20 School men who should organize and keep together. In short, a score of branches of the Alumni Association might well be formed, with comparatively little effort on the part of any individual, and with assurance of mutual assistance and closer fellowship. Applied Science can materially assist in such work of organization, and any information or list of addresses required is awaiting request.

NEWER FIELDS

It required a notice in the daily press recently to lead us to investigation of the number of our graduates and undergraduates who have turned to the automobile industry as a field of employment. The men who have to their credit a shop course in the electrical or mechanical industry, have, for some time, been readily assimilated by the manufacturing interests, and the demand at present approaches that for men of experience on structural steel work. In short, the trained mechanical or electrical engineer has of recent years a broad field in addition to that of the shop and the engineering office. It is in the ranks of the sales department. A well known automobile authority states that the most successful salesman is the one who possesses a thorough technical knowledge of the product he sells so that he is enabled to converse intelligently upon any phase of its construction. A thorough conception of the function of working parts, etc., creates confidence in the prospective buyer. The openings for electrical and mechanical engineers are yearly increasing, which bears out the statement that the possessor of technical training is rapidly proving a necessity in every department of the industries concerned.

ENGINEERING ALUMNI ASSOCIATION FUNCTIONS

Pittsburg Branch

On October 24th the University of Toronto Club of Pittsburg gathered at the Fort Pitt Hotel for its annual dinner and election of officers. Mr. B. A. Ludgate, of the class of '85, gave an interesting talk on "Railroading," and Mr. E. H. Porte, '11, gave a descriptive talk on the work of the Hydro-Electric Power Commission in Ontario.

The following officers were elected for the ensuing year:—President, J. G. R. Alison, '03; vice-president, O. E. Hill; secretary-treasurer, M. L. Miller, '03, 206 Suburban Ave., Pittsburg, Pa.

There are approximately 30 School men in and around Pittsburg, although not all were present at the meeting, the attendance from S.P.S. was very representative.

Montreal Branch

Montreal, Nov. 5th, 1912.

It's good to see the School we knew,
  The land of youth and dream,
To greet again the rule we knew
  Before we took the stream.
Though long we've missed the sight of her,
  Our hearts may not forget;
We've lost the old delight of her,
  We keep her honour yet.
—"The Best School of All"
—Henry Newbolt.

United by a bond of a similar training and a profession in common, about thirty School men resident in Montreal held their first annual dinner of the year at Cooper's Restaurant on Friday evening, Nov. 1. The special occasion of the evening was the visit of Dean Galbraith, who for the day had come back to the city of his birth to receive the fellowship and honor of the local association. Rumor has it that outside of some risky experiments with a certain office building elevator he spent the day quietly with a few of the senior men. The man "who discovered the law of gravitation," not the make of the elevator, was responsible for the excitement, if we are to believe W. D. Black, '09. The man that built the pyramid would have seemed a more plausible explanation to the "Bridge" men present, but no doubt Mr. Black has this in keeping for future occasion.

"There was no perceptible comment upon the meal itself, and it is hoped the committee may understand that they now have Host Cooper working up somewhere near the knee of his efficiency curve.

"After the toast to the king was honored, Mr. G. H. Duggan, '83, proposed the health of the guest of the evening, 'Our Dean,' and Mr. J. M. Robertson, '93, in appropriate words responded to the same with certain interpolations by 'Burnside' '99, of 'School' and football fame.

"The Dean replied briefly to the cheers of the men and the appreciative words of the speakers, along the thought of the benefits that they had received by being all trained together. The real and practical truth of his remarks appealed to all present. By a standing vote an expression of good wishes was sent to our men in the Cobalt region, and Dean Galbraith was asked to present the same to them when at their dinner the following week.

"It was also voted that a message of kind memories be sent Doctor Ellis, and that the Dean be asked to tell him that we hope to have him with us during the coming year.

"The officers elected for the ensuing year were:—Hon. president, Dean Jno. Galbraith; president, R. A. Ross, '90; vice-president, W. J. Francis, '93; advisory committee, J. M. Robertson, '93, J. M. R. Fairbairn, '93, W. J. Francis, '93, W. D. Black, '09, L. R. Wilson, '09; secretary treasurer, H. W. Fairlie, '10, 1577 Mance St., Montreal.

"The remainder of the evening was spent in short speeches with Mr. Ross assuming his newly acquired duties as president. There is every indication that this year's meetings will be even more successful than the previous one. So far they have tended to strengthen the pride of all our men in the "Best School of all."

Among those who were present to enjoy the occasion, according to the autographs on a menu received recently at this office were:— J. Galbraith; G. H. Duggan, '83; R. A. Ross, '90; J. M. R. Fairbairn, '93; Walter J. Francis, '93; J. M. Robertson, '93; J. T. M. Burnside, '99; D. C. Tennant, '99; G. W. Dickson, '00; W. H. Sutherland,'02; F. W. Burnham, '04; J. P. Watson, '04; A. L. Harkness, '06; J. H. Brace, '08; W. P. Murray, '08; A. M. Bitzer, '09; W. D. Black, '09; F. H. McKechnie, '09; L. R. Wilson, '09; H. W. Fairlie, '10; R. M. Walker, '10; F. Bowman, '11; J. C. Martin, '11; A. J. McFadyen, '11; C. A. Meadows, '11; E. H. Niebel, '11.

The Timiskaming Branch

That School ties remain intact even in the rush of the greatest silver mining camp of the age, and in the rapid advancement of sister camps and towns, has again been vindicated by the degree of success which attended the second annual dinner of this branch of the graduate body. On Friday evening, November 8th, the School men in the district assembled as in an old time rally to join in songs, yells and like cherished practices of former days, and particularly to impress their love and loyalty to the School and Dean Galbraith.

Although having been with the men in Montreal during the previous week at their similar re-union, and although due in New York city a few days later, the Dean again honored the Association with his presence. He brought with him an expression of good wishes and remembrance from the men who were present at the Montreal dinner.

The assembly in Haileybury included besides graduates of the School, a number of those—and genuine School men they are—whose profession could not forego their services sufficiently long to allow them to graduate, and likewise a few who purpose experiencing the graduating ceremony at a little later date. The development of the Timiskaming District is well fertilized with the technical knowledge acquired at the School. A study of the positions which they occupy shows how indispensable its graduates are to the country's business. Busy men they are, and full of admiration for the progress of the north country, but from Cochrane, Elk Lake, Porcupine, Gowganda, Cobalt and New Liskeard, they gathered into Haileybury where the Hotel Matabanick had its spacious dining room decorated like an undergraduate's den. The table was arranged in the form of a huge **T** decorated with flowers and bunting representative of the Faculty colors. The menus were also of yellow, blue and white.

The president of the Association, Mr. E. V. Neelands, with the Dean, R. H. James, and Fraser Reid on his right, and Professor Haultain, R. W. Brigstocke and S. B. Clement on the left, formed the crest of the **T**, while a double flank of School men lined up to complete the emblematic letter.

After a ceremonious toast to the King, a toast to Timiskaming was proposed by H. T. Routly, '06, who dealt briefly with the glowing agricultural and mining wealth which the district presents for the livelihood and enjoyment of the keen and ardent type of man, so marked everywhere as a companion to growth and development. The toast was ably responded to by Ben Hughes. His remarks pointed out the necessity in the management of mining interests as in any other modern business enterprise, of the conscientious and common-sensed man. The impetus of professional knowledge is oft times lessened in value if tact and judgment do not prevail. The lot of the mine manager is often a baneful one if those higher up are not equipped with a composite knowledge of the ins and outs of daily operations. High tribute was paid by Mr. Hughes to the wealth and growth of the north land, and his remarks are borne out by facts and figures. The estimated production of the Cobalt silver mines for the present year is $17,900,000, totalling $87,000,000 worth of silver during the last eight years. The camp is entering upon its ninth year in a better condition than ever before. Many of the closed down mines have been re-opened, and numerous old properties are returning to the limelight. In Porcupine the estimated production for the year is $2,000,000. worth of gold. Mills are in the process of construction, that will double the present milling capacity of the camp.

"The Faculty of Applied Science and Engineering" was toasted by Mr. B. Neilly, '07, who referred to the Faculty and its alumni as a wheel, strong and forward-moving, the Dean as the hub, the heads of the departments as felloes, and the undergraduate body as the rim. Around it all, and very essential, though farthest from the centre of the mechanism, and its strength bespeaking the value of the entire principle of motion are the alumni themselves.

Professor Haultain in replying referred to the marked efficiency of the principle on which the Dean has based his methods since the foundation of the institution. He showed the superiority of them over other and less tenable methods, in a manner as assuring as it was new to the members of the Association. His remarks were most eagerly applauded and as a view from a different pedestal created unusual interest.

Mr. H. Irwin, '09, who was present as representative of the Engineering Society and of the Toronto Branch of the Engineering Alumni Association, dealt briefly with the work of these organizations in Toronto, and with the necessity of the undergraduate and graduate bodies of the Faculty co-operating to furnish the strongest bond between them and the School.

Mr. R. H. James proposed the toast to the Engineering Profession. Although brief in his remarks, he struck a bold keynote in favor of commercial instruction in the Engineering course. He understood that the courses in the Faculty of Applied Science now included considerable instruction of this nature, and he complimented the Dean upon such timely revision. In response, Mr. H. W. Sutcliffe, on behalf of the civil engineers and Mr. H. T. Cawley representing those engaged in mining, alluded to the rapid development during the past several years of that portion of Ontario, the former commenting also upon the suitability of climatic conditions to the agricultural industry.

Then, for contrary to the toast list that to "Our Guest" had purposely been postponed, Mr. Alex. Smith, in a reminiscent mood, reviewed several instances during his School career, typical of those of every student, and dealing with occasions of personal contact with the Dean. He brought out most skilfully the dominant features of the undergraduate's impression of the man, gained by the same occasional associations with him. The Dean, upon rising to reply was given a reception characteristic of the esteem in which he is held in the hearts of Timiskaming School men. His remarks dealt lightly with academic affairs. He referred, however, to the excellent work accomplished by Major R. W. Leonard, the honorary president of the Timiskaming Branch of the Association, as a member of the Board of Governors of the University. His remarks were for the most part in praise of the great advance Northern Ontario was making.

"Sister Institutions" was proposed by Mr. H. G. Kennedy, who believed that an association combining engineering graduates of all universities would be very advantageous to the profession in Canada. Mr. S. B. Clement, representing McGill University, in reply, commended the suggestion, and complimented Mr. Neilly upon his apt reference to the Faculty as a great wheel, with the Dean at its center. He furthered the exemplification by observing that the progress of engineering among other professions in Canada would be greatly enhanced by the united endeavours of the three or four similarly existing wheels.

Mr. Fraser Reid, replying for Queen's, dwelt upon his association years ago with Professor Haultain while the latter was engaged directly in mining, and observed this companionship as having been one of the most profitable he had ever experienced. Mr. R. W. Brigstocke responded for R.M.C. and Mr. Weede later replied for his own College, the Colorado School of Mines.

A toast to the ladies was likewise observed and responded to, the information transpiring of the advent into the prospecting field of a number of ladies in the farther north.

The success of the dinner firmly assures its annual recurrence. Much credit is due to the executive, and to the Dinner Committee consisting of Messrs. Routly, Cawley, and Campbell.

School men of Timiskaming present were:—President E. V. Neelands, manager Hargraves Mine, Cobalt; Secretary-treasurer H. W. Sutcliffe, of Sutcliffe and Neelands, surveyors and engineers, New Liskeard; B. Neilly, manager, Penn-Canadian Mines, Cobalt; S. Thorne, manager, Silver Bar Mine, Cobalt; A. D. Campbell, engineer, O'Brien Mines, Cobalt; H. T. Routly, of Routly & Summers, surveyors and civil engineers, Haileybury; G. F. Summers, of Routly & Summers, Haileybury; A. D. McDonald, engineer, Penn-Canadian Mines, Cobalt; H. G. Kennedy, engineer, Cobalt Lake Mines, Cobalt; C. G. Titus, engineer, Timiskaming Mines, Cobalt; J. H. C. Waite, engineer, Drummond Mines, Cobalt; Jno. A. Brown, engineer, Routly & Summers, Porcupine; H. E. Cawley, mining engineer, Cobalt; E. W. Neelands, of Sutcliffe & Neelands, New Liskeard; Geo. Johnston, mining engineer, Elk Lake; H. M. Carroll, engineer, Routly & Summers, Haileybury; L. J. Duthie, engineer, McEnhaney Mines, Porcupine; Alex. Smith, of Carter & Smith, mining engineers, Porcupine; W. R. Nickle, Transcontinental Ry., Cochrane; G. Pilly, Transcontinental Ry., Cochrane; P. Maher, Timiskaming and Northern Ontario, Haileybury; A. D. Wylde, engineer, Haileybury; Frank Perry, mining engineer, Haileybury.

The guest list included: Dean Galbraith, Prof. H. E. T. Haultain; Mr. S. B. Clement, superintendent of maintenance, T. & N. O. Ry. (representing McGill University); Mr. Fraser Reid, mill superintendent, Coniagas Mines (representing Queen's University); Mr. R. W. Brigstocke, manager Drummond Mines (representing Royal Military College); Mr. Weede, engineer Townsite Mine (representing Colorado School of Mines); Mr. H. Irwin, Toronto (representing Toronto School men); Mr. R. H. James, manager O'Brien Mines, Cobalt; Mr. R. Taylor, manager Right-of-Way Mine; Mr. Gordon Kennedy, Northern Concentrators, Cobalt; Mr. R. F. Kellock, Cobalt; Mr. Ben Hughes, Toronto "Globe;" Mr. Carl Green, Cobalt "Daily Nugget."

THE INDUSTRIAL CHEMICAL CLUB

The first monthly dinner for the year was held recently after an instructive trip through the plant of a large local soap-making industry. An important part of the dinner was a live discussion on the subject of "The Future of Chemists in Canada and the United States," opened by Mr. D. J. Huether, '08. After touching upon the various industries in which the chemist is successfully employed, and the many different branches of industry which are persistently demanding his attention, Mr. Huether, as an exemplification of increased efficiency in manufacturing processes under the chemist's supervision, cited numerous cases where a saving of hundreds of dollars per day was attributable to a change of operative methods recommended by the chemical engineer.

WHAT OUR GRADUATES ARE DOING

L. C. Mitchell, '11, has recently accepted a position as chemist with the German-American Sugar Co., of Bay City, Mich. He was previously with the Guantanamo Sugar Co. in Cuba.

N. H. Manning, '09, is Toronto manager of the Canadian Inspection Co.

W. R. Worthington, '04, is assistant engineer in charge of sewers for the city of Toronto, succeeding J. D. Shields, '94, who has just resigned. Mr. Shields is severing his connection with the staff of the city engineer to engage in private practice.

Among the recent changes in the staff of the Faculty of Applied Science and Engineering may be noted the following:

Mr. R. W. Moffatt, '05, formerly of the Department of Drawing, has resigned and has accepted a position as lecturer in civil engineering at the University of Manitoba.

Mr. L. B. Taylor, lecturer in mechanical engineering, has also resigned and has been succeeded by Mr. M. B. Jackson, a graduate of McGill University.

Mr. W. C. Blackwood, '06, of the department of physics, has been engaged permanently on the teaching staff of the Technical High School. Mr. Alan Fraser, '10, of the same department last year, is a division engineer for the Canadian Northern Railway. Mr. G. L. Wallace, '11 succeeds Mr. Blackwood as demonstrator.

W. R. Key, '09, last year in the department of applied mechanics has A. Young, '11 as his successor. Mr. Key is with Routly & Summers, roadway engineers.

A. G. Code, '10, R. V. Macauley, '11, and R. Taylor, '11, are new members of the staff in the electrical engineering department J. H. Parkin, '11, is in the mechanical engineering department. In drawing and architecture the following are among the sessional appointments: F. E. Watson, '11, G. K. Williams, '10, W. J. T. Wright, '11, and G. R. Workman, '09. In surveying the new instructors are: J. A. Macdonald, '10, L. A. Badgley, '11, and W. J. Baird, '10. M. Pequegnot, '08, and H. Hyatt, '11, are in charge of the practical work in the structural engineering course mentioned editorially last issue. In the department of chemistry D. J. Huether, '08, A. R. Bonham, '11, and R. A. Cunningham, a graduate of Edinburgh University, are new staff members.

DIRECTORY OF THE ALUMNI

Giving each month, in alphabetical order, the location of a number of the graduates. The entire list will be reviewed in the twelve issues beginning November 1912.

The graduates will confer a favor by advising us of any and all instances where the list is not up-to-date. Addresses unknown, or no longer correct, are hard to eliminate entirely from our records. If graduates will see that the information given about *themselves* is exactly as it should be, and that that concerning their class mates is also correct to the best of their knowledge, the department will soon be most reliable.

A

Acres, H. G., '03, is associated with the Hydro Electric Power Commission, Toronto, as assistant engineer.

Adams, J. H., '10, is in Summerland, B.C., in the employ of the Kettle Valley Railway as surveyor.

Adams, O. F., '10, is taking his fourth year in the Faculty of Applied Science and Engineering, University of Toronto.

Aitken, J., '11, is assistant chemist for the Canada Cement Company in its manufacturing plant at Kilbourn Siding, Que.

Akers, H. G., '08, is a member of the firm of Akers, Mason & Bonnington, chemical engineers, Toronto.

Alexander, J. H., '04, is engaged in engineering and contracting in Winnipeg.

Alison, T. H., '92, is with the Bergen Point Iron Works, Bayonne, N.J., as chief engineer and secretary of the firm.

Alison, J. G. R., '03, is in the employ of the Riter-Conley Manufacturing Co. of Pittsburgh, Pa.

Allan, J. R., '92, is in Renfrew, Ont., carrying on a general engineering and surveying practice.

Allan, J. L., '00, is in Dartmouth, N.S., on Government service, as office engineer on the construction of a branch line from Dartmouth to Dean, N.S.

Allan, L. B., '11, until recently with the Roadways Dept., City Hall, has accepted a position in journalistic work.

Allen, F. G., '07, was assistant to chief engineer B. F. Sturtevant Co., Hyde Park, Mass., until recently. We do not know his present address.

Allison, C. B., '08. His present address is unknown to us.

Alport, F., '08, until recently resident engineer at Redditt, for the Transcontinental Railway, is taking a post graduate course this year in the Faculty of Applied Science.

Amos, W. L., '06, is with the Toronto Electric Light Co. in their engineering department, as their chief draughtsman.

Amsden, W. G., '10, is at Neepawa, Man., superintending the waterworks and sewerage development for Chipman & Power.

Anderson, A. G., '92, is a hardware merchant at Port Dover, Ont.

Anderson, F. J., '07, is at Niagara Falls, Ont., with Anderson & Barry, engineers and surveyors.

Anderson, R. M., '08, is a member of the firm of Speight & Van Nostrand, engineers and surveyors, Toronto.

Andrews, E., '97, is resident engineer for the Maenofferen Slate Quarry Co., of Portmadoc, North Wales.

Angus, H. H., '03, has received an appointment to the staff of the Canadian Domestic Engineering Co., Toronto.

Angus, R. W., '94, is professor of mechanical engineering, University of Toronto.

Apsey, J. F., '88, is assistant division engineer to the Baltimore Sewerage Commission.

Archer, E. G., '11, is in the employ of the Canadian Westinghouse Co., Hamilton, Ont.

Ardagh, A. G., '93, has a private practice in Barrie, Ont., land surveying and engineering.

Ardagh, E. G. R., '00, is lecturer in chemistry, University of Toronto.

Arens, A. H., '06, is resident engineer and mine surveyor for the Inverness (N.S.) Railway & Coal Co.

Arens, E. G., '09, is in Hamilton, Ont., with the Canadian Westinghouse Co., engineering department.

Arens, H. W., '03, deceased.

Arens, J. R., '08, is with the Dunlop Rubber Co., Toronto, as chemist.

Armer, J. C., '06, is manager of the *Canadian Manufacturer* Publishing Co., and secretary-treasurer of the Commercial Press, Limited, Toronto. He is president of the Engineering Alumni Association, Toronto Branch.

Armour, R. H., '05, is in New York City with the Westinghouse Electric and Manufacturing Co.

Armstrong, H. V., '09, is at Estevan, Sask., superintending the installation of a water power plant for Chipman & Power, Toronto.

Armstrong, J., '95, is district engineer for the Grand Trunk Pacific, at Quebec.

Ashbridge, W. T., '88, is at Kelowna, B.C., where he has designed and superintended the construction of waterworks and electric light plant.

Augustine, A. P., '07, is in Vancouver, B.C., and is engaged in land surveying.

Austin, E. T., '09, is in the employ of the Mond Nickel Co. at Coniston, Ont., as assistant engineer.

Aylesworth, C. B., '05, previously in the Canadian Westinghouse Co.'s drafting room, has no address with us at present.

B

Badgley, L. A., '11, recently on hydrographic survey work, with the department of the Interior, is a demonstrator in surveying, University of Toronto.

Bain, J. A., '00, is in Ottawa, as structural engineer, Department of Public Works.

Bain, J. W., '96, is associate professor of applied chemistry, University of Toronto.

Baird, J. A., '10, is in practice with his father in surveying and general engineering, Leamington, Ont.

Baird, W. J., '10, recently with R. R. Grant, O.L.S., is a demonstrator in surveying, University of Toronto.

Baker, M. H., '06, is city engineer for St. Thomas, Ont.

Baldwin, F. W., '06, is engaged with Graham Bell, Esq., Hammondsport, N.Y., and Baddeck, N.S., in experimentation and manufacture of aeroplanes.

Ball, E. F., '88, is chief assistant engineer of resurveys, N.Y.C. & H.R. R.R. Co., New York City.

Ballantyne, H. F., '93, is in New York, where he has for some years been carrying on an architectural practice.

Banting, E. W., '06, is a demonstrator in surveying, University of Toronto.

Barber, Frank, '06, is engineer for York county, and is carrying on a consulting practice in bridge and concrete engineering.

Barber, H. C., '08, is assistant engineer of the Hamilton (Ont.) Hydro-Electric Department.

Barber, H. G., '02, is with the Department of the Interior, Topographical Surveys Branch, Ottawa.

Barber, T., '99, is hydraulic engineer for Chas. Barber & Sons, manufacturers of turbine water wheels and accessories, Meaford, Ont.

Barber, W., '05, is with the city of Toronto, in the roadways department.

Barker, H. F., '94, is in the city. He is a member of the firm of Godson Paving Co.

Barley, J. H., '00, is in the engineering department Canadian Westinghouse Co., Hamilton, Ont.

Barnett, H. A., '10, is with the Canada Pacific Railway Co. construction department, Toronto.

Barrett, J. H., '04, is with the Wm. Davies Co., Limited, Toronto, as superintendent.

Barrett, R. H., '01, deceased.

Barry, W. H., '09, is a member of the firm Anderson & Barry, engineers and surveyors, Niagara Falls, Ont.

Bartlett, E., '08, is engaged in private practice as engineer and surveyor, in Medicine Hat, Alta.

Bartley, T. H., '11, is in Mutana, Sask., engaged on Government resurvey work, under R. C. Purser, '06.

Bates, M., '06, deceased.

Batten, H. L., '11, is engineer for the Inspiration Copper Co., Miami, Arizona.

Beatty, H. J., '91, resides in Eganville, Ont., as an engineer and surveyor.

Beatty, J. A., '03, is a member of the firm of Morrow & Beatty, contractors, Peterboro, Ont.

Beauregard, A. T., '94, until recently laboratory engineer, Public Service Corporation, New Jersey, is now residing in Gravenhurst, Ont.

Beckstedt, R. D. S., '09, is in the employ of the Cataract Power Co., Hamilton, Ont., in their testing Dept.

Bedford, F. J., '08, is at Lakefield, Ont. We do not know his professional engagement.

Begg, W. A., '05, is townsite inspector for the Department of Public Works at Regina.

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CLAYS AND CLAY INDUSTRIES OF CANADA*

By J. Keele, '93

The demand for structural materials in all parts of Canada which are already developed, or in process of development, exceeds very largely the home production. Clay products, as a matter of course, have been the materials most urgently required, and large quantities are imported yearly from the United States and Great Britain.

The need for building material is greatest in the prairie provinces, where wood and stone suitable for this purpose are of rare occurrence. These provinces are now looking to the possibility of utilizing their clay and shale resources. Several manufacturers from Eastern Canada and the United States are either erecting clay working plants or prospecting for suitable deposits in those regions.

The clay manufacturers in many parts of the Eastern Provinces are branching into new and better methods of production, and making a greater range and higher class of wares than formerly. At this stage of the development of the country the raw materials most sought for by the clay worker are those which make up into structural wares, such as building, paving and fire bricks, sewer pipe, electrical conduits, fireproofing, and field drain tile.

During the last four years the Geological Survey branch of the Department of Mines have carried on special investigations on the clay and shale resources of Canada. As it was important to get this information before the public as quickly as possible, the examinations were confined principally to deposits, situated on or near existing lines of transportation. Later on it was proposed to extend the investigations to those outlying districts which are reasonably sure to be provided with transportation in the future, which will bring any deposits found there into economic importance. A very brief review of our knowledge to date will be given here, and only with reference to the manufacture of the materials above mentioned.

Building Bricks

Surface clays suitable for the manufacture of common brick occur in all the provinces. Many of the larger valleys in Eastern

* Read before the Engineering Society, Dec. 11, 1912.

Canada are floored with extensive sheets of clay, the most notable being the great plain of the St. Lawrence in the province of Quebec, where clay is found up to 100 feet in thickness. Clay beds of smaller extent are also found at the higher levels up to 700 feet above the sea, where they occur chiefly as terraces, bordering streams. A very extensive sheet of clay, altogether detached from the southerly areas, is found along the line of the National Transcontinental Railway in Northern Ontario and Quebec.

Surface clays occur rather widespread in the provinces of Manitoba, Saskatchewan, and Alberta, especially in the Red River and Saskatchewan valleys.

There are large deposits of surface clays suitable for brick making

Fig. 1.—Chief Centre of the Common Brick Industry in the Province of Quebec, St. Jean Deschaillons, on St. Lawrence River

in British Columbia, particularly those of the Thompson River and Okanagan valleys in the interior, and of the Fraser River valley and the vicinity of Victoria on the Pacific coast. The surface clays are of recent origin, geologically. They are not consolidated and may be used directly as they are dug from the bank for brickmaking. They may come so close to the surface as to form the soil where crops are grown, or they may be covered with so much gravel or sand or swamps as to be inaccessible to the clay worker.

They have been laid down either in estuaries, like the marine clays of the St. Lawrence or Fraser River valleys, or in large bodies of water ponded between ice fronts and land margins, like those of the clay belt in Northern Ontario and Quebec and the Manitoba clays, or in lakes entirely surrounded by land, or along the margins of rivers. They vary in structure from stratified thinly bedded clays, showing definite seasonal accretions, to massive or vertically jointed clays without any horizontal structure, seeming as if sedimentation were unceasing while the deposit was being laid down. The color of the raw clay is most generally bluish grey, but larger areas are of a red brown or dirty yellow. Their plasticity is usually good. With the exception of a portion of the Ontario clays which are buff burning, the eastern clays burn to a red color. The Manitoba clays are mostly buff burning, while the majority of the clays further west are red burning. The clays that burn buff contain a high percentage of lime. The surface clays in general have low fusing points. They will not stand overfiring, so that they are not adapted to the manufacture of vitrified wares.

Their principal use is for common brick made by the soft mud process. Some of these clays, however, can be made into bricks

Fig. 2.—A portion of the plant of the National Brick Company at Laprairie, Quebec

by the stiff mud or wire cut process, and into field drain tile. They are also used occasionally for making terra cotta lumber, or porous hollow blocks, by the addition of sawdust to the raw clay.

The surface clays are mostly unsuited to the manufacture of facing brick made by the dry pressed process, as they either give a brick with a soft porous body, or the shrinkage is so uneven after firing, that the bricks are too variable in size in the kiln.

Shales are clay sediments, deposited in still water bodies, frequently forming beds of great extent and thickness which have become hardened by heat and pressure. Most shales when finely ground and mixed with water have good plasticity, so that they can be moulded into any desired shape. Shales of value for making clay products are found in all the older geological systems, even as low down in the scale as the Ordovician.

Slates are clay sediments in which the hardening processes have proceeded to such a degree as to destroy all plasticity. Such material is usually of little value to the clay industry.

Shales vitrify at low temperatures to dense bodies and usually make an exceedingly tough, strong product. They are of the greatest importance to the clayworker, and materially assist in the industrial development and wealth of the regions in which they occur.

Most of the numerous beds of shale in the Carboniferous system of Nova Scotia and New Brunswick are admirably adapted for the manufacture of a large range of clay products. In Quebec and Ontario the Medina shale of Silurian age and the Utica-Lorraine and Medina shales of Ordovician age are employed for brickmaking both by the dry pressed and wet moulded processes.

The Cretaceous and Tertiary shales and clays of the prairie provinces are worked to a limited extent already, with prospects of their being much more widely utilized. Many of these shales, however, which underly the western provinces, cannot be worked by wet moulded processes as they crack badly while air drying.

Beds of shale which may be utilized for brickmaking occur scattered through the mountain regions in British Columbia, these being generally of Cretaceous age. A thick series of shales of Tertiary age occurs at Sumas mountain, south of Mission Junction in the Pacific coast region. The latter excel all other shales so far found in Canada in their usefulness to the clay worker.

Paving Blocks

The paving brick shales are much more restricted in their distribution than the common and dry pressed brick shales. A shale suitable for this purpose must have slow vitrifying properties, and be able to withstand a fairly high fire without softening. The finished product must be tough, so as to resist impact without breakage, and have a low absorption in order to withstand the disintegrating effects of freezing and thawing. The coal measures in Nova Scotia and New Brunswick contain certain beds which are suitable for this purpose. The red Medina shales in Quebec and Ontario may by cautious burning be made into pavers, but the range between their vitrification point and softening temperature is too small to give the best results. In the province of Alberta, some of the Cretaceous shales have been found near Calgary, Lundbreck and at Entwistle, west of Edmonton, which are suitable for pavers. The best slow vitrifying shales which will make tough paving blocks, so far found, are those of Sumas mountain.

Fire Bricks

Those clays which will stand in firing to the softening point of cone 27 (1670°C) are classed as fire clays, and bricks made from them are used in various industries where a high degree of refractoriness is called for. Fire clays occur in the Musquodoboit valley and at Shubenacadie on the Intercolonial railway line in Nova Scotia. A shale bed over a coal seam at Inverness in Nova Scotia and another under the coal at Flower cove, New Brunswick, so nearly fulfil the requirements that they may be provisionally classed as fire clays. Between the New Brunswick locality and the Dirt Hills region south of Moosejaw in Saskatchewan, we have not found anything approaching a fire clay, except in one instance where Kaolin or China clay occurs in Archaen rocks at St. Remi, about forty miles north of Montreal.

The fireclay beds in the Dirt Hills in southern Saskatchewan are of good workable thickness and fairly widespread. They are light grey, to white, highly plastic, and the most refractory clays at

Fig. 3.—Beds of white fireclay in the Dirt Hills, south of Moosejaw, Sask.

present known in Canada. They occur interbedded with impure shales, soft sandstones and lignites of Tertiary age.

The remarkable series of Tertiary shales at Sumas mountain contains one bed of fire clay, and another that approaches it very closely in refractoriness.

A residual clay from schistose rocks, which is a fire clay, is obtained at Kuyoguot, on the west shore of Vancouver Island.

With the exception of some beds of Kaolin on the Missinabi River in Northern Ontario, which are probably refractory, these are all the fire clay localities at present known in Canada.

Sewer Pipe

Clays or shales suitable for the manufacture of sewer pipe should be able to stand a fairly high temperature, at least cone 5 1230°C.)

without softening. They should burn to a hard impervious body, and take a good salt glaze. The localities already given for paving blocks apply also to sewer pipe as the requirements for both these wares are somewhat similar. A sewer pipe body may also be made up by using a smaller proportion of refractory shale or clay mixed with a more fusible one. The refractory clay acting as a skeleton, or support to the fusible part, the latter serving to give denseness to the body.

Electrical Conduits

These are hollow wares burned to a hard body, with smooth exterior surfaces to which a salt glaze is applied. They must be absolutely impermeable to water, and structurally sound, so as to withstand pressure when buried underground. They are generally

Fig. 4.—Pressed brick plant of Calgary Brick Co., Brickburn, Alta.

made from a dense burning clay or shale or from stoneware and shale mixed, or a mixture of fire clay and impure clays.

The Carboniferous shales of Nova Scotia and New Brunswick will supply the raw materials for these wares for the eastern market. The Cretaceous shales in Manitoba, the Dirt Hills clays in Saskatchewan certain shales in Alberta, and the Sumas mountain shales in British Columbia will furnish the Western raw materials.

Fireproofing

This class of hollow clay ware is coming into wide use, not only for casing in steel structures, and for floors and partitions, but also for walls of buildings, where the blocks alone are used.

Hollow blocks would seem to be the ideal building material for those provinces where wood and stone are so scarce. Buildings made of them, by reason of the air spaces in the walls, are warm in winter and cool in summer.

Fireproofing should be made from shale which has good plasticity, and capable of standing more fire than ordinary surface clay, as they must be burned hard without deforming, and have a fairly high compressive strength. Most of the Carboniferous shales of Nova Scotia and New Brunswick, the Medina shales of Quebec and Ontario, many of the Tertiary and Cretaceous shales and clays of the Western provinces are suitable for this purpose.

Clay-working Industry

The surface clays are worked in all the provinces to supply local demands for common bricks. So widespread are these clays, that bricks made from them are only rarely transported for long distances from the place of manufacture. The smaller plants are simple in operation, there being only one brick machine, and the green bricks are dried on the ground, or in open racks. There are

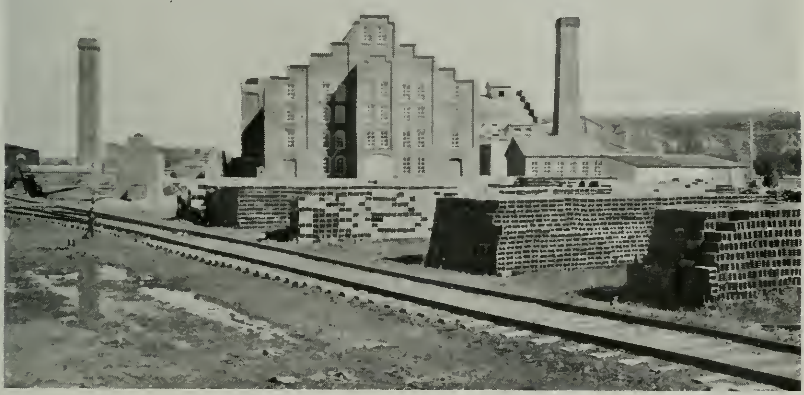

Fig. 5.—Works of the Alberta Clay Products Company, at Medicine Hat, Alta.

no permanent kiln buildings, the clamp or scove kiln being generally set up for each burning. These plants operate about six months in the year, the output varying from 500,000 to 3,000,000 bricks for this period.

Plants with a large output can only be operated successfully when located conveniently to a large market. Most of the common brick plants producing 8,000,000 to 22,000,000 brick per year are situated in close proximity to the larger cities. They are equipped with several brick machines, artificial driers, and permanent down draft or continuous kilns.

Plants producing dry pressed and plastic bricks made from shales, involve a much larger expenditure of capital than those operating on surface clays. Shale bricks plants must be equipped with grinding machinery, stiff mud or dry press machines, artificial dryers, and permanent kilns. The power necessary to drive a shale brick plant is a costly item of installation and maintenance.

A notable group of recently erected shale brick plants are those located at Laprairie and Delson Junction on the south side of the St. Lawrence River, fourteen to eighteen miles from Montreal. There are three plants of the National Brick Company and one of the St. Lawrence Brick and Terra Cotta Company. They produce stiff mud, tapestry, dry pressed and enamelled bricks from the red burning shale of the Utica-Lorraine formations. The output of the combined plants is about 700,000 bricks per day, and operations continue for about ten months in the year.

There are several shale brick plants in the vicinity of Toronto, the Don Valley Works being the oldest and largest. This plant

Fig. 6.—Clay bank of the Alberta Clay Products Co., at Coleridge, Alta.

produces stiff mud bricks from surface clay and dry pressed bricks rom the Hudson River shales, the total output exceeds 25,000,000 during the season.

There are two brick plants in Manitoba using shale, one at Leary where a red dry pressed brick is made from Niobrara shale and another at LaRiviere, where the Pierre shale is used. These shales belong to the upper part of the Cretaceous system.

The Estevan Brick Company make red dry pressed bricks from soft shale underlying a seam of lignite. This is the only plant at present of this kind in Saskatchewan.

There are six shale brick plants in operation in the province of Alberta. These are located at Medicine Hat, Red Cliff, Brickburn near Calgary, Sandstone, Blairmore, and Edmonton. They all make red bricks only, except at Red Cliff, where a limited number of buff bricks are produced from a special seam of clay shale. The

Medicine Hat and Red Cliff plants burn with natural gas, the others all use either bituminous coal or lignite for fuel.

The only shale brick works operating at present in British Columbia is situated at Clayburn, close to the Sumas mountain. A fine rich buff colored facing brick, as well as red brick are produced here.

The plants at present under construction which will place bricks on the market for the season of 1913, are located as follows:—At Montmorency Falls, about six miles from the city of Quebec, to use the Lorraine shale. At Russell, Cooksville and Meaford in Ontario. Two new shale brick plants are being operated on the islands in the vicinity of Victoria, B.C., and shale brick plants are being erected at Calgary and Edmonton in the province of Alberta.

Paving Brick

These are at present produced at only two points in Canada. One plant located at West Toronto and using Lorraine shale, which

Fig. 7.—Unworked deposits of Cretaceous shales at Entwhistle, Alta., near line of the Grand Trunk Pacific Railway

is mixed with a small proportion of surface clay, and one at Clayburn, using Tertiary shale of Sumas mountain. A plant is being erected at Calgary, which will make this class of wares.

Fire Brick

These are made at only one point in Canada, at Clayburn, B.C. A semi-refractory brick is made at Westville, Nova Scotia, from a bed of Carboniferous shale underlying a coal seam. They are used at the steel works in Sydney, being found satisfactory as a lining for ladles into which the molten steel is poured from reverberatory furnaces.

Fire bricks and special shapes of refractory goods are made at the Standard Drain Pipe Company's works at St. Johns, Quebec, and at the works of the Montreal Fire Clay Company, but their clay is brought from the state of New Jersey in barges.

A brick plant is being erected at a point in the Dirt Hills, Sask., about twenty-five miles south of Moosejaw, where it is proposed to manufacture fire brick.

Sewer Pipe

The plants producing sewer pipe in Canada are located at New Glasgow, Nova Scotia, St. Johns, Quebec. Toronto and Hamilton in Ontario, and at Victoria, British Columbia. A mixture of Carboniferous shale is used at New Glasgow, and gives good results. At St. Johns a certain proportion of fire clay brought from New

Fig. 8.—Dry pressed brick plant at Blairmore, Alta., bank of Cretaceous shale in rear

Jersey is mixed with surface clay obtained close to the works. The greater part of the body is composed of the surface clay. The fire clay acts as a skeleton or "stiffner" to hold the surface clay under fire. The Ontario plants use the red Medina shale, obtained from Waterdown, near Hamilton. At Victoria, a mixture of surface clay and fire clay from Kuyoguot is used.

A plant is being erected at Calgary for the manufacture of sewer pipe, and this company expect to have their goods on the market early in the season of 1913.

Fireproofing

There is only a meagre production of this desirable class of clay products in Canada. A branch works of the National Fireproofing

Company of the United States is located at Waterdown, four miles from Hamilton. A large part of the output of this plant is sold in Toronto. The material used is weathered Medina shale.

The Alberta Clay Products Company at Medicine Hat, produce annually, a large quantity of fireproofing. The clay is obtained from selected beds in the soft Cretaceous rocks which occur so abundantly in this region. The burning is done with natural gas, furnished free from the municipal wells.

INSTRUCTIONS RESPECTING WATER POWERS

By A. V. White, M.E., '92

In the summer of 1911 the Commission of Conservation, Canada, commenced an investigation in British Columbia respecting the inland water resources of that Province. The work was continued during the season of 1912. This investigation permits the use of reconnaissance methods, by means of which knowledge may quickly be had respecting the general character, magnitude, and locations of the water-powers of the country.

The need of some brief statement setting forth some of the fundamentals which should govern in the gathering of the water power information has often presented itself in connection with the work. To meet this urgent need arising in connection with the research, a pamphlet was prepared by the writer to act as a guide to those who may be interested in the collection of preliminary data relating to these inland waters. The following article is extracted from the pamphlet referred to and contains a few suggestions of probable interest to the majority of engineers.*

Guiding Principles

In order to assist to a better appreciation of the general subject of water conservation, it is deemed profitable here to make a few remarks along the lines laid down in a recent report of the Commission of Conservation of Canada, entitled "Water Powers of Canada." This report, which is freely quoted in what follows, points out that precipitation by rainfall, or snowfall, virtually constitutes the only source of inland water supply. Speaking broadly, of the annual precipitation upon the earth, about one-half is evaporated: about one-third is "run-off"—that is, it runs off over or through the ground, and eventually reaches the sea; and about one-sixth either joins the ground water, or is taken up in plant structure, or is otherwise absorbed in processes incident to the ground. The natural and cultivated properties of the land on which the rain and snow fall largely determine the efficient uses to which precipitation is applied.

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* This pamphlet is entitled *Instructions relating to the gathering in the field of certain Preliminary Information relating to Water Powers*, by Arthur V. White, and published by the Commission of Conservation, Ottawa, 1912. The pamphlet draws attention to the fact, that while it is intended to be of service to engineers, nevertheless one of its chief objects is to acquaint road inspectors, timber cruisers, forest rangers, fisheries inspectors, and others, with the principles underlying an intelligent investigation of inland water resources. Ed.

It is in this connection that forests are so indispensably associated with the precipitation, and hence with water as a natural resource. Whatever opinion may be entertained respecting the effect of forests in influencing the amount of precipitation, the burden of opinion is that no feature of the topography of the country ministers more efficiently to the gradual and economical run-off from the precipitation than do forest areas. Thus it is that failure to intelligently conserve forest areas has wrought havoc by causing a great destruction of forest floors and agricultural lands, which, humanly speaking, can never be restored, to say nothing of the annual destruction to property by flood run-off, which seems yearly to increase rather than diminish. The run-off is the chief factor entering into water-flow problems as they relate to power development.

A deforested, eroded, and scoured territory, which has lost the humus of the soil, cannot retain the beneficent rains which, instead of being retained in the ground and transmitted into plants by the various processes of growth, carry destruction in the pathways of their torrential run-off. The water is necessary to the soil, and the soil, with its plant growth, is necessary to an economical disposition of the water. The interests of municipal and domestic water supply, water for manufacturing and industrial purposes, irrigation, navigation, and water power are all interrelated and interdependent. They all depend on the same natural source—precipitation.

In the case of water power developments, therefore, it would be well to consider whether or not the industries which might use the water powers would prove to be a menace to the district of their proposed location, and thereby spoil the watershed or waters for other necessary uses. Thus, wood-pulp mills, for example, which might completely denude the timber lands of trees at or near the headwaters of important waterways had better not be established at all; or if established, then only under the strictest regulation and supervision designed to conserve the forest growth.

Along this line, therefore, in some instances, it may be possible for the engineer, or observer, when making his observations, to indicate what he thinks this or that particular water-power might be used for; whether, we shall suppose, for municipal purposes to serve a neighboring town or settlement, for mining, for manufacturing wood pulp, or, etc. Sometimes some such remarks prove to be suggestive to persons seeking opportunities for industrial development.

Pollution by Factory Wastes

The effects likely to result from the pollution of waterways by the waste products emitted from the industries utilizing power from these waterways are also very important factors for consideration. The maintenance of a pure and sufficient domestic water supply is a vital consideration; and, hence, a class of industrial waste products that will destroy life in the waters into which they are turned must be regarded seriously in their probable influence on human life. If any special instances of stream pollution are observed, it would be well to make a memorandum of such facts. When one realizes how even a great waterway like the Great Lake system has been polluted, too great caution can hardly be exercised to conserve the purity of our inland waters.

Water-Powers Require Classification

The amount of water-power is determined by two factors; first, the hydrostatic head, or the vertical distance through which the water may fall; and, second, the amount of water which may be made to operate upon the water-wheels. There are, however, many characteristic features associated with water-powers, which differentiate one power from another, and which determine the commercial and economic values of the individual powers. It is as unreasonable not to differentiate between water powers as it would be not to differentiate between timber tracts, mineral lands, or the items of any other natural resource varying in quantity, quality, and situation.

In presenting water power information, effort should be made to make brief remarks upon features which may have special bearing upon any specific possible power sites.

By way of illustration, it may be remarked that the St. Lawrence River, owing to the vast storage capacity of the natural reservoirs found in the Great Lakes, has the most uniform flow of any large river in North America, or, probably, in the world. Therefore, other conditions being equal, water-power developments on this river will be of very much greater value than developments on a river subject to such great variations of flow as take place, for example, on the Mississippi. Inasmuch, therefore, as the uniformity of the flow of water greatly affects the values of water-powers situated upon various water-courses, it would be fitting for the observer, or engineer, to note any features that might appear capable, or appear to be made capable, of contributing towards uniformity of stream flow.

Reservoir Sites

In connection with the subject of uniformity of flow, one may be on the lookout either for natural reservoirs, such as lakes, or river expansions, or for natural sites where reservoirs may be created by means of dams. In such reservoirs the run-off from precipitation may be impounded, and subsequently discharged gradually throughout the year. Water-powers situated within the range of the direct influence of such natural storage reservoirs may be of incomparably greater value than other water-powers not so favored.

When the subject of storage reservoirs is under consideration, it should not be forgotten that Nature also stores her waters elsewhere than in lakes and rivers. Forest floors, extensive areas covered with plant growth, soils and sub-soils, the gravel-beds of streams, and the great swamps of the country, each and all, constitute valuable water reservoirs. In such reservoirs there is a widespread and satisfactory distribution of waters, which enables Nature to yield her supplies gradually and as required. A discreet conservation and utilization of such reservoirs will, in general, be found to be much more desirable than some of the large artificially constructed reservoirs, where the liability of accidental destruction of large construction works is always more or less of a menace.

In passing, it may be noted that where an early selection of reservoir sites is made, and the same held under Government control, so that no settlement, railway construction, or other similar improvements, is allowed to take place upon such reservoir sites, the expense and trouble incident to future reimbursement for expropriated properties will be avoided. Hence the desirability of the Government having knowledge of the existence of such sites.

Actual Measurements Required

When information regarding water-powers is to be gathered, it is extremely important that the data be sufficient, and of the class that will enable a sound opinion to be formed upon the general water interests involved.

But little confidence can be placed in any reports of water-powers not based upon actual measurements, for, without measurements, the best judgment of explorers, and even engineers, as to the heights of falls and the amounts of water discharging over them, is frequently very wide of the results disclosed by actual measurements.

This is well illustrated by an experience related by the engineer in charge of much of the field work of steam-gauging for the Hydro-Electric Power Commission of the Province of Ontario. This engineer stated that prospectors who had been at the falls on the Kawashkagama River told him, in good faith, that the falls were capable of developing 30,000 horse-power at low water; and he was further assured by a surveyor, who claimed familiarity with what he was speaking about that the Kawashkagama River was able to yield as much power as the Kaministikwia River. After a hard journey, the engineer arrived at the falls, and, instead of the 30,000 horse-power reported found the 317 horse-power given for the Kawashkagama River in the report of the Hydro-Electric Power Commission! If these prospectors had published a report of their mining or geological investigations, and incidentally mentioned that 30,000 horse-power could be developed at low water on the Kawashkagama River, such an assertion would have been very misleading.

Reconnaissance Surveys

When the knowledge of the quantities of water-power that may be available in particular places is required on short notice, and when sufficient records of actual observations do not exist, it is possible to estimate the probable amounts of power available. For such preliminary estimates, data are secured by what may be termed a reconnaissance survey of the general situation; but it must be recognized that the conclusions reached by such methods are not comparable with the results deducible from actual observations of individual water-power conditions extending over a series of years.

It will be profitable to explain, very briefly, these reconnaissance methods for estimating water-power. First, the area of the watershed in question is ascertained by measurement from the best available maps; to this area is applied an assumed run-off coefficient such as would be suggested by a general knowledge of the precipitation, and of the topography, and other characteristics of the territories involved. The wise choice of the coefficient used will, of course, depend upon the good judgment and knowledge possessed by the engineer. This run-off coefficient, as it is termed, is a quantity which represents the amount of water that may be drained off any specified area during a stated period, and is usually expressed as so many cubic feet per second per square mile. Obviously, if the area of the watershed is known to be so many square miles, and each square mile, under specified conditions, will yield so much water, then the total yield of water from the whole watershed will be the product of the factors just mentioned.

When the discharge of a stream, or river, is actually measured, it is usually accomplished by means of floats, or by using a current-meter. The principles involved are very simple. They consist essentially of measuring the velocity of the flow of the stream by means of floats, or meter, and measuring also the area of the cross-section of the river at the place for which the velocity has been thus obtained. The volume of the water which passes a given point is the product of the area of the cross-section of the stream and the velocity of flow at that point.

A concrete illustration will make these methods of estimating clearer. Take, for example, the case of a water-power like Healey Falls, on the Trent River, Ontario. The fall is here considered to have an effective head of 60 feet, and we will further suppose that it is desired to ascertain the horse-power available at low water. From the map of the district it would be ascertained, by measurement, that the drainage area above the fall is about 3630 square miles. If the engineer had previously ascertained that the run-off in some other similar territory was .4 cubic feet per second per square mile, he would use this co-efficient and thus obtain an estimated run-off, or discharge of 1,452 cubic feet of water per second (3,630 square miles × .4). Assuming water-wheels of 80 per cent. efficiency, this 1,452 cubic feet of water per second, with a fall of 60 feet, would give approximately 8,000 horse-power. If actual, yet insufficient, discharge measurements were made at Healey Falls, such data would be criticized by the engineers according to the time of the year at which they were made, etc., in order to deduce what the Trent River would discharge at its lowest stage; and this quantity, so derived, would then serve as a check upon the flow estimated by means of the previously assumed run-off coefficient and drainage area.

Estimating the Horse-Power

The theoretical horse-power available at any point on a stream is the product of the effective height through which the water falls, and the weight of the water falling in a given time. Thus:

Let Q represent the flow of water in cubic feet per second,
h represent the effective fall in feet.

Horse-power $\frac{5\ Qh}{44}$

Considering a good turbine to develop 80 per cent. of the theoretical power, we have

Horse-power $\frac{Qh}{11}$

Hence, a simple rule for estimating the horse-power that may be developed under favorable conditions is: *Multiply the flow in cubic feet per second* (Q) *by the effective head in feet* (h), *and divide the result by 11.*

It must not be forgotten that, in order to state in a reliable manner the power available for any place, it is necessary to give the stage of the river (namely, the height of the surface of the river with respect to a zero or bench-mark), at which the amount of power stated may be produced.

Certain Data Indispensable

When the data collected is published it will be presented in tabular form, so as to be convenient for ready reference. The information communicated by engineers and others should, therefore, always be of a character that permits reduction to tabular form. The essential facts required to be known in every instance are:

(1) Name of river upon which the fall, rapid, or canyon is located:

(2) Local name of fall, rapid or canyon:

(3) Description, giving location of fall, rapid, or canyon (if adjacent to a branch of a stream, state definitely whether power-site is on main river or on the branch, and where:

(4) What total head in feet is obtainable at the site mentioned, and how is the head made up? That is, what portion of the head is direct fall, what portion rapids, and, about, in what distance does the drop, or fall, in any particular rapid occur?

(5) How is the head measured?

(In the pamphlet of instruction there follows at this point a tabulated series of questions and supposititous replies to same, also a table representing how the data supplied by field observers will appear when published. Ed.)

Floats

When floats are utilized for the direct measurement of the velocity of streams, those in common use are surface, subsurface, and tube- or rod-floats.

Subsurface-floats.—The subsurface-float is designed to measure velocities below the surface and may be made to float to any depth. By arranging the submerged float at the depth of mean velocity, it may be utilized in observing mean velocity directly. Allowance must be made, however, for the accelerating effect of the attached line and surface-float.

Tube- or Rod-floats.—The tube- or rod-float is designed to measure directly the mean velocity in a vertical. It is generally a cylinder of tin, about 2½ inches in diameter, weighted at its lower end and plugged with wood or cork at its top. Small extra weights to make it float at the exact depth desired may readily be added by admitting water or by putting in shot. The tube should be graduated and alternate feet painted black and red in order that the depth of the flotation may readily be observed.

A number of tubes, of different lengths, are necessary for measuring the velocity of different depths in an ordinary cross-section. A float of this type, consequently, is best adapted for use in artificial channels in which the depth is nearly uniform. Natural channels are generally too rough and too variable to permit of satisfactory use. In field-work, where it appears expedient to employ rod-floats, these may be improvised by using dry saplings, cut to suitable lengths and weighted with stones tied to their lower ends.

Although designed to measure directly the mean velocity in a vertical, the tube cannot be made to float in contact with the bed of the stream, and, consequently, it does not receive the effect of the slowest moving water. The rougher the bed the greater the error in this respect. A factor less than unity is, therefore, necessary to reduce the observed velocity to the mean.

Memoranda Regarding the Determination of Approximate Stream Discharge by Surface Floats*

Although the method of determining the discharge of streams with floats is not usually so convenient, or simple, as with the current-meter, it is, however, less expensive, and for all practical purposes, especially in reconnaissance work, the results are quite as good as those obtained with the current-meter, provided the measurements are not to be used in conjunction with daily gauge heights in order to determine the daily discharge.

To determine the discharge by means of floats, select a straight course along the stream in question, the length of the course being, roughly, about twice the width of the stream. The cross-section throughout this course, and for a short distance above and below it, should be as uniform as possible; and the bottom should be as smooth as possible and free from all large projections. Rather than run floats over bad reaches in the stream, it is preferable to shorten the course, although it is rarely desirable to take a course less than 50 feet in length, unless the stream is less than 10 to 20 feet wide.

*The data respecting stream measurement by surface-floats, here given, have been furnished as a result of special research made by Mr. R. H. Bolster, and have been made available, for present purposes, by the courtesy of Mr. M. O. Leighton, Chief Hydrographer of the United States Geological Survey.

At the upper end of the course set two rods, rod 1 on the river bank, and rod 2 about 50 to 100 feet back from the river, so that a line through them will be, as nearly as possible, at right angles to the direction of the stream over the selected course. Carefully measure the distance from rod 1, located nearest the river, to the lower end of the course, and there locate rod 3 at an equal distance back from the river. Going next back from rod 3 the same distance (measured) that rod 2 is from rod 1, locate rod 4, which should be exactly the same distance from rod 2 as rod 1 is from rod 3. NOTE.—In very narrow streams, rods 2 and 4 can frequently be dispensed with, but in wide streams they should always be used.

Have an assistant loosen floats,[1] consisting of small blocks of wood (weighted, if necessary, to avoid wind effect on the surface exposed above the water), a short distance above the upper end of the course, spacing them across the stream at intervals of about one-tenth the width of the river. Sight past rods 2 and 1 and note with a stop-watch,[2] or an ordinary watch, the time when a float passes the upper end of the course. Go to the lower end of the course and similarly note the passage of the same float past staffs 3 and 4. The average of time the float runs, divided into the distance apart of the upper and lower ends of the course, will give the average surface velocity in feet per second.

Determine four cross-sectional areas (or more if desired), located at 1-8, 3-8, 5-8, and 7-8 the distance between the upper and lower ends of the course. Stretch a tagged telegraph wire, measured cord, or steel tape across the river at the points indicated, and, at regular intervals, take soundings, recording them as indicated in the table below. Ten sounding points, equally spaced, should ordinarily be sufficient.

Cross-section One-eighth Below Upper End of Course

Station.	Depth in Feet.	Width in Feet.	Mean Depth in Feet.	Area in Square Feet
12	0.	..	..	..
20	1.1	8	.6	4.8
30	4.3	10	2.7	27
40	5.6	10	5.0	50
50	6.3	10	6.0	60
60	7.6	10	7.0	70
70	7.0	10	7.3	73
80	6.1	10	6.6	66
90	5.3	10	5.7	57
100	4.0	10	4.6	46
110	2.1	10	3.0	30
117	0.	7	1.0	7
			Total area,	491

1 A corked-bottle float, with a flag in the top and a weight in the bottom, makes a very satisfactory surface-float, as it is but little affected by the wind. In flood measurements good results can be obtained by observing the velocity of debris, or of floating cakes of ice.

2 Stop watches are necessary for the satisfactory observation of velocity by floats, and for integration by meters. They are recommended for use in all meter-work.

Total area at ⅛ point	491
Total area at ⅜ point (here assumed to be)	500
Total area at ⅝ point (here assumed to be)	458
Total area at ⅞ point (here assumed to be)	511
Total	1,960
Average cross section	490 square feet

The average of the four areas can be taken as the average cross-sectional area of the course. The soundings can be made by wading the section with a graduated rod, or from a boat with graduated rod, or with weight on the end of a graduated cord, if too deep for wading. The tagged wire can be used to hold the boat in position.

The mean surface velocity (feet per second) **x** the mean cross-sectional area (square feet) **x** a constant K = the discharge of the stream in cubic feet per second.

The constant K varies quite widely under different channel conditions, ranging from a minimum of about .70 to a maximum of about .90 or more. In general K can be said to vary inversely as the slope (or velocity), inversely as the roughness, directly as the depth and indirectly as the width (for narrow streams).

The following table will serve as an approximate guide in the determination of the most probable coefficient K. Interpolate for conditions not given in the table.

Velocity (Feet per Second)	Average Depth (Feet)	Size of Material on Bottom (Feet)	Coefficient
2 or less	2 or less	½ or less	.80 to .85
2 or less	2 or less	1	.75 to .80
5	2 or less	½	.80
5	2 or less	1	.75
10 or more	2 or less	½	.75
10 or more	2 or less	1	.70
2 or less	5	½ or less	.85 to .90
2 or less	5	1	.85
2 or less	5	3 or more	.85
5	5	½ or less	.85
5	5	1	.85
5	5	3 or more	.80 to .85
10 or more	5	½ or less	.80 to .85
10 or more	5	1	.80
10 or more	5	3 or more	.80
2 or less	15	½	.90
2 or less	15	1	.90
2 or less	15	3 or more	.90
5	15	½	.90
5	15	1	.90
5	15	3 or more	.85 to .90
10 or more	15	½	.90
10 or more	15	1	.85 to .90
10 or more	15	3 or more	.85 to .90

The coefficient close to abutments, or piers, usually lies between .90 and 1.00, and is often greater than unity. Similarly for channels with rectangular sides and a width not greater than about three times the average depth, the coefficient is likely to be higher than .90 and sometimes greater than unity.

Convenient Equivalents

The following is a list of convenient equivalents for use in hydraulic computations:

In British Columbia, under the "Water Clauses Consolidation Act, 1897," section 143, one miner's inch was declared to be a flow of water equal to 1.68 cubic feet per minute.

Therefore, one miner's inch = .028 cubic feet per second, and one cubic foot per second = 35.7143 miners' inches, approximately.

A flow of one miner's inch per second = 0.1745 imperial gallons per second.

1 second-foot equals 40 California miners' inches (law of March 23, 1901).
1 second-foot equals 38.4 Colorado miners' inches.
1 second-foot equals 40 Arizona miners' inches.
1 second-foot equals 7.48 United States gallons per second.
1 second-foot equals 6.2321 imperial (British) gallons per second.
1 second-foot for one year covers 1 square mile 1.131 feet, or 13.572 inches, deep.
1 second-foot for one year equals 31,536,000 cubic feet.
1 second-foot equals about 1 acre-inch per hour.
1 second-foot for one day covers 1 square mile 0.03719 inch deep.
1 second-foot for one 28-day month covers 1 square mile 1.041 inches deep.
1 second-foot for one 29-day month covers 1 square mile 1.079 inches deep.
1 second-foot for one 30-day month covers 1 square mile 1.116 inches deep.
1 second-foot for one 31-day month covers 1 square mile 1.153 inches deep.
1 second-foot for one day equals 1.983 acre-feet.
1 second-foot for one 28-day month equals 55.54 acre-feet.
1 second-foot for one 29-day month equals 57.52 acre-feet.
1 second-foot for one 30-day month equals 59.50 acre-feet.
1 second-foot for one 31-day month equals 61.49 acre feet.
1 inch deep on 1 square mile equals 2,323,200 cubic feet.
1 inch deep on 1 square mile equals 0.0737 second-feet per year.
1 foot deep on 1 square mile equals 0.88 second-feet per year.
1 mile equals 5,280 feet.
1 acre equals 43,560 square feet.
1 acre equals 209 feet square, nearly.
1 cubic foot of water weighs about 62.5 pounds.
1 horse-power equals 550 foot-pounds per second.
1 horse-power equals 746 watts.
1 horse-power equals 1 second-foot falling 8.80 feet.
1 1-3 horse-power equal about 1 kilowatt.

To calculate water-power quickly: $\frac{\text{Sec.-ft.} \times \text{fall in feet}}{11}$ = net horse-horse-power on water-wheel realizing 80 per cent. of theoretical power.

C. Hughes, '09, is engineer-in-charge of surveys for the St. John & Quebec Railway at Fredericton, N.B.

J. S. Parker, '11, is at Burks Falls, Ont., as mechanical engineer in charge of power equipment for the Knight Lumber Company.

F. A. Dallyn, '09, of the Ontario Board of Health, is collecting data concerning the water in Lake Huron, Lake St. Clair and River St. Clair, for a report to be presented to the International Joint Commission, relative to lake pollution.

BITUMEN IN MODERN PAVEMENTS

By J. B. Temple, B.A.Sc.

Part II

In the closing paragraphs of the preceding part of this article a short historical treatment of sheet asphalt was given together with an illustration of the important part which the temperature range plays in the formulae for a pavement.

The materials composing a sheet asphalt wearing surface are a uniform mixture of asphaltic cement, a mineral aggregate (consisting of sand) and a mineral dust filler (pulverized limestone).

[1]"The materials shall be mixed in the following proportions by weight:—

Asphaltic cement	10 to 18 per cent.
Sand	85 to 67 per cent.
Mineral dust	5 to 15 per cent.

"The refined asphalt shall contain no admixture of coal tar, coal tar products, or any inferior bituminous matter.

"The flux used in the manufacture of the asphaltic cement shall be either liquid asphalt or maltha, asphaltic petroleum residuum, paraffin petroleum residuum or other softening agent from which the lighter oils have been removed by distillation without cracking until the flux has the following characteristics: Specific gravity .924 to 1.05 at 78 deg. F. Flash point not less than 325 deg. F. in a New York State closed oil tester. It shall not volatilize more than 5 per cent. at 325 deg. F. in seven hours. When the refined asphalt is not already of the proper consistency the cement shall be prepared by tempering the asphalt with the flux as above specified in proportions approved by the engineer. They shall be melted together and thoroughly agitated by approved appliances until they are completely blended into a homogeneous asphaltic cement. The agitations shall be continued until the cement is used and the cement shall never be heated to a temperature exceeding 325 deg. F."

It is also required in these specifications that the sand be sharp and clean, that the whole of it shall pass a 10 mesh sieve, 15 per cent. an 80 mesh sieve, and at least 7 per cent. shall pass a 100 mesh sieve. In the case of the pulverized limestone it is required that 80 per cent. pass a 200 mesh sieve.

The exact proportioning of the above materials is determined by the engineer and depends upon conditions before mentioned. The point sought for is to produce the densest mixture practicable. However, the bituminous matter soluble in carbon bi-sulphite in any pavement is never less than 9 per cent., nor greater than 12 per cent.

The sand and the asphaltic cement are heated separately to approximately 325 deg. F., and are mixed along with the mineral

* City of Toronto revised specifications, Sept. 1911. See D-6.

dust in an asphalt mixer, which is designed to agitate the material until a thoroughly homogeneous mass is produced. Provided the above has been successfully carried out the asphalt is ready to be carted in covered waggons to the street under construction.

It has been the custom in most cities of late to lay the asphalt on a binder which consisted of broken stone slag or gravel not exceeding 1½ inches heated and mixed with hot asphaltic cement in proportion of 15 gallons of latter to 1 cubic yard of stone.

This binder was spread and rolled to the depth of 1 inch on top of the concrete sub-grade and the idea was that the hot asphalt would penetrate the voids and (the binder being plastic) it would prevent the surface from "creeping" away from the foundation.

Most of the bulging, rolling and cracking of the surface was attributed to this creeping or the parting of the asphalt from the concrete foundation. Although this binder has come into general use there are many authorities that claim that it will not hold the surface mixture from undue movement and is of no particular value. So far it is just a case of argument, but good engineering practice seems to favor this bond between the surface mixture and the concrete. To ascertain its value experiments are now being carried on in Houston, Texas. Several surfaces have been laid on the rough concrete which was previously coated with a mixture of asphaltic cement.

Up till two years ago all sheet asphalt pavements were laid in Toronto directly upon the concrete foundations, but as the binder was heralded as a "Cure All" for paving defects, there have hardly been any pavements laid of late without it. However, its use is yet in the experimental stage.

Before the surface mixture is placed all contact surfaces of curbs, gutters, manholes, joints, etc., must be painted with hot asphaltic cement. The asphalt should reach the street at a temperature ranging from 250 deg. to 350 deg. F., and is spread to the required depth (1½ to 2 inches) with hot rakes. It is then compressed with a hand roller, after which hydraulic cement or pulverized limestone is swept over it, and as soon as the material will bear it, it is rolled with a steam roller (at least 5 tons in weight). Places not accessible with the roller are thoroughly tamped with hot irons made for that purpose. It is an important point that all contact surfaces should be perfectly dry.

Asphalt Block

Asphalt blocks have been used extensively of late on both residential and heavy traffic streets. This class of pavement possesses several advantages over sheet asphalt. Among others it requires no special plant near the work. This is an advantage to small towns that have not enough paving work to keep a plant running. An asphalt block pavement is also easily repaired and shares most of the good points of a brick surface, but is not so noisy or dusty. If placed upon a solid concrete foundation it is somewhat more permanent than sheet asphalt and will not crack nor be so slippery. As asphalt block pavement wears, the corners and sharp edges get broken and it presents a rather rough surface. Therefore it is advantageous to lay out this pavement with a rather higher crown than sheet asphalt. One great disadvantage against the common use of this pavement is the first cost. In Toronto it costs $3.80 to lay a square yard of block on 5 inches of concrete, as contrasted with $2.00 for sheet asphalt on the same depth of foundation.

Asphalt blocks are composed of asphaltic cement, crushed trap rock and inorganic dust. The blocks contain from 6 per cent. to 8 per cent. bitumen and the remainder is the mineral aggregate, the coarsest particles, which are not larger than 3/8 in., down to the fine dust or filler composed of limestone or cement or a mixture of the two.

In the manufacture of the blocks the trap rock is first crushed and screened. The different sizes are then proportioned by weight and are mixed in a mixer with hot asphaltic cement (300 deg. F.). The result of mixing the asphaltic cement with the dry mineral aggregate produces within two or three minutes an absolutely homogeneous mass. This is then conveyed to the mold boxes, where a pressure of one hundred and twenty tons is applied to the top, bottom and two sides of the block by four springs. It is then discharged, examined, and if up to the standard, is placed on a conveyor and cooled by passing through water. By this method one batch of 1,500 pounds from the mixer will make 70 to 80 blocks, and a plant with five mold presses has a capacity of from 20,000 to 30,00 blocks a ten-hour day.

Various physical and chemical tests are made upon asphalt blocks to determine their probable efficiency. The principal physical ones are breaking, rattler, and impact tests, while the main chemical one is the extraction of the bitumen.

The breaking test is similar to the one used in concrete. The block is placed (widest face uppermost) on two lateral supports which are equidistant from the middle and pressure applied (at the middle) across the entire width by the passing down of a wedge-shaped piece of cast iron. The amount of pressure required to break the block is automatically registered.

The block that gives the highest value in this test is not always the best, for this value depends on the hardness of the asphaltic cement, and it is often desirous to have a relatively soft cement.*

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*Howard Hottel in "*Contract Rceord*," August 2, 1911

The impact test is supposed to represent the blows of traffic. The block is firmly placed upon a cement base and the blow delivered through a spherical end plunger resting upon the centre of the widest face of the block, and the latter is adjusted so that the spherical end of the plunger is pressed firmly upon it by two spiral springs.

The blow is struck by a hammer weighing 2 kilograms, which is raised by a rope and pulley, and released automatically. The test consists of 1 cm. fall of the hammer for the first blow and an increased fall of 1 cm. for each succeeding blow until block breaks, and the number of blows required to do this represents the toughness.

The rattler test is supposed to represent the wear and tear upon a pavement from horses' hoofs and waggon wheels. It consists of placing 18 to 20 blocks in an iron shell which is made to revolve. After the blocks are tightly wedged in so that they won't move, and so that they present a level surface, a shot charge of 50 pounds of 2½ in. castiron cubes, having sharp corners and weighing about four pounds each, is put in the rattler. The cover is placed on and the machine is revolved at the rate of 37 revolutions per minute.

The revolutions of the rattler are recorded automatically upon a dial, and one test consists of 10,000 revolutions. The average loss per cent. of weight by this test will be about 8.7 per cent. or will run from about 7.02 per cent. to 10.98 per cent.

The amount of bitumen present is obtained by extraction with either cold carbon bisulphite or hot benzol. In the former test the mixture and carbon bi-sulphide are placed in a pair of revolving cones separated by a felt ring.

As the cones are swung at high velocity in a small centrifugal machine, the solvent filters through this felt ring. The operation is repeated until the filtrate comes through clear.

The latter method consists of placing the material in a soxhlet apparatus and making a continuous extraction with hot benzol.

The analysis of a block picked at random is given by H. C. Hottel as:—

Size, 12x5x3 inches.
Weight in air, 15 lbs. 7 ozs.
Weight in water, 9 lbs. 4 ozs.
Specific gravity, 2.5.
Impact at 77 deg. F., 46.
Bitumen, 7.3 per cent.
Passing 200 mesh sieve, 17.1 per cent.
Passing 80 mesh sieve, 4.0 per cent.
Passing 20 mesh sieve, 6.3 per cent.
Passing 10 mesh sieve, 12.0 per cent.
Passing 4 mesh sieve, 28.0 per cent.
Retained on 4 mesh sieve, 2.0 per cent.

Specific gravity of mineral aggregate, 2.92.
Penetration of asphalt cement, 30 cm.
Average loss in rattler, 7.5 per cent.
Ductility of asphalt cement, 15 cm.

The passing of the mineral aggregate through the screens determines whether it is graded properly, and the amount of bitumen, the density of the block and the density of the mineral aggregate give the per cent. of voids present.

The blocks are laid upon a solid cement foundation (5 or 6 in.), which conforms to the shape of the finished road. Upon this foundation is placed about one-half inch of slow setting cement mortar made in the proportion of 1 part cement to 4 of clean, sharp sand entirely free of pebbles over one-quarter of an inch. This mortar cushion must be struck off true to the cross section and present a perfectly smooth surface and in no case shall the mortar cushion be laid so far in advance of the pavers as to allow the initial set to take place before the blocks can be laid.

Upon this mortar surface the blocks are immediately laid with close joints and uniform surface, the pavers standing upon the blocks already laid and not on the bed of mortar. The blocks are laid at right angles to the curb except at street intersections where they are placed diagonally and the longitudinal joint should have a lap of at least four inches.

When the blocks are laid with all joints tight as possible, the pavement is rolled or rammed and flooded with water and the filling applied. This grout filler is applied in two operations. In the first the mortar is much thinner than in the second, and is composed of one part cement and one part sand. It is mixed in a box, carried to the pavement in scoop shovels and rapidly swept into the joints till they are about half-full. In the second operation the grout is thicker and is composed of two parts cement and one part of sand. It is applied till all the joints are full and a surplus shows on top of the block pavement.

Creosoted Wood Block

Creosoted wood blocks have many advantages that recommend them for some classes of work as an almost ideal pavement. They are noiseless, elastic, somewhat dustless, and present good footing for traffic. They are also easy to handle and quickly laid.

Past experiences with wood as a paving material had been somewhat disappointing and even the first creosoted blocks were not very durable, but as methods of manufacture improved, the durability and adaptability of the blocks improved probably more than 100 per cent.

In common with other block pavements, the maintenance cost is light, as it requires no special plant or tools for repair work.

The great disadvantage with creosoted wood block is the cost, which is now a trifle more (in Toronto) than a first class asphalt block, and on account of the ever-increasing scarcity of suitable timber this price will always keep advancing. This is a serious drawback for its extensive use in the future. The woods from which the blocks are generally made are sound long leaf yellow pine, Oregon or Douglas fir and several other trees of this type. It is absolutely essential that the timber from which the blocks are sawbutted shall be sound and free from coarse knots, worm holes, decay, bark, etc.

The blocks are manufactured truly rectangular and uniform and dressed on all sides except the top and bottom. They are then placed in an iron cylinder and sterilized by steam at about 250 deg. F. and 40 lbs. pressure for at least 3 hours. All fluid matter is drained from the cylinder and a vacuum pump set to work which produces a vacuum of at least 24 inches, the wood blocks being kept hot the while by means of steam coils in the cylinder. Creosote oil conforming to the required specification is then run in at a temperature between 180 deg. F. and 200 deg. F., and maintained under pressure till the blocks contain at least 18 pounds of creosote oil per cubic foot of wood. (This is somewhat modified for woods containing a great deal of natural pitch.)

In J. W. Howard's "Standard Specifications for Creosoted Wood Block Pavement" several tests for the materials are also described, the most important for the finished block being the indentation or pressure test, which is in brief as follows:—

"The blocks are dried at 100 deg. F. for 12 hours, then a polished steel die of 1 sq. inch on its lower face, square edges, corners, and perpendicular sides, is placed on a dried block firmly supported in a compression testing machine. A pressure of 8,000 pounds is applied quickly and maintained exactly one minute. The die must not descend and indent the block more than one-eighth of an inch..........The die is placed anywhere within one-half inch of the edges of the block and so as to compress lengthwise the wood fibres."

It is also noted that a block dried as above should not absorb more than 4½ per cent. of water. The methods of laying are very similar to those described for asphalt block. Expansion joints varying from ¾ to 1 inch are constructed between the curb and the wood paving blocks, or in other locations as the engineers may direct. These joints are filled with bituminous paving cement.

After the blocks are laid and wedged and rammed as close as possible, they may be grouted with Portland cement mortar, as also before described for asphalt block, but it is becoming a common practice to use a bituminous paving cement filler.

This is heated till it is thoroughly liquid and will run into the joints freely when spread on the pavement. An excess of this bitumen is used, and while it is still hot there is spread over it a ½-inch layer of clean, coarse sand or dry crushed stone screenings with particles not exceeding ¼ inch and not smaller than 1-32 inch in size.

Some Other Bituminous Pavements

There are many other uses of bitumen in roadway work, but most of them are but modifications of the methods already mentioned. This branch of highway construction is a comparatively new departure, and as yet very little has been done to standardize the different methods. In fact, no ironbound rules could be drawn up to cover all cases, as local conditions and climate will always determine the proportions and manner of application. This is particularly true in those cases relating to the bituminizing of macadam or gravel roads, for though in every case the principle is the same, there are innumerable methods to arrive at the sought-for result, namely, a hard, homogeneous, waterproof and dustless wearing surface.

A pavement that is often mentioned as asphalt macadam is a modification of our tar macadam before mentioned. In consists in painting the finished road with hot asphalt (about 320 deg. F.), and while this is still hot a layer of small rock is spread on it. This is in turn painted as before, and over it is spread a thin layer of screenings or small stones and sand.

There are also a great many modifications in the "mixed method" of surfacing roads, the best example of which is "butilithic."

The cold mixing method is becoming quite popular of late. This consists in mixing the top course with a bituminous cement which is liquid at ordinary temperatures but which contains some volatizing material (like benzine). Many of these "cold asphalts" are controlled by patents.

One pavement of this last type that deserves special mention is a patent pavement somewhat after the lines of bitulithic, called "Westrumite." This asphalt cement is liquid at ordinary temperatures and is shipped in barrels or tank cars and is mixed cold (on the street) by hand or in a concrete mixer with proportions of broken stone, sand and mineral dust. It is then spread to a thickness of 1½ to 2 inches on a concrete or macadam foundation and rolled until hard.

This pavement has been used successfully in Brantford, Guelph, and Stratford, and presents a durable, elastic, non-slippery, waterproof surface, but it is somewhat inclined (particularly if recently laid) to ooze and soften up to a noticeable extent in warm weather. However, more care in proportioning and mixing the different materials may help to regulate this.

There is one more pavement of this class that deserves mention, namely "Amiesite." It may be described as another modified bitulithic surface for macadam roads and is composed of 90 per cent. bituminous cement and crushed stone.

On a Telford base is spread about 3 inches (loose measurement) of this material made with stone in sizes from ½ in. to 1½ in. This is rolled once and on top is placed a 1 inch filler course, consisting of Amiesite made of stones running from ¼ to ½ inch. The surface is then rolled and finished until it is compact and uniform.

This pavement has been used in many towns and on country highways throughout New York State. New Jersey, Pennsylvania, and adjacent states, and appears to be giving satisfaction.

The chief point patented in this pavement is the compound forming the bituminous binder in which they claim that all the soluble salts (common to other asphaltic cements) are neutralized, giving a material of uniform elasticity for different temperatures.

A new pavement that has just been patented is of interest on account of its radical departure from any material now on the market. It is called "Cork Brick." It consists of finely-granulated cork mixed with asphaltic cement and molded like asphalt blocks. When the bricks are laid on concrete, the foundation should first be covered with a layer of hot bituminous cement. It is stated that the bricks absorb less than 1½ per cent. of water by immersion, and that they afford an excellent foothold whether wet or dry. As yet these blocks are but an interesting experiment.

A pavement that has attracted widespread interest of late and received favorable comment in engineering journals is one devised about four years ago by E. W. Graves, city engineer of Ann Arbor. It is a concrete pavement with bituminous wearing surface, and consists of a 4½ inch gravel concrete base and a 1½ inch wearing surface, mixed one part cement to two parts sand. The concrete is laid in strips one-half the width of the street and 25 feet long, an expansion joint being placed every 25 feet across the street perpendicular to the axis and at each curb. The block is given a rough finish by means of a street broom. After finishing one section the form is moved across to the other side of the street and the other half laid right against that which has been previously placed, leaving as close a joint as possible in the centre of the road.

After the concrete has hardened the surface is sprinkled with a thin coat of hot bitumen, which is covered with a coat of sand. Approximately one-half gallon of bitumen is applied per square yard of surface and a cubic yard of sand will cover about 250 square yards, making a wearing surface from ¼ to ⅜ inch thick. Although common coal tar has been used in this work with good results, a specially prepared distilled tar was found to be more satisfactory. The people in Ann Arbor are very enthusiastic over their pavement, and at present petitions are on file for over 100,000 square yards. It is stated that this pavement can be put down for less than $1.00 per square yard, which is figured on a basis of labor at $2.00 for nine hour day, cement $1.10 to $1.30 per barrel, and gravel at $1.00 per load of 1 1-3 cubic yards.

A prominent point in the foregoing is the lack of standardization of methods in vogue to acquire somewhat the same result. This is partly due to the fact that this branch of highway science is yet in its infancy, but the great controlling factors (as before emphasized) are the conditions, geographical, geological, financial, etc. Geographical will include the climate, location and purpose and requirements the road will have to meet. Geological may determine the materials used and quantity and quality of such, and the drainage and nature of the ground; lastly, the amount of money at hand to spend on the road will be a large controlling factor.

But no matter what method used or result sought, whether elaborate or crude, several points will be emphasized when it comes to using bitumen as a binder or cement. One of the most important is the proper proportioning of our materials. Firstly, the stone must be graded from the largest down to a powder, and each size proportioned as to reduce the voids to the greatest extent. Sufficient bitumen (but no more) must be used to thoroughly fill the remaining voids and evenly but thoroughly coat every particle of aggregate, so that when the mass is cold it shall present a density as near as possible to that of the solid rock from which the aggregate has been made or "within 5 per cent." of it.

Another point that has been noticed in many specifications and reports is that the work must be carried on in dry weather and materials and surfaces be thoroughly dry. This is a point that is often disregarded if the contractors are in a hurry to finish the job. This brings out the fact that when possible the best time to let contracts for bituminous pavements is in the early summer months. The writer has seen bituminous pavements (the contract having been let in the late fall) being laid during blinding snowstorms and drizzles.

A point of pre-eminence is the character of the bitumen, the different grades, essentials, etc., which have been mentioned. We must have as our binder a tar that will not soften in hot weather not get brittle during the cold. In other words, one that has a great elasticity and large temperature range between the melting and brittle points; however, we must not have one with so high a melting point that it will be too difficult to work. That is one of the disadvantages claimed for petroleum residuum compounds for use in tank waggons, as the steam coils will not make the material sufficiently fluid to flow readily through the hose. As yet the ideal bituminous cement is not on the market.

BIOGRAPHY

James W. Tyrrell, 1883

James Williams Tyrrell, C.E., O.L.S., D.L.S., was born on the 10th of May, 1863, at Weston, Ontario, where he received his early training, first at private schools, and later at the High School under the tuition of the late George Wallace, B.A.

At the age of seventeen he entered the School of Practical Science, Toronto, and there, during the first year, formed one of a class of eight. In his third or final year this class became reduced to two—G. H. Duggan being the other survivor. D. Burns of the class of the previous year graduated with the above two, and these three formed the graduating class of 1883.

During the summer vacation of 1882 Mr. Tyrrell accompanied the late Francis Bolger, P.L.S., as assistant upon the survey of the Township of Ratter, north west of Lake Nipissing, and there in the swamps of that district received his initiation as a knight of the chain and compass, and it was a strenuous initiation, well fitted to prepare him for later and more arduous experiences.

After leaving the School of Science in the spring of 1883, he obtained a position as topographer on the staff of the Canadian Geological Survey and for two years acted as assistant to Dr. Robert Bell, LL.D., the assistant director.

During those years he surveyed and mapped the shores and the 3000 islands of the Lake of the Woods.

In the spring of 1885 he obtained his commission as a Provincial Land Surveyor from the Ontario Government, and the same season was appointed hydrographer and meteorological observer to accompany a Dominion Government expedition to Hudson Bay and Strait. With this expedition, which was under the command of the late Captain A. R. Gordon, R.N., he sailed from Halifax in the S.S. Alert in May, 1885, and did not return until October of the following year.

During the intervening months Mr. Tyrrell was engaged in exploring and surveying the harbors and shores of Hudson Bay and Straits and in taking meteorological, tidal, and other scientific observations, all of which have been published in the departmental reports.

During the winter of 1886-7 he was engaged in Toronto in preparing the maps and charts of his surveys, and these have also been published by the Canadian Government and the British Admiralty.

In February, 1887, he obtained his commission as a Dominion Land Surveyor, and in the spring of that year obtained employment as an assistant engineer on construction of the International Railway of Maine—the eastern extension of the C.P.R. He remained on this work for nearly two years and gained much valuable experience, but during the autumn of 1888, hearing of a favorable opening for a surveyor in Hamilton, Ontario, he formed a partnership with the late G. B. Abrey, P.L.S., and opened an office in that city for the practice of municipal engineering and surveying. In the spring of 1889 he received the degree of "C.E." from the University of Toronto, and in June of the same year was married to Miss Isabel Macdonald, youngest daughter of the late James Macdonald, Esq., of Toronto.

For several succeeding years he devoted himself to private practice, and among his many successful undertakings built the first inclined railway in Hamilton at the head of James Street. This was opened for traffic on the 11th of June, 1892.

In the spring of 1893 he was invited to join his brother, J. B. Tyrrell, then of the Canadian Geological Survey, upon an extensive exploration of the so-called Barren Lands west of Hudson Bay, and, leaving his local business in charge of a partner, he was engaged upon that now historic expedition for a period of eight months, and performed with his brother a journey of over three thousand miles, and one of the most notable in Canadian history.

This remarkable exploration has since been graphically described and illustrated in "Across the Sub-Arctics of Canada," an entertaining book written by the subject of this sketch and published by Briggs & Co., of Toronto. Of this book Mr. F. C. Selous, the famous sportsman writes:—"I am not given to paying undeserved compliments, but I can truly say that I know of no more fascinating book of travel than 'Across the Sub-Arctics of Canada.'"

Besides the exploration above mentioned, Mr. Tyrrell, in whom the love of wild life is strongly developed, has made many long and interesting journeys, among which may be mentioned:—Mine surveys at Lillooet, B.C., in 1895; mine survey in various parts of Nova Scotia in 1896; mine surveys at Rainy River and at Red Lake, North Ontario, in 1897; mine surveys at Crow's Nest, B.C., and in New Brunswick, in 1898; mine and timber surveys at Lillooet and at Agassi, B.C., in 1899, and in 1903 mine surveys in various parts of Newfoundland.

Whilst engaged on surveys in the mountains of British Columbia in the summer of 1899 he received a telegram from the hand of an Indian courier asking him, on behalf of the Canadian Government, to undertake an exploration of the "Barren Lands" lying between Great Slave Lake and Hudson Bay. This work was undertaken and occupied eleven months of the year 1900, and was successfully carried out and fully reported upon.

In August, 1901, Mr. Tyrrell again responded to the "call of the wild," and took passage for the Klondike gold fields, where he followed with a fair degree of success, the occupation both of miner and surveyor for a period of one year.

The latter part of 1902 was spent in Hamilton, but many months of the succeeding years from 1903 to 1910 were spent on Dominion Government survey work in the provinces of Manitoba, Saskatchewan and Alberta. In all about one hundred townships were subdivided during these years, and whilst some surveys were performed under pleasant circumstances, others were accomplished under the most adverse conditions.

During the summer of 1905 a railway exploration survey was made for a private syndicate from Prince Albert via the Saskatchewan, Nelson and Churchill Rivers to Fort Churchill, and a complete map of Churchill harbour was made. The return of this journey was made by way of the Nelson River and Lake Winnipeg.

In the year 1906 Mr. Tyrrell was elected president of the Association of Ontario Land Surveyors, with which he has been actively identified since its inception.

He is at the present time head of the engineering and surveying firm of J. W. Tyrrell & Company, of Hamilton—the other members of the company being John E. Jackson, O.L.S., D.L.S., and Oliver R. Blandy, O.L.S. They enjoy the benefits of a large and profitable business.

Mr. Tyrrell takes an active interest in military affairs, being a captain in the corps of Guides, and he is the happy possessor of an ideal family of two sons and two daughters, none of whom have, as yet, chosen their callings in life.

A. S. McCordick, '09, has received an appointment to the staff of the city engineer of Sault St. Marie, Ont., on electric light and water power installation and distribution.

J. A. Elliott, '11, has been engaged with the Casner Electrolytic Alkali Co., of Niagara Falls, N.Y.

F. A. Robertson, '08, until recently with the Canadian Inspection and Testing Laboratories, has accepted a position with the Canadian Cement Company in their publicity department.

G. H. Bowen, '09, has engaged with the Hamilton Gear and Machine Co., Toronto.

V. A. Newhall, '10, is with the Department of the Interior. He is engineer of inspection of irrigation surveys at Calgary.

T. J. Farrelly, '11, has accepted a position with the Bell Telephone Company, at the head office in Montreal, on transmission engineering.

W. W. Gray, '04, is located at Edmonton, Alta., in the employ of the Edmonton Light & Power Co.

W. P. Brereton, '01, is in Winnipeg in charge of a scheme for bringing city water supply from Shoal Lake, Man.

H. H. Angus, '03, is discontinuing his consulting engineering practice to accept a position with the Canadian Domestic Engineering Co. in their Toronto office.

R. J. Fuller, '11, resigned recently from the staff of the Canada Foundry Company, to accept an appointment to the staff of the City Architect, Toronto.

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EDITORIAL

THE FRUITS OF LABOR

At the Engineering Alumni dinner, held recently in Toronto, our research scholars may have experienced occasional sensations of monstrous responsibility, developing into the disquieting forecast that they must succeed in producing something of material value from their undertakings, that the eyes of twelve hundred fellow School men are upon them; that the movement, in its initial stage will sacrifice its future unless it adorns itself with a full measure of success this year. In reality nothing was said to uphold or contradict such apprehension—they received no inkling from the graduate representation of its feelings in the matter of results, and hence the soil for consternation.

Whatever misgivings they may have entertained as to the relative responsible nature of their duties compared with those of the crowned heads of Europe, they must, first of all, feel that every member of the graduate body wishes each of them real success and benefit from their year's labors.

The research fellows, moreover, and those in whose charge they work, are vitally interested in the outcome of their study and will derive from it all possible good. That is the universal graduate opinion. The Engineering Alumni Association is providing the funds to equip two men with a year's special training that will make them a greater credit to the School and its graduates, and therein lies the interest which it is taking in their progress. It is not vitally interested in the result, but will, to be sure, possess a pronounced degree of admiration for their men should the investigation work result in addition to useful knowledge in the special subjects under examination.

The men should feel assured that it is not a question of showing a material return, however, but that it is the earnest desire of the graduate body that each makes the most of his opportunities for research, let the outcome be what it will. If they do this, their efforts will have been successful, in so far as the supporters of the movement are concerned. And they must not attack their work of endeavouring to solve scientific problems under an unnecessary strain of responsibility. It has a semblance to a joke-writer trying to fill up a funny page against time, in which case the resulting columns are not abundant in masterpieces.

ENGINEERING SOCIETY ACTIVITIES

At its general and sectional meetings some very instructive papers have already been presented to the Society this term. Although the attendance at the School is smaller this year than usual, the fact is not noticeable at the different meetings. They have been unusually well attended.

The first meeting, on October 18th, was more introductory in nature than anything else, nothing by way of a paper on a technical subject having been attempted. President Ritchie called upon Dean Galbraith to address the students, which he did in a very general way, dealing with the objects and scope of the lines of instruction on the Faculty time table. The benefits of the Society to its members, and the opportunities it makes possible for them to take advantage of, formed a subject of interest to the newer men. Mr. T. H. Hogg, '07, gave a short history of the Engineering Society and the close relation of the graduate body to it, in the course of which he commented upon the excellent work of Mr. K. A. Mackenzie, '06, in the interests of both bodies.

The matter of the annual dinner was discussed, the general expression tending toward a dinner more "School" in its naturel with better facilities for an intermingling of students and graduates.

The first sectional meetings on October 30th, were extremely well patronized. Mr. E. A. James, '04, the Engineer to the York County Highway Commission, spoke to the civil section on "County

Highways—their Construction and Upkeep." His lecture was well illustrated, and dealt for the most part with the various methods of road building, and materials of construction, with a view to their durability and safety. He touched upon the value of dust preventatives, and explained the action and efficiency of a number of preparations now on the commercial market. In the discussion following, Mr. W. M. Treadgold, '05, referred to the splendid work that Mr. James is doing in the interests of good roads leading into the city. Professor Wright and Mr. A. T. Laing, referred to the steps that are being taken by the Faculty of Applied Science in providing an efficient course of instruction in this branch of engineering, the time having matured when it should form a necessary part of the training of School men.

The electricals and mechanicals were addressed by Mr. Wills Maclachlan, '06, on "The Business Side of Central Station Work." His paper, which was published in the November issue of Applied Science, was of particular value to undergraduates, dealing as it did with points of importance on the commercial side of electrical engineering. The information his paper contained is not at the disposal of the average student in this course, and is only learned, some times inopportunely, by personal contact with office routine after graduating.

The miners and chemists were addressed by Professor Guess, of the department of metallurgy, whose resume of a trip through Peru, was of special interest and full of instructive data concerning engineering work in the south. He touched upon the transportation facilities to the interior region and also upon the progress that was being made on the Panama Canal.

Mr. J. A. MacMurchy, '96, chief draftsman for the Westinghouse Machine Co., East Pittsburgh, a paper from whom was published in March, 1910, issue of Applied Science, as a previous address to the Engineering Society—"A Novel Form of Reduction Gear," again favored the society with a paper at its general meeting on November 15th. The lecture, which was profusely illustrated with lantern slides, dealt with "The Evolution of the Reaction Steam Turbine." Many valuable points connected with the design and manufacture were exemplified. The large audience was fortunate in having the address, which was of special value to them, delivered in such an able manner by Mr. MacMurchy, he having an excellent conception of the parts of particular interest and value to the undergraduate, combined with a thorough knowledge of the subject itself. Dealing with the earliest forms of the steam turbine, the speaker traced the history of its development down to the present time and spoke of the methods of construction of the various types. He described high and low pressure turbines, pointing out the advantages and difficulties met with in endeavoring to obtain the highest possible efficiency. The wheel reaction of the Parson's turbine in 1884, was traced through its development to 1896, when the Westinghouse Co. acquired the patent right for America, and to the year 1907, when the special demand came for turbines of larger units.

He explained the modern turbines of high power and the methods that were being employed to secure better efficiency in them. The special adaptation to develop power and to use the exhaust steam for heating purposes was also touched upon. The lecturer spoke emphatically of the skill in design and workmanship necessary to obtain accurate results in turbine manufacture.

Professor R. W. Angus, in moving a vote of thanks, outlined the general replacement of turbines and other forms of rotary engines for reciprocating engines. He stated that two turbines of Mr. MacMurchy's construction are being used on the high-pressure fire system in Toronto.

It is to be hoped that Mr. MacMurchy can rearrange the subject matter of his paper for publication in Applied Science, that it may be of like benefit to graduates. His devotion to the subject, his sacrifice of time and duties in coming to Toronto, to address the Engineering Society, and his generous treatment of the methods of construction, were very heartily appreciated by the students.

On November 25th, a special meeting was called to hear Mr. E. L. Cousins, '06, Engineer to the Toronto Harbor Commission. Mr. Cousins is in the front rank among recent graduates of the School, and his professional attainments since graduation are interesting. Until 1910, he was division engineer for the Grand Trunk Railway Co., with headquarters at Toronto. In July of that year he became assistant city engineer, in charge of railways, bridges and docks, from which he resigned after 18 months' service to accept his present position with the Harbor Commissioners. His success in this capacity has claimed the interest of every citizen of Toronto, and of all the harbor engineers throughout America, in his comprehensive set of plans for the development of the city water-front. This was the subject of his address to the Society at the special meeting. In February of this year preliminary work was commenced under his direction, to make a complete survey of the water-front, from Victoria Park to the Humber, together with a hydrographic examination of a harbor bed. Some 8,000 soundings were required to furnish data concerning the depth of water and ultimate depth of rock. A complete investigation was made of the nature of the material with a view to reclamation work and to dredging the harbor to afford proper facilities for docking boats of any size.

Then, on December 13th, another important general meeting was held, the speaker being Mr. J. Keele, '93, who described the resources of Canada for the clay industries. His lantern slides were interesting views of clay deposits in various parts of the Dominion. his paper appears elsewhere in this issue. Mr. Keele was commissioned by the Dominion Government to make a complete investigation of the clay resources of Canada. His work in the field is now being supplemented by a laboratory investigation into the nature and properties of several tons of samples procured from the numerous clay beds. This is being carried on at present under Mr. Keele's direction in the metallurgical laboratories of this institution.

EXCURSIONS

Several trips of importance have been made to industrial plants in and out of the city during the past month. Mr. T. R. Loudon took about 160 men of the senior years to the works of the Lackawanna Steel Company at Buffalo. The trip was, as usual, most instructive, and the management of the Company, and Mr. Loudon as well, were the recipients of expressions of appreciation from the students for their painstaking care in affording them ample opportunity to see the various stages of manufacture. The excursion was certainly one of pleasure, but primarily one of instruction, and no small thanks is due Mr. Loudon for his yearly efforts in making the trip a complete success.

Another profitable trip was to Niagara Falls. About 40 men of the fourth year, accompanied by Prof. R. W. Angus, were the guests of the Ontario Power Co., The Canadian Niagara Power Co., and the Toronto-Niagara Power Co., on the Canadian side, and the Achison Graphite Co., on the New York side of the river.

On the occasion of the Intercollegiate post series game between McGill and Varsity at Ottawa, the fourth year men in large numbers were afforded an opportunity of visiting several industrial works in that city and Hull. Among these might be mentioned the visit to the large plant of the E. B. Eddy Co., where a most courteous reception was given them.by the management. The different departments devoted to the manufacture of matches, fibre-ware, paper, etc., were all investigated. Prof. Gillespie, who is accomplished in the knack of enducing educative replies from guides, for the benefit of the men in his charge, accompanied the party.

The men taking the sanitary engineering course have taken a few afternoons off, and count them exceedingly well spent. Especially so in the case of their trip to Stratford, Galt, Berlin and Preston, with Dr. Amyot and Prof. Gillespie accompanying them. At Stratford the city engineer, Mr. A. B. Manson, '09, made their visit most enjoyable and instructive. The old septic tanks were in the process of cleaning, and the new sprinkling filters, which have since been put into successful operation, were just being finished.

In Galt, Dr. Vardon, the M. H. O., directed their attention to the waterworks system. The supply is provided through a system of gallery construction as well as from wells.

At Berlin, besides a close examination of the most efficient and up-to-date slow sand filter in the province, there was a beet sugar manufactury to inspect. Dr. Amyot was most instrumental in affording every chance for the men to get acquainted with the processes. The slow sand filter and septic tank system in Preston formed the basis of a visit there that proved also of value.

In Toronto, the development towards more and satisfactory disposal of sewage has not been overlooked. Prof. Gillespie and Mr. Laing accompanied a party of men to the Toronto sewage disposal works, where Mr. J. H. Nevitt, '03, who is assistant engineer, main drainage department, acted as guide and took pains to elucidate the functions of the various compartments and machinery, as planned for the finished work. A similar visit was made to the filtration plant at the Island.

On December 6th the Government experimental stations, in charge of which is Mr. F. A. Dallyn, '09, was also visited under Dr. Amyot's guidance.

The men in roadway engineering have made several trips to local points to examine the season's work in road building. The Lake Shore Road, Weston, and North Toronto roads were among those visited. The efforts of Mr. A. T. Laing and of Messrs. E. A. James, '04, A. E. Jupp, '06, who was superintendent of that part of the work done by Routly, '06, and Summers, '07, roadway engineers, Haileybury, and J. T. Howard, '13, resident engineer, made the trips very profitable.

SOCIAL FUNCTIONS

Owing to the necessity of holding the Engineering Dance earlier in the Easter term than usual, it has been given the place of the annual school dinner in January, while the latter will be held on February 13th It was announced in the October issue that the dinner might be held toward the end of the present term, but owing to the numerous meetings and other functions, the idea was necessarily discarded. The engineering dance will be held on Friday evening, January 24th, in the Knights of Columbus hall. The old gymnasium is now a matter of history, its demolishment being the first stroke preparatory to the erection of the new Massey Memorial building. Consequently, in the absence of another building in the University that could adequately accommodate this important function, the hall on Linden St. providing accommodation for 225 couples, was engaged. Every effort is being made to eclipse the Engineering dances of previous years, which have already superceded all other University social functions.

THE ELECTRICAL CLUB

With the close of this University year the University of Toronto Electrical Club completes the eighth year of its existence. The members of this year's executive are:

President	R. J. Allen, '13.
Vice-President	R. G. Matthews, '14.
Secy.-Treas.	F. R. Sims, '13.
Councillors	W. B. Buchanan, '13,
	P. H. Mills, '14,
	E. D. W. Courtice, '14.

The first meeting of the year was called on October 22nd, 1912, to hear Mr. Horatio A. Foster, Mem. A.I.E.E., Mem. A.S.M.E., Consulting Engineer of New York and Editor of *Foster's Electrical Engineer's Handbook*. His subject was Engineering Reminiscences, and the talk was full of interest to the students in that it showed the peculiar difficulties under which the pioneers in electrical engineering in this country worked. Mr. Foster also gave an idea of the rapid strides made in electrical work in the course of one man's life time. The meeting was well attended despite the inclement weather and about fifty students were on hand to thoroughly enjoy the most interesting talk.

The next meeting was held on Nov. 6th, and was addressed by Prof. R. W. Angus. His subject was "Turbine Pumps and their Application." The address was well illustrated with slides and the subject was well handled by Prof. Angus in his usual clear-cut style. The meeting was thrown open for discussion afterward and the number of questions asked evinced the interest taken in the address by the members.

The third meeting was held on Nov. 28th. The subject "Electrical Illumination" was taken by Messrs. M. B. Hastings, '11, and J. H. W. Joyner. Mr. Hastings presented his subject in his usual breezy style. A good attendance turned out to hear him.

As the object of the club is two-fold, viz., to give the members an idea of the most modern practice in mechanical and electrical engineering by means of papers more technical than are given in the meetings of the Engineering Society, and secondly, to develop the ability of the students in expressing themselves in public, the latter part is accomplished through the discussions on the paper of the evening. These discussions are always helpful and often bring out points which the speaker has failed to make clear.

Besides the fortnightly meetings, during the fall term, there have been trips made to points of interest in the city and neighboring places. On Nov. 9th, a visit was made to the Russell Motor Car Co. works, a large number of members availed themselves of the opportunity of visiting this plant. Another trip was that made to the Sunbeam Lamp Co. plant, while a third excursion was to Niagara Falls under the direction of Prof. Angus, where the different power plants were visited. These excursions are very profitable to the students in that they give them a chance to see something of the methods and organization of the different manufacturing and power companies.

By such excursions and by its meeting the club is endeavoring to fill a place in student life by opening before the members the opportunities in the field of mechanical and electrical engineering, a purpose which in itself justifies the existence of the Club, and the flourishing condition of the Club shows the degree to which the students appreciate the effort.

THE ARCHITECTURAL CLUB

The Architectural Club of the University of Toronto was formed during the latter part of 1911 and during the first few months of its existence made a little start towards bringing the men of the department in closer touch with professional interests.

An added impetus was given to the club, however, at the beginning of the present term, due largely to the changing character of the Department of Architecture, in which the artistic has begun to supplant to a certain extent the engineering tendencies of the early days. Two of the meetings have been held at down town tea-rooms, and the concensus of opinion is that the presence of "eats, smokes," and good fellowship, coupled with a purely informal talk by a porfessional man who is "doing things" will do more for the growing club than the presence of a scattering of men, in a large class-room, and attending them with a feeling that it is a duty, could ever do.

The executive of the present year have attempted to broaden the scope of the club by obtaining permits to visit all the buildings in the course of erection on the grounds. They also hope to have trips over large structures when they are completed and during the course of erection, with a talk by the architects in charge on the actual scene of operations.

Four meetings have been held during the present term and all have been largely attended. Mr. J. B. K. Fisken, B.A.Sc., '10, opened the year with a travel talk on Southern Europe. Mr. John M. Lyle, the honorary president of the club, on "Style in Architecture," spoke at the next meeting which was the first held down town. Mr. J. Keele, '93, talked later in the year on "Colour in Design," and Mr. J. P. Hynes closed the meetings of the Christmas term with an interesting discussion on architectural education.

In summary, the club has held a very successful year and should become a connecting link of vital importance between the professional interests and the School. Mr. John M. Lyle, the honorary president, has always taken a great personal interest in architecturel education, and the club is to be congratulated on having him for the premier position.

A great deal of thanks must be tendered to Prof. C. H. C. Wright for the kindly interest and able advice he has given throughout the creative period of the club.

The executive of 1912-13 is made up as follows:—Mr. John M. Lyle, honorary president; Burwell R. Coon, '13, president; L. C. M. Baldwin, '13, vice-president; J. Murray Robertson, '14, treasurer; Merrill Denison, '15, secretary; A. Curry Wilson, '14, councillor; Kenneth C. Burness, '15, councillor; Francis A. Swinnerton, '16. councillor.

THE ENGINEERING PROFESSION

An Impassioned Appeal for Closer Organization of Qualified Engineers

By P. D. Hardup, B.Sc.

The present moment offers a rare opportunity to address a few words to you, dear Editor, anent the subject of "The Engineering Profession." (I think that is the usual manner adopted to introduce a subject of this kind). During the past year engineers in general and the engineering profession in particular have been freely discussed, boosted, abused and generally criticised by the press throughout the Dominion.

Being so well known to most of the engineers of the country—for who can say that nearly all engineers at one time or another, and most of them all the time, are not well acquainted to Pretty D. Hardup?—I write with some authority.

Of course, sir, you can understand that to deal with the engineering profession with any degree of fairness and propriety would require an extensive treatise reaching into many volumes. Just stop and imagine the writer trying to treat the queston alone of the lady engineer in less than 500 pages. The possibilities of that one chapter of the profession by itself, which was barely suggested in ten or fifteen pages written for APFLIED SCIENCE in 1907 by that eminent engineer, E. C. Easy, C.E., would cover several volumes in themselves, and the "School" has had some experience here. We have only to search amongst the handsome faces of the B.A.Sc.'s of 1911-12 to find that out. We cannot, therefore, in but a page or two, make more than a few cursory statements on the subject which, perhaps, is the farthest reaching one that could be recorded.

The first question that comes before us is: What is an engineer? Without turning up one of those painful encyclopediae that that book agent "stung" you with last week (oh, engineers are sure some easy bunch!), let us take the definition given by a reliable dictionary. "Engineer, [formed on type of charioteer, musketeer, etc.]. Originally one who managed military engines or artillery;" (ah ha, there's where our 2nd Field Company plays its part); "now, one who manages a steam engine or has to do with the construction of steam-engines or steam-machinery," (exit, 2nd Field Company, enter, donkey-engine operator—we're progressing); "or a person skilled in the principles and practice of engineering, either civil or military," (enter the lady-killer and the boy scout, arm in arm), and so on, *ad. lib.*

So we all must agree that a person calling himself, or herself, an engineer, and not further qualifying the term, may rightly be inferred to operate an engine for some railroad. Why, I know men who go about wiring houses who call themselves electrical engineers. And, pray, why not? The engineering profession is certainly one open profession. It is the one profession that typifies British freedom. Any one can be an engineer, whether he runs a steam engine, a gasoline launch, installs water-pipes, or does a thousand other things.

The doctor, the lawyer, the chartered accountant, the dentist, the school teacher, the veterinary surgeon, and any one of several other respected and refined professions can rest fully and absolutely assured that they are what they say they are and no one can gainsay him, or her, with impunity. Not so the engineer. Half the engineers in the country can show nothing more than some class of membership in the society, and many even have not that. And does that membership really show anything in particular as far as actual qualifications are concerned, in most cases; and does it afford any real, definite and protected standing that will permit a man, or not permit him, to build bridges, or engines, or buildings, or railroads?

There is one profession, like ours, yours and mine, dear Editor—the ministry. Goodness knows anyone can be a minister. I understand that there are colleges in the States that turn them out, degree and all, after six months. But even that is not always necessary. If a minister gets tired of one denomination, he joins another; if he is thrown out of one he forms a new one and sometimes becomes a wonderful bishop or a divine prophet. Thus we have "some hundreds" of him in America.

So you see from this how closely related are these two professions—the ministry and engineering. The general system and the organization in each profession are the same in practice and only different in appearances.

I noted that a couple of dailies recently carried want ads. for barbers' helpers and bakers' helpers under the heading of "Mechanics Wanted." While these may be right, I do not know, I imagine now that the plumbers call themselves "sanitary engineers" and city commissioners style themselves "city engineers," that head bakers and head barbers will be advertised for under the heading of "mechanical engineers." By that time scavengers will be "sanitary experts."

I might elaborate along these lines, my dear sir, till I am devoid of breath. But what is the good? The conclusion is the same. But let us keep up hope. After all we have the matter in our own hands. It will only be a matter of time when engineers will hold their profession with as much pride and dignity as do the doctors, the lawyers and the others. These are all well organized, as even the bricklayers, the carpenters, and the plumbers are organized.

The engineer is not organized. He is not necessarily a graduate nor a member of any body or organization, except when he becomes a surveyor, and very often may be a poorly informed person.

"So there you are, and if you are not, where are you?" to quote the words of a popular comic opera.

ANNUAL DINNER OF CLASS '15

"One of the best class dinners I have ever attended," was the way Dean Galbraith described the annual dinner of the class of '15. The dinner itself, held at McConkey's on Wednesday, Dec. 11th was a splendid success, and reflected much credit on the efforts of President Steel and his executive. Several innovations were worked into the program, the most successful being the presence of the "Toike-Oikestre." Mr. Leach, the leader of the orchestra, has a splendid aggregation of musicians, and they made it very enjoyable, both during the banquet and also by the selections which they rendered during the progress of the toast list. After the toast to the king, the toast to the "School" was proposed by Mr. C. K. McPherson, who outlined briefly the many and varied lines of work in which graduates of the "School" are at present engaged.

Dean Galbraith, in replying was, as usual, very interesting and very humorous. He explained that the reason a man comes to university is to be educated like his fellow, like the men with whom he will have to compete during his business career. The greatest asset a man can possess is to be placed on a level with his competitor, as far as education is concerned. The Dean said that an educated man was the only man who was not afraid to discuss things with which he was not perfectly familiar. He referred to the immense number of subjects being taught at the present time, due to the fact that it was very difficult to get rid of the old subjects and to give room to the newer and more up-to-date things that were so necessary for success to-day. In closing he emphasized the value of experience and explained that while the graduate of to-day was educated along a great many more lines than the graduate of ten years ago, still the older man with the wider experience holds an advantage over his younger rival.

Mr. E. M. Monteith proposed the toast to the University, which was replied to by Dr. W. H. Ellis. Dr. Ellis spoke of the different mental pictures or conceptions of a university which were held by different people. To some it was a collection of buildings, of the nature of a factory and doing a regular commercial business; to others it was a heaven, whose streets ran with beer while the saints walked around with their faces spotted with court plaster. Some would associate thoughts of their university with odours of the dissecting room or the smell of sulphuretted hydrogen, while a large majority think of their alma mater as the training ground for their social and intellectual natures.

The inference to be drawn is that a man's idea of his university reflects the character of the man himself and the side of college life which appealed most strongly to him during the course.

The toast to "Modern Engineering" was proposed by Mr. D. B. Webster, who gave an account of the work of the chemical engineer. This was very interesting as the chemical engineering course is comparatively new and not very well understood by the majority of the students.

In replying to the toast, Mr. T. R. Loudon said that he did not have any work with the second year and consequently he did not see them as often as he had during the first year. He referred to one occasion towards the first of the term when he looked out on the south campus upon a scene of activity and evidently considerable interest. On this occasion he had "seen" more of the men than ever before. He referred to it as a very poorly concealed "skin" game. In dealing with the trend of modern engineering Mr. Loudon said that until quite recently engineers had not been vitally interested in the commercial or business end of their work. They had been called in to give advice on certain undertakings, or to carry out the mechanical work in connection with certain projects, but the financing and developing of the work had been left to other men. To-day that is all changing, the engineer sees that he has fields of work along commercial lines; that the separation of business and engineering is not imperative. There is no necessity for the business man to make the huge profits, while the other man does all the planning and constructing. To accomplish this end the speaker showed that the engineer must have a thorough knowledge of costs and cost systems in order that he may speak with accuracy when he has to answer the question, "How much will it cost?"

"Class '15" was proposed by Mr. J. T. Mogan, who referred to the quotation applying to his toast, "Blessed are the Peacemakers." Mr. Mogan intimated that the ability of the year in the "piece" making line had been fully demonstrated on several occasions but he thought that the efforts of peacemakers had not always been appreciated.

Mr. J. Roy Cockburn, in response to this toast thanked the boys for the honor they had conferred upon him in choosing him as their patron saint. He assured them of his interest in the year, and in closing gave them a very excellent motto in the form of Kipling's description of a perfect man, which runs in part:—

If you can keep your head when all about you,
Are losing theirs and blaming it on you;
If you can trust yourself when all men doubt you
And make allowance for their doubting too.....

The last toast on the list was the one to athletics. It was proposed by Mr. E. H. Jupp, of hockey fame. He outlined briefly the athletic endeavours of '15, dwelling chiefly on the fact that the aim of the class had been to interest more men in athletics and to afford them opportunities to indulge in the different branches that appealed to them. To this end, inter-section leagues had been formed in hockey, baseball, and this fall, in rugby. In the hockey section the Electricals had been "champs," while in rugby they had to give place to the civils. The year had also made a very strenuous fight for the Loudon shield, emblematic of the inter-year hockey championship at the School.

Prof. C. H. C. Wright, in reply, said that he thought athletics were a very necessary part of a man's college education, the training he received in athletic competition being invaluable. He spoke of the big men of athletics who were members of year '15, "Pete" Campbell, captain of the "firsts" and "Dusty" Brown of Ottawa-McGill reputation and others who had helped to win honor for the university. Then in the inter-faculty we had the honor of winning the Mulock Cup, largely through the efforts and hard work of the energetic manager, Roy Cavers. We must give much credit, it is true, to the first year men, but still the men of year '15 made a brilliant showing and could be relied upon, when a hard game was ahead, for such men as Catto, the captain, Daniels, Cockburn and Adlard, Wallis, Graham and O'Reilley. Prof. Wright noted that on consulting the class lists of last year one would almost infer that honors in examinations had been made a condition for membership on the team.

At the request of President Steel, Prof. Wright gave a detailed description of the wonderful new gymnasium and club house which is now in course of erection, and which we owe largely to the interest and efforts of Mr. Vincent Massey.

After a vote of thanks had been tendered to the guests, the executive and orchestra, the evening was brought to a close by singing our national anthem.

THE ALUMNI DINNER

The Toronto Branch of the Engineering Alumni Association held its semi-annual dinner on Dec. 17th, the president, J. C. Armer, '06, occupying his official chair. Dean Galbraith honored the occasion by his presence, and the one hundred School men who represented the graduates of his School were delighted to have him as their guest and to hear him at his best. In calling the members from refreshment to attention the President expressed his pleasure at the good attendance despite the numerous counter-attractions for the same evening. It was regretted that the meeting of the Society at Chemical Industry at the same hour prevented the attendance of Dr. Ellis and a number from his department, including Mr. Shaw, one of our research scholars. Professor Haultain, W. E. H. Carter, and a number of others, whose great interest in the Scholarship movement occasioned an assurance that they would be there with something of importance to say, were keenly missed.

At the head table, besides the Dean, and Mr. Armer, were Prof. L. B. Stewart, C. H. Mitchell, G. R. Mickle, E. A. James, H. W. Price, T. R. Loudon, and T. H. Hogg.

The discussion of the evening surrounded the progress of the research scholarship movement. The secretary described what had already been done, particularly from the financial view. The enterprise had been a topic of conversation among a number of ardent School men for several years. In May, 1911, the Association drew up and adopted a set of by-laws to govern scholarships. During a few months in 1911 a canvass among graduates resulted in contributions to the value of $950.00 yearly for three years. Of this amount about $825. had already been collected as first and second payments. First payments amounting to $320. had not as yet been received. In June, 1912, a further call for subscriptions netted $250. yearly for three years. Of this $210 has already been received as first payment.

Thus, before the awarding of two scholarships last October, the graduates had subscribed $1,200 yearly for three years.

The two scholarships, to the amount of $500 each, are being paid in six equal monthly instalments, the first in October, 1912. The March payment will make a total of $1,000. expended towards research in the laboratories of the School. The only other expenses are those incidental to furthering the movement and general items of printing, postage, exchange on cheques, amounting in all to $111.75 since May, 1911.

Dean Galbraith, in commenting upon the great value of the movement, expressed his opinion that each research scholarship must be governed by its own particular conditions, and that the prime difficulty for the association lay in defining these conditions. Stress was brought to bear upon the importance also of what scientists had previously solved before attempting an invasion into the realm of knowledge undiscovered. The proper selection of graduates to carry on our research work—men specially gifted—means much to stimulate and improve research. Finally he warned us to expect disappointments here and there in our work, and not to hope for success to crown every effort.

C. H. Mitchell spoke encouragingly of the movement. He intimated that in the graduate body there would be many with problems of vital importance to them in their work, but who had neither the time, facilities nor ability for research themselves, and who would gladly present their problems for consideration, if required, believing that if these problems were given to the men who have the ability for such investigative work, material good would ensure. He also suggested that our present research fellows, Messrs. Shaw and Dobson, should be communicated with by those graduates who are confronted with problems of similar nature.

Professor Price explained the method adopted by Mr. Dobson in studying the disturbances in high tension transmission lines and described how good progress had already been made in perfecting an automatic operation of the oscillograph.

In the course of the evening's talk the announcement was made of the election of T. R. Deacon, '91, to the mayoralty chair of the city of Winnipeg and was given a rousing reception.

The "Toike Orchestre" furnished quite sufficient music to eliminate all the ear-marks of a business meeting and was accorded a unanimous vote of thanks for its kindness in taking such a prominent part in the evening's proceedings.

M. B. Watson, '10, and T. A. Fargey, '09, have entered the employ of the Toronto Electric Light Co.

W. Almon Hare, '99, president of the Hare Engineering Co., Limited, Toronto, has returned from a summer spent in Europe.

F. H. Sykes, '05, has been appointed chief examiner of plans for the city architects' department, Toronto. Mr. Sykes was previously assistant structural engineer in this department.

H. P. Rust, '01, has been appointed engineer-in-charge of one of the largest hydro-electric developments in the West, by the Great Western Power Co., in San Francisco.

Wm. Snaith, '07, who was associated with Frank Barber, bridge and civil engineer, Toronto, is secretary-treasurer of the Thor Iron Works, Limited, a new corporation equipped for the fabrication of steel tank and plate work, steel trusses and light structural work.

DIRECTORY OF THE ALUMNI

Giving each month, in alphabetical order, the location of a number of the graduates. The entire list will be reviewed in the twelve issues beginning November 1912.

The graduates will confer a favor by advising us of any and all instances where the list is not up-to-date. Addresses unknown, or no longer correct, are hard to eliminate entirely from our records. If graduates will see that the information given about *themselves* is exactly as it should be, and that that concerning their class mates is also correct to the best of their knowledge, the department will soon be most reliable.

B (*Continued*)

Beith, R. E., '09, is in the employ of the Department of Public Works, Toronto.

Bell, G. G., '05, is with Sawyer & Moulton, a firm of consulting engineers, Portland, Me.

Bellisle, J. P., '06, deceased, May, 1906.

Bennett, G. A., '09, is, according to last report, with the Department of the Interior, Calgary. His home is in Edin, Ont.

Bergey, A. E., '94, is an instructor in the Carnegie Technical Schools Pittsburgh, Pa.

Berry, E. W., '10, is on Dominion land survey work, Department of the Interior, Ottawa. He is a D.L.S. man.

Bertram, G. M., '01, is manager of the Joplin, Mo., branch of the Sullivan Machinery Co., manufacturers of mining and quarrying equipment.

Betts, H. H., '06, is in Rio de Janeiro, Brazil, for the Rio de Janeiro Tramway, Light & Power Co.

Beynon, D. E., '06, is in the employ of the Dunlop Tire & Rubber Goods Co., Toronto, as superintendent.

Billings, J. H., '11, is in Cochrane, Ont. We don't know upon what kind of work he is engaged.

Bingham, H. C., '10, is in the office of the city engineer, Moose Jaw, Sask.

Birchard, E. R., '09, is in the employ of the Russell Motor Car Co., West Toronto, in the transmission gear department.

Bissett, D. C., '10, is engineer for the Dome Mines, Porcupine, Ont.

Bissett, G. W., '06, is mill superintendent for the Canadian Exploration Co., Limited, at Naughton, Ont.

Bissett, J. R., '11. His home is in Kincardine, Ont. We do not know his present employment.

Black, G. E., '08, is with the Ontario Government as roadway engineer, and is at present in charge of work at the Ontario Prison Farm, Guelph.

Black, R. G., '95, is managing director of the Federal Engineering and Supplies Co., Toronto.

Black, W. D., '09, is superintendent of the eastern branch of the Otis-Fensom Elevator Co., with headquarters in Montreal.

Blackwell, R. H. H., '10, is resident engineer for the Canadian Northern Ry. at Biscotasing, Ont.

Blackwood, A. E., '95, is manager of the New York office of the Sullivan Machinery Co.

Blackwood, W. C., '06, is instructor in physics, Technical High School, Toronto.

Blair, W. J., '02, is carrying on a civil engineering and surveying practice, with office in New Liskeard, Ont.

Bleakley, J. F., '85, is engaged in a general engineering practice at Bowmanville, Ont.

Blizard, D. C., '09, is in the engineering department of the Toronto Electric Light Co., Toronto.

Boeckh, J. C., '06, is in Toronto, and is with the Boeckh Brush Co. as a member of the firm.

Bonnell, M. B., '04, whose home is in Bobcaygeon, Ont., has no business address with us at present.

Boswell, E. J., '95, is on the engineering staff of the Canadian Pacific Railway Co., with residence in Toronto.

Boswell, M. C., '00, is lecturer in organic chemistry, University of Toronto.

Boswell, W. O., '11, is in electrochemical work. His home address is 25 Roxborough St. W., Toronto.

Boulton, W. J., '09, for several years with the Welland Ship Canal engineering staff, and on a post graduate course last year, is in the West this fall.

Boustead, W. E., '90, deceased.

Bow, J. A., '97, is in Great Falls, Mont., with the Boston & Montana Mining & Smelting Co.

Bowen, G. H., '09, is chief draughtsman for the Hamilton Gear and Machine Co., Toronto.

Bowers, W. J., '01, deceased, December, '06.

Bowes, H. F., '08, is superintendent of the Warren Bituminous Paving Co., Toronto.

Bowman, A. M., '86, was a member of the Pennsylvania Contracting Co., Pittsburgh, when last heard from.

Bowman, E. P., '10, His home is in West Montrose, Ont. We do not know his professional activities.

Bowman, F., '11, is with the Dominion Biidge Company in the office at Lachine, Que.

Bowman, F. M., '90, for ten years with the Riter-Conley Mfg. Co., as secretary and director, is now vice-president and director of the Blau Steel Construction Co., Pittsburgh, Pa.

Bawman, H. D., '07, whose home is in London, Ont., is with H. D. Symmes & Co., Niagara Falls, Ont.

Bowman, H. J., '85, is a member of the firm of Bowman & Connor, consulting municipal and structural engineers, Toronto and Berlin, Ont. It was Mr. Bowman who contributed the first paper read before the Engineering Society. Its title was "North-West Surveys." It was not published in the Proceedings, as Mr. Bowman went to the front in the Rebellion of '85 before getting his notes in shape for printing.

Boyd, D. G., '94, is in Toronto, in the Department of Lands and Mines, Parliament Buildings.

Boyd, W. H., '98, is in Ottawa, topographical branch, Geloogical Survey, Department of the Interior.

Brace, J. H., '08, for three years with the New York Telephone Co. plant and equipment departments is now with the Bell Telephone Co., in Montreal in the same capacity.

Brackenreid, T. W., '11, is in the employ of the Canadian General Electric Co., in Peterborough, Ont.

Brady, W. S., '07, until recently with the Westinghouse Electric and Manufacturing Co., Pittsburgh, is at his home in Toronto at present.

Brandon, E. T. J., '01, is assistant engineer for the Hydro-Electric Power Commission, Toronto.

Brandon, H. E., '06, is chief engineer of the Vulcan Iron Works, Winnipeg, Man.

Bray, L. T., '00, is in Edmonton, Alta., in the Department of Public Works.

Brebner, G., '85, deceased, Feb. 21, '07.

Brecken, P. R., '08, is assistant secretary Y.M.C.A. with headquarters in Toronto.

Brereton, W. P., '01, is in Winnipeg, Man., He is engineer in charge of the city project to supply water from Shoal Lake.

Breslove, J., '03. We do not know his present address. He was in the steam turbine department of the Westinghouse Machine Co., Pitts burg, when last heard from.

Brian, M. E., '06, is city engineer of Windsor, Ont., and also engineer for several adjacent townships,

Bristol, W. M., '05, is in the Halifax, N.S., office of the Canadian Westinghouse Co.

Broadfoot, F. C., '06, is engaged in concrete contracting work at Coquitlam, B.C.

Brock, A. F., '10, is with the Canadian Copper Co., at Copper Cliff, Ont.

Brock, W. M., '11, is taking post graduate work in the Faculty of Applied Science and Engineering.

Brodie, W. M., '95, is, to the extent of our present information, with the Green Engineering Co., Pittsburgh, Pa.

Broughton, G. H., '07, is manager of the People's Trust Co., Penticton, B.C.

Broughton, J. T., '01, is chief engineer of the Scotdale Foundry & Machine Co., Scotdale, Pa.

Brouse, W. H. D., '11, is in this city, with Smith, Kerry & Chace.

Brown, J. M., '02, was in the steam turbine department of the Westinghouse Machine Co., Pittsburg, when we last heard from him. We do not know his present address.

Brown, T. W., '06, is engaged in surveying and civil engineering work at Saskatoon, Sask.

Brown, D. B., '88, who was, when last heard from, locating engineer, Grand Trunk Pacific, is on our list of unknown addresses.

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THE COMPOSITION OF FUSEL OIL FROM BEET MOLASSES*

By M. C. Boswell, '00, and J. L. Gooderham, '11.

The published proximate analyses of fusel oil are very few and mostly relate to the distillates from potatoes and corn. This arises from the fact that, until comparatively recent years, fusel oil from any source was regarded as more or less valueless. In Canada, after legislation put a premium on its destruction, this product was allowed to run away in drains or used as a constituent of a cheap burning fluid. The numerous purposes to which it is now applied and for which it is indeed indispensable, have changed this custom so that it has become four or five times as valuable as the alcohol from which it is separated.

The production of fusel oil from the fermentation of beet molasses depends industrially on a supply of crude material from beet sugar refineries, which did not come into existence on a large scale in Canada until about seven years ago. An alcohol plant, capable of handling from 30,000-40,000 tons of molasses per annum, was established in Toronto in 1905, and very considerable quantities of fusel oil have since been produced, for which a home use, or an export value, has to be found.

The researches of Ehrlich[1], carried on since 1903, ultimately led to the conclusion that the production and composition of fusel oil depend on the character of the substance fermented, mainly with relation to the quantities of leucine and isoleucine present. As beet molasses mash differs very widely from that from potatoes or grain, it might be expected that a corresponding difference would be noted in the quantities and proportions of the amyl alcohols. The particular composition of beet molasses fusel oil is hence a question of considerable technological importance.

The fusel oils of commerce differ very widely in their general characteristics, such as color, specific gravity and solubility in water, being influenced not only by the nature of the material operated on, but by the form of distilling apparatus, the process followed, and the care of the operator. The excise authorities generally look

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1 Summarized in Harden's *Alcoholic Fermentation*, 1911, pp. 75-82.

sharply after the presence of ethyl alcohol, and their requirements regarding this affect the presence of other alcohols soluble in water. In the United States, the official and commercial regulations confine the term "crude fusel oil" to that from which the lower alcohols have been so far removed by washing, that a loss of not more than 10 per cent. is realized by agitation with an equal bulk of water. The term is thus used in this paper. Hence the percentage of water-soluble alcohols in fusel oil will depend, to some extent, on whether the manufacturer has found it necessary to wash his oil in order to meet the excise requirements respecting ethyl alcohol.

The oil examined was amber in color. It was found that the substance or substances causing the color were soluble on shaking in dilute caustic soda. Traces of iron and copper were found, due probably to contact with these metals in the process.

The specific gravity of the sample, taken by the pycnometer, at 15° C. was 0.8370. This is somewhat higher than the figures given for fusel oil from corn, which differ widely as stated by various authorities. Worden[2] gives the range for ordinary samples of washed oil as between 0.810 and 0.835. It is evident that this character will be largely influenced by the amount of water dissolved in the oil, and also by the lower alcohols which have escaped the washing-out process.

In the fusel oil examined, the lower alcohols (ethyl, propyl and butyl) were roughly estimated by agitating equal volumes of oil and water thoroughly in a measuring tube, and noting the increase in volume of the water layer. This amounted to 8 per cent. In a similar manner the amount of water was determined approximately by agitating 10 cc. of the oil with 100 cc. of petroleum benzine and measuring the water layer. This amounted to 5 per cent. Then 500 cc. of crude unwashed fusel oil was thoroughly dried over anhydrous sodium sulphate and fractionated repeatedly until the volumes of the fractions remained constant. The result was as follows:

I.	II.	III.	IV.	V.	VI.	VII.
75°–80°	80°–85°	85°–90°	90°–105°	105–115°	115°–120°	120°–125°
7 cc.	18 cc.	6.5 cc.	11 cc.	22 cc.	27 cc.	29 cc.

VIII.	IX.	X.	XI.
125°–128°	128°–130°	130°–133°	residue
45cc.	260cc.	33cc.	10cc.

TOTAL, 473.5 cc. WATER, 20.0 cc. LOSS, 6.5 cc.

A sample of the crude oil was thoroughly agitated with water, and the oil separated and dried: 500 cc. of this on fractionation gave the following:

I.	II.	III.	IV.	V.	VI.
75°–80°	80°–85°	85°–90°	90°–110°	110°–115°	115°–120°
none	none	very little	10 cc.	10 cc.	25 cc.

VII.	VIII.	IX.	X.	XI.
120°–125°	125°–128°	128°–130°	130°–133°	residue
40 cc.	75 cc.	278cc.	51 cc.	10 cc.

TOTAL, 499 cc. LOSS 1 cc.

2 Worden, *Nitro-Cellulose Industry*, 1, 2[illegible]8

On comparing the results of the two fractionations it will be noted that fractions I, II and III have practically disappeared from the washed oil. These were identified, as will be shown later, as lower alcohols which are more or less soluble in water.

Although the boiling points indicated the particular alcohols which were present in the various fractions, it was decided to substantiate this by transforming the alcohols into esters. On examining the literature, it was found that the esters of acetic acid were more completely described than those of any other acid, and consequently served best for purposes of identification. Action with acetyl chloride alone was found to be unsatisfactory, yielding a mixture in each case difficult to fractionate, and always leaving a high boiling residue, indicating that the reaction was not one of simple esterification alone.

The method of Einhorn[1] was adopted and proved very satisfactory.

Accordingly 10 grams of each fraction were dissolved in about 60 grams of pyridine, and a little more than the theoretical quantity of acetyl chloride was added. After standing for 6-8 hours the mixture was poured into cold dilute sulphuric acid. The ester which separated as an oil was dried over anhydrous sodium sulphate and fractionated.

The following were the results:

Fraction I (75°–80°).—See table.—The boiling point indicated ethyl alcohol, which was confirmed by the iodoform reaction.

Fraction II (80°–85°).—The b. p. indicated the presence of isopropyl alcohol—b. p. 82.8°. The ester on fractionation boiled chiefly at 90°–94°, the boiling point of isopropyl acetate. This fraction was hence largely isopropyl alcohol.

The boiling points of fractions III and IV, as well as fractions VII and VIII made it difficult alone to decide with certainty as to the particular alcohols present. However, upon transformation into acetic esters, and careful fractionation, it was found possible to identify them.

Fraction III (85°–90°).—As this fraction was very small, it was esterified and added to the ester from fraction IV.

Fraction IV (90°–105°).—The ester distilled chiefly between 110°–120°. It was hence the isobutyl ester—b. p. 115°–117°. A little isopropyl, and traces of amyl esters, were also detected.

Fraction V (105°–115°).—The b. p. indicated the presence of isobutyl alcohol—b. p. 108°. The largest portion of the ester was recovered at 110°–120°, the temperature being very constant at 115°–117°, indicating isobutyl ester. A very small quantity of normal butyl ester, with a boiling point of 125°, was obtained. This fraction hence consisted chiefly of isobutyl alcohol with some normal butyl alcohol.

Fraction VI (115°–120°).—The b. p. indicated the presence of normal butyl alcohol—b. p. 117°. The main portion of the ester came over at 120° to 130°; mostly at 125°, the boiling point of the

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1 Liebig's *Annalen*, **301**, 95, Einhorn.

n. butyl ester. Some methyl normal propyl carbinol ester, with a boiling point of 133°–135°, was recovered also. This fraction hence consisted chiefly of *n.* butyl alcohol with some methyl normal propyl carbinol.

Fraction VII (120°-125°).—The ester of this fraction on distillation separated very sharply into two fractions, the larger with b. p. 133°-136° indicating methyl normal propyl carbinol ester, and the smaller with b. p. 138°–139° indicating isoamyl ester. Hence, this fraction consisted chiefly of methyl *n.* propyl carbinol with some isoamyl alcohol.

Fraction VIII (125°–128°).—A small portion of the ester came over between 130° and 137°, containing some methyl *n.* propyl carbinol ester. The largest fraction, which was very constant, distilling between 137°–140°, represented the isoamyl ester. This fraction was chiefly isoamyl alcohol, with a little methyl *n.* propyl carbinol.

Fraction IX (128°–130°).—The b. p. indicated the presence of active amyl alcohol, b. p. 128.5°. Practically all the ester came over between 141° and 142°, being the boiling point of active amyl ester, with a small amount of the isoamyl ester, which boils at 137°–140°. This fraction was hence chiefly active amyl alcohol, with a small amount of isoamyl alcohol.

Fraction X (130°–133°).—The b. p. indicated the presence of isoamyl alcohol, b. p. 131.5°. Practically all the ester came over between 138°–140°, proving it to be the isoamyl ester, with a small quantity of active amyl ester. This fraction hence consisted of isoamyl alcohol with some active amyl alcohol.

The Residue (XI), which amounted to 10 cc., was placed in a small flask and distilled. About 8 cc. came over below 150°; a very little up to 180°; and about 1½ cc. was left in the flask. This last residue appeared to have decomposed with the production of brownish vapor. The 8 cc. that came over was esterified and the ester fractionated, and found for the greater part, to distil between 135°–140°, being the boiling point of the isoamyl ester. That which was collected at 140°–150°, and was fairly constant between 141°–142°, was the active amyl ester. Very little came over above 150°, but if a sufficient quantity had been available, would probably have been found to consist of the hexyl and heptyl esters. This residue hence consisted of isoamyl alcohol and active amyl alcohol with probably small quantities of higher alcohols.

There were no semi-solid substances observed toward the end of the operation as has sometimes been the case with fusel oil from corn.

Ten grams of fusel oil were titrated against a standard potash solution using phenolphthalein as the indicator. 100 grams of fusel oil contained 4.5 cc. normal acid. This is equivalent to 0.5 per cent. free acid in the oil, calculated in C_5H_{11}—COOH as a basis.

Ten grams of fusel oil were boiled with 75 cc. of 0. 5 N.KOH for one hour, under a reflux condenser. After cooling, the excess of alkali was titrated against standard acid.

One hundred grams of oil contained 18.4 cc. of normal free acid and acid from esters. Of this quantity, 4.5 cc. were free fatty acids, while the balance (13.9 cc.) represented the acids from the esters. Using $C_5H_{11}COOC_5H_{11}$, the amyl ester of capronic acid, as a basis for calculation, this is equivalent to 2.5 per cent. ester in the oil.

The bases present in the oil were separated in the usual manner. The amount was too small for purification and estimation. However, the distinctive odor of pyridine was recognized.

Furfurol could not be detected.

Consequently, "the composition of fusel oil from beet molasses" may be summarized as follows:

		Cc. from 500 cc.	Per cent.
Ethyl alcohol		5	1
Isopropyl alcohol		20	4
Isobutyl alcohol		30	6
n. Butyl alcohol		30	6
Amyl alcohols	Methyl *n.* propyl carbinol	40	8
	Active amyl alcohol	210	42
	Isoamyl alcohol	130	26
Fatty acids		2.5	0.5
Esters of the fatty acids		12.3	2.46
Pyridine and other bases		Present	Present
Hexyl alcohols, etc		Traces	Traces
		479.8	95.96
Water		20.0	4.00
Total		499.8	99.96

This composition does not present any marked difference of practical importance from that given for corn by Le Bel,[1] and largely quoted, which is as follows:

	Per cent.
Normal propyl alcohol	3.69
Isobutyl alcohol	15.76
Amyl alcohols	75.85
Hexyl alcohols	0.13
Free fatty acids	0.16
Fatty acid esters	0.30
Terpines and terpine hydrates	0.08
Furfurol, heptyl alcohol and bases	0.02
	95.99

The amount of total amyl alcohols, which, industrially, is the chief point, shows a difference of only 0.15 per cent. The respective figures for butyl alcohols differ by 3.76 per cent., though the propyl closely corresponds. This is, however, of little importance, as it shows only that one sample of oil was washed more than the other.

1 Maercker's *Spiritusfabrication*, p. 53.

THE PRINCIPLES OF SCIENTIFIC MANAGEMENT*

By Frederick W. Taylor, M.E., Sc.D.

(On the occasion of his visit to Toronto to address the Canadian Club, Dr. Taylor postponed his return to Philadelphia long enough to meet the members of the Engineering Society in Convocation Hall, and to address them on the subject to which he has devoted so much of his time and energies. Thier interest, evoked by Frank B. Gilbreth in his lecture entitled, "The Place of Motion Study in Scientific Management," delivered in March of last year, was keenly in evidence, and a few hours' notice furnished a large undergraduate audience, together with a few of the graduates and others. It is regrettable that the necessary hasty arrangements prevented a wider representation from the city's industries.

The following is an extracted form of one of the most valuable and interesting addresses delivered to this Society in many years.—Ed.)

In his opening remarks Dr. Taylor presented his subject as referring principally to workers of co-ordinated industry, in distinction to isolated workmen, it being applicable only to the former.

Nineteen of every twenty workmen believe that it is to their best interest to turn out as little rather than as much work as possible. It is the most serious fallacy that possesses our working class, and is attributable to two causes, for neither of which are the workmen themselves to blame.

First, if it be suggested to a group of workmen that they double their output, they reply that the procedure would throw one-half of their fellow-workers out of employment. To them it appears self-evident, and others, among whom are many of our philanthropists, uphold the belief, heralding over-production as one of the greatest social evils conducive to national idleness. It is immensely true in every trade, so its followers believe, that in going slow, their interests are advanced. Any device, therefore, tending to increased output is rebelled against by this deeply rooted nature.

No more fallacious than such belief exists, and it is borne out by history everywhere, with but one exception, that the introduction of such a device or system, into any trade, instead of forcing men out of work, has provided more work for men of that trade. The exception is in farming. Improved processes in the United States have reduced the providers of food supplies from eighty per cent. in years past to thirty-five per cent. at the present time, because the human capacity for food does not increase from generation to generation. This is the only instance where such a condition obtains.

As an illustration of the effect in other forms of labor, Dr. Taylor referred to the cotton industry, its history being comparatively older and its evolution more spectacular. The power loom was invented early in the last quarter of the eighteenth century, but the year 1840 witnessed the climax of its introduction, after a struggle many years in duration, to gain entrance into the manufacturies. In Manchester, Eng., the workmen felt that these looms would throw 3,500 of their 5,000 men out of work, and they strongly resented such outside intervention between them and their daily bread. Conditions were grave, as it was most difficult in those

* Before the Engineering Society, January 21st, 1913.

days to change one's trade, or even to move from one works to another. No alternative means of livelihood presented itself. The result was clear and concise. They forced the establishments, destroyed the looms, and maltreated the operators. Their rioting, however, did not affect the entrance of the loom into the industry.

Be the means what it may, bitter opposition, adverse legislation, public opinion, trade unions—all forces are powerless and futile in defeating the introduction of labor-saving development, and the effect is frequently that of accelerating its use.

The speaker stated that there is great opposition from labor leaders to Scientific Management, but since that opposition has become open and strong, Scientific Management has gone ahead more rapidly.

The result in the case of the cotton industry in the three-quarter century that has elapsed has been that the workmen have been proven wrong in their convictions. Has the increase of output thrown laborers out of work? In 1840 there were 5,000 workers. At the present time there are about 265,000 employed at the same work in Manchester. For every yard of cloth in 1840 there are now five hundred yards manufactured, though the population of England has not more than doubled within that time.

"There is a broad meaning back of it all. Wealth need only be brought into the world, for the world to use it. Although there are undeniable cases of over-production, they are abnormities, due to a general cause—the world undertaking a greater number of new enterprises than available capital warrants. It is a disease to which the public is susceptible, and the panics of 1873 and 1893 are unforgotten. On the other hand production is necessary to wealth, which is derived from two sources, viz., out of the ground, and by manufacture at the hands of man. The relation of wealth to production should be recognised, particularly by the poorer classes; their impression is erroneous that by far the major part of the bounties of this world are consumed by the wealthy classes. The reverse is the truth.

"The best index of progress in the world is the increase in output per individual, it being a measure of the increase of prosperity of the individual. The 'good old times' slogan indicates the user to be ignorant of conditions, as increase in output per man has provided such a variety of good things of life that the workmen of to-day live as the kings of yesterday. Luxuries of history are considered necessities now."

Reverting to the previously discussed condition in the farming industry, apart from those who provide the food supplies in the United States, sixty-five per cent. of the population may now engage in other industries as against the twenty per cent. years ago. This indicates *increase in output per individual*, which is the object of Scientific Management.

"Soldiering"

The second belief the workman entertains as a reason for going slow, Dr. Taylor emphasizes as being again in no way attributable to the man himself. It is illustrated by the case of a workman being paid $2.50 per day and making 10 pieces a day, entering then upon the piece-work system. The foreman pays him twenty-five cents per piece for the ten pieces which he turns out. Gradually the laborer increases his output, probably reaching twenty pieces per day, thereby doubling the contents of his pay envelope. Both laborer and foreman are well satisfied with the result.

But at the annual meeting of the board of directors, the pay-roll may properly be called for and closely examined. The foreman must explain his action in paying $5.00 per day instead of $2.50 per day. A storm of protest ensues, savouring of competitors' prices and pay-rolls, and resulting in measures to prevent the supposed ruin of the firm's labor market. The foreman is obliged to reduce the workman's salary to perhaps $2.75 per day.

"There are a great many bitter things said against the working man, concerning his selfishness, his tyranny, etc.; some of them are true, but there is just one thing that the working man of our country is not—he is not a fool. It is only necessary to give him one lesson, or at the most two, and he becomes a 'soldier' for life. He studies just how much the management will permit him to earn, and that is the amount of his output."

The fallacy of going slow is of such vital importance that the evil of it cannot be pointed out too strongly. There is not the slightest doubt that this is the greatest evil of the age in England. She is suffering from under-production, not over-production, and no voice is raised in protest. England preceded this continent by a generation in the adoption of the policy of "soldiering," and the result has been detrimental to the reputation of the working man hailing from her shores, although he is, especially the steel worker, the most skilled workman in the world. The speaker cited cases where the laborer from across the seas absolutely refused to increase his output, curtailing it at every turn, thus necessitating drastic measures against his employment. The same thing is going on in England to-day and is the reason for unemployment and poverty. The policy of curtailing output strikes at the very root of the trouble.

"The first step of Scientific Management was to endeavor to prevent this diminishing output, and each succeeding step has been an earnest endeavor to remedy other existing evils in previous forms of management. Scientific Management is no new or untried theory, and is no food for profound suspicion. It is a gradual evolution tested and proven step by step. It is the fruit of many men's ideas. Some years ago over fifty thousand men were working under its principles while the number has probably doubled since that computation was made.

"As in the case of all labor saving devices, the ultimate result is that the general public gets the entire profit. The end of it all is that the whole world is going to profit from it. At first the companies that have introduced it are reaping large profits, many of them more than doubling their output. They are the pioneers, and as such are entitled to the gains."

A workman under Scientific Management immediately increases his wages from 33 to 100%. This increase is not the greatest good to the working people, however, but the change of mental attitude toward work on the one hand and employers on the other is a more important part of their lives. They have changed from war to peace. There is now co-operation for the same object. The old suspicious watchfulness is supplanted by confidence, peace, conscientious work, and, on the whole, a feeling of satisfaction and pleasure that the employers are profiting as well as themselves. Scientific Management has been introduced in almost every department of industry, and in the thirty years in which it has been thriving there has not been a strike in a place where it has been in force, although scores of strikes have occurred in other and similar works.

What Is Scientific Management ?

"It is not any efficiency device for increasing output; it is not a bonus system; it is not a cost system; is not motion study, or time study; it is not unloading a lot of blanks at the goods entrance and saying, 'There is your system, go ahead and use it.' Most people think of it as one of these things. Scientific Management cannot and does not exist until there has been a complete mental revolution on the part of the workmen and the employer, and until this great and complete mental revolution has taken place, scientific management does not exist."

Part of the cost of manufacturing is the cost of material. Another part is the cost of production of the article, and a third is the overhead expense. The difference between the sum of these three and the selling price is the surplus. All labor troubles are due to the division of this surplus. The workmen desire as much as they can get in the form of wages, etc., and the owners as much as they can get in the form of dividends. Under Scientific Management they have ceased combat over the division of this surplus. The result has been a surplus so large that both contenders get more than they ever received before. The workmen get at least 33% more wages, and the company gets larger profits. This is one result of the mental revolution.

Dr. Taylor pointed out forcibly the delusion almost universal among workmen that the division of the surplus in the past has been entirely wrong; that the working men are not getting their proper share of the general profits of capital and labor. Although in some cases it is true, their feelings have been rashly augmented by the labor leaders, newspapers and the public. In an article on "Division of Capital," in the *Atlantic Monthly* of June last, Norman Faig showed their conviction to be wrong. All that the working man can ask for is that the profits that accrue to capitalists should come to the people of the United States. They themselves could not demand all this profit. If it should be divided in the manner suggested there would be thirteen cents per day per man as dividend. It shows conclusively that the hope of the workman does not lie in the division of capital. It lies rather in an increase of output.

The speaker outlined the older type of management where for example, 500 to 1,000 men in perhaps twenty different trades, have acquired their knowledge, not by books, but by observation and by traditional word of mouth. This is just the condition that obtained in the Middle Ages, and still largely obtains. Yet, in spite of lack of progress his trade is the workman's greatest asset. To achieve the best results one realizes that he must get the initiative of his workmen, but one's realization of "soldiering" forces him to the conclusion that to render this initiative the workman must receive a larger remuneration than his competitors. The employer who has the pluck to do this, and to continue doing it, will find that his men will respond to such good treatment. This is the highest type of management under the old system, yet it cannot compete with Scientific Management, for under the latter there is no spontaneity on the part of the workman, but continuous effort. This, because of the new and unheard-of burdens which the management assumes.

The Four Principles

The first of these principles is the gathering-in of the great mass of traditional knowledge held by the workmen; recording it, and reducing it to laws, rules and mathematical formulas. These deductions become of immense assistance is increasing the output. Rule-of-thumb knowledge is replaced by science.

Secondly, it becomes the management's duty to study carefully every man in the plant, his capacities, possibilities and limitations; and to train each to the highest class of work for which he is shown to be fitted—progressive selection and progressive study.

Thirdly, the science and the scientifically trained man are brought together. This is difficult. It can be accomplished only by binding the workman to work by science. This, however, does not cause appreciable trouble. Nine-tenths of the trouble experienced comes from forcing the management and owners to assume *their* burdens.

And, fourthly, a great mass of work formerly done by the workmen is now partly taken over by the management, until the whole is more equally divided. On the management's side there is generally one man for every three workmen.

These principles are deduced from years of study and work under Scientific Management. The system is no longer something which might be found beneficial if tried—it has been well tried—and pays.

The Power of Scientific Management

To illustrate the application of the principles of Scientific Management, Dr. Taylor chose the operation of *shovelling*. A careful study and series of observations in a plant where four hundred to six hundred shovellers were employed resulted in a reduction in the cost of handling iron ore from eight cents per ton to less than our cents, after paying the workmen employed 60% higher wages, establishing a labor office, employing teachers to instruct the men how to scientifically handle a shovel, and timekeepers, etc., to record performances.

Investigation showed that the loads upon shovels under old methods varied from three and a half to thirty-eight pounds. Placed on a scientific basis, a load of about twenty-one pounds to the shovel, proper motions, simple and untiring, the work was now being done by 140 men. Furthermore, investigation into their private affairs showed the workmen to be living better lives, in every way, than before.

Illustrations were also given in the operation of machinery. The speaker claimed that not one in fifty of the machines in the factories of America are speeded accurately. The majority of them are 200% to 400% out, and from two and a half to nine times as much work could be done by them if they were properly adjusted. In the work of the high-class mechanic science is so great a factor that he cannot gain the proper knowledge of himself.

Dr. Taylor instanced, in closing, a case in machine manipulation where mathematicians were confronted with a problem involving twelve unknowns, and struggled with it for eighteen years. Now the problem is solved in twenty seconds on a slide rule taking care of the twelve variables.

"If you are willing to pay the price in time and hard work, things that have through the ages been termed impossibilities, can eventually be solved and put to use for the good of man."

OIL FOR MACADAM ROADS

E. A. James, B.A.Sc.[1]

Automobile traffic has revolutionized our ideas of permanent road construction. Whereas a dozen years ago a well-constructed waterbound macadam road was considered about as permanent a road as could be desired for country traffic, with the constantly increasing use of the high-speed rubber-tired automobile, such roads have in many cases disintegrated faster than they could be maintained.

It has been clearly demonstrated that the bond in ordinary macadam road is insufficient to protect it against the somewhat complex action of the automobile tire traveling at high speed. The dust raised by this class of vehicles is blown entirely off the road and a fresh lot of dust raised, this repeated action resulting in the wearing down of the road surface, in some cases several inches in a single season.

While oiling a road is not considered a permanent remedy for this disintegration, it serves to keep the dust down, thus preventing the next lot of dust being raised, and by this means temporarily preserving the road. There are many varieties of oil on the market for this purpose, some of which are little better than water, while others, having a bituminous base, on the evaporation of the

1 Chief Engineer York Highway Board.

volatile constituents, leave a certain amount of bitumen to act as an aid to the binder in the road. This bituminous residue is increased at each successive application, so that as time passes, the applications may be made fewer and lighter.

The cost per year of applying oil at current prices, amounts to from eight to fifteen per cent. of the original cost of the road if built

Cost, per application, of oiling one mile of road, of different widths with varying quantities of material.

Oil, 7½ cents per gallon.

Cost of application, $25.00 per mile.

Width of Road	Square yards per mile	¼ gallon per square yard	½ gallon per square yard	¾ gallon per square yard	1 gallon per square yard	1¼ gallons per square yard
10ft.	5 867	$135	$245	$355	$465	$ 575
12	7,040	157	289	421	553	685
14	8,213	179	333	487	641	795
16	9,387	201	377	554	729	905
18	10,560	223	421	619	817	1,015
20	11,733	235	465	685	905	1,125

Oil, 8½ cents per gallon.

Cost of application, $25.00 per mile.

Width of Road	Square yards per mile	¼ gallon per square yard	½ gallon per square yard	¾ gallon per square yard	1 gallon per square yard	1¼ gallons per square yard
10ft	5,867	$150	$275	$400	$525	$ 650
12	7,040	175	325	475	625	775
14	8.213	200	375	550	725	900
16	9,387	225	425	625	825	1,025
18	10,560	250	475	700	925	1,150
20	11,733	275	525	775	1,025	1,275

Ordinarily the following applications will suffice:—

First Year—First application, ½ gallon per square yard.
Second application, ¼ gallon per square yard.

Subsequent Years—Two applications, each ¼ gallon per square yard.

by day labor, or from five to ten per cent. if built by contract. The expenditure will be well repaid in the elimination of the dust nuisance and the decreased cost of maintenance, as well as in the increased life of the road.

INDIVIDUAL EFFICIENCY[1]

By Norman A. Hill, B.S.[2]

What is *efficiency?* One hears and reads a lot about it these days, but I doubt if one man out of ten can define correctly the technically accepted meaning of the word. This is only natural as it has almost as many meanings as the word "engineer"—which as you know, may be the familiar cognomen for the man who rakes the ashes out of our apartment house boilers or the man who is carrying out the much talked-of international ditch which is to join the Atlantic and the Pacific. Col. Goethels is an enthusiast on efficiency, and in speaking of efficiency engineers says:—

"There are several heads of businesses in this enlightened country who still laugh at the efforts of the efficiency engineers to eliminate waste and supply more needs at less expense.

"They conduct their business in their merry old hit-or-miss manner and are confident that they are doing things correctly as Jim Driscoll was when he left the farm for a steel mill and was sent by the boss to measure a plate with a foot rule.

"Jim came back in the course of an hour or so and reported as follows:—'The plate is the length of the rule and three fingers over, with this piece of cobblestone, and the stem of my pipe, and my foot from here to here, bar the toe-cap.'"

To get back to the point and for our purposes in this paper define efficiency—we will call it the "ratio between the useful work performed by a prime mover and the energy used in producing it." In applying it to the individual then it is the percentage of useful work done in any operation in a unit time, to the energy applied to the doing of it. Now, in speaking of human efficiency we must bring in the element of mental energy expended as well as physical—or elbow-grease effort. The efficiency of a machine is comparatively easy to determine for a machine can't think and its standards of performance can be quite readily found, and speaking of labor saving machine work, Dr. F. W. Taylor answers his critics and obstructionists to efficiency as follows:—

"Two men stood watching a steam shovel at work. With a clatter and a roar the shovel bit into a steep bank, closed on a carload of earth and dumped it on a waiting freight train.

"'It drives me wild,' said the first onlooker, 'to see that monster taking the bread out of good men's mouths. Look at it. Why, it's filling up those flat cars faster than a hundred men with picks and shovels could do it.'

"But the other onlooker shook his head and answered:

"'See here, mister, if it would be better to employ a hundred men with picks and shovels on this job, wouldn't it be better still, by your way of thinking, to employ a thousand men with forks and tablespoons?'"

Since the talk given you by that eminent efficiency expert,

1 From paper read before the Engineering Society, Jan. 15th, 1913.
2 Consulting Engineering and Efficiency Specialist.

Mr. F. B. Gilbreth, last year, you probably have some fairly definite idea of the general principles of scientific management as applied to one phase of the building industry—that very old art of Brick-laying. Now what we want to think about to-day is how to apply those same principles of waste energy elimination to our daily life as engineers and business men. The very first thought is: that little or nothing can be done to increase one's own individual efficiency in college or professional life till the firm determination is made that we will *know ourselves*. Here let me insert an excerpt from a recent article by Arnold Bennett:

"Few people—in fact very few people indeed—ever realize the priceless value of the ancient counsel: 'Know thyself.' It seems so trite, so ordinary. It seems so easy to acquire—this knowledge. Does not every one possess it? Can it not be got by simply sitting down in a chair and yielding to a mood? * * * And yet this knowledge is just about as difficult to acquire as a knowledge of Chinese. Certainly 999 people out of a 1,000 reach the age of sixty before getting the rudiments of it. The majority of us die in almost complete ignorance of it, and none may be said to master it in all its exciting branches. Why, you can choose any of your friends—the wisest of them—and instantly tell him something glaringly obvious about his own character and actions—and be rewarded for your trouble by an indignantly sincere denial! You had noticed it; all his friends had noticed it. But he had not noticed it. Far from having noticed it, he is convinced that it exists only in your malicious imagination. For example, go to a friend whose sense of humor is notoriously imperfect, and say gently to him: 'Your sense of humor is imperfect, my friend,' and see how he will receive the information. So much for the rarity of self-knowledge.

"Self-knowledge is difficult because it demands intellectual honesty. It demands that one shall not blink at the facts, that one shall not hide one's head in the sand, and that one shall not be afraid of anything that one may happen to see in looking around. It is rare because it demands that one shall always be able to distinguish between the man one thinks one ought to be, and the man one actually is. And it is rare because it demands impartial detachment and a certain quality of fine shamelessness—the shamelessness which confesses openly to one's self and finds a legitimate pleasure in confessing. By way of compensation for its difficulty, the pursuit of self-knowledge happens to be one of the most entrancing of all pursuits, as those who have seriously practised it are well aware. Its interest is inexhaustible, and grows steadily."

To get on the track of our commonest faults let us consider three to which I believe that the engineer is particularly subject:

(1) Self-satisfaction.

(2) Laziness, in that there is a disinclination to study anything analytically unless we see its direct bearing on our chosen profession.

(3) Procrastination, the putting off till to-morrow the things we should do to-day.

Now, to give you three concrete examples of these too common faults with us all: The average engineering graduate or undergraduate is full of the first, and often scorns the dirty faced chap in overalls whom he sees oiling an engine, but who probably knows more about steam engineering as an applied science than the college man will know for many a year after cutting his pin feathers in the real work-a-day world.

As to laziness and disinclination to study what seem to be alien subjects: take salesmanship for instance. Few of us realize on leaving college that *salesmanship* is the first thing we need, and the thing we will always need since we are every day selling our services, our brains, our knowledge, and our ability to "deliver the goods" to our employer or client.

As to procrastination, this is so readily acknowledged a fault, that I hardly need dwell on it, but will say that the little motto we see in so many live-wire offices to-day—*Do It Now*—is one of the best little creeds that you can have, for you can never tell, when you postpone, how much you may lose by a forfeited opportunity.

Mr. Dooley says, "Opportunity knocks at every man's dure wanst—on some men's dure it hammers till it breaks down th' dure, an' thin goes in and wakes him up if he's asleep, and afterwards it wurruks f'r him as a night watchman."

Now, to outline a remedy for these most common faults that contribute to individual inefficiency, three obvious steps in the right direction are:

(1) Increase your net worth to yourself by making an absolutely honest self-inventory, not as to your cash capital, anticipated inheritance, pull to land a job or any of the too much counted upon assets, but on your resources and liabilities as a man and an engineer. and what you really do know that is of intrinsic worth to yourself and others. Let me quote here a little stimulus to self analysis that was written by Thomas Dreier, of Boston, one of the cleverest brain merchants of to-day, a man who makes a large income by selling live-wire ideas and inspirational essays, through the *New England Character* magazine:

"You, Mr. Owner of a human life, are the greatest man in the world. The payment of two cents for a stamp places at your service a postal service that encircles the globe.

"For five cents a fifty million dollar subway is offered for your use, and while you ride you are protected by every device discovered by human ingenuity.

"You desire to dash across a continent and the payment of a few dollars, representative, perhaps, of a few days' work—calls billions of dollars, thousands of men, miles of protected track into use for *your* pleasure.

"*You* spend one cent and there comes to you the news of what the world is thinking and doing—that modern Mercury—the triumph of all time, the daily newspaper.

"You wish to hear the voice of a far-away friend and the marvellous network of wires—the master telephone system—is *your* slave. The ocean is tamed and made *your* servant by the monster steamships whose comforts are yours.

"In the fields millions are toiling to supply *you* with food and in the cities countless thousands are serving as ministers to *your* comfort. Fishermen brave the perils of the sea, miners delve deep into the earth, explorers plunge deep into the jungles—all for *you*.

"Alladin with his wonderful lamp, Midas with his touch of gold, Alexander with the world under his feet—their powers were as the powers of children, whereas your power is as the power of a giant. *P.S.—What are you doing to pay for it all?*"

The second step toward increasing your own personal efficiency is to perfect a daily work plan. Pre-arrange your daily and hourly schedule with the idea in mind that you are not going to waste so much time by bluffing yourself into thinking you are doing useful work when you are "soldiering on the job." The very first thing after honesty with yourself and your fellows is to put your mind in order. *Think systematically*—act with true co-ordination. *Imitation* with intelligence, *competition* of the fair play order, *loyalty* to yourself and your employer or client, *concentration* on the task in hand to the exclusion of all trifling or mind wandering, *wage earning as a by-product* and not as the chief object in your work, but an ambitious goal held high as your chief incentive to constant self-improvement. *Pleasure in your work*, *relaxation* and periodic recreation with plenty of hearty, healthy fun-getting exercise, and a consistent and spontaneous *love of the game* of business and life are big factors for success.

It is safe to say that with the average embryo engineer or the man in active practice, by six months' assiduous application to the principles I have tried to set forth he can more than double his output of useful work per day, and when he is through and it is time to play he can enjoy it thoroughly and sleep better every night with the feeling that he *knows* just what he has accomplished and that he is making good and will continue to do so as long as he tries to live up to his efficiency principles as an individual.

As an example of actual results, it is reported by an authority that the installation of scientific management in the office of the Society of Mechanical Engineers in New York City, where no more than twelve persons were employed, saved the society $14,000 a year.

In closing let me give a few good rules for any man, some of them original, some of them appropriated:—

1. Don't tell what you are going to do to a competitor till you have done it.

2. Keep down expenses, but don't be stingy.

3. Make friends—no favorites—in business.

4. Stick to your chosen calling but not to chosen methods Be original.

5. Make business plans ahead—but don't make them in cast iron.

6. Keep a high vitality, keep cool, and keep sober.

Books of value on this subject are :

"Increasing Human Efficiency in Business," by Walter Dill Scott; "Power of Will," by Frank Channing Haddock; "Business Power." by Frank Channing Haddock; "Efficiency," by Harrington Emerson; "Applied Methods of Scientific Management," by Frederick A. Parkhurst; "Shop Management," by Frederick W. Taylor; "Principles of Scientific Management," by Frederick W. Taylor; "Maximum Production," by C. E. Knoeppel; "Works, Wages and Profit," by H. L. Gantt.

MACADAM ROAD MAINTENANCE

W. Huber, B.A.Sc.[1]

Eternal vigilance is the price of a good permanent macadam road. No matter how much care may be exercised in building it, no matter what the quality of the material used, it can be considered at best but a temporary solution of the good roads problem if at the time of building or immediately thereafter proper provision is not made for its systematic maintenance.

The proper and most economical time to commence the maintenance of this class of road is the day it is opened to traffic. No stone used on road construction is absolutely homogeneous, no bottom is absolutely uniform in its bearing power, and, therefore, no two consecutive sections of road can be considered to have absolutely the same strength. Curious as it may seem, ordinary traffic will sometimes show up small weak spots in a road bottom over which the roller passed showing no indication of their existence, the result of which will probably be a small rut—a rut, perhaps, too small to inconvenience traffic or even to be noticeable to a person driving over it, yet large enough to collect water and soften the surrounding roadway.

Assuming that the road has been properly constructed, i.e., with well compacted sub-grade, properly under-drained, the drains running to free outlets, side-ditches carefully constructed, the road properly crowned and the metal properly bound, the idea of maintenance is to maintain these ideal conditions. As the stability of the new road is in so large a measure influenced by the facilities for drainage supplied, so will the durability of the road depend largely upon the care with which these drainage facilities are maintained. The principal work of the man on maintenance will, therefore, be to keep the drainage both above and under the road as perfect as when it was first constructed. This includes keeping the road well crowned, the sides clean and sloping to the ditches, the side-ditches open and their outlets free, drain and culvert openings clean, and ruts and depressions filled immediately they become noticeable.

The amount of work required in such maintenance will depend, of course, on several factors—quality of material used in construction,

1 Chief Assistant Engineer, York County.

nature and amount of traffic, nature of soil, grades, climate, weather, tc.

The system of maintenance should be as simple as possible and not more than two men should be concerned in the work of any one section, viz., the road superintendent and the man actually engaged in the work. Regarding the latter, it is true, as in many other cases, that it pays to have a first-class man, even at a rate of pay higher than paid to one of mediocre ability. He must be a man who can understand the principles on which roads are built for permanency, and who can reason for himself. A man at this work will often be working for days at a time without direct supervision, and he must be a man who can be trusted to do his work and who can also be trusted to find work for himself. A man of this description will save the road superintendent many gray hairs, and will leave him time to devote to his heavier problems.

The equipment required for road maintenance other than complete re-surfacing is simple—a pick, a shovel, a wheel-barrow, a fairly heavy tamping-iron and a pail, being all that is required. There should also be deposited at short intervals on the road-side, small piles of crushed stone and grit. For small repairs the stone may be somewhat finer than the regulation two-inch size used in construction. From one to one and a half-inch will be found most satisfactory. The grit for repair work should be selected for its cementing quality, even more than in construction work. For this work it will be found profitable to secure and store a car of the very best grit obtainable, even at a higher price and freight rate than ordinary grit.

The length of road which one man can properly look after varies with local conditions, but ordinarily a single man can keep from four to six miles in good repair. If it is found that he cannot keep up with the work, his section should be shortened, rather than another man added, as it is found the most economical work is done by men working singly.

The best time for examining the entire length of a section is just after a rain. This will show up all ruts and other depressions, and also any obstructions or lack of grade in side ditches, drains and culverts.

The best method for filling ruts and low spots in the surface is to pick the stone loose in and for several inches around the depression, add a little fresh stone and grit, wet it, and tamp thoroughly. It may be found that traffic will disarrange the stone somewhat, but if it is gone over a few times at intervals of a day or so it will be found to have set and become an integral part of the road, and, if the work has been carefully done, indistinguishable from the remainder of the road. These small depressions should be remedied as soon as they appear, remembering that each one forms a basin for the collection and retention of water which in turns softens the road. This work all resolves itself into an attempt to keep the surface drainage perfect.

Another cause of trouble in macadam roads is the allowing of the earth sides to become cut up and become higher than the edge of the stone, thus impounding water that would otherwise run off. These earth shoulders should be kept trimmed below the level of the stone. In this connection an occasional trip over the road with a split-log or plank drag will be found economical. This will necessitate the hiring of a team for an occasional day, but the expenditure will be well justified, and it will be found that the longer this practice is continued, the less dragging will be required, as the surface of the earth shoulder will become hard, smooth and impervious to water and able to support traffic almost as well as the stone section. In fact, this part of the road, where this method has been followed, is in dry weather often preferable for driving to the macadam section.

The remaining most important part of the maintenance man's work is the keeping of all ditches and drain and culvert outlets open. This work will be heaviest in the spring and fall, when ditches tend to become clogged with leaves and other debris. During the winter special pains must be taken to keep all these water-courses in first-class working order, bearing in mind that the principal idea in winter is to have a course ready for the water as soon as the snow starts to melt. In this as in other work, it is easier and cheaper to anticipate trouble than to remedy it after it occurs.

These few points, then, comprise what seem to be the essential features in Macadam Road Maintenance, and if they can be put any more briefly, may be stated as follows:

Start maintenacne as soon as the road is built.

Put a good man at the work.

Keep both stone and earth sections smooth and properly crowned.

Remove every obstruction to water running off and from under the road both in summer and winter.

And lastly, and most important of all—keep eternally at it.

W. Almon Hare, '99, president of the Hare Engineering Co., Limited, Toronto, has returned from a summer spent in Europe.

F. H. Sykes, '05, has been appointed chief examiner of plans for the city architects' department, Toronto. Mr. Sykes was previously assistant structural engineer in this department.

H. P. Rust, '01, has been appointed engineer-in-charge of one of the largest hydro-electric developments in the West, by the Great Western Power Co., in San Francisco.

Wm. Snaith, '07, who was associated with Frank Barber, bridge and civil engineer, Toronto, is secretary-treasurer of the Thor Iron Works, Limited, a new corporation equipped for the fabrication of steel tank and plate work, steel trusses and light structural work.

V. C. Thomas, '08, is in the manufacture of hydraulic turbines with Wellman Seaver-Morgan Co., of Cleveland, O.

A. R. Robertson, '08, until recently with the Canada Foundry Co., is now with McGregor & McIntyre, Toronto.

BIOGRAPHY

Eugene W. Stern, '84

We are too modest about the accomplishments of School men and particularly of those across the border. No matter how many visits to Gotham we may have had to our credit, each succeeding trip with its first glimpses of massive buildings, bridges, etc., creates, in no small degree, wonder and amazement, and let it be said hereafter, admiration for the prominent part that some of our School men have played in that great city's development.

One of these men is Eugene W. Stern, '84.

He was born in Toronto, August 20th, 1865, and Jarvis Collegiate Institute had a share in preparing him for entrance into the School of Practical Science in 1881. At the end of the first year, and with one of the prizes in engineering already to his credit, he chained the summer of '82 on township surveys in the Nipissing District. The following summer was also spent by him in the Nip., as instrument man on township survey work, and the second prize in Engineering dangled from his belt. Then in April, 1884, he graduated, taking with him his third and the year's first prize, indicating his enviable position at the head of the class list.

The Northern and Pacific Junction Railway, now a part of the Grand Trunk railway system, employed him as rodman on construction in the vicinity of Cyprus, Ont., until November of that year, and until November of the following year as assistant engineer, having in his charge the construction of twelve miles of road, with headquarters at Novar, in the Parry Sound district.

He was back at S.P.S. during the following year as fellow in engineering, and has in this respect distinction of being the first assistant to Principal Galbraith in the branch of work designated in the curriculum by the word "Engineering."

From August, '86, to March, '87, he was employed as draftsman in the office of the Passaic Rolling Mills, Paterson, N.J., working on the shop plans of the Washington Bridge over Harlem River, a 500-foot plate girder arch construction, and also on the shop plans of various railroad bridges, draw spans, turn tables, and so on. For the following six months he was with the Grand Avenue Railway Co., of Kansas City, Mo., as assistant engineer on the construction of their cable railway.

Four and a half years were then spent by Mr. Stern with the Chicago Bridge and Iron Company, of Chicago, previously the Kansas City Bridge and Iron Company, the greater part of this time being spent as assistant engineer designing railroads and highway bridges, including the bridge over the Msississippi River at Winona, Minn., also considerable roof and sub-structure work.

Back to Missouri in February, 1892, Mr. Stern held the position of chief engineer for the Koken Iron Works, St. Louis, for over six years in full charge of the design and supervision of the construction of many city buildings, roofs and bridges, the St. Louis Coliseum being one of them.

In July, 1898, he went to New York. He became chief engineer of the Jackson Architectural Iron Works, in complete charge of design and superintending the construction of the steel work of many high office and loft buildings.

For the last eleven years Mr. Stern has been a consulting engineer, making a specialty of buildings and foundations. He has, during this period, designed or supervised the constructional work of nearly one hundred buildings, costing about thirty million dollars, the contract price of the engineer's work of these amounting to about six million dollars. Among these are: the Terminal Station at Hoboken, N.J., for the Delaware, Lackawanna & Western Railway; also passenger station at Scranton, Pa., and Ferry House at 23rd Street, New York, for the same railway; New Ferry House for Erie Railway, at 23rd Street; B. Altman & Co.'s store at Fifth Avenue and 35th Street; National Park Bank; Travelers' Insurance Company, Hartford; New York Evening Post; State Liberty and Supreme Court Building, Hartford; Physicians' Office Building, 12 storeys; residence for J. P. Morgan, Jr.; Guaranty Trust Company's Building, 8 storeys, on pneumatic caisson foundations; Auerbach candy factory, 11 storeys; Architects' Office Building, 20 storeys; Cotton Exchange Building, 21 storeys, on pneumatic caissons. He has also been associated on the construction of the thirty-two storey City Investment Building, also on pneumatic caisson foundations; Union Passenger Station, Chattanooga, Tenn.; and the State Armory, Hartford, Conn.

Mr. Stern has been a member of the American Society of Civil Engineers since 1897, and of the Canadian Society of Civil Engineers since April, 1909. He is secretary of the American Institute of Consulting Engineers. He has also been, since its inception, a staunch member of the Engineering Society, and has contributed several articles to its publications.

The world well knows why we are proud of Eugene W. Stern, '84.

G. G. Powell, '02, has been recommended by Works Commissioner Harris to the position of deputy city engineer for Toronto and the recommendation has been approved by the city council.

J. H. Curzon, '11, is chief draughtsman for T. Martin, '96, divisional engineer for C.P.R. at Moose Jaw, Sask.

M. B. Watson, '10, and T. A. Fargey, '09, have entered the employ of the Toronto Electric Light Co.

PNEUMATIC CAISSONS FOR TALL BUILDINGS

By O. W. Ross, B.A.Sc.

In every big city, owing to the prevailing prices in real estate every inch of available space must be utilized, with the result that the foundations of a new building must be very close on either side with those of the adjoining buildings. The buildings must also be as lofty as possible and consequently, the increase in the erection of skyscrapers in the past few years has been made in the face of grave and increasing engineering difficulties. The study of the laying of the foundations of almost any large building will bring out what these problems are, and how the resourcefulness of engineering contractors has been developed.

The preparations involved in the erection of the modern skyscraper are enormous. The foundations must often be laid to bed rock through many feet of quicksand and water bearing strata which is probably already heavily loaded by an adjoining building. In digging, water and soft mud may be encountered, but a few feet below the street level. Were this soft mud pumped out or removed by any of the old time methods, more of this fluid material would enter the excavation from either side and the adjoining structures would settle and later collapse. It is the work of the laying of these foundations that has allied science and necessity in the working out of the new problems.

When one carries iron and steel construction below the surface, whether on land or water, he is at once confronted with the question of corrosion. In so far as that construction is of a temporary character, this may be disregarded. But when it is proposed to use material in permanent works, then the question becomes a very serious one. However, the opinion seems to be fairly well founded that if the concurrent action of water and atmospheric oxygen can be prevented, corrosion will not take place or will proceed at quite a slow rate and engineers now seek to exclude the air or the water.

Compressed air has solved the problem as it has solved many others in the development of construction. Compressed air made the rapid building of steel structures possible by the rivetting hammer. But the application of the principle underground is more crafty. The pneumatic caisson process in conjunction with the Moran Air Lock is the way that compressed air has been applied to these difficult foundation problems.

Perhaps it would be as well to state that there are two distinct forms of caissons. There is a caisson open at the top, whose sides, when it is sunk in position, emerge above the water level, and which is either provided with a water-tight bottom or is carried down, by being weighted at the top and having a cutting edge round the bottom, into a water-tight stratum, aided frequently by excavation inside. There is also a bottomless caisson serving as a sort of diving bell, in which men can work when compressed air is introduced to keep out the water in proportion to the depth below the water level, which is gradually carried down to an adequately firm foundation by excavating at the bottom of the caisson and building up a foundation on the top of its roof as it descends. Where foundations have to be carried down to a considerable depth in water bearing strata, or through the alluvial bed of a river, to reach a hard stratum, bottomless caissons sunk by excavating under compressed air are used.

The caisson, considered as an aid to sinking foundations through wet material, consists of an inverted box having a sectional shape according to the work it is intended to do. The principle is, that so long as the air pressure in this box is maintained equal to or slightly above the water pressure upon the outside, down to the lower edge of the caisson, water cannot enter. Work is carried on in the chamber formed by the caisson, in many cases the work of laying the masonry on top of the caisson being carried on at the same time. As excavations advance the caisson sinks, the air pressure in the inside being reduced slightly until the dead weight of the caisson itself, and the masonry on its top, are sufficient to overcome the frictional grip or resistance due to the bearing upon the outside surface of the material it is passing through.

These bottomless caissons afford a procedure applying to building foundations which has demonstrated itself as applicable to practically all conditions. The certainty of success has made them a strong favorite with engineers, although the expense is very great.

History of Pneumatic Processes

Since the year 1894, the pneumatic process has been used extensively in laying foundations for buildings but it is only lately that the necessity for it has been fully appreciated, and that it has been carried to a great degree of refinement.

The method of compressed air for enabling operations to be carried on under water in the form of building a foundation is merely a modification of the diving bell. Papin, an eminent physicist, born at Blois in 1647, was the man responsible for this idea of employing a continued supply of compressed air thereby enabling workmen to build under a large diving bell. The use of compressed air was demonstrated more forcibly in 1779 by Coulomb when he presented to the Paris Academy of Science a paper detailing a plan for executing all sorts of operations under water by the use of compressed air. The method and apparatus used by him then was very similar to that in use at the present time.

A patent for a device for sinking tubular shafts through earth and water, by means of compressed air, was taken out in England, in the year 1831, by Earl Dundonald, then Lord Cochrane. He used an air lock very much like the ones of to-day and he placed it, in a similar position, at the top of the main shaft. He was, at the time of his invention, engaged in tunneling under the Thames, and he applied this compressed air system to this work and also to other similar enterprises. Another man, also an Englishman, by the name of Bush, in 1841, devised a plan for sinking foundations by means of compressed air and he likewise patented his device. In 1850 a bridge was to be constructed at Mayenne, and C. P. fawn Muller, a German, with a device very similar to that used by Cochrane and Bush, undertook to sink the foundations by the use of compressed air. He failed, however, as his plan was not executed, but it brought to light the usefulness of this method to some extent.

The application of the compressed air method, which was similar to a diving bell, as has been said, to a cylinder forced down by undermining was first made, about 1841, at Chalons for working a coal seam rendered inaccessible by the infiltrations of the Loire. After having begun the shaft by beating down a cylindrical lining of sheet iron about 60 feet, 40 inches in diameter, it occured to the engineer, M. Triger, to cover over the top of the cylinder, and by forcing air in to drive out the water and admit the workmen. He did this because, when he reached a layer of coarse gravel, he could force the tube no farther, so he brought compressed air into play. An air chamber was formed at the top with double doors, serving as a sort of lock for the passage in and out of the cylinder of men and materials without giving an outlet to the compressed air. The pressure he used was never greater than two atmospheres. The water was discharged through a small tube, into which, several feet from the bottom, a jet of air was allowed to enter, thus diminishing the specific gravity of the column till it was rapidly blown out. In 1845, M. Triger sank another cylinder 6 feet in diameter to a depth of 82 feet, in the same way, and suggested the employment of the method for the foundations of bridges.

The first bridge foundations of this kind were carried out in the years 1851-52, at the Rochester bridge on the Midway, which has masonry piers each supported on 14 cylinders, 6 feet 11 inches in diameter, filled with concrete. Having begun with the vacuum process, which Dr. Potts of England, has the credit of inventing, till on alighting on old foundations it proved useless, Mr. Hughes M. Inst. C. E., conceived the notion of reversing the current of air and sinking the cylinders by the help of compressed air. The success of this method recalled to mind earlier suggestions in the same direction such as the patent of Lord Cochrane for excavating foundations by compressed air and also the success in stopping the rush of water into the Thames Tunnel by forcing in air. It was now realized that the many advantages of the compressed air process would cause it to entirely supersede the vacuum process and the pneumatic process of to-day is really the compressed air process.

The foundations of the piers of the Kehl Bridge were accomplished by a combination of the principles of the compressed air process, the sinking of a pier by its own weight, and the coffer dam system. As the bed of the Rhine at Kehl consists of large masses of gravel liable to be disturbed to a depth of 55 feet below water level, it was deemed advisable to carry the foundations down 70 feet below low water. It was there that the first pneumatic caissons were employed, there being three shafts to each caisson.

In America the pneumatic process was first used in 1852 for a drawbridge over the Harlem River at Third Avenue, where a number of cast iron cylinders about four feet in diameter were sunk to support each pier. Sometimes where cylinders of small diameter have to be used the excavations are extended beyond the cylinders at the bottom, and filled with concrete to give a greater bearing surface; this plan was adopted at the Harlem Bridge. In 1856 and 1860 Pneumatic Pile Foundations were constructed in South Carolina. At the St. Louis Bridge in the year 1870, foundations were carried to a greater depth than had ever been previously attained. The depth reached 109 feet 8½ inches, in this case has not yet been exceeded. Another interesting case of the use of Pneumatic caissons, is the Brooklyn Bridge. Here the excavating was done by a scoop dredger when possible. When hard soil was met with the shafts were shut and the excavation performed by manual labor under compressed air. Ever since certain New York contractors decided to bring over a French engineer, and learn all he could teach them about compressed air methods, the system has improved. They have universally adopted the pneumatic system and have introduced many improvements.

Pneumatic caissons have been used mostly in New York City, and they are a necessity there in the building of foundations for skyscrapers. The extreme height of some of the structures and the consequent imposition of tremendous loads is only one part of the problem, because this merely requires that piers be sunk to hard pan or bed rock. The chief difficulty connects itself with the presence of water and when this is associated with sand, we have the great problem which confronts foundation engineers. The difficulty does not centre itself upon securing penetration but upon the preservation of the foundations of adjacent structures. If the water is removed in large quantities from the immediate sight, this may at once entail a settlement of an adjacent foundation. It is this consideration, perhaps, more than any other, which has brought the pneumatic caisson into such general use in the sinking of foundations for large buildings. During the past few years the procedure has been almost revolutionized because the application of it has been so necessary and extensive to great foundation problems.

General Principles of Caissons

The fundamental principle underlying the compressed air or pneumatic process is simply that the atmospheric pressure of 15 lbs. per square inch will support a column of water, in a tube or pipe from which the air has been exhausted, about 34 feet high, when the open end is immersed in a body of water, or 1 lb. will balance a column 27 inches high. Practically these heights cannot be supported, as a perfect vacuum is almost impossible. But it is commonly stated that we must have 1 lb. pressure for every 2¼ feet of depth below the water surface, to keep the water out of the working chamber. The actual pressure is 15 lbs. more, as we have to balance a like pressure on the surfact of the water outside the caisson; this excess is constant for all depths. So that if the depth below the water is 90 feet, the actual air pressure in the caisson is about $45 + 15 = 60$ lbs. The uplifting effect is, however, only 45 lbs.

Ordinarily, it becomes necessary to reduce the air pressure in the caisson very materially at times in order to allow the caisson to sink; at other times, however, it is necessary to cease altogether, adding weight to the caisson to prevent a continuous or too rapid sinking. This, of course, depends both upon the actual resistance at the lower or cutting edge of the caisson which may or may not be very great, and upon the frictional resistance on the exterior surface of the caisson and the structure upon it. It is, therefore, in general, better to have as little frictional resistance on the side surfaces as practicable, and to provide as great a direct resistance at or a little above the cutting edge as is consistent with economy and convenience of construction and subsequent ease of prosecuting the work.

As the working chamber should be practically air-tight, some special means of entering and leaving the working chamber must be provided. The air lock has this object in view, and wherever it is planned or whatever its design it must be an airtight box with two doors, both opened toward the greatest pressure—that is toward the air chamber or some air tight channel or shaft communicating with it. However, as the air lock in a special form will be dealt with later on, it is not necessary to describe it here. Strong and tight iron shafts are built into the caisson, and should always reach well above the surface of the water; the main shaft through which the men enter and leave need not be over four feet in diameter. This is made in sections, which are bolted together through internal flanges, between which rubber bands or some soft and impervious substance is placed, so as to render the joint air tight. Ordinary, red lead worked up with short strands of ordinary lampwick will answer every purpose; it is easily obtained and applied.

A smaller shaft, not over 18 inches or 2 feet in diameter for letting concrete or other material into the working chambers is used also. It is better to have at least two of these; they are provided with a door at the top and bottom only, the entire shaft being an air lock. Pipes from 4 to 6 inches are also built into the caisson—the larger for connection with the air hose and force pump for water, the smaller for use in blowing out the material.

Compressed air is rarely, if ever, required until the caisson rests firmly on the bed of the river, or in its proper position for the foundation. As soon as it rests this way the men go in by means of the air lock and see that everything is in good working order and then the caisson is ready for business. Now, if everything is ready below, a gang or shift of men pass into the lock and thence into the caisson and the work of excavating the material in the caisson is commenced. One thing can be relied on, so long as the air pressure required by the depth is maintained, the water will not rise above the extreme lowest line of the cutting edge of the caisson, and in sinking through some materials, water has to be pumped into the caisson in order to carry on the work. If the caisson is not heavily weighted before the air pressure is put on, it is liable to lift and careen.

The effect on men working in compressed air is very interesting and instructive. It has created a disease which will be described at another place in this article. For this reason the men must be carefully selected and great precautions taken for their comfort and care. A code of signals is always used by which the men in the caisson can communicate their wants to those above. All oscillation in the pressure should be avoided as the immediate effect of reducing the air pressure even by only a few pounds is to set up a dense fog. A complete outfit of the machinery needed should be at hand as much time and money are lost and great inconvenience caused by the want of them. This gives vaguely some idea of the essential points in connection with pneumatic caissons and the actual construction and operation of them should now be examined.

Underpinning Adjoining Buildings

As has been said in the introduction, the removing of material close to adjoining buildings will often cause them to settle and later

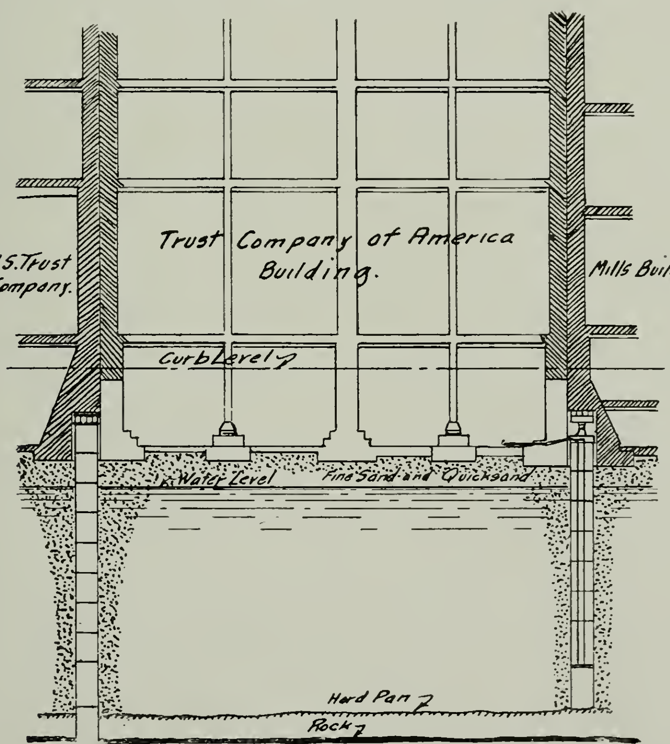


Fig. 1. Showing how Pneumatic Caissons were used in underpinning the buildings adjacent to The Trust Company of America Building while the old building was being wrecked.

collapse. The constructors to whom is entrusted the responsibility both of planning and doing the work of excavating near another building have solved these problems by employing the caisson in conjunction with the Moran Air Lock.

The principle of the air lock was used for the underpinning of the adjoining buildings as well as for part of the main work of the laying of the foundations for the building of the trust Company of America on Wall Street, New York. Fig. 1 shows how the work was begun even while the old building was being wrecked. Niches about 5 feet above the cellar floor and 5 feet wide were cut in the walls of the adjoining buildings with electric and steam drills at intervals of about every 6 to 9 feet. These were carried downward through the old foundation, and through the sand under the foundation until the water line was struck. Then a six foot length of rivetted steel pipe, 36 inches in diameter, was jacked down into the sand, thereby employing the weight of the building in constructing the new underpinning. A downward opening door was installed at the top of this length, a second length was bolted to the first, and then the second downward opening door was installed, completing the miniature air lock.

As shown in the figure, compressed air was supplied to the bottom chamber, and the work pushed lower and lower through quicksand or hardpan, as successive lengths of pipe were bolted to the top and material excavated. When rock was reached, the entire cylinder was filled with concrete, the steel pipe remained, and when steel beams were placed as shown in the left side of the sketch, the underpinning at that point was completed.[1]

Twenty-seven concrete piers constituted the foundation work proper under the Trust Company of America Building. The remarkable speed with which these piers were sunk to bed rock was made possible mainly from this one fact. The air lock used allowed the material excavated in the caisson to be hoisted to the open air in one continuous haul, being handled but once in transferring from bottom of the caisson up to the dumping place, generally a truck.

In Fig. 2 is shown the four boom traveler derrick, which was equipped with four double drum hoisting engines, and which effectively covered the entire area. It served to place the caissons, one of which weighed 20 tons, and was 14 x 31 x 8 feet high at their proper location. It also hoisted men and material in and out of the twenty-seven working chambers. Fig. 2 also shows the air lock in place near the top of the picture. A man was placed on the ground as gauge tender, to keep the pressure steady for the convenience of the men in the working chamber, and another man at the air lock to communicate signals between the excavators and the engineers.

The piers were sunk through soft soil to bed rock without weakening the adjoining buildings. They were sunk end to end with only 12 inch spaces between, and the chain of piers around the entire site was made perfect by welding or bonding between the ends of the piers. This kept the water from entering either the basement or the sub-basement of the Trust Company of America building.

This solid wall type of bonded foundations constructed has this

1 Sc. Am. Supp. Apr. 20, 1907, Fds. Problems in N.Y.C.ivl., Ripley.

great advantage. The piers in the centre of the lot can generally be sunk without the expense of the compressed air method, for there is little danger of any water seeping in from the outside, and therefore of weakening the other buildings.

Caisson Construction and Operation

General Make-up and Size of Caissons

Foundations which are constructed by aid of compressed air generally employ a cylindrical caisson of iron, divided into two unequal parts by a horizontal partition, the upper part, which is the

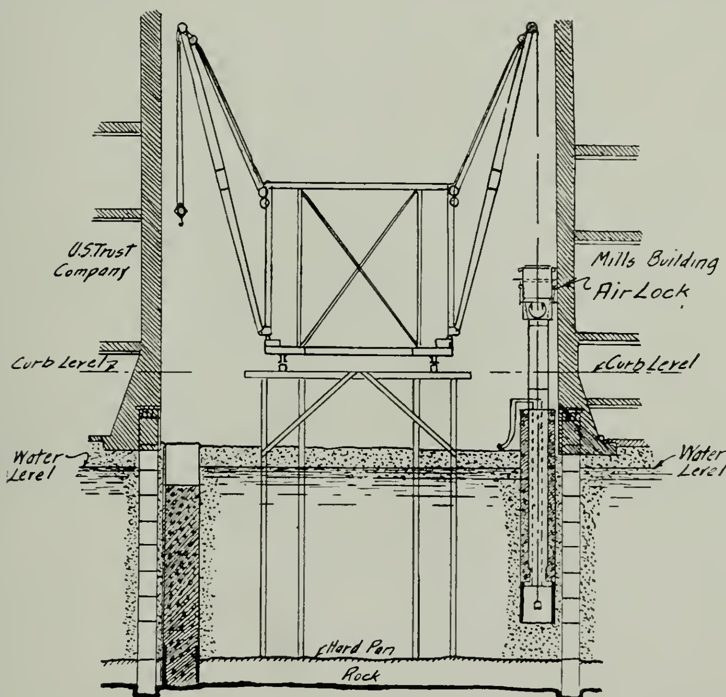
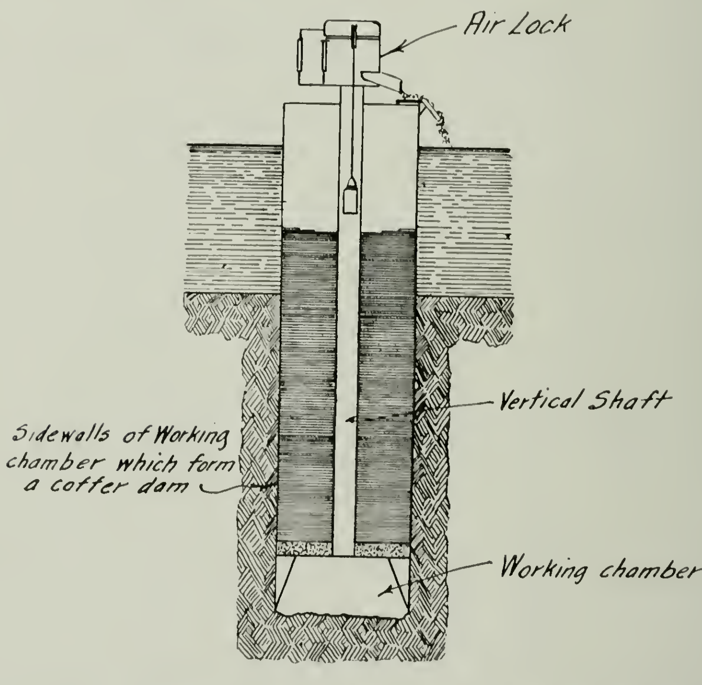


Fig. 2. Showing the air lock in position on the Pneumatic Caissons used for the main foundations of The Trust Company of America Building.

larger, is the caisson proper. It is a cofferdam within which the masonry is built in the open air. The lower part, which is filled with compressed air, and within which the excavation is carried on, is called the working chamber. It is furnished with one or two shafts made of boiler iron, which are surmounted with an iron chamber called the air chamber. Adjoining this is the "equilibrium" chamber, or air lock, through which workmen and materials must enter. A pipe from the compressing engine furnishes the air chamber with compressed air. The air chamber and air lock are generally located above the highest level of the water, in order to insure the escape of workmen in case of accident. Fig. 3 exhibits the relative position of the various parts as was the design of A. Heinerchiedt in the year 1880. We draw from this that the essential parts of the pneumatic caisson are really the working chamber, the vertical shafts and the air lock and the side walls of the working chamber which are carried up to form a coffer dam.

The usual method of making a caisson is to build it first, with the roof or deck about 6 or 7 feet from the cutting edge—the site having being first excavated to the water level—work in the open by cheap labor, of course, being cheaper than excavation in the air



No. 3. Relative position of various parts of Pneumatic Caisson. Design of A. Heinerchiedt in 1880.

chamber by high priced sand hogs, with the cost of the compressor plant, etc., in addition.

For ordinary caissons, great variation has existed, and still exists, in the design and construction, some engineers using very thick timber side walks with a timber roof or deck 10 or 12 feet thick, others reducing the thickness of the timber roof to 3 feet, while others again use plain concrete or reinforced concrete and employ timber only for forms, while a few build the whole caisson and cofferdam of steel and cast iron. A good example of steel caissons was the Mutual Life building where the sizes ran from 3 ft. diameter for underpinning cast iron caissons, to 8 x 22 ft. for main caissons. These caissons are fairly represented by the two adjoining figures. Fig. 4 shows a typical caisson, employed in constructing the foundation for a large building, fairly started, and Fig. 5 shows the same caisson when it has reached bed rock and is about ready for the concrete in the air chamber.[1]

Several contractors in New York have recently tried sinking caissons of concrete, using timber for forms and removing the forms

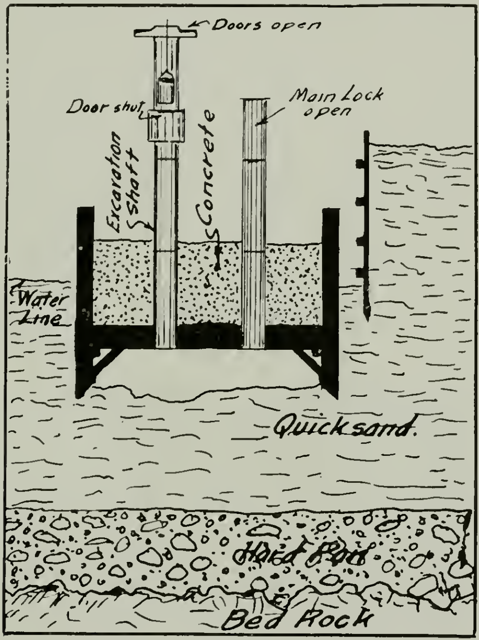


Fig. 4. A Typical Caisson, fairly begun.

as soon as possible. Theoretically, this method is the cheapest of all, but practically it has been found that it paid to leave an outside shell of timber on to permit the sinking to proceed continuously, which is not possible when removable forms are used, necessitating a cessation of sinking for a day or so, sometimes several times for each caisson, to permit the concrete to harden before being subjected to the friction of the ground.

The removal of forms required considerable labor, sometimes high priced, as in the case where iron angles were used and the forms were held together by means of steel bolts, which gave the iron unions a chance to insist upon the bolts being put in and taken out by iron erectors.

1 Pneumatic Caissons, T. K. Thomson. Sc. Am., Supp. Oct. 10, 1908, p. 234.

All wooden caissons should have an outside tongued and grooved sheeting of 2in. or 3in. plank laid vertically to avoid friction on long horizontal joints. Most contractors, however, use plank with a calking edge instead of tongued and grooved, and then calk with oakum.

For small caissons, say from 5 to 12 feet square, there should be a horizontal wall of 8in. or 10in. timbers from the cutting edge to the roof instead of the plank sheeting, properly braced at the corners, and inside of this there should be a 12in. x 12in. belt course under the roof. One solid course of 12in. x 12in. timbers is ample for the roof or deck, and if concrete is placed on the deck as fast as the caisson is sunk, the plank sheeting will be sufficient for the side walls above the deck, with light horizontal waling pieces spaced about 5 feet apart vertically.

For large boxes, up to 30 feet wide, 27 inch sides, below the deck, have been used; that is, 3in. plank against the 12 x 12 horizontals,

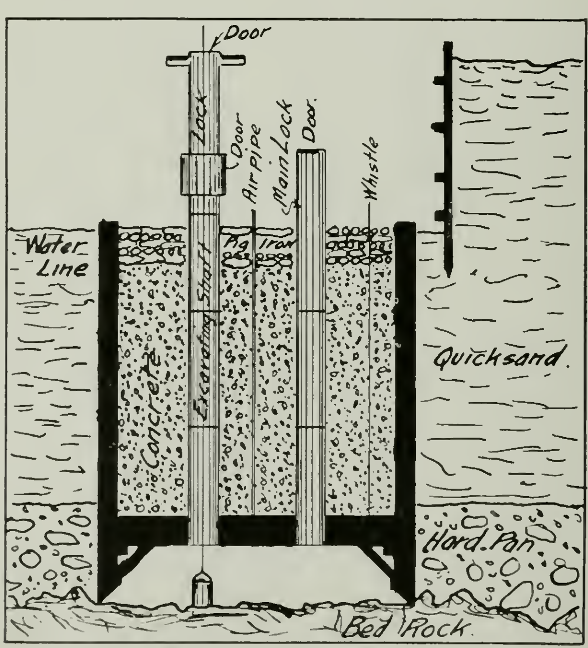


Fig. 5. The Caisson at Bed Rock, ready for concrete in air chamber.

inside of which were placed a wall of 12 x 12 posts, about half of which extended from the cutting edge to the roof and the rest projected from 2 to 6 feet above the deck, while the corner posts and an intermediate about every 15 feet apart were extended to the top of the cofferdam, properly spliced at the joints.

Above the deck, horizontal 12 x 12 inch walings placed from 3 to 5 feet apart vertically were placed outside of the posts, the sheeting being spiked to the walings.

In the concrete were placed in the cofferdam on top of the caisson as fast as the caisson was sunk, all the bracing above the deck could be removed as the concrete reached the bottom of the brace, or omitted altogether in some places, but it is often necessary to keep the concrete 20 to 30 feet lower than the surface of the water in order to prevent the caisson from becoming too heavy, when very heavy cofferdam bracing will be required to withstand the hydrostatic head.

In sinking the first caisson for a New York City skyscraper, the Manhattan Life Building, steel caissons were used, on top of which brick work was built, but it was found that the friction broke the new mortar, thus pulling the brickwork away from the caisson. In any case, the cofferdam should be very securely attached to the caisson, the necessity of which was proved in a river caisson, where the clay was taken out of the air chamber and dumped over the side of the cofferdam, to which it adhered and broke the whole cofferdam, 106 feet long, away from the caisson.

Many small New York caissons have been built with wooden sides and a 2 inch plank "form" under the roof, on which 2 feet of concrete has been laid and allowed to set for a couple of days, after which the form was removed and the concrete continued. At first, forms were also used instead of cofferdams for the sides above the roof, but after this scheme had been used for 3 or 4 buildings it was abandoned as not economical in practice.

In these caissons, sometimes the steel shafts were left in, and in other cases collapsible steel shafts or wooden forms for the shafts were used and then removed. Removing or leaving out the steel shaft in a small caisson is very risky and has been attended by accidents, where the caisson has broken in two owing to greater pressure on one side of the jutting edge than the other.

Steel caissons have been used a great deal in the past, but are not used a great deal in New York now, except perhaps for circular caissons, especially where of very small diameter. The advantage of using steel for round caissons up to 10 or 12 feet in diameter, consists in the rapidity with which the light sections of cofferdam can be bolted on and filled with concrete, the time saved often being enough to pay for the extra cost of the material. Another advantage is the ease with which they can be made watertight.

Small caissons for underpinning purposes are made from 30 to 36 inches diameter, of cast iron or built up steel plates. A good plan is to use steel cutting edge sections and make the upper sections of cast iron, using 1½ to 2 inch metal. In underpinning the adjoining buildings to the extension of the Mutual Life Building, in 1900, twenty-six of the small caissons from 60 to 80 feet deep were used.

Much difference of opinion exists as to the proper form of cutting edge, which, as might be inferred, is the bottom of the caisson, the idea being that it cuts its way into the underlying material, though, as we have seen, it is often necessary to excavate under the cutting edge itself. Many strive to obtain a knife edge (for the cutting edge) by means of steel plates and angles; while in many cases an 8 inch channe laid flat has served the purpose. The knife edge, is of course, ideal, but it is very expensive, and where it is really needed is almost sure to become bent and distorted, in which case it is far worse than no cutting edge at all.

Twenty-seven inch inside diameter is the smallest pneumatic caisson that men have worked in comfortably, but even then they were cramped somewhat for room, and 33 inch inside diameter or 36 inch outside has been found to be a much better size.

For the main caissons of a new building, anything under 6 feet in diameter is unsatisfactory, as there is not sufficient room for the men and bucket, and besides it is hard to keep small caissons plumb and in line.

In the above only those caissons in which the roof is left in place have been considered, but there are many places where it is desired to sink the caisson shell with a temporary roof, and, of course, a temporary weight, where, for instance, the base of the column must be set below the surface of the ground before the main part of the cellar is excavated. This has been done in a number of cases in New York in recent years where there are from three to four floors below the street level, both for the purpose of saving time by allowing the erection of the steel work to commence before the cellar is excavated, and also in order that the steel work and concrete floors may be used, as the cellar excavation proceeds, to obtain sufficient bracing for the side caissons, which are usually only 6 to 8 feet wide, forming a wall around the building sometimes 60 or 70 feet below the street line, and are entirely too light to withstand the enormous water and earth pressure without the horizontal bracing afforded by the floors.

The material of the caisson proper and of the cofferdams may be of wood or steel; the shaft will be of steel or some material which can be made air-tight when the air is under pressure. The concrete is first placed on the roof of the working chamber, within the cofferdam but outside the shaft. The upward prolongation of the shaft wall, of the cofferdam and of the hollow cylinder of concrete resting on the roof of the working chamber proceed somewhat together. When sinking to the final depths has been completed, concrete is laid in the working chamber and carried on up the shaft to the surface.[1]

(To be continued)

S. E. M. Henderson, '00, is in charge of the switchboard department of the Canadian General Electric Co., Peterborough. C. E. Sisson, '05, is in charge of transformer work for the same company.

J. H. Caster, '07, until recently with the Canadian General Electric Co., of Peterborough, is now in the employ of the Toronto Hydro Electric system.

1 Modern Steel Caissons, J. F. Stringer, Ir. Trd. Rev. Jan. 6 1910 page 103.

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EDITORIAL

The executive has announced the twenty-fourth annual dinner of the Engineering Society to be held at McConkey's on the evening of February 13th, 1913. Invitations will be mailed within the next few days.

THE SCHOOL DINNER

This year's dinner will be a return to the genuinely enthusiastic event of years ago. We have been leaving our latitude in many respects. Last year's dinner showed the undergraduate attendance to be as follows, by years:—

1. From a total of 265 members, 40 were present—15.1%
2. From a total of 216 members, 33 were present—15.3%
3. From a total of 154 members, 8 were present—5.55%
4. From a total of 163 members, 69 were present—42.3%

798 150 18.75%

A careful investigation made clear the fact that previous executives have devoted much attention to the careful compilation of their guest lists at the expense of provision of features of interest and enjoyment to the undergraduates. Dinners of recent years have been important in their own way. Efforts to advance the interests of the School, by bringing together guests and staff, have been successful in that conversational enlightenment and benefit have been the result.

As for the undergraduate, his was not the opportunity of chatting with the men of prominence who assembled at the guest table, nor even with the graduates generally, who held interests in common with themselves, or with members of the staff. From an educative point of view there was little or nothing which he could acquire as he was not in the mood, or which he could not acquire by reading at some future date. The student does not attend the School dinner for the same reason that he attends lectures, and if there is not recreative enjoyment for him the dinner naturally loses his support.

It is similar with the graduate. In other societies and on other occasions he hears or reads all that there is of value in the after dinner speech, and if this event does not savor of old time School spirit and enthusiasm he entertains a feeling akin to Goldsmith's Traveler, and his interest wanders elsewhere.

It is evident from observation and analysis that the School dinner is no longer *the* School dinner when it does not retain the interest of the graduate and much less so in the case of the student. The function can be of much greater value to the Faculty of Applied Science and Engineering by having for its primary object a cementation of its undergraduate and graduate bodies. An event it should be such that interest will not flag nor enthusiasm fade in the midst of a series of after dinner speeches.

This year's dinner will be one entirely for School men. It is to be full of entertaining features for student, graduate, staff member and visitor, and its chief function is to be a revival of School spirit.

THE QUESTION OF CERAMICS

The Canadian Clay Products Manufacturers' Association at its recent convention in Toronto, devoted a great deal of discussion to the best ways and means of presenting their great need for technical knowledge bearing upon the raw materials employed in the production of brick, tile, etc., and upon the mechanical methods in vogue in their manufacture. This has been a much discussed subject at every annual meeting of the Association for years, and the great necessity for the establishment without further delay of an educational department devoted to ceramics led its members to approach President Falconer for relief.

In earlier copies of APPLIED SCIENCE (Jan. 1910, and Jan. 1911) mention has been made of a similar movement six years ago, which occasioned the appointment, by the Minister of Education, of a special committee to investigate what has been done in the United States towards the development of technical training in ceramics. There followed the committee's report, including in detail a description of the department of ceramics in the University of Ohio, at Columbus, together with proposals for similar requirements if such a course were to be established in the University of Toronto. The Faculty Council tendered its approval, as did also the University Senate, but the Board of Governors arrested the progress of the movement because of insufficient room and funds.

Of great importance to the clay industries of Canada and to the University is the work which Mr. J. Keele, '93, is doing for the Geological Survey of Canada in the laboratories of the Faculty at present. Mr. Keele's paper in the last issue of APPLIED SCIENCE shows well his knowledge of the country's resourceful clay beds. He is the best informed man in the Dominion on the subject, and the results of his experimental work here on the great variety of clays and shales —samples gathered from all parts of the country—will be of utmost value.

Another vital asset to the clay products men in their movement is the fact that there is at the present time sufficient space available for the housing of machinery and equipment necessarily belonging to such a department. The east wing of the Chemistry and Mining Building, until recently occupied as a museum, has been vacated, the specimens having been removed to their new and spacious home on Bloor Street. The wing would provide a fair working space for present needs although it is less than two-thirds as extensive as the department at Columbus, as may be noted from a comparison of the space (1) at the University of Ohio with that (II) as proposed for the University of Toronto.

	I	II
Glass work	285 sq. ft.	480 sq. ft.
Ceramic Physical Laboratory	527	....
Instructor's Laboratory	283	320
Balance room	153	...
Ceramic Chemical Laboratory	1,469	...
Lecture room	1,094	960
Museum and Office	698	660
Storage	895	780
Main work room	1,933	1,100
Pottery machinery	1,074	1,500
Machinery room	698	...
Motor room	256	...
Kiln room	1,444	...
Private room for staff	...	320
Metallurgy	...	320

The Canadian Clay Products Manufacturers' Association, at its initial session, appointed a special committee to confer with representatives from the staff of the Faculty of Applied Science, and to formulate a plan of procedure. Assured of the co-operative spirit in the Faculty towards an endeavor to inaugurate such a course, a delegation of over seventy, representing all the clay provinces of the Dominion, waited upon President Falconer, and its leading men presented their request. A communication from a manufacturer of brick machinery was also read, offering to donate to any Canadian university or school, of which the Association might approve, a complete laboratory equipment consisting of a brick machine, grinding pans, automatic cutter, dies, etc., that would establish a course. Dean Galbraith voiced his sympathy with the movement, informing the delegation that his annual reports for many years have contained an intimation of the great need for a course of instruction for the benefit of the clay industry. Dr. Ellis outlined the work and report of the special committee previously mentioned, he himself having been a member.

The president in reply expressed his interest in their agitation and his apprehension of the need of technical training for men proposing to devote their lives to the industry. The vital question he stated was that of funds. No university in America was carrying on its work at so low an expenditure per student as the University of Toronto, and the situation was becoming graver yearly. He intimated to the delegation that they should not delay in bringing their matter to the attention of the Board of Governors and of the Provincial Government, and confirmed the Dean's statement that when the funds for such a course were once available, the Association might be assured that great care would be exercised in outlining and maintaining an efficient course in ceramics.

The members of the Association were well pleased with the evidences of co-operative feeling prevalent in the University, with the reception given them by President Falconer, and likewise by several members of the Board of Governors, whom they approached later.

SOME IMPORTANT EXPERIMENTAL WORK

Mr. J. Keele, '93, who with Professor Heinrich Ries, of Cornell University, prepared a report entitled "The Clay and Shale Deposits of Western Canada," mentioned in "Applied "Science" for September, is at present engaged in a series of laboratory experiments in the metallurgical laboratories of the Faculty of Applied Science and Engineering. Several tons of samples were brought by Mr. Keele to Toronto, and are being tested for their utilitarian values in the various branches of clay products manufacture.

Work of this nature had not before been undertaken in Canada, the government having on other occasions recoursed to the facilities offered in the laboratories of Cornell University. This departure from previous custom is an important item for the University of Toronto and particularly for the School.

In Mr. Keele, the Geological Branch has, without doubt, the best informed man in the Dominion upon the country's clay resources, and his knowledge not only of the clay, shale and sandstone beds, but of qualities and usefulness of their contents, has placed him upon a pedestal as an authority whose word and work is of immense value to the country.

The school is also fortunate in being able to claim him as one of its graduates, and as one who delights in devoting his spare moments toward the instruction of others. The classes in metallurgy, architecture and mining have benefited greatly by Mr. Keele's interesting talks on the subjects varying on formations, from the natural to the scientific.

The work which the Geological Surveys Branch is carrying out in our laboratories will have a great influence upon the future of the clay industry in Canada, and the University of Toronto is winning distinction as being the seat of the important investigations.

LECTURES ON VECTOR ALGEBRA

At the request of Dean Galbraith, the President has invited Dr. Alexander Macfarlane, F.R.S.E., to give a short course of lectures on the subject "Vector Algebra."

The utility of vector ideas and of graphical constructions based on vectors is familiar to all engineers. The engineer can make no progress without means of dealing with forces, stresses, velocities, acelerations, not to speak of numerous kinds of vectors in electrical engineering.

The more familiar facts, however, relate to processes analogous to addition and subtraction; thus a large field is left involving multiplication of vectors and more complicated processes which is largely *terra incognita* to the engineer.

Dr. Macfarlane has made the analytical study of such relations his special field and is in fact president of an international association for the promotion of such studies.

It is hoped that this invitation from the University may be useful to members of the staff and graduates as well as to any senior students who may wish to attend.

The lectures will be given during the week beginning February 10th, at a place and time to be arranged.

CANADIAN CLUB OF NEW YORK.

Dean Galbraith attended the eighth annual banquet of the Canadian Club of New York, and as usual, his presence was hailed with delight. Indeed, among the great men of America few are so universally respected and loved as John Galbraith, and as he took his seat at the guest table among fifty statesmen, presidents of banks and railroads, and like officials, many realized that there were few even in that wonderful array of brains and capabilities who could compare their achievements to those of the man who founded and built up the School of Practical Science.

Some idea of the calibre of other guests may be gathered from the following list of guests, a stronger and more important group of men having never before graced a Canadian banquet in the United States: Sir Edmund Walker, president Canadian Bank of Commerce; Professor Willis L. Moore, Department of Agriculture, Washington; Mr. Frank Vanderlip, president National City Bank, New York; Mr. William C. Brown, president New York Central Lines; Mr. James G. Cannon, president Fourth National Bank, New York; Captain Albert Gleaves, U.S.N., Commandant Brooklyn Navy Yard; Mr. David R. Forgan, president National City Bank, Chicago; Hon. A. S. Goodeve, Railway Commissioner, Ottawa; Mr. Ralph Peters, president Long Island Railroad; Dr. Daniel M. Gordon, principal Queen's University, Kingston; Mr. Lewis L. Clark, president American Exchange National Bank; Rear-Admiral Bradley A. Fiske, U.S.N., commanding First Division, U.S. Atlantic fleet; Sir Robert Williams, former partner of the late Cecil Rhodes, South Africa; and a score of others. The Right Hon. R. L. Borden and Mr. E. J. Chamberlain, president G.T.R., expressed their regrets at being unable to attend.

The president of the Canadian Club of New York, T. Kennard Thomson, '86, had the honor of presiding and calling upon the following for speeches: Col. the Hon. Sam Hughes, Minister of Militia and Defence, Ottawa; Prof. Willis L. Moore, Dean Galbraith, Sir Edmund Walker, William C. Brown, David R. Forgan, Principal Gordon, Hon. A. S. Goodeve, and Mr. C. W. Barron.

Ernest Thompson Seton gave the members a rare treat, as did also Mrs. A. A. Watts, wife of one of the members of the club, who recited "The Spell of the Yukon" and "Grin," by Robert W. Service.

On the same day Mr. Thomson gave a luncheon to about fifty of the guests at the Engineers' Club of New York, at which a score of excellent speeches were made. Among them were those of John A. Stewart, representing the proposed celebration of one hundred years of peace; Hon. Sir Alexandre LaCoste, Ottawa; Mr. C. W. Barron, owner and publisher of "The Wall Street Journal" and "Boston News Bureau"; Charles Warren Hunt, secretary American Society of Civil Engineers, and the past-presidents of the Canadian Club of New York, together with the presidents of other Canadian Clubs.

CLASS '14 DINNER

A very successful dinner was held by the third year at the St. Charles, in Toronto, on Wednesday evening, December 18th, 1912. Over one hundred and twenty-five of the class were in attendance. The speech list was enlivened by selections by the Science Octette and by the School's "Symphony Orchestra," conducted by Mr. Foote.

The first toast of the evening was proposed by Mr. H. J. MacKenzie to "Our Alma Mater," and responded to by Dean Galbraith. The Dean based his speech largely upon the value of the general training, to any man preparing himself for any profession, adding in his usual good style from his store of reminiscences, incidents in the past life of the School as amusing as they were historical. He referred particularly to a squirrel hunting expedition in which our Professor Wright was pronounced by an Indian band of spectators a very good hunter indeed.

Mr. R. G. Matthews proposed the toast to the Faculty of Applied Science. In replying Professor Wright made reference to the status of the School men in industrial communities, emphasizing the widespread effect of the thorough knowledge and training acquired by men at S.P.S. The toast to the "Year '14" was proposed by Mr. F. C. Mechin and replied to by Mr. W. J. Smither, after which Mr. G. M. Smyth introduced "The Engineering Profession," to which President Ritchie of the Engineering Society responded.

A toast to athletics was very heartily responded to by Mr. T. R. Loudon at the intimation of Mr. E. B. O'Connor. The renown of many of the members of the year in athletics is enviable, and Mr. Loudon's remarks created a volume of applause.

The evening's entertainment and pleasure were brought to a close by a vote of thanks moved by Professor Wright and seconded by Dean Galbraith for the very efficient manner in which the event had been conducted, pronouncing great credit due to the president of the year, "Dutch" Macpherson, and his executive, for the success of the event.

"THE TOIKE-OIKE CLUB" OF MONTREAL.

The graduates in Montreal having grown desirous of a shorter and more concise name for their association, have chosen the above to designate them and their official representative body in future. The name is well chosen in that undergraduates temporarily in the city on business or pleasure need entertain no feelings of dubiety as to it being a club for graduates alone.

A meeting is to be held in Montreal, at Cooper's Restaurant on the evening of January 28th. The annual meeting of the Canadian Society of Civil Engineers will bring many School men into Montreal and those who can should attend the "Toike-Oike" smoker that evening, to meet as many as possible of the School men in Montreal.

RE-UNION OF CLASS '09

The class of 1909, of which T. Harold Crosby is president and G. Ross Workman, Secretary, purposes holding its first re-union dinner on February 14th. The date was set between that of the School dinner (February 13th) and the Queens-Varsity Intercollegiate hockey game at Arena Gardens (February 15th). It is understood that these events are being included in the programme for the re-union.

The place where the dinner will be held on St. Valentine's night has not been decided upon. The members of the class have been notified of the date only, and their support, which will be evidenced by the returned postcards enclosed in their circulars will largely determine the nature of the proceedings.

THESES FOR DEGREE OF B.A.Sc.

The following is a complete list of theses presented by men of the fourth year for the degree of Bachelor of Applied Science. The bracketted figure following each name designates the course the candidate is following, thus: (1) Civil Engineering; (2) Mining Engineering; (3) Mechanical Engineering; (4) Architecture; (5) Analytical and Applied Chemistry; (6) Chemical Engineering; (7) Electrical Engineering; (8) Metallurgical Engineering.

Candidate.	Title of Thesis.
Adams, O. F. (7)	Power Factor Measurement.
Allen, R. J. (7)	Electrical Ignition.
Alport, F. (1)	Design of a Power Plant.
Anderson, A. S. (3)	Boiler Furnaces.
Avery, C. R. (1)	Water Purification.
Baldwin, L. C. M. (4)	Design of Theatre.
Beatty, F. W. (1)	Precise Levelling.
Beatty, W. B. (1)	Longitude.
Bell, C. A. (2)	Explosives—The Nature of the Break.
Bell, R. S. (7)	Electrification of Railways.
Binns, R. E. (2)	The Classification of Ores.
Black, B. S. (1)	Modern Country Highways.
Blain, D. (1)	Plate Girders.
Bonter, E. R. (7)	Practical Application of Induction Motors.
Brereton, L. R. (7)	Electric Pumping.
Brock, W. M. (1)	Brick, the Ideal Wall Material.
Brown, B. (4)	Design of a Railway Station.
Buchanan, T. R. (2)	The Effect of Impurities on the Electrolytic Assay of Lead.
Buchanan, W. B. (7)	Rotary Converters—Their Application and Efficiency.
Burrows, B. H. A. (3)	Improvements in the Modern Locomotive.
Cain, E. T. (3)	Alloy Steel.
Caldwell, W. B. (2)	The Manufacture of Ferro-Alloys in the Electric Furnace.
Cameron, O. L. (1)	Water Purification.
Campbell, L. L. (1)	Preservation of Railway Ties.
Carmichael R. M. (3)	Turbine Pumps.
Carrie, G. M. (1)	Dust Prevention.
Clark, H. A. (8)	An Investigation of Ferro-Alloys by the Electric Furnace.
Clarkson, G. E. (6)	Dyestuffs.
Clegg, B. D. (3)	Low Pressure Steam Turbines.
Coleman, J. H. (7)	The Transformer—Design and Types.
Cook, G. M. (1)	Fireproof Building Construction.

Coombs, J. A. (1)..... Railway Tubes and Tunnels.
Coon, B. R. (4)........ Design of a Bank Building.
Curtis, W. T. (2)..... The Breaking of a Rock by Explosives.
Dates, A. J. (1)....... Concrete as a Fireproofing.
Davison, H. D. (3).... Steam Boilers.
Deitch, E. L. (7)...... Automatic Motor Starting.
DeLaporte, A. V. (5).. The Utilization of Certain Commercial Wastes.
Diamond, R. W. (2) .. An Investigation of the Hydro-Metallurgy of Copper.
Duncan, W. G. (7).... High Tension Insulators.
Fleming, D. H. (1).... The Septic Method of Sewage Disposal.
Flint, T. R. C. (7).... Street Illumination.
Foote, F. F. (3)....... The Design and Construction of Cupolas as Used in the Founding of Grey Iron.
Galbraith, J. S. (1).... Slow Sand Filtration with Special Reference to the Toronto Plant.
Garnham, W. H. (2).. The Bearing of Different Sampling Methods on the Absolute Assay Value of an Ore.
German, A. M. (1).... The Disposal of Municipal Refuse..
Goodman, H. M. (1) . Irrigation—With Special References to Dominion Government Work in Saskatchewan.
Gray, A. G. (1)....... Modern Track Standards.
Gray, A. J. (3)....... The Design and Construction of Foundry Cupolas.
Gray, E. R. (1)....... Design and Construction of Sewers.
Hadcock, J. P. (7).... Commutation.
Hall, H. G. (7)....... Lightning Protection.
Hamilton, J. R. (1)... Concrete Piles, Types, Manufacture and Driving.
Harris, H. C. (7)...... Automatic Control of Direct Current Motors
Hawley, H. A. (1).... Aesthetics in Design of Concrete Arches.
Hayman, A. W. (1)... Design and Construction of Bridge Piers.
Hearn, R. L. (1)...... Electric Subway Systems.
Heinonen, H. J. (1)... A Discussion on Slow Sand Filtration and Sterilization of Water.
Henry, R. A. (3)...... Gas Producers, Dealing with Their Construction, Action and Use.
Hill, T. A. (7)......... Single Phase Electric Traction.
Holden, O. (1)........ Street Railway Trackwork.
Howard, J. T. (1)..... Concrete Roads.
Howlett, T. F. (7).... Insulation of Electrical Machines.
Ireson, E. T. (1)...... Canalization of Rivers.
Junkin, R. L. (1)..... Plane-Table Topography, as Practised by the Geological Survey of Canada in Ontario.
Kelly, S. S. (7)....... Transformer Cores and Core Losses.
Kerr, A. E. (7)....... Interpole Motors and their Industrial Application.
Kilmer, C. E. (7)..... Electric Power Line Troubles.
Laing, J. S. (1)....... Costkeeping.
Leslie, A. (7)......... Electrical Distributing Systems.

Lillie, G. L. (7)....... Distribution for Electric Railways.
Livingston, H. D. (4) .Design of a Colonial Residence.
Lytle, L. B. (7)....... Electric Traction Systems.
MacKenzie, H. A. (7). Storage Batteries.
MacKenzie, H. R. (1) Reinforced Concrete Abutments.
Maclachlan, K. S. (6). The Modification of Fats.
MacPherson, A. R. (1)Concrete Pavements.
MacTavish, W. H. (1)Topographic Surveying as Practised by the Department of Militia and Defence.
McCarthy, T. V. (1).. Mechanical Filtration of Water.
McConnell, R. S. (4).. Design of a Collegiate Institute.
McFaul, W. L. (1).... Sewage Disposal Plants for Small Communities.
Mickleborough,K.F.(1) Methods of Sewage Filtration.
Mickler, G. J. (7)..... Rates of the Sale of Electrical Energy.
Millman, N. C. (1).... Wharves and Mooring Piers.
Moore, T. R. (1)...... Irrigation.
Mulqueen, F. J. (1)... The Sao Paulo Electric Co.'s Power Plant at Soracaba, Brazil.
Murdie, W. C. (1).... Topography.
Mutch, D. A. S. (8)... A Metallurgical Engineer's Report on a Possible Undertaking.
Newton, K. L. (8).... An Investigation of the Hydro-Metallurgy of Copper.
Oke, W. V. (1)....... Some Reinforced Concrete Systems.
Otto, C. J. (5)........ Some Mixtures of Unknown Compositions Occurring in the Products of Wood Distillation.
Parkinson, N. F. (1).. Concrete Arches.
Peart, J. W. (7)...... Unit Switch System of Multiple Control.
Perron, J. E. (1)...... Tunnelling.
Phillips, J. J. (1)...... Fabrification of Structural Steel.
Quail, H. C. (1)...... The Corrosion and Preservation of Iron and Steel with Particular Reference to Structural Steel.
Ratz, E. G. (7)....... Electric Locomotives.
Relyea, P. J. (6)...... The Utilization of Atmospheric Nitrogen for the Production of Nitric Oxide and Other Compounds.
Riddell, J. M. (1)..... Methods of Base Line Measurement.
Ritchie, J. E. (1)..... Timber Preservation.
Robertson, C. S. (1) .. Sludge Disposal.
Roblin, H. L. (1)..... Roadbed from a Maintenance Point of View.
Rothery, L. W. (3).... Steam Turbine Blading.
Rous, C. C. (7)....... Water Wheel Governors.
Russell, C. H. (7)..... Three Phase Transformers.
Scarlett, A. A. (7) .... Internal Combination Engines as Applied to Turbine Propulsion.
Sewell, L. (1)......... Plane Table Topography.
Seymour, H. L. (1) ... Sewage Disposal by the Method of Live Earth Beds.

Sharp, M. C. (7)...... A System of Illumination for a Manufacturing Plant.
Shaw, K. E. (3)...... Beet Sugar House Machinery.
Sims, F. R. (3)....... Diesel Oil Engines, their Principle of Operation, Thermal and Mechancial Efficiency.
Sinclair, D. G. (2).... The Effect of Impurities on the Electrolytic Assay of Lead.
Soper, R. W. (4)...... Design of a University Theatre.
Spellman, W. A. (1)... Roadways.
Strathy, J. M. (7)..... High Speed Dynamo Electrical Machinery.
Sutherland, D. (1).... Sewage Disposal.
Tasker, R. (1)........ Bituminous Pavements.
Thompson, W. K. (2). The Bearing of Different Sampling Methods on the Absolute Assay Value of an Ore.
Thompson, D. J. M.(1) The Corrosion of Iron and Steel.
Thomson, D. J. (7)... Insulators for High Tension Transmission Lines.
Torrance, T. E. (7)... Street Lighting.
Trow, R. M. (2)..... Efficiency in Methods of Screen Analysis.
Ure, W. G. (1)....... The Flat Slab System of Reinforced Concrete Floor Construction.
VonGunten, C. F. (1). Electrolysis.
Watts, R. E. (3)...... Carburation and Carburetors for Oil Engines.
Webster, C. A. (3).... Centrifugal Fans.
Webster, H. (4)....... Design of a School of Architecture.
Weir. D. H. (1)....... Improvement and Maintenance of the Highways of Ontario.
Whately, H. E. (7).... Single Phase Series Commutating Railway Motor.
Winters, W. S. (1).... Water Supply and Purification.
Wood, R. F. B. (1).... Caissons.
Wright, A. J. (7) ..... High Voltage Protective Devices.
Yorke, L. P. (7)...... Electric Furnace Temperature Measurements.
Young, R. B. (7)..... Mercury Vapor Apparatus.

WHAT OUR GRADUATES ARE DOING

A. E. MacGregor, '10, is in the employ of the Board of Works, London, Ont.

F. T. Nichol, '10, is in Winnipeg managing the branch in that city of C. W. Noble & Co.

A. W. Lamont, '09, for several years with the Canadian Westinghouse Co., in Winnipeg, will join the staff of the Toronto Hydro-Electric System on Feb. 15th.

E. H. Phillips, '00, and W. M. Stewart, '06, are members of the engineering and surveying firm of Phillips, Stewart & Lee, Saskatoon, Sask.

A. G. Wheler, '11, is engineering salesman for Edgar M. Moore & Co., Pittsburg, Pa.

W. J. Walker, '07, is division engineer for Transcontinental Railway at Hearst, Ont.

T. J. Cunerty, '11, is with the Westinghouse Electric & Mfg Co., at East Pittsburg, in the publicity department.

R. W. E. Loucks, '09, is a member of the firm of Brown & Loucks (T. W. Brown. '06), engaged in general engineering, surveying and contracting with offices at 410 Drinkle Bldg., Saskatoon, Sask.

C. W. Dill, '91, resides in Winnipeg, where he has become associated with the National Paving Co., as general manager.

E. A. Neville, '09, is a member of the firm of Neville & Stewart. engineers and surveyors, 428 Vancouver Block, Vancouver, B.C.

H. B. Thompson, '10, is with the Dominion Bridge Co., in the Toronto office.

A. H. Munro, '10, is at Campbellford, Ont., on Trent Valley Canal construction.

J. B. Minns, '07, is with the Canadian General Electric Co., as sales engineer in the Winnipeg office.

L. G. Ireland, '07, formerly with the Midland Construction Co., has accepted a position with the Hydro Electric Power Commission at Brantford, Ont.

A. H. Hull, '06, for several years with Smith, Kerry & Chace, in their Toronto office, is now in the employ of the Hydro Electric Power Commission.

R. L. Harrison, '06, is engineer-in-charge of the Toronto Eastern Railway, and resides at Oshawa, Ont.

F. W. Burnham, '04, has recently accepted a position with the Canadian Westinghouse Co., Hamilton.

M. B. Heebner, '11, is with the Foundation Co., as assistant engineer on the Pitt River bridge, main line C.P.R., at Coquitlam. B.C.

A. M. West, '08, is assistant engineer of North Vancouver.

A. F. Macallum, '93, city engineer of Hamilton, was recently elected vice-president of the American Society of Municipal Improvements.

F. W. Baldwin, '06, is associated with Graham Bell in the manufacture of hydroplanes that have a speed of 55 miles per hour.

E. F. Hinch, '10, is resident engineer of construction with the Toronto Power Co. at Port Credit, Ont.

S. Young, '11, is with the Saskatchewan Government in the Department of Public Works, Regina.

E. A. Jamieson, '10, is resident engineer for the C.P.R. on the erection of the Pitt River Bridge, main line, Coquitlam, B.C.

J. H. Ryckman, '06, until recently with the Chicago, Rock Island and Pacific Ry. Co., has accepted the appointment to the staff of the Strauss Bascule Bridge Co., Chicago.

W. D. Walcott, '11, is now in Toronto in the employ of the Canada Foundry Co.

W. M. Philp, '09, until recently with the Canadian General Electric Co., Peterborough, has resigned to accept a similar position with the General Electric Co. at Schenectady, N.Y.

C. H. Rogers, '06, is manager of the Peterborough Canoe Co at Peterborough, Ont.

DIRECTORY OF THE ALUMNI

Giving each month, in alphabetical order, the location of a number of the graduates. The entire list will be reviewed in the twelve issues beginning November 1912.

The graduates will confer a favor by advising us of any and all instances where the list is not up-to-date. Addresses unknown, or no longer correct, are hard to eliminate entirely from our records. If graduates will see that the information given about *themselves* is exactly as it should be, and that that concerning their class mates is also correct to the best of their knowledge, the department will soon be most reliable.

B (*Continued*)

Brown, G. L., '93, resides in Morrisburg, Ont., and is engaged in civil engineering and surveying.

Brown, L. L., '95, is superintendent of the Foundation Company, New York.

Brown, T. D., '04, is in Calgary, Alta., western representative for the Canadian Fairbanks-Morse Co.

Brown, J. A., '07, is with Routly & Summers, in their branch office at Porcupine, Ont.

Brown, E. I., '08. His home address is Paris, Ont. We do not know his professional engagement.

Brown, C. E., '09, is in Hamilton, Ont., with the Canadian Westinghouse Company.

Brown, H., '11, whose home is in Port Sidney, has been in Calgary during the summer.

Browne, E. W., '09, His present address in unknown to us. He was in Hamilton last year.

Browne, M. O., '10, is in Toronto, but we do not know what his present employment is.

Bryce, W. F. M., '08, is in the office of the city engineer, Ottawa, Ont.

Buchan, P. H., '08, is assistant engineer, construction department, British Columbia Electric Railway, Vancouver.

Buchanan, J. A., '09, is on survey work in the West. His home address is in Comber, Ont.

Burke, M. A., '90, deceased.

Bucke, W. A., '94, is manager of the Toronto district office of the Canadian General Electric Co.

Bunnell, A. E. K., '06, is engineer in charge of the construction on the Lake Erie & Northern Railway, from Brantford to Galt.

Burd, J. H., '03, has been engaged in surveying and civil engineering work in Sudbury and other places. We have no address at present.

Burgess, E. L., '03, is with the topographical surveys branch, Department of the Interior, Ottawa.

Burgess, J. R., '10, is inspector at the plant of the Algoma Steel Co., Sault Ste. Marie, for the Robert W. Hunt Co.

Burns, D., '83, is a member of the teaching staff of the Carnegie Institute of Technology, Pittsburgh, Pa.

Burns, J. C., '87, deceased.

Burns, J. E., '09, is managing editor of " Referendex," Toronto.

Burnham, F. W., '04, is in the engineering department of the Canadian Westinghouse Co., Hamilton.

Burnham, N. G., H., '10, is in charge of a hydrographic survey party on the Red River Navigation Survey for Manitoba Hydrographic Survey Commission.

Burnside, J. T., '99, is in Montreal, where he is engaged in engineering work for the Harbour Commission.

Burwash, L. T., '96, is Government mining engineer and recorder for the Yukon, with headquarters at White Horse.

Burwash, N. A., '03, is with Speight and Van Nostrand, surveyors and engineers, Toronto.

Bush, C. E., '07, after spending the summer on topographical work in the West, has just returned to Toronto.

Byam, F. M., '06, is in the employ of McGregor & McIntyre, Toronto, as chief engineer.

C

Cain, E. T., '11, is taking a post graduate course in engineering this year

Calder, J. W., '04. is withthe Hydro-

Electric Power Commission at Port Arthur and Fort William, Ont.

Cale, W. C., '10, is with the Stone and Webster Engineering Corporation, as engineer on transmission line construction, at Keokuk, Iowa.

Cameron, N. C., '04, is associated with the Dominion Engineering and Construction Co., of Montreal.

Cameron, A., '06, is in Winnipeg, Man., in the employ of the Vulcan Iron Works, Limited.

Cameron, M. G., '09, who has been engaged on the Trent Valley Canal, near Peterboro, has no address with us at present.

Cameron, C. S., '11, has Beaverton, Ont., for his home address.

Campbell, A. D., '10, is in Cobalt, Ont., as mining engineer for the O'Brien Mines.

Campbell, A. J., '04, his home in Collingwood, Ont. We do not know the nature of the work upon which he is employed.

Campbell, A. M., '04, was, until recently, in Chilliwack, B. C. His address has changed recently, and we cannot supply it.

Campbell, W. G., '02, who resides in Toronto, is engaged in railway contracting, at present in the vicinity of Perth, Ont.

Campbell, A. R., '02. We have no address at present.

Campbell, R. J., '95, was with the Western Electric Company of Chicago, but latest advice indicates that he is no longer there.

Campbell, G. M., '96, is superintendent of the power apparatus shops of the Western Electric Co., at Riverside, Ill.

Campbell, W. C., '05, whose home is at Keene, Ontario, is in the West, engaged in mining engineering.

Campbell, N. A., '08, is chief chemist for the Canada Cement Co., at Calgary.

Campbell, R. A., '09, is in the employ of the Tagona Light and Power Co., at Sault Ste. Marie, Ont.

Campbell, A. W., '06, in with the Hydro-Electric Power Commission, Toronto.

Campbell, J. E., '08, has no address with us at present, except his home address at Coldstream, Ont.

Campbell, C. D., '11, is town engineer of Galt, Ontario.

Canniff, C. M., '88, is managing editor of the "Engineer Clubman," a journal in the interests of the members of the Engineers' Club of Toronto.

Carey, B., '89, has no address with us at present.

Carlyle, W. M., '10, is secretary-treasurer of Carlyle and Beck, concrete contractors, Toronto.

Carmichael, C. G., '02, deceased.

Carpenter, H. S., '97, is superintendent of Highways, Department of Public Works, Regina.

Carroll, A. M., '08, is a member of the engineering staff of Routly & Summers, Haileybury, Ont.

Carroll, M. J., '06, is with the Department of the Interior, Ottawa, in the Topographical Survey Branch.

Carscallen, H. R., '08, is on hydrographic work in the West, with P. M. Sander, at Calgary.

Carson, W. R., '05, is mechanical engineer in charge of plant and construction, Grasselli Chemical Co., Cleveland, O.

Carter, W. E. H., '98, is a member of the firm of consulting mining engineers, Carter and Smith, Toronto.

Carter, J. H., '07, until recently with the Canadian General Electric Co., Peterboro, is now with the Hydro-Electric Power Commission.

Caudwell, N. S., '10, is in his second year in law, Osgoode Hall.

Cavell, E., '07, last year a member of the staff department of drawing, has no professional address with us. His home is in this city.

Chace, W. G., '01, is a member of the firm of Smith, Kerry and Chace, Toronto.

Chadwick, R. E. C., '06, is now Eastern manager of the Foundation Company, Limited, with offices in Montreal.

Chadwick, W. W., '11, resides in Hamilton, Ont. We are not informed as to how he is employed.

Challen, G., '08, is at 25 Coombs St., Southbridge, Mass, We do not know his professional work.

Challies, J. B., '04, is hydraulic engineer, department of the Interior, Ottawa.

Chalmers, W. J., '89, is assistant engineer Ohio River Improvement, U. S. Government, and resides at Vanport, Pa.

Chalmers, J., 94', is structural engineer, Department of Public Works, Edmonton.

Chandler, R. B., '11, is in the office of the City engineer, Saskatoon, Sask.

Charlesworth, L. C., '93, resides in Edmonton, and is director of Surveys for the Province of Alberta.

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PNEUMATIC CAISSONS FOR TALL BUILDINGS

By O. W. Ross, B.A.Sc.

PART II

In the foregoing part of this article dealing with caisson construction we find there are two distinct bodies of concrete which are separated from each other by the wall of the shaft and the roof of the caisson. The roof is thought to be a serious matter, for, if it deteriorates, a settlement of one part of the composite pier is to be expected. The pneumatic procedure is usually adopted because of the presence of water, and whether the roof be of wood or steel, the action of water at a considerable depth is ordinarily regarded as a preservative one. However that may be, in New York especially, the tendency has been to get rid of it altogether. Quite recently, in the construction of the foundation piers for the tall building of the United States Express Company, there was put into practical effect the idea of eliminating the roof. The roof is only a temporary affair under the old conditions as well as these newer ones. The United States Express Co. building is the first case of the actual elimination of the roof. The shaft casing may also be removed but not the shaft lining as it must connect the air lock and the working chamber until the sinking is completed and the air pressure finally removed.

Fig. 6 is a sectional view of a typical pneumatic caisson, which has reached its final position with its cutting edge on the bed rock. Notice the heavy timbers of the working chamber. Sometimes the side walls have to be excessively thick and the roof thicker yet it is largely a question of the depth to be penetrated and the character of the soil. In the case shown in the figure, walls and roof are moderate. Above the caisson proper is the concrete surrounding the working shaft and enveloping this concrete is the cofferdam, which has been left in. The tube which conducts the air to the working chamber penetrates the concrete on the right. When the bottom has been properly cleaned off, and the sections of collapsible steel shafting have been removed, the working chamber and the shaft may be filled with concrete. If it is desired to tie the superstructure to the pier, it may be accomplished at this juncture—that is, before the final concreting.

It is not always necessary to carry the caisson to bed rock, even though the excavation for the pier is carried that far. Thus, at the Singer Building, the bed rock was overlaid by a stratum of hard pan and when the caisson had fairly entered this material, it could be stopped and the excavation completed without its use, but the concreting of the caisson and its shaft could, of course, not be done until the excavation was completed.

Calculating Strains

It is necessary to use considerable common sense and experience in attempting to calculate the strains in a caisson. As regards the

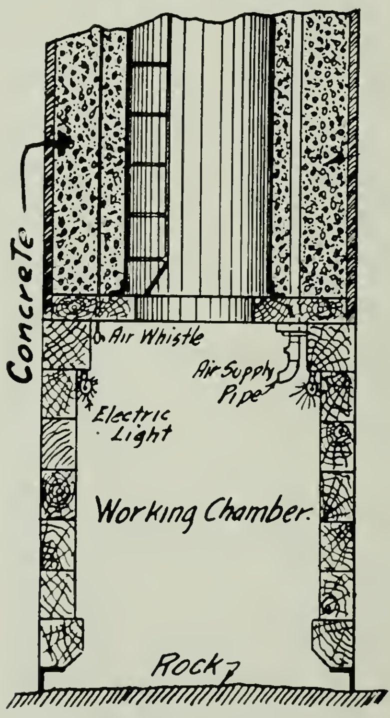

Fig. 6—Sectional View of Typical Pneumatic Caisson where Bed Rock has been reached by Cutting Edges.

deck, for example, it is very easy to calculate the weight to be carried by the deck and the strains that would result therefrom, and we know that the air pressure acting up against the roof will counterbalance a great deal of this weight, making it, in fact, something like a pontoon floating in water. But on the other hand, the air pressure is often slaked down to almost nothing in order to overcome the friction, and is raised again before much water has time to enter the working chamber; and sometimes an accident to the air plant

1 T. Kennard Thomson: *Pneumatic Caissons*.—"Construction," Toronto, Nov. 1908.

will suddenly cut off the supply of air, throwing a tremendous strain on the roof. If the principal weight on the roof is concrete it will in many cases be self-sustaining unless too fresh.

The same with the sides. If the material were absolutely homogeneous all round and the caisson were sunk absolutely plumb, which almost never happens, and the air pressure were kept just equal to the outside pressure, then we would have practically no strain on the sides; but all practical caisson men have seen the sides of caissons collapse, and some very strongly built ones at that. A very much more frequent cause of accident than loss of air pressure is to strike some obstruction on one side, deflecting the cutting edge, and thus throwing much of the weight of the caisson on the weakened side, making bad worse.

A caisson 8 feet wide has had its sides so distorted and compressed that there was not room left for a 29 inch bucket to enter the working chamber from the shaft. In this case the working chamber was made too light to start with, and collapses occurred in the working chamber, and a couple broke in two above the deck and had to be stopped where they were in the quicksand, some 20 feet above hardpan, and the excavation continued under the cutting edge by lining the sides, as in the case of a vertical tunnel—a very risky proceeding, but successfully accomplished.

Some caissons have been sunk as much as 5 feet out of plumb, an inexcusable state of affairs for a small caisson, for while we have said that very few caissons are absolutely plumb, still there is no excuse for their being more than a few inches out.

Large concrete steel caissons have been sunk and in one case it was claimed that by using reinforced concrete the company had saved $100,000, as compared with the cost of the steel caisson they had contemplated; but an equally large caisson, 46 x 130 feet of wood, the total cost of which would be only about $25,000 would have been possibly better. So if the cost of the reinforced concrete caisson were compared with a wooden caisson it would be rather difficult to show a saving of $100,000.

In building wooden caissons it is not best to halve the timbers or use dovetailed joints, but to use butt joints as much as possible with plenty of drift bolts. The trouble with butt joints, however, is that while a carpenter will make a dovetail or half-joint fit he will probably leave an inch or so play in a butt joint.

The deck timbers, as well as those in the sides, should be planed on one side and one edge, for the sides would otherwise vary too much to get a good job, while the planking for the outside and inside of the air chamber should be either tongue and groove, or the sides should be planed for a calking joint. The plank should, of course, have its faces also planed.

It is very important, and difficult, to keep the water out of the cofferdam, and it requires great care with the calking, for sometimes a joint under the cutting edge is not completely calked, with the result that the water finds its way up through the sides and into the roof or deck and thence through the concrete, forming a very bad leak which it is impossible to stop, as its location cannot be discovered. This often necessitates continual pumping in the cofferdam while new concrete is being deposited, which is, to say the least, of no benefit to the concrete.

One of the most important contrivances on a pneumatic caisson is the air lock, without which the work cannot be carried on.

The Air Lock

The theory of the pneumatic caisson is of course, that an air pressure equal or slightly superior to that due to the head of water above the foot of the caisson will exclude the water and keep the interior dry, and this it does perfectly. If the shafts are left open the water will rise in the working chamber until no additional water can enter. If the strata to be gone through are perfectly impervious, the contained water can be pumped out and the caisson sunk by open air methods, and if but a small quantity of water enters, the pumps may, perhaps, be relied on to keep the interior in condition, but if air compressed to a tension constantly equal to the hydrostatic pressure is supplied in sufficient amount, then the work chamber can be kept quite free of water irrespective of the permeability of the soil, therefore, when the caisson has become well settled, the air locks can be added. The office of the air lock is quite analogous to that of the hydraulic lock on a canal. In the latter case, by the use of a lock-full of water from the supply at the upper level a ship is enabled to make the passage between the two levels. So with an air lock. It is a device which by the use of a lock-full of compressed air permits a person or load or empty bucket to pass to and fro between the working chamber and the external atmosphere. With the locks added and the compressed air turned on, the men are enabled to proceed with the excavation until the required level is reached. It is understood that the compressed air plant must continue at work for two reasons: to compensate for the loss of air occasioned every time the lock is used and also to increase the pressure as penetration to lower levels advances.

The air lock in general use in the United States is, fundamentally, it seems, the invention of D. E. Moran, Vice-President of the Foundation Company. He has improved his original device, so that now the Moran air lock can be operated, so it is claimed, with despatch and safety. While despatch is by no means to be sought while the men are passing through, it is of high value in making disposition of the spall.

By referring to Fig. 7, a view of this air lock will be seen in three different situations. Such a lock is fitted to the upper end of the working shaft. This union is made air-tight, of course. There are two horizontal doors, each of which may be swung downwards into a vertical position. The upper one of these closes the external entrance to the lock; the other a short distance below, when closed, completes a division of the total space subject to air pressure into two compartments. The upper compartment is quite small; the lower extends to the bottom of the working chamber. These doors are both closed as shown by the top view. There is, however, a tubular connection between the two compartments, as may be seen in all the views. There is a three-way cock in this connection by which the upper and lower compartments may be put in communication or the upper may be opened to the external air. The conditions disclosed in the top view represent the situation immediately precedent to opening the upper door for entrance. The air pressure in the lock chamber is already at normal, or will soon become so by the equalization taking place.[1]

As soon as the air pressure in the lock falls to that of the outside atmosphere, the upward pressure against the upper door will be removed, and it may take the vertical position shown in the middle view. The empty bucket may now be introduced and by swinging this somewhat to the left the door may again be closed. If now you turn the three-way cock to cut off the lock chamber's connection with the external air and establish it with the lower compartment,

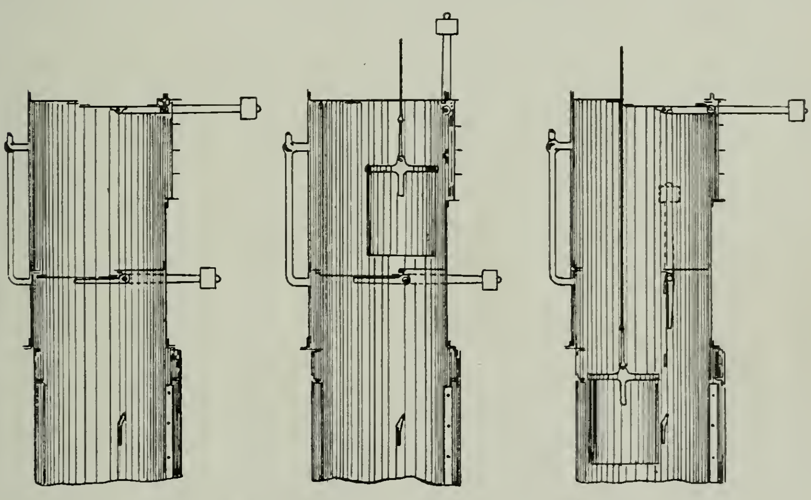

Fig. 7—Moran Air Lock in three different positions.

there will be an inrush of compressed air into the compartment, bringing the pressure there into equality with that below. The excess upward pressure against the lower door will now be removed, thus permitting the opening of it, which is the situation shown in the lower view, and the bucket may be lowered. There is a vertical separation of the shaft below the lock into two passage ways—one for the workmen, one for the material.

This seeks to avoid the danger of men being struck by passing buckets. In passing out, the three operations are gone through in reverse order. Thus the lower view may represent the bucket ascending into the lock chamber where the same air pressure exists and as soon as the bucket is well into this chamber, the lower door

1 Modern Steel Caissons. J. F. Stringer, Ir. Trd. Rev., Jan. 10, p. 101

may be closed and the cock turned and there will follow an equalization of pressure between the air in the lock chamber and the external atmosphere. This lock-full of compressed air will be lost, but no more, as the connection of the lower compartment is now cut off. The upper door may now be opened and the bucket withdrawn as shown in the central view, and if we now close the upper door, we have again the conditions represented in the upper view. It is sometimes necessary to adopt precautionary measures to prevent the workmen coming up from the heavy pressure of the working chamber from passing out of the lock too quickly. Thus, in building the foundations of the Clinton Bridge, where the pneumatic system was employed for part of the work, a regulating valve was employed. When the pressure was in the neighborhood of 35 pounds, corresponding to a depth of perhaps 75 feet below the water, the pressure of air in the lock chamber would not be allowed to fall to that of the outside air under 15 or 20 minutes, and there was thus allowed some time for nature to readjust matters.

A section of the shaft itself is sometimes converted into an air-lock by connecting two doors to it, but the specially designed air-lock which can be connected with the shaft at its top, bottom or any intermediate point is also used. The air lock at the top, being simply a section of the shaft is preferable, as any section can be converted into an air-lock, or the whole section if so desired. This arrangement possesses many conveniences, and it is much safer than when located at or near the bottom. The number of patents of air locks is numerous, but they are all after the same plan as the Moran Air Lock, and on the whole, it is probably the best and most universally used.

Removal of the Earth

The removal of the earth from the caisson is accomplished in several ways. (1) One device is the sand lift, which consists of a pipe, reaching from the working chamber to the surface controlled by a valve in the working chamber. The sand is heaped up around the lower end of the pipe, the valve opened, and the compressed air in the working chamber forces a continuous stream of air and sand up and out. Mud or semi-liquid soil may be removed by this means by immersing the lower end of the tube and opening the valve, but this method is most effective with sand. Although the sand-lift is efficient there are some objections to it.

(1). Forcing the sand out by the pressure in the caisson decreases the pressure, which causes the formation of vapors, so thick as to prevent the workmen from seeing.

(2). The diminished pressure allows the water to flow in under the cutting edge and (3) if there is much leakage, the air compressors are unable to supply the air fast enough. Notwithstanding these objections, it is largely used.

The mud pump is free from the above objections to the sand lift, and in mud or silt is more efficient than it. The mud pump is based upon the principle of the induced current, and this principle is utilized by discharging a stream of water with a high velocity on the outside of a small pipe, which produces a partial vacuum in the latter, when the pressure of the air on the outside forces the mud through the small pipe and into the current of water by which the mud is carried away. Fig. 8 gives some idea of the mud pump now in use showing the direction of the water and material.

A screen is placed at the lower end to prevent any large material or sticks, etc., from entering.

The clay hoist is a device for hoisting material in a bucket by means of compressed air, and is particularly useful when excavating

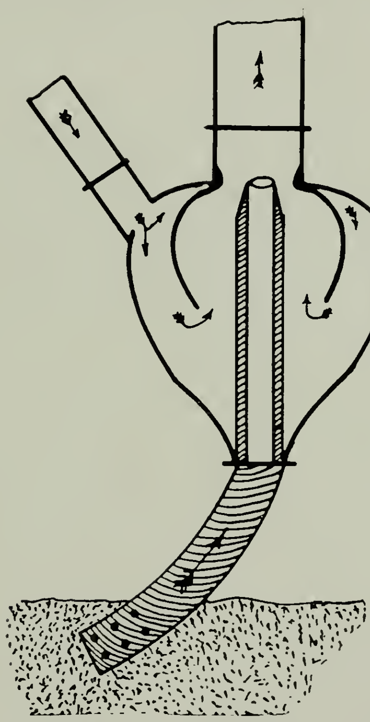

Fig. 8.—Mud or Sand Pump for removing material from working chambers

stiff clay, which cannot easily be removed with either the sand lift or the mud pump. It consists of a cylinder and piston placed at one side of the top of the material shaft.

The piston is actuated by air pressure, and is connected to a cable to which is attached a bucket working up and down through the material shaft. At the top of the shaft are two doors operated by levers from the outside, to facilitate the passage of the buckets. This device is very effective.

In making the excavation, the material should not be removed from under the shoulders until the middle space has been excavated to a depth of two or more feet below the cutting edge, so as not to leave the caisson unsupported for any great length of time, and not at all under the lower side, if the caisson is out of level.

Sinking the Caisson

The only economical method of sinking is to have just sufficient weight so that the caisson will continue to move downward as fast as the cutting edge is undermined. Too much weight is obviously dangerous, as in soft material there is a risk of the cutting edge penetrating the material until the air chamber is filled with earth and water, and even if the men have all had time to escape it is expensive work digging in from the shaft to make room for the men and buckets.

The usual method, as Mr. Thomson describes, after a caisson has fairly started on its downward course, is to dig about a foot below the cutting edge, except just around the cutting edge itself, then removing the material directly under the cutting edge itself, and by slightly reducing the air pressure for a very short interval the net weight of the caisson and its load is increased enough to overcome the friction and to allow the cutting edge to reach the bottom of the excavation. In many places, however, it is impossible to keep the water level below the cutting edge, in which case it is not usual to excavate below the cutting edge.

When passing through hard material, such as hard pan, boulders, or rock, it is important to see that the excavation is made wide enough, or the caisson will surely become jammed. In fact, a 3-foot diameter cylindrical cast-iron underpinning caisson has become so jammed that four hydraulic jacks aggregating 320 tons would not bulge it, and as the jacks were acting against the wall of a building it was not considered safe to jack any more for fear of injuring the building that was being underpinned.

The proper form of cutting edge varies, but it and the sides should of course, be designed with the object of giving the maximum room to work at or under the cutting edge, for, at the best, removing the material at the cutting edge is very much more expensive than removing the rest of the material.

Advantage is often taken of the absences of the men from the working compartment to lower the air somewhat, which is equivalent to adding weight to the caisson and usually the structure sinks a short distance, and then the air pressure is restored again. It might be thought, perhaps, that the reduction of the pressure a few pounds could have no great effect, but if we consider this a moment, it will be evident that the air pressure is, ordinarily, assisting in the support of the structure, and this support is exerted over an area equivalent to a large diameter. The reduction of a single pound in the pressure is consequently equivalent to the addition of considerable weight, and it is easily seen, then, that the reduction of several pounds would have substantial effects. In certain pneumatic caisson work at New York, considerable reductions in pressure were made even with the men in the working chamber.

Of course, such an expedient would only be temporary, as the pressure was really required to overcome the hydrostatic head.

In using the pneumatic method, one has to overcome not only the skin friction between the surface of the caisson and the soil, which may amount to a great deal and varies, of course, with the character of the strata penetrated, but there is a very considerable resistance to penetration due to the pressure of the air that excludes the water, and as one goes down below the hydraulic level the pressure required to effect this exclusion constantly increases. As this pressure is exerted in all directions, upwards as well as downwards, and the resistance to penetration is that due to the total exposed area multiplied by the air pressure, which increases the hydrostatic head. Thus in sinking a caisson one must overcome with the weight of the caisson itself and its accessories, and with that of the load added, not only a skin friction that is becoming greater and greater, but also a constantly increasing thrust upward from the compressed air. In practice, it is often necessary to assist the augmenting load of concrete very considerably. To accomplish this extra loading with an economy of space, pig iron may be used, cast in such forms as to be convenient to handle. This may seem a trifling matter, but it is not to be so regarded. In putting down 116 piers for the new Municipal building in New York City, The Foundation Company used $25,000 worth of such weights. Not only is that amount of capital tied up by this one item, but it cannot be entirely recovered, because, to scrap the iron it must first be broken up which costs money. Thus it is evident that the proper sinking of the caisson is very important, because if it is not properly done, it may entail enormous expenditures.

Concreting the Working Chamber

The filling of the air chamber with concrete is an important proceeding. Bucket locks are much used for concreting the working chamber as well as for excavating small caissons, but for the large caissons or where there are two shafts, a special concrete lock is used. This is usually an ordinary three foot shaft with a door in the bottom and a cone above the lower door. The lock is placed on top of the shaft and has a hopper arranged over it. As soon as a yard or so of concrete has been dumped into the lock, the top door is shut and the bottom door is opened, allowing the mass to fall down the shaft into the working chamber. The concrete can thus be taken in about as fast as the men below signal that they are ready for it.

Concrete should be made very wet, wherever possible, but the men in the air chamber do not like it wet at all, and they are always asking for drier concrete. As long as the concrete is spread in approximately horizontal layers it cannot be too wet, but when it is necessary to bench it around the sides and under the roof it is impossible to use wet concrete. It is customary to fill the air chamber in horizontal layers within about three feet of the roof and then bench the concrete around the sides and under the deck until there is only a space under the shaft left. The men, of course, prefer, where they can, to keep a working space about 5 feet high. The concrete is usually carried to within three or four inches of the roof, and the remaining space is then filled with mortar packed in place with a wooden rammer about one by three inches by three feet long, driven or pounded with an eight pound hammer, which gives a very good job, but is, of course, very slow.

Sometimes the concrete is carried up horizontally to within 18 inches of the deck and allowed to set hard, at least 12 hours being necessary, when the air is taken off and wet concrete is dumped down the shaft. The trouble with this method is to be sure that all the spaces under the roof get filled, for no one else who has not tried it would believe that the water in the concrete could disappear so completely. It has been seen in a caisson with two 3-foot shafts about 6 feet centre to centre, where the concrete was dumped down one shaft in an absolutely "sloppy condition," that when work was suspended to examine the concrete, it was found that the concrete was filling the shaft it was dumped into without filling the space under the deck to the adjoining shaft. Concrete has been dumped into a shaft so wet that one would expect to see a couple of feet of water on top of the concrete, and yet when the work was stopped the concrete looked almost dry.

If mortar is to be made watertight, the proportion should never be poorer than one volume of cement to two volumes sand, to insure filling all the voids in the sand. For the same reason the proportion of cement and sand should be the same for concrete where as much stone can be used as can be covered, depending on the smallness of the stone or gravel and the wetness of the mass; much more stone can be used if the stones are small and the mass wet. Caissons have been made watertight against a head of 80 feet of water by concreting to about 6 inches above the cutting edge and then placing a layer of mortar about 2 inches thick and covering this at once with good wet concrete 1-2-4. And yet many say that it is impossible to make concrete hold water, which, however, is certainly true as far as "dry" concrete is concerned, that is, concrete that requires ramming to bring the moisture to the surface.

The concrete in the cofferdam above the deck should also be put in very wet, and though it is very customary to use 1-3-5 concrete for this purpose, it is preferable to use a 1-2-4 mixture, though the amount of stone could be increased as stated above if judgment is used.

Great care should always be exercised when pumping is necessary to avoid pumping the cement out of the concrete and thus ruining the mass. The amount of concrete placed on the deck of the caisson while sinking often depends on the amount of weight required for the penetration. The friction on the sides starts at the surface and the concrete on the deck has to be kept above the surface of the ground until all the concrete is in that will be required for the finished structure, when pig iron or other temporary weight has to be added.

Caisson Disease[1]

When a novice enters an air lock the pressure is, of course, at atmosphere, and as soon as the outer door is shut (it is usually held shut by the pressure of the air) the pressure is gradually increased; but no matter how slowly it is increased, one has, at first, more or less trouble in equalizing the pressure on both sides of the ear drums. This is usually accomplished by closing the nostrils with a finger and thumb and then blowing the air through the throat into the ear passages. Sometimes beginners cannot do this, and occasionally even an old timer will get caught this way if he happens to have a bad cold.

The result of getting "blocked" is that one or both ear drums may be ruptured, causing intense pain, or some blood vessel in the head may burst.

The most common complaint is known as the "bends" which only attacks one after leaving the caisson, sometimes several hours after, and thus tends to bear out the theory that caisson disease is caused by the air forcing the blood away from the surface and the bubbles of air remaining in the system when the person has left the air chamber too quickly.

The bends generally attack the arms or legs, and sometimes the lower part of the body, causing more or less intense neuralgic pains or cramps, which are said to resemble rheumatism, but to be worse. Yet, in spite of the intense pain and suffering, they rarely result in death.

The worst effect, however, is paralysis, which attacks the limbs or body, though generally the legs or lower part of the body.

Sometimes the victim becomes paralyzed on the whole of one side. This trouble also, as a rule, attacks the unfortunate man shortly after he has left the compressed air, though sometimes not for several hours after. It is very rare for a man to be paralyzed while in the air chamber, though some have been killed the first time they have entered, and before they could get out.

Occasionally an old-timer, who has always considered himself immune, has been bowled over. When paralyzed, some completely recover after a few hours' treatment, some remain partly maimed for life, while others succumb as a result. Some experienced men claim that they can tell when they are going to get the bends or be paralyzed while still under compression, in spite of the assertion of other writers and experimenters that all forms of caisson disease are contracted during decompression.

Forty-five or fifty pounds above atmosphere is about the limit in which men have performed actual work, and these high pressures are always attended with great risk and loss of life.

There are a number of theories advanced, and there is much in all of them concerning the cause of caisson disease, from which the following established facts can be set down.

(1) The more rapidly one enters the high pressures, the more

[1] T Kennard Thompson—Sc. Am. Supp. Oct. 17—08.

rapidly the blood is forced from the surface, and the greater risk of bursting blood vessels in the head or of fracturing ear drums.

(2) The longer one stays in compression and the more work that is done, the greater the danger of being paralyzed or of getting the bends.

(3) The quicker the pressure is reduced on leaving the caisson, the greater the danger.

(4) In many cases foul air has done more damage than fresh air at a much higher pressure. Undoubtedly, tallow candles in the early caissons, and gas in the Brooklyn Bridge caissons, did much to knock the men out.

(5) It is very dangerous to enter a compressed air chamber with an empty stomach.

(6) It is advisable to put on warm clothing and take hot coffee on coming out if there is any danger of getting chilled.

(7) The more energy expended in compression, the greater the danger. We know that the excess of oxygen in the compressed air renders the men very much more active than when in ordinary atmosphere, with a consequently greater fatigue.

(8) It is suicidal for anyone with weak lungs, heart or nerves to enter the lock.

(9) Even healthy people cannot be sure what effect compression will have on them until they try it.

(10) The most reliable remedy is recompression in a hospital lock.

(11) Electrical treatment is sometimes efficacious.

(12) Most important of all, as much time as possible should be taken in decompression—the more, the safer.

It has been found from experience that the same remedy will not always have the same effect on the same man; for instance, after suffering from the bends for several hours, it was found that a hot cup of coffee produced a profuse perspiration and relieved the pain, which, however, quickly returned; so a very hot bath was tried, which also banished the pain until the bath room was left behind. Then complete relief was obtained from a mild electric shock. Another time the electric battery was tried by the same person at once and failed to do any good.

In excavating there is always considerable escape of air under the cutting edge, etc., which, of course, has to be replaced by fresh compressed air, which keeps the atmosphere in the working chamber in a fairly good condition, whereas, when concreting after the concrete has covered the bottom above the cutting edge the loss of air is very much less, and hence less fresh air is received from the compresor, and the air becomes more and more contaminated as the concrete proceeds and the working chamber contracts, with greater danger of bends and paralysis. Sometimes, old-timers have gone in to uncouple bolts in the upper sections of the shaft, and in a short time have been taken out dead.

In one case, a rubber pipe caught fire and the compression pumped the stifling fumes of burnt rubber into the working chamber, from which the men were with difficulty rescued.

When blasting in the working chamber, it is usual for the men to go out; but in one case where the working chamber consisted of several compartments the men walked into an adjoining compartment, out of the reach of any flying stones, etc., and after one of the discharges, one of the number was taken out dead.

Thus it is shown that application of compressed air underground has not only called into being a new type of man, "the sand hog" (the term applied to the man who works in the air chamber) but it has created a disease.

Regulations

For a number of years past there has been in France an effort to minimize the risks to which compressed air workers are exposed by the formulation of a code of rules and regulations governing all work carried on under pressure. The following notes serve to indicate the scope of the regulations now in force.[1]

It is stipulated that a physician shall be employed and shall have charge of the medical supervision of the men; before a man may enter the air he must present a certificate, issued by a physician, establishing his fitness for this kind of work. No man may be retained for work in air if his certificate is not renewed 15 days after employment and thereafter once a month. Provision is made for examining any workman who experiences trouble with nose, throat, or ears, or any man who desires to be so examined. An individual record mentioning all accidents or cases of illness, even though slight, must be kept up to date for each member of the force. Measures must be taken to prevent the introduction of intoxicating liquors on the work; any workman in a state of drunkenness shall be kept away from the work for 24 hours.

The time for compression shall be at least 4 min. when increasing from 1 to 2 kg. per square centimeter, total effective pressure, and at least 5 min. for each kilogram above 2 kg. per sq. centimeter (a pressure of 1 kg. per sq. centimeter is slightly less than one atmosphere being about 14.22 lbs. per sq. inch.)

The time for decompression shall not be less than indicated below; 20 min. per kilogram for pressures above 3 kg. per sq. centimeter, effective pressure, 15 min. per kilogram for pressures between 3 and 2 kg. per sq. centimeter, effective pressures, 10 min. per kilogram for pressures from 2 kg. down to an effective pressure of zero.

If the effective pressure does not exceed 1 kg. per sq. centimeter, the time to decompress down to zero may be reduced to 5 min.

It is forbidden to lower a caisson by suddenly reducing the pressure in the working chamber without first taking out the men.

Every lock must be fitted with a pressure gauge. If the effective pressure exceeds 1 kg. per sq. centimeter a recording gauge must be provided.

The height of the working chamber must be sufficient to allow

1 Regulation of Compressed Air Work in France, Eng. Rec. Dec. 4, 1909.

a workman to stand within it, in any case the height shall not be less than about 5 feet 11 inches.

The quantity of air supplied to the working chamber shall be at least about 1412 cub. ft. per hour per man. Carbonic acid gas shall not exceed one part in 1000.

In case the air supply shall be cut off the contractor shall order his men out of the working chamber after waiting for a period of 10 min. at the most.

It is forbidden to blast in the working chamber unless the workmen have left it and they shall not re-enter until the atmosphere within has become normal. (This measure does not prevent the men from seeking refuge in the shaft or locks.)

The volume of air in the lock shall be at least about 21 cub. ft. per man. The renewal of air in locks during periods of decompression exceeding 10 min. shall be assured by opening simultaneously, inlet and outlet valves thus allowing a flow of air through the lock.

In summer locks exposed to the sun shall be protected by a tent or matting kept wet.

When the work requires more than 20 men in the air at one time, communication between the working chamber and the surface shall be provided for by telephone.

Special precautions should be taken to prevent, in case of an attack of giddiness, a man's falling at the entrance to the lock.

Provision is also made for controlling entrance to and exit from the air from both the high and low pressure sides. The shaft should be accessible at all times and ladders maintained in it.

Equipment must be provided for taking out of workmen if they are unable to climb the ladders. The air lock, shafts and working chamber shall be illuminated by electric lights.

Precautions shall be taken in the working chamber to prevent workmen from passing underneath the shafts.

Each air pipe shall be fitted with a check valve, which will close when the pressure in the working chamber exceeds that in the pipe.

Automatic regulation of the pressure of air sent into the caisson should be provided for.

An outfit for affording aid to the injured shall be kept on hand; it shall include a tank of oxygen under pressure or other means of supplying quickly and easily a supply of oxygen.

When the work is carried on under an effective pressure of more than 1.2 kg. per sq. centimeter, a house, where the men coming from the air may rest, shall be built near the entrance to the work; its dimensions shall depend upon the number of workmen working simultaneously in the compressed air. It shall be suitably ventilated and fitted with wash stands, soap and towels for each workman, dressing room and couches.

When the pressure in the working chamber exceeds 2 kg. per sq. centimeter there must be installed a hospital lock containing a bed and large enough to receive 2 attendants.

All equipment such as machinery, pipe valves, ladders and cables must be tested weekly

The joining of successive sections of the caissons shaft must be rigidly inspected.

Under certain conditions the regulations regarding the recording gauge, the maximum amount of carbonic acid gas, the telephone, the automatic regulation of the air pressure and the hospital lock, may be modified; in the last case, the physician must be consulted.

Compressed air workers must be at least 18 years old. These rules must be posted conspicuously. If these regulations were observed strictly in all casison or compressed air work, no doubt the number of fatalities and cases of caisson disease would be greatly lessoned.

Conclusion

Except in very shallow water or very deep water, the compressed air process has almost entirely superseded all others. The following are some of the advantages of this method.[1]

1. It is reliable, since there is no danger of the caissons being stopped, before reaching the desired depth, by sunken logs, boulders, etc., or by excessive friction, as in dredging through tubes or shafts in cribs.

2. It can be used regardless of the kind of soil overlying the rock or ultimate foundation.

3. It is comparatively rapid, since the sinking of the caisson and the building up of the pier go on at the same time.

4. It is comparatively economical, since the weight added in sinking is a part of the foundation and is permanent, and the removal of the material by blowing out or by pumping is as uniform and rapid at one depth as at another—the cost only being increased somewhat by the greater depth.

5. This method allows ample opportunity to examine the ultimate foundations, to level the bottom, and to remove any disintegrated rock.

6. Since the rock can be laid bare and be thoroughly washed, the concrete can be commenced upon a perfectly clean surface; and hence there need be no question as to the stability of the foundation.

A few years ago it would have been impossible to erect a building as lofty as are now erected upon the same sites without surrendering so much of the lower floors to caring for the foundations load as to render them practically untenantable. A cantilever system has been so thoroughly worked out in all its details during the past few years that although at some places and columns of a building are outside of the outside edges of the respective caissons, the load they bear is transferred by means of the cantilevers and bolster shoes so as to be evenly distributed over the base of the piers formed by these caissons.

After the caisson has reached bed rock and the chamber at the bottom and also the shaft is filled with concrete it becomes a solid monolith. On these monoliths the modern skyscraper rises.

1 Treatise on Masonry Construction. Baker. page 306.

CONCERNING THE HUDSON BAY ROUTE

By William Batten McPherson, B.A.Sc.

For more than twenty years the people of Western Canada have endeavored to persuade the Government to construct a line of railway to Hudson Bay from some point in Manitoba, and to erect proper terminals and docks at either Port Churchill or Port Nelson, believing that the move would render communication between the Western Provinces and Europe many hundred miles shorter than by the present Atlantic ports. These people realized that Canada would be faced by even more serious transportation congestion than the United States had been. To-day it is imperative that Canada should have as direct, open and rapid transportation with Europe as is possible. We are a nation in the midst of an enormous constructive period in which our imports annually exceed our exports by many millions of dollars. Imports that do not adjust or create debts must be paid for with exports. The faster this produce is laid down at tidewater, the greater its value to the Canadian producer and the better for the nation.

With the rapid and increasing growth of the Canadian West—Manitoba, Saskatchewan and Alberta—and the consequent enormous grain production, the necessity of creating an outlet for this production of our wheat fields and indeed for the other natural resources of north-western Canada has become a matter of serious import.

The cultivable area in the provinces named has been conservatively estimated at 175,000,000 acres, and while it would be hazardous to count upon the uncultivated portion being as fertile as that which has already come under the plough, it is believed to be safe to reckon upon its production in at least the ratio of one to two, so that we can reasonably count on ten times the present grain yield of these provinces when all the now virgin soil is brought under cultivation; and the wheat produced will amount to 1,000,000,000 bushels a year. This, with other crops, will bring the total to 2,000,000,000 bushels a year.

With the extension of the grain growing area the difficulty of transportation has increased enormously. Since 1896 there has been a continual grain blockade to such an extent that neither the outgoing grain nor the incoming freight could be handled by the railways with any reasonable dispatch. The condition to-day is that the crop of one year cannot be marketed before the crop of the next year is harvested.

Concurrently with the expansion of the grain-growing area. other industries have expanded in like ratio. Any arrest of Western development will be as keenly felt from the Atlantic to the Great Lakes as it will in the country beyond. Even though the double tracking of the Canadian Pacific and the inauguration of the Grand Trunk Pacific should double the rail-carrying power, the transportation problem would still be a larger difficulty in arrest of development that it is to-day.

Hudson Bay as the Outlet

A new outlet is to be opened. The present scheme of the Government consists in the building of 418 miles of railway from the Pas on the Saskatchewan, north-east of Lake Winnipeg, to the mouth of the Nelson River on Hudson Bay.

At the north of this enormous river the large docks and elevators are to be constructed to provide for loading grain and other produce for shipment to Europe. This port in the heart of Canada, in the meridian of the Mississippi, will undoubtedly become of immense importance.

The trunk lines of Canada have now more traffic than they can hope to handle expeditiously. Each year, even with increased mileage constructed, the glut is becoming worse. The Great Lakes route will always receive capacity in advance of terminal and ship facilities.

Fig. 1—The commencement of Port Nelson, unloading the first supplies, July, 1912

The eastern provinces are stretching out constantly demanding increased transportation. The Hudson Bay route—short rail haul—will do something to discount trouble in the future. The route over which Manitoba's early settlers arrived in 1811-12 and other years, will be given modern fittings. Many years ago a struggle of long duration took place chiefly throughout the western prairies and rocky mountains between the Hudson's Bay Company operating through Hudson Bay (York Factory) and the north west Company with headquarters in Montreal, both marketing their furs in London.

Eventually, in 1821, the Hudson's Bay Company was victorious because it was able to bring in its supplies and take out its furs cheaper and with greater despatch than its rivals. Hudson Bay navigation proved reliable then and ever since.

The following table serves to illustrate the saving in miles, considering distances from points in the west to tidewater at the Atlantic and Hudson Bay.

FROM	TO MONTREAL	TO PORT NELSON	SAVING
Winnipeg	1,422	885	537
Brandon	1,555	880	675
Regina	1,780	714	1066
Medicine Hat	2,080	1016	1064
Calgary	2,262	1194	1168
Prince Albert	1,958	667	1291
Battleford	1,994	816	1178
Saskatoon	1,924	746	1178
Edmonton	2,247	1069	1178

From these ports the sea voyage is:

From Montreal to Liverpool 2761 miles; from Port Nelson to Liverpool 2946 miles.

On its face therefore, there is an advantage of a saving of hundreds of miles by the Hudson Bay route. The other port of Churchill is about 200 miles north of the Nelson.

The country between the cities stated and the Port of Nelson is, comparatively speaking, level and free from engineering difficulties. Churchill has an excellent natural harbor, rock-enclosed, with a capacity for three or four dozen good-sized ships. It is 470 miles from the Western end of Hudson Strait. The Nelson, which is about the same distance from the Strait, possesses capacities of enlargement practically illimitable. A channel basin would require to be opened and the harbor would then accommodate innumerable ships. The channel at present existing is one which may with certainty be said to enable a ship drawing twenty feet of water to enter safely at all stages of the tide, and no doubt extended surveys will show more favorable conditions. Although discovered in the year 1610, and navigated at least once annually since 1667, Hudson Bay has remained an unknown sea, to the general public at least. It is the third largest enclosed marine area in the world, being exceeded by the Mediterranean and Carribean seas. The area is approximately five time the combined areas of our great lakes, and it has a tidal coast line of about six thousand miles. Into the Bay is discharged a score of magnificient rivers, some of which rank among the largest on the continent.

Hudson Strait, which is the chief connecting link between the Bay and the North Atlantic Ocean is 450 miles long and not less than 45 miles wide, with a deep clear channel. It is here that navigation is most likely to be delayed through the presence of ice which, in certain seasons, will probably always be an obstacle in the navigation of Hudson Strait, although a full knowledge of its character and movements will greatly reduce danger from such a source.

There are three classes of ice to be met with in and about the Strait, viz., icebergs, ordinary field ice, produced in the Bay and Strait, and Arctic ice. Numbers of the bergs may be seen in the Strait chiefly along the north side, but they will never be much source of worry owing to the width of the main channel. Twice as much difficulty is experienced in the Strait of Belle Isle owing to the narrowness of the course. Nine-tenths of all bergs which enter the Straits gain access through Fox channel, where glaciers exist. The other source of icebergs is through Gabriel Channel, a connection between Davis Strait and Hudson Strait between Resolution Island and East Bluff. This channel has a strong polar current, but ice from this source is carried into the north Atlantic.

Field ice which, is rather local in formation, often attains five or eight feet in thickness, but becomes broken up into pans and ultimately melts. A great tidal wave from north Atlantic into Hudson Strait and through it into and across Hudson Bay affords an interesting study. That current is not as wide as the Strait, but on either side for miles there is an eddy created, which, running in a direction contrary to the main stream, has a peculiar and decided effect upon the floating ice. Its general effect is to keep the channel of the maincurrent open and to join it into the broad eddies along the shores. Hudson Bay and Strait do not freeze solid, but the floating ice would probably render them unnavigable for ordinary steamers for perhaps seven months in the year. June has well set in before much melting of the ice commences, and the middle of July would, as a rule, be reached before navigation became safe. In the autumn and until late in November, no ice is formed either in the Strait or Bay, sufficiently heavy to obstruct ordinary navigation. About this time there may be considerable danger from the passage of northern pack ice across the mouth of the Strait, and also to a much less degree, from the ice from Fox Channel partly closing the western entrance to the Strait.

Fogs are liable to occur in proximity to the ice fields particularly in the early season, but at other times are not prevalent and the weather is ordinarily fair. Ships go through ice to the harbors of Russia, Sweden, Germany and Norway every day of the Northern winter—specially constructed steamers in all probability—but they keep an open channel for the ships of commerce.

Hudson Strait

There are three entrances to Hudson Strait from the North Atlantic, viz., that between Cape Chidley and the Bulton Islands, five or six miles wide; the main channel, between those islands and Resolution Island, about forty-five miles wide, and that between Resolution and the north main coast, about ten miles wide. The first is called Grey Strait and the latter Gabriel Strait. These are the narrowest channels except at the western extremity where Nottingham, Salisbury and Mill Islands divide the strait into four channels. The main one, and that usually traveled between Nottingham and Cape Wolstenholme, or Cape Digges is about thirty-five or forty miles wide; that between Nottingham and Salisbury is not more than twelve miles wide; that between Salisbury and Mill about the same; and that between Mill and the north main coast (Fox Sand) probably fifteen miles.

Except at the points named and excepting also between North Bluff and Cape Prince of Wales, in the centre of the Strait where the distance is about sixty-five miles, the width of Hudson Strait is over one hundred miles. At the entrance from the north Atlantic the water is very deep, over three hundred fathoms in the centre of the Strait. The shores on both sides throughout are high, rugged and barren with deep waters close to the cliffy, rock-bound coast. As you proceed westward toward Hudson Bay the water becomes shallower. The average depth of water in Hudson Bay is about eighty fathoms, except in the southern portion, where it does not much exceed sixty.

The distance from Cape Chidley, at the eastern end of the Strait, to Cape Digges at the western end, is about four hundred and fifty miles, the distance from Cape Digges across the Bay to Churchill or the mouth of the Nelson is not more than 550 miles. The total distance from Port Nelson to the north Atlantic does not exceed one thousand miles.

Hudson Strait and the centre and west of the Bay are free from shoals, rocks or islands and such impediments as are to be reckoned with on the St. Lawrence route, and from the Nelson River to Cape Chidley and the Atlantic Ocean there is not an obstruction or hindrance to navigation.

Navigability

After three centuries of exploration the navigability of Hudson Bay is, to most people, a vexed question. Sir Martin Frobisher first discovered Hudson Strait in July 1576, and two years later, with a fleet of fifteen vessels, sailed several days through it. He was in quest of ore. A number of years following this, expeditions visited Hudson Bay, which had been discovered in 1610 Most of these expeditions were in search of the north west passage. Since 1668 the Hudson Bay Company have used the Straits and Bay regularly, with singular good fortune, and remarkable freedom from wreck trouble. From 1670 until 1870, when Canada purchased the exclusive right of the Company, more than seven hundred and fifty vessels, ranging from seventy-gun ships to ten-ton pinnaces, crossed the ocean, passed through the Straits, and sailed the Bay in the service of the Company, and only two have been lost. These craft were sailers—most of them of rude construction—helpless when in ice where wind is usually deficient, sailing where no charts existed and using crude methods of navigation as compared with those of to-day. Navigation was good enough to admit the French several times and in 1782, La Perouse, the French Admiral, brought a seventy-four gun line of battleships, and two frigates of thirty-six guns each, to the mouth of the Nelson River.

From 1860 many American whalers have made annual trips into the Bay. The Hudson Bay Company has averaged two ships a year. The Canadian Government has sent many ships in and out of the Straits. This past summer saw the steamers Beothic, Stanley, Minto, Arctic and Nascopic come through the Straits to Churchill and the Nelson, and return later to their various ports without mishap.

As the charts of the Bay stand to-day, they are compilations largely from information supplied by various navigators as the result of numerous trips; consequently accurate records are lacking. For many years—at least seventy-five—whalers and fishermen of the United States have visited the Bay with unusual success. United States statistics for a recent period of ten years show an average value of $30,000 per cargo, of more than fifty trips, of oil, fish and whalebone. Apart from showing value of fisheries it is significant of reasonable safety in these northern waters because these schooners from Massachusetts and Connecticut were not specially built. Several navigators of varied ice experience say that navigation of the Straits is safe for ordinary "tramp" steamers from the middle of July to the first of November, and possibly to the middle of that month. Mr. J. W. Tyrrell, an explorer of much varied experience in Hudson Bay says, "From my personal observation, I am of the opinion that for suitably constructed vessels, Hudson Straits are navigable for five months of the year—from the middle of June to the middle of November—with a possibility of an additional two weeks before and after these dates."

Land Approach to Port Nelson

In building the Hudson Bay railway from "the Pas" on the Saskatchewan to Port Nelson, a distance of 418 miles, no engineering difficulties are encountered. Already fifty miles have been graded and steel is now being laid. Seventy five miles more have been cleared and the contracts for the whole distance have been let.

The country through which this line runs contains innumerable lakes and streams which are bordered by areas of good timber varying from a few acres to some as large as forty or fifty square miles, and in the aggregate total several thousand square miles and of some commercial value.

A clay belt suitable for cultivation runs much farther north and east from the Saskatchewan than is generally believed. There are, of course, some stretches in this vast area which are swampy or semi-barren, but there is quite the average which obtains in Northern Ontario, while the climate is not so severe as to be prohibitory. The long summer days give more hours of sunshine than is the case in Southern Manitoba and Ontario, and consequently, crops can be ripened with no greater liability to failure from frosts than was experienced by the early settlers in Manitoba. There are very many large lakes, with sturgeon and whitefish, which will now be made accessible to the world's markets.

The first section of the railway is through a comparatively level country underlain by flat beds of limestone, affording easy grades and cheap construction, and where swamp is met a good bottom is usually to be had at from three to four feet. The Saskatchewan will require the only large bridge on this division.

The remaining section is underlain by granite in places, but the cutting will not be serious and the major portion of the grading is in clay loam. Economical ballast may be obtained and curvature will average $50^{0}30^{1}$ a mile over the whole route. A grade of .4 both ways has been laid out. Altogether there will be three important bridges, namely the Saskatchewan crossing, another at Manitou rapids on the Nelson and the third at Kettle rapids which is also on the Nelson. Timber for the remainder of light bridging and for piles may be obtained over most of the distance to the Port.

The cost of the Railway complete with equipment and with a modern harbor and terminals has been estimated to amount to $25,000,000.

The Port

Port Nelson is at the mouth of the Nelson River, which is about the size of the St. Lawrence at Brockville, its discharge being close to 200,000 cubic feet per second. It carries the drainage waters of a continent, being the outlet of Lake Winnipeg, which, in turn, is fed

Fig. 2—York Factory, near Port Nelson, Hudson Bay.

by the Saskatchewan, rising in the Rockies, and the Red which rises in Minnesota.

The river mouth is a mile and a half wide at Seal Island opposite Flamborough Head, at the head of tide water and ten miles in width opposite Beacon Point which is twenty miles or so below.

The location of the docks and terminals will probably be some ten miles below Flamborough Head at a point where the river is three miles or more in width at high tide. At low tide quite extensive flats are exposed. Tides vary, running from 11 to 17 feet.

On the ebb tide the current flows about three miles an hour, increasing abreast of Beacon Point to probably six miles an hour. So great is the discharge of the river that a perceptible current may be noticed several miles out to sea. Tide readings are being taken regularly every ten minutes day and night in order to prepare accurate tables. Salt water does not come above Beacon Point.

By the 20th of December, the river is usually frozen over at head of tide and the ice gradually creeps down the estuary. This ice usually goes out about the middle of May. Tide action soon breaks up the large floes and the current is sufficient to keep them from returning to the river.

Being some ten miles from the mouth of the channel, the anchorage will be protected from serious sea by shoal water and the roadstead will probably resemble that of Quebec in the matter of exposure to stormy weather.

The river bottom is a bluish clay with occasional pockets of coarse sand with boulders scattered through it, and is stiff, affording excellent holding material for anchorage. The material on the flats is sometimes spongy on the surface but is hard underneath. Much stone for construction can be quarried some miles above Flamborough Head—some also can be obtained from the flats. Spruce is the only timber here, but may be found probably large enough for piling.

Electrical power can be developed in plenty throughout the adjacent country. The Commission of Conservation report on the waterpowers available on the Nelson River as follows:

Site	Approximate Head in feet	Estimated Horse Power
Limestone Rapid	85	1,400,000
Long Spruce Rapid	85	1,400,000
Kettle Rapid	96	1,290,000
Birthday Rapid	24	320,000
Gull Rapid	67	900,000
Grand Rapid	20	270,000
Rapids above Sepewesk Lake	31	416,000
Bladder Rapid	10.6	147,000
Whitemud Falls	30	403,000
Ebb and Flow Rapid	11	148,000
Rapids above Cross Lake	45	605,000

The drainage area of the Nelson River is given at about 430,000 square miles, the estimated horse power is based on a flow of 118,000 cubic feet per second, taken when the river was at low stage. With these many power sites scattered along the length of the Railway electrification could easily be adopted. There are, of course, other power sites on the Hayes River, but these are not as accessible to the line.

During the past summer a party of thirty engineers and men arrived at Port Nelson by the steamer "Beothic" bringing materials for camp buildings and two years' complete supplies. Their work will consist in studying conditions, taking soundings and so on, to be followed immediately by actual construction.

For the past two years parties have been engaged in chart work off the mouth of the river—the C. G. S. "Minto" spending the summer of 1912 there. The "Arctic" was in the Bay and Straits all summer on magnetic work. There are many matters in connection with this new route which will be cleared up satisfactorily at an early date. It is said that insurance, which is extremely high for the St.

Lawrence route will be exorbitant for Hudson Bay. However, if it is demonstrated that for four or five months risks are at all reasonable, insurance will be satisfactorily adjusted.

Many anticipate difficulty in obtaining enough suitable ships to take advantage of the four or five months of navigation annually, but if business is plentiful, boats will be forthcoming.

There will be large and important industries opened within the next few years in Hudson Bay. For the past seventy years whalers have been visiting this territory from the Atlantic coast of the United States. Their schooners total $100,000 annually. Scotch whalers from Dundee also pay regular visits . The whales from Hudson Bay are worth from $10,000 to $20,000 apiece. In 1886 Lieut. A. R. Gordon gives the average value of each whaling cargo from the year 1846-1875 at $46,000 and Mr. A. P. Low in 1904, using information supplied by Captain Comer, an American whaler, places the average value of a whaling cargo between 1891 and 1904 at about $35.000. It is easily seen that this industry should be valuable to Canada. These fisheries are vast and varied. Bowhead or Arctic whales are worth $14,000 a ton and an adult whale will yield 1,500 pounds of oil and bone. Then the porpoise or white whale is present at the mouths of all the large rivers in thousands. These whales are about fourteen feet long and are valuable for their hide and oil. The walrus, is very common, in the northerly and westerly portions of the Bay and has a considerable commercial value. Several varieties of seal exist in great plenty. Salmon and cod swarm the waters. The salmon is so abundant and of such quality that an industry like that of British Columbia may be opened up. The Hudson Bay Company make annual shipments to Europe at present from Ungava Bay on the south side of the Strait.

It is easily seen that this new route will, in the next few years, show what exists in this region of Canada to be added to our reserve of natural resources. The rocks over much of the bordering region give promise of mineral wealth. Enough exploration has been done to hold great attraction to the prospector. However, apart from the latent resources of the Bay, this new route means much to the West. At half a cent per ton mile, it means fifteen cents saved for each bushel on the whole trip. When a crop of 60,000,000 bushels is laid down annually via the Hudson Bay Railway, the saving will be $9,000,000, which is seriously worth something to the producer. Once grain commences pouring out this way the ships will soon appear with west bound cargoes in return. On the shipping of cattle a saving of at least $5.00 to $6.00 per head will be effected in freight; considerable loss due to shrinkage which occurs when animals are confined on a transcontinental rail haul will be avoided, and the animals will be marketed in better condition.

In conclusion, the route is commercially feasible; the country exploited will furnish a good deal of wealth to the Dominion; the waters will yield much to our people; a large tract of land eminently fitted for settlement will be opened up; an additional outlet will be provided for the west, and simultaneously we will have a new entrance to Canada. The question is truly national.

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THE DEVELOPMENT OF THE RE-ACTION STEAM TURBINE

By J. A. MacMurchy, '96.

We do not know when or by whom the steam turbine was invented, but it was probably the earliest form of steam engine. It is known to have been used two thousand years ago, and strange to say, at even this time both types—impulse and re-action, had been invented. At this very early day the application of the turbine was extremely limited because there was not then in use any machinery which needed to be driven at the extremely high speeds of revolution which are necessary to permit of its use. With the introduction of electrical machinery, however, a possible field was opened for a high speed prime mover, and in 1884 Mr. C. A. Parsons, of Newcastle, England, invented a form of turbine involving the re-action principle, and entered into partnership with Messrs. Clarke & Chapman, with a view to manufacturing steam turbines, and the electric generators which they were to drive. Many mechanical difficulties were encountered, making it necessary to do a great deal of experimenting, and it was unfortunate for Mr. Parsons that there was no market at that time for units of large capacity, consequently, he had to struggle with the manufacture of machines of capacities which were least suited to the type of turbine which he had invented. The first unit built was of about 6 h.p. In 1889 the partnership with Messrs.

Clarke & Chapman was dissolved, and Mr. Parsons lost the control of his patents for the time being. During the next few years he did an enormous amount of experimenting with other forms of turbines, particularly the radial flow re-action turbine, but without any par-

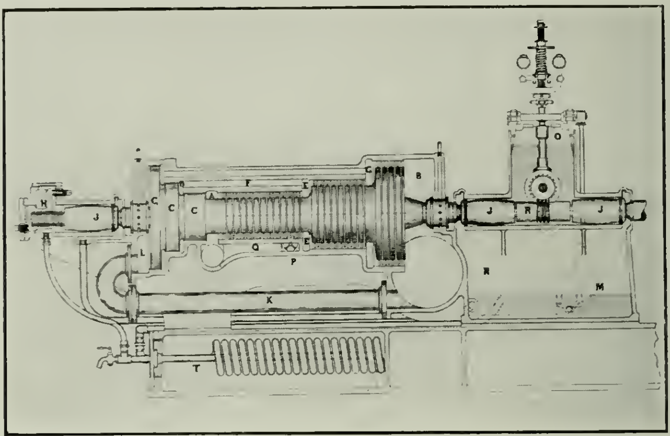

Fig. 1—Section through 400 KW. steam turbine built in 1900

ticular success, except to considerably broaden his knowledge of the subject. In 1894 he regained control of his original patents and from that time on, the development of the parallel flow re-action type

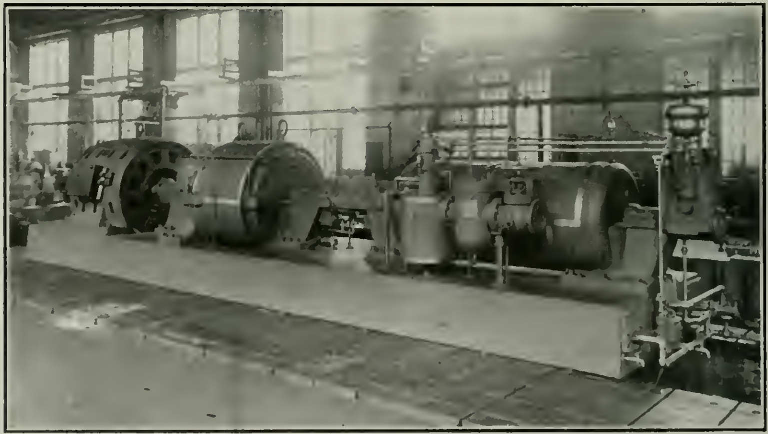

Fig. 2—Two-cylinder, 1,000 KW. steam turbines built in 1902

of turbine, which has now come to be best known as the Parsons turbine, was very rapid. In 1896 The Westinghouse Machine Company of Pittsburg, purchased from Mr. Parsons the patent rights to build this type of turbine in America for land purposes, and Mr. Francis Hodgkinson, who had been associated with Mr. Parsons for some time, was employed to develop the turbine on this continent. After assuring themselves that their turbines were suitable for service, a number of the machines of the form shown in Fig. 1, were built, the first three being furnished the Westinghouse Air Brake Co. in 1899. These turbines were of 400 K W. capacity, and were used to drive alternating current generators, the speed being 3600 R. P. M. From the first day they were remarkably successful, and more than fifty of this design were built. Later experience with turbines in service, particularly with superheated steam, indicated the desirability of a number of changes which were incorporated in the later designs.

The most serious defect in the early designs was in the use of the deep longitudinal ribs on the stator which seemed to be needed to give

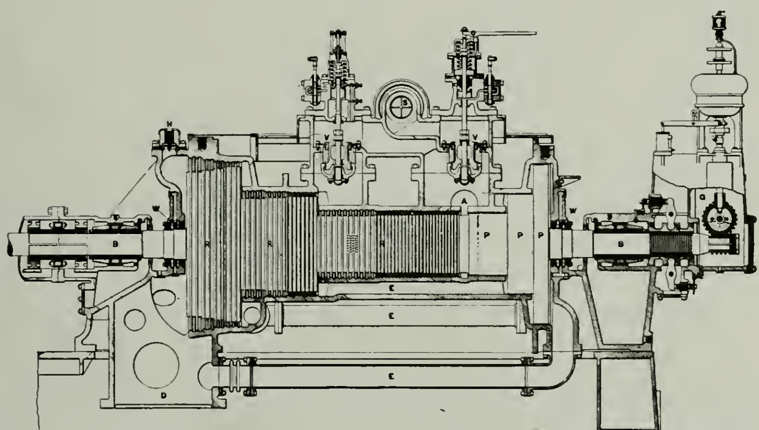

Fig. 3—Section through 1,000 KW. turbine built in 1904

stiffness and to preserve the alignment of the machine. It was found, however, that while these ribs gave very little trouble with machines using saturated steam, yet when used with superheated steam the centre line of the cylinder would warp due to the portion of the rib which was in contact with the hot steam expanding more than the lower portion of the rib which was exposed to the atmosphere and remained much cooler. For the same reason, the equilibrium passages which were cast integral with the cylinder casting were objectionable. Difficulty was also experienced with the glands, consisting of two groups of snap rings, with steam slightly above atmospheric pressure admitted in the space between to make sure that any leak would be a leak of steam outward into the engine room rather than a leak of air into the turbine cylinder. There was little difficulty in making these glands tight and they absorbed very little power, but the disadvantage was that they wore out in a few months, and, although the cost of replacing the rings was small, the necessity of opening the cylinder to replace the rings was very objectionable, and the desirability of inventing some other form of gland became apparent.

In 1902 turbines were built on this continent in two cylinders connected in tandem, Fig. 2; the high pressure cylinder expanding steam from boiler pressure to about atmospheric pressure and the other cylinder from this pressure to the vacuum obtainable in the condenser. The reason for the adoption of the two-cylinder type of turbine was that it was felt that there was a considerable loss of power inside the turbine cylinder due to the water of condensation in the steam being thrown out towards the tips of the moving blades by centrifugal force, and there forming an annulus of water through which the tips of the blades ploughed with sufficient friction to absorb much power. The steam in going from the high pressure cylinder

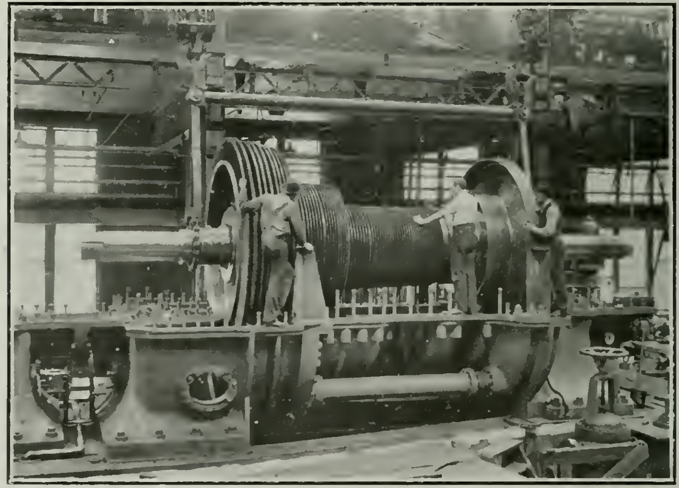

Fig. 4—View showing rotor of 7,500 KW. being lowered into casing

to the low pressure cylinder in these two cylinder turbines, passed through a receiver where practically all of the water was mechanically separated from the steam, and the steam was re-heated by passing it through tubes which were surrounded with high pressure steam, and, as a result, the steam entered the low pressure cylinder comparatively dry. Very good results were obtained from the first machines which were of about 1000 K.W. capacity each. It was found, however, that about as much steam was used for the re-heating process as was gained by the reheating, and this feature was thereafter omitted. Unless considerable was to be gained, this type of turbine was, of course, objectionable because of its much greater cost, and the greater space occupied, and in addition there were more bearings, couplings, etc., to look after and keep in repair, and as the gain in economy was not great, the two-cylinder type was discontinued after about fourteen had been built. Some of these earliest machines are now operating at the DeBeers Consolidated Mines in South Africa. It is interesting to note that in developing these two-cylinder turbines, there was incidentally developed and tested both the non-condensing turbine, which is represented by the high pressure cylinder, and the exhaust steam or atmospheric turbine, which is represented by the low pressure cylinder, and although low pressure turbines were not at all generally used until some years afterwards, their practicability and high economy was thoroughly established at this time.

A couple of years afterwards turbines were again being built in a single cylinder in sizes up to 7500 K.W. A typical turbine of this period is shown in Fig. 3. The noticeable change over the early

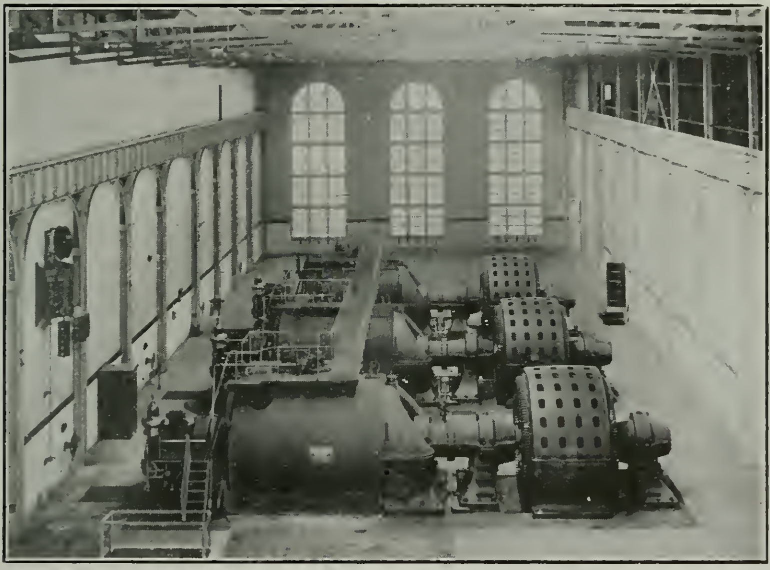

Fig. 5—Three 5,500 KW. turbines in power house of Pennsylvania Tunnel and Terminal R. R. at New York

single cylinder turbine is the absence of the longitudinal ribs and the long cored equilibrium passages; the exhaust being at the bottom and the steam chest located on the top of the cylinder. Fig. 4 shows a 7500 K.W. turbine of this period, and it will be noted that it strongly resembles the smaller size except in dimensions. Fig. 5 shows three of these turbines in the power station of the P. T. & T. Co. at Long Island City, New York.

In 1907 the demand for larger units was becoming very noticeable, and higher speeds were possible because builders had made great progress in developing revolving field A. C. generators. About this time Mr. Westinghouse became impressed with the desirability of building these large size units double flow. It is worthy of note here that the first Parsons type turbines built were double flow, and were so built because no one knew how to build them single flow; but it must be remembered that these early machines were of small capacity as we measure capacity to-day, and the objection to their being double flow was consequently very great, as blades which would have been uncomfortably short in a single flow machine, were only half that

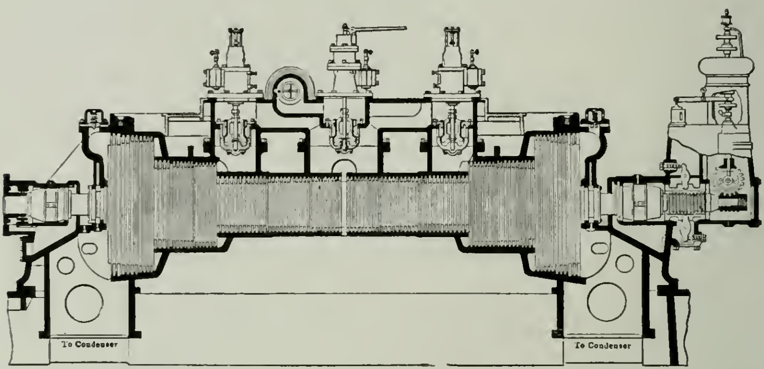

Fig. 6—An idea of what an all-Parsons, high-pressure, double-flow turbine would be

length in a double flow machine. The double flow machine had twice as many rows of blades, so that when suitable steam packing was invented, which would balance the steam pressure on the blade drums, and also compel the steam to flow in one direction, builders

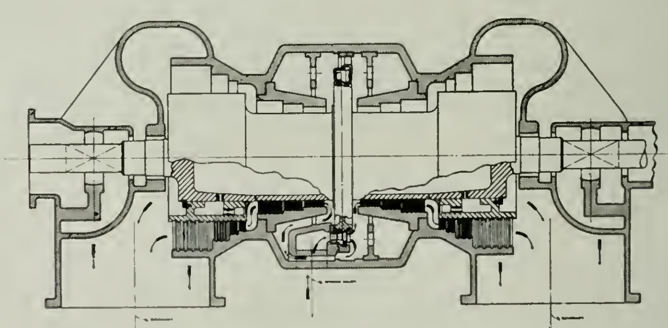

Fig. 7—Section through Westinghouse double-flow turbine

of the Parsons type turbines immediately abandoned the double flow turbine for the single flow. When the demand arose for large units at high speeds the conditions were quite different, for the blades in the low pressure end of the machine had become uncomfortably long, hence the tendency to go back to the double flow construction. The objection to the double flow turbine that it had twice as many rows of blades as the single flow machine still existed. A strictly

Parsons type turbine if built single flow would have the general appearance as shown in Fig. 3. If built double flow, it would appear as shown in Fig. 6. Looking at the double flow machine we notice the extreme length of the high pressure section, and it may be said that this is by far the least efficient section of the turbine and only does about one-fifth of the work. Mr. Westinghouse therefore proposed to substitute for this an impulse element, which occupied very little space, and was probably as efficient as the section of the Parsons turbine which it replaced so that we then had a turbine which is shown diagramatically in Fig. 7, and of which Fig. 8 is a photograph showing the cover turned back. Certain combinations of speed and capacity are sometimes met in double flow turbines

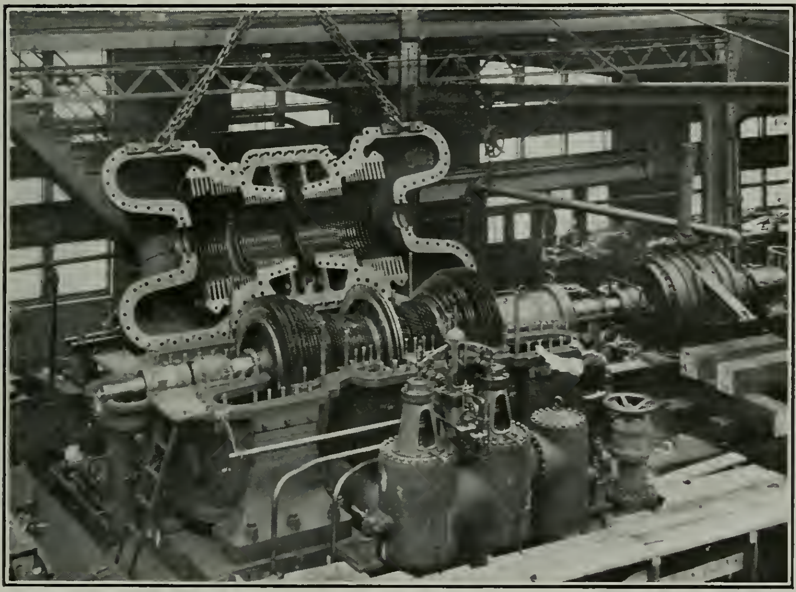

Fig. 8—View of 1,000 KW., 1,800 R.P.M. Westinghouse double-flow turbine. showing upper half of casing turned back so as to expose rotor

where the blades in the intermediate section are too short to be as efficient as they might be. Mr. Westinghouse suggested making this section single flow, and carrying half the steam back through the spindle to the other end of the low pressure section as shown in Fig. 9, using dummies to balance this single flow section, and in this way doubling the length of the short blades.

These turbines, consisting of a high pressure impulse element followed by Parsons blading, the intermediate element being either single or double flow, and the low pressure element double flow, are now the standard practice of The Westinghouse Machine Company for large capacity units. For instance, turbines of 2000 KW. and over running at 3600 R. P. M.; 4000 KW. turbines and over at 1500 or 1800 R. P. M, are built this way. Smaller units than these are best built single flow, excepting low pressure or exhaust steam turbines, and even in single flow machines it is generally considered advisable to substitute an impulse element for the high pressure section for the sake of avoiding high temperatures inside of the main cylinder casting. It will be understood that the steam expanded

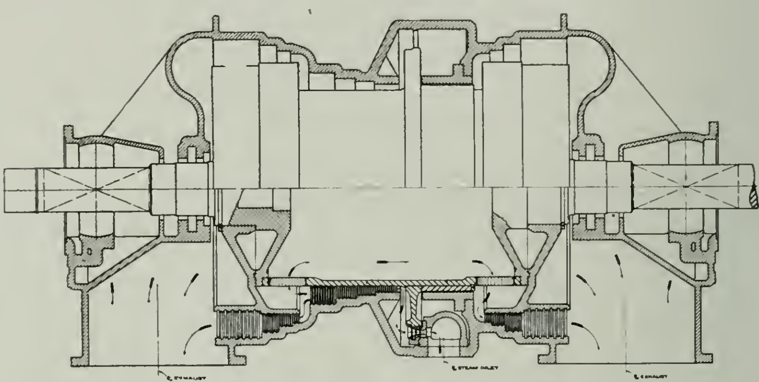

Fig. 9—Section through Westinghouse semi-double-flow turbine

through quite a range of pressures in the nozzles, with a corresponding reduction in temperature, will enter the main cylinder at a temperature, which is not liable to cause the cast iron of the cylinder to grow. The result of combining an impulse element, (which does

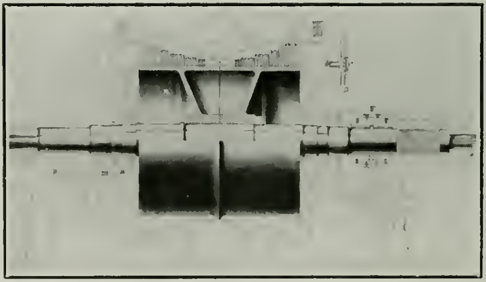

Fig. 10—Section through low pressure turbine

about one-fifth of the work) with Parsons blading (which does about four-fifths of the work) is that we have made a combination of the most efficient portions of the two great types of turbines, and have eliminated the most inefficient portion of each. It also gives us a short and very rugged machine with fewer objectionable features than any pure type turbine yet brought out (except in very occasional cases where a turbine is required to meet some extraordinary condition).

Prior to 1907 the largest turbine designed to run at 3600 R. P. M. was a 500 KW. but in that year a number of turbines of 1000 KW. capacity were brought out to run at 3600 R. P. M., and in 1909 a

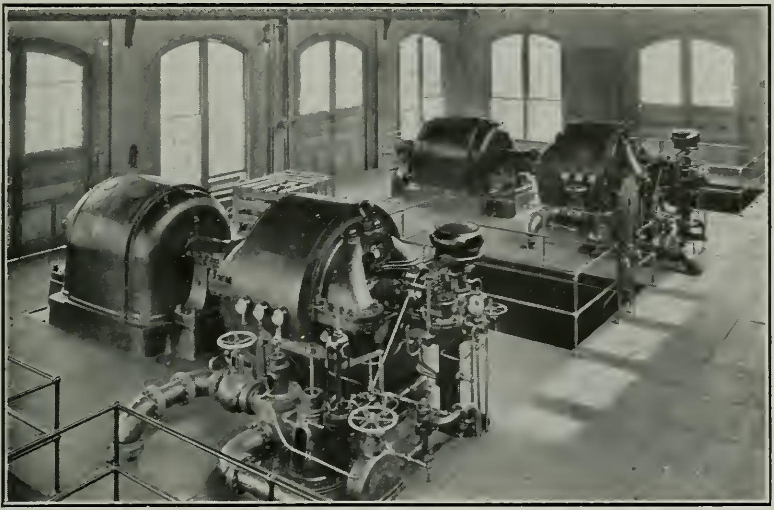

Fig. 11—View showing two 1,500 KW. low pressure turbines at Rankin, Pa.

still further increase of speed was noticeable when 2000 KW. turbines were designed to run at 3600 R. P. M. and a 10,000 KW. unit at 1800 R. P. M. To-day 3250 KW. turbines are running at 3600

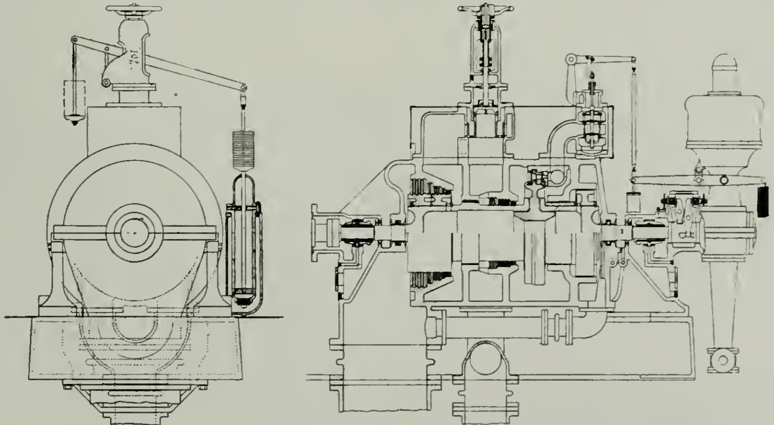

Fig. 12—Section through Westinghouse bleeder turbine

R. P. M., and 15,000 KW. at 1800 R. P. M., and 20,000 KW. at 1500 R. P. M., are being built. The increase in speed has not entailed greater risk in operation, for the construction of rotors and the method of blade attachment has been so improved that the stresses are not higher than in the old slow speed turbines.

In 1907 low pressure turbines were first built in America. By low pressure turbines we mean turbines to develop power from steam at about atmospheric pressure. The steam may come from the exhaust of reciprocating engines or any other source, and is expanded in the turbine to whatever vacuum is obtainable. A great many of

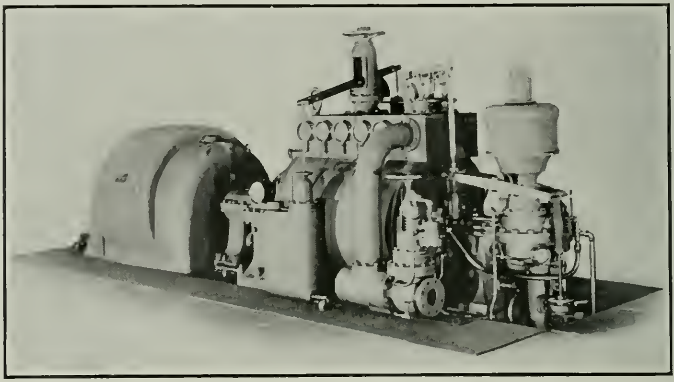

Fig. 13—Exterior view of turbine shown in Fig. 12

these turbines have been built in sizes up to 5000 KW. A typical section through one of these turbines is shown in Fig. 10, and an installation view of the two 1500 KW. turbines is shown in Fig. 11.

A modification of this is found in a mixed pressure turbine which consists of an impulse element followed by the blading of a low pres-

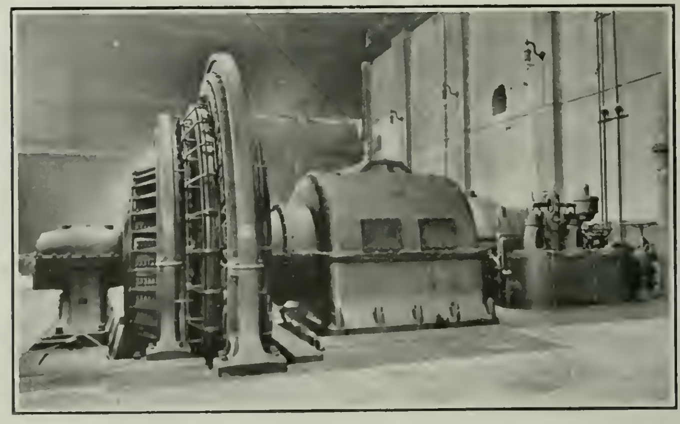

Fig. 14—View of 1,800 P. M. non-condensing turbine driving 3,759 K.W., 180 R. P. M., D. C. generator through Westinghouse reduction gear

sure turbine. These mixed pressure turbines are used in cases where it is desired to develop power from the exhaust of reciprocating engines or any other source, but in which the supply of steam being intermittent, it is necessary to provide for admitting high pressure steam to the cylinder through nozzles which expand it down to about atmospheric pressure, and the velocity energy so obtained is taken up in the impulse blading. The steam then develops further power by expanding through the low pressure blading.

Still another special adaptation of the turbine is found in what is known as the Bleeder Turbine shown in Figs. 12 and 13, which resembles an ordinary condensing turbine, except that provision is made for extracting steam for a heating system from that part of the turbine where the steam has been expanded down to the pressure desired, and equipping the turbine with a valve which automatically passes on to the low pressure blades any steam not required for the heating system.

During the past few years the field of the turbine has been greatly enlarged by the invention of gears which are able to transmit large powers and to reduce the speed of the turbine to that necessary for efficient D. C. generators. A 3500 KW. set is shown in Fig. 14.

Even at this late day it is impossible to predict the trend of future turbine work. The remarkably rapid strides of the past few years have carried the art to a highly advanced stage, but there is no indication that the years to come will be any less productive of developments. The solution of many problems connected with design, materials and manufacture incidental to building the turbines of to-day opens up new fields which seem to be constantly widening. Whereas in 1904, for instance, the design of a 7500 KW. turbine involved great difficulty, it is possible to-day to design a machine of 30,000 KW. capacity, four times the size, with greater certainty of its successful operation and high efficiency.

THE MOOSE JAW WATER SUPPLY

By P. Gillespie, B.A.Sc., A. M. Can. Soc. C.E.

That portion of Alberta and Saskatchewan between the 54th parallel of latitude and the International Boundary comprises nearly 250,000 square miles. It is drained by the Saskatchewan and Assiniboine Rivers, and contains not a single body of water as large even as Lake Simcoe. On a basis of only 20 persons to the square mile, this region would become the abode of five millions of people. The present population is something in excess of 800,000.

When we consider that the great centres of population in Europe, St. Petersburg, Christiania, London, Paris and Berlin, lie north of the 49th parallel of latitude, that the great migrations of history have been westward and northward, that Canada is the last great area awaiting the enterprise and energy of the pioneer, that while in point of population, the United States of America stood 100 years ago where Canada stands to-day, her railway mileage was not until

1857 equal to that of the Canada of to-day, nor her foreign trade as great as that of this country at the present time until the year 1861, it will, I believe, be granted that the growth I anticipate is a very moderate one indeed, and that the problems consequent thereon are really only beginning. One of these is that of water supply.

To the life-long resident of Ontario, with its fine series of inland and border streams and its magnificent chain of great lakes, this special problem of the Western plains will scarcely appeal. In the prairie provinces as indicated above, the scarcity of streams or lakes capable of serving large communities has rendered it both acute and unique. In consequence, it has become the most serious which the growing centres of population in the West are called upon to solve.

The city of Moose Jaw, Sask., is situated on the main line of the C. P. R., some 420 miles west of Winnipeg, and 40 miles west of Regina, the provincial capital. In the language of the surveyor, it lies in Township 16, Range XXVI., West of the Third Meridian. Its present population is approximately 25,000, probably half of whom are dependent directly or indirectly upon railway operation and maintenance for a living. It is surrounded by an excellent agricultural district, and of late years, has experienced a period of growth and prosperity which would be regarded as phenomenal in older districts. In consequence it has outgrown many of its public services including its water supply. Up to a few weeks ago this was obtained partly from a well in the city near the confluence of Thunder Creek and Moose Jaw Creek, which is fed by an infiltration gallery receiving water percolating from the creeks through the soil; and partly from Snowdy Springs, so-called, seven miles distant in a south westerly direction, the supply flowing by gravity through a ten-inch wooden main. Two years ago a deep well was bored at a point adjacent to the present city power house in the hope of locating natural gas. On reaching a depth of some 1200 feet the drilling was temporarily abandoned, a heavy flow of water having been encountered. This water is saline and by itself not potable. In cases of fire it was the custom to pump raw creek water and gas well water into the distributing system, the subsequent draining of which by hand having been relied upon to free the mains from water unfit for domestic use. Of late years the supply has proved quite inadequate to the needs of the citizens, so much so in fact, that at times water was available in the service pipes for an hour only three times a day.

In the spring of 1911, Mr. Walter J. Francis, C.E., of Montreal, was asked by the municipality of Moose Jaw, to investigate the entire situation and advise as to a water supply for this western city. Mr. Francis began his investigation early in May. This involved a study of some ten suggested sources, most of which were found to be impossible because of one or more of three reasons, viz., insufficient quantity, unsatisfactory quality or prohibitive cost. Among the sources investigated were the Moose Jaw Creek, Last Mountain Lake, the Snowdy Springs, the South Saskatchewan River and Sandy Creek, all well-known to residents of Southern Saskatchewan. For the reasons indicated above, all were rejected for immediate develop-

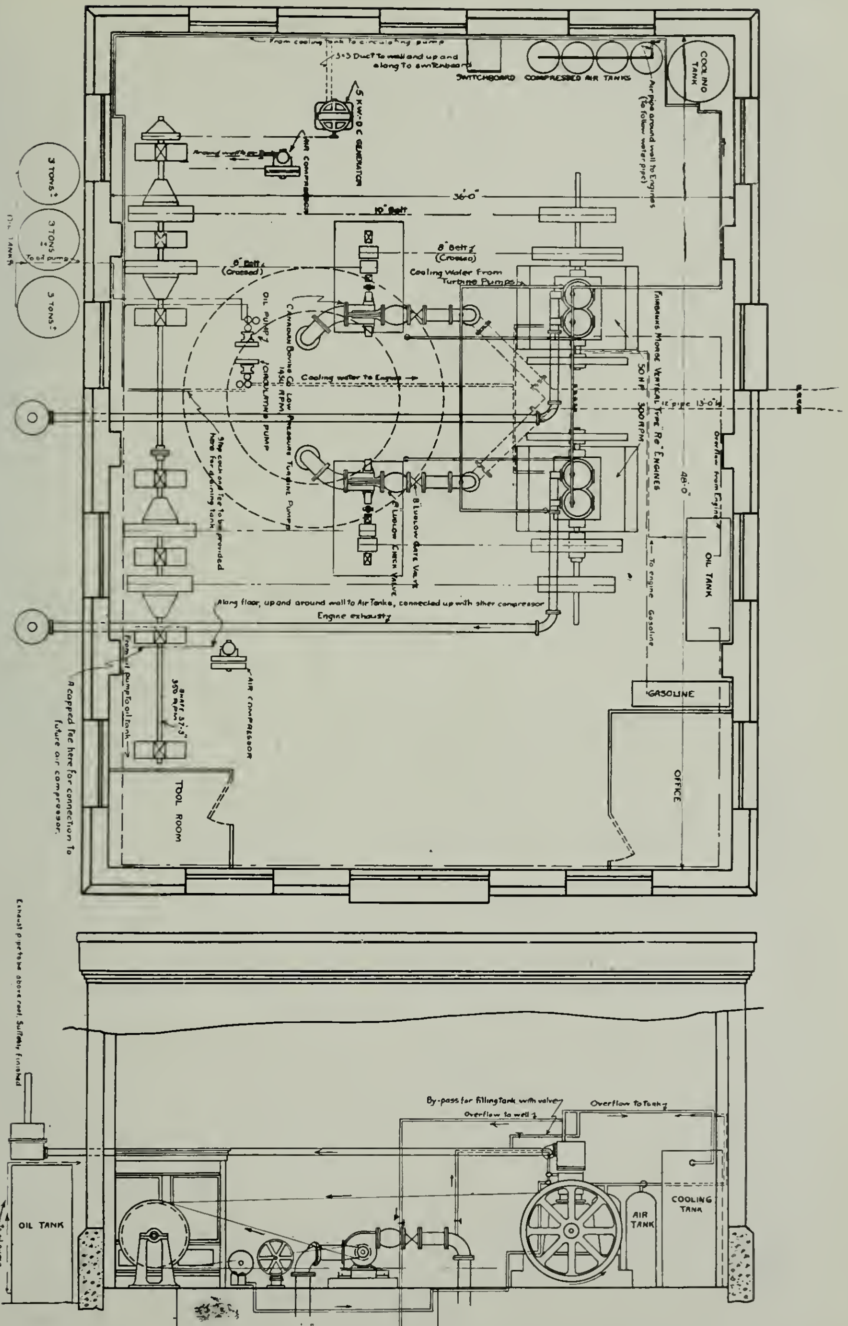

Fig. 1——Plan and Section of the Headworks Pumping Station

ment, save the last mentioned—Sandy Creek—a stream near Caron some 20 miles west of the city, along the main line of the C. P. R.

Mr. Francis' report in brief suggested that the city proceed at once to conserve its then present supply by installing a separate high-pressure fire system in the business district. This would enable the city to cease using the limited domestic supply for such purposes as street watering, most manufacturnig processes and fire fighting. The city was also advised to proceed at once to make a thorough exploration of the valley of the Sandy Creek. The indications at the time the report was prepared were that there was available there one million gallons of water per day. If this by subsequent investigation should be confirmed it would mean that this quantity together with the supply at that time serving the city, would be sufficient for a city of 30,000 people. The ultimate source, it was obvious, must be the Saskatchewan River, in event of the population very much exceeding the limit indicated. Moreover, if the Sandy Creek project were to be developed, much of the necessary installation would become a part of the Saskatchewan development since both sources lie in the same direction from Moose Jaw. The expense involved in utilizing the Saskatchewan necessarily placed it beyond the immediate reach of any single municipality as far distant as Moose Jaw, but a suggestion was made that the city combine with other interests and prepare at once for the use of the Saskatchewan River water at a time not far in the future.

The city council of Moose Jaw, with characteristic western enterprise, immediately voted an appropriation for the investigation of Sandy Creek, which investigation was conducted during the summer months of 1911. Weirs were installed in eight different places on the creek from which daily readings covering several months were obtained. A number of deep test wells were drilled in various places across the wide valley of the creek revealing the presence of a lower supply of water (apparently separated from the upper by an impervious stratum of clay) whose analyses were markedly different from those of the surface water. The knowledge acquired during the exploration tended to confirm the earlier opinion as to quality and quantity and Mr. Francis' firm, Walter J. Francis & Company, were authorized to proceed with the preparation of final plans and specifications, and the supervision of the work. The contracts for the work were awarded during the early months of 1912, and construction was actually begun in April of that year. The water was in use in Moose Jaw before the end of November or within eight months.

The works consist of an infiltration or collecting gallery terminating in a main well over which is constructed a headworks pumping station, a pressure main, a headworks reservoir of 500,000 gallons capacity, a gravity main 96,200 feet long extending from Caron to Moose Jaw, a storage reservoir (in the city) of 2,000,000 gallons capacity, a second pumping station and an elevated tank.

The Infiltration Gallery

The infiltration gallery will consist when complete of 4,000 lineal feet of 20-inch glazed tile laid with semi-open joints in the water bearing sand of the valley of Sandy Creek, at a depth of about 16 feet. Manholes are provided every 800 feet or wherever changes in direction occur. The invert of the pipe has a gradient of 0.4% and is approximately parallel with the natural surface of the ground in which it lies. The lower semi-circumference of each joint is sealed with a cotton sack filled with what was originally dry cement and sand. This is carefully placed in the invert of the bell when the pipe is laid. This sack adapts itself to the irregularities of the tile, while still soft, and later on prevents the admission of sand to the pipe. The upper half of the joint is protected by a depth of one foot of graded gravel which, for the sake of economy, is confined in a cheaply constructed box of spruce lumber scribed to the curvature of the tile. This also prevents the entrance of sand into the interior of the pipe. It will be seen from this that the gallery is intended to drain the surface stream and that it may lower the level of the ground water down to but not below the axis of the pipe.

The laying of this gallery in a water-bearing gravel and quicksand presented some special difficulties. Two parallel rows of 9-inch U. S. Steel Company's interlocking steel sheet piling 18 feet long were driven one on either side of the proposed centre-line of the gallery and distant thereform 2 feet. This was accomplished without special trouble with the aid of a 2¼-inch McKiernan-Terry pile hammer fitted with special driving cap, and by a liberal use of the water jet. The first six feet of depth of excavation was done by hand after which a 6-inch Goulds centrifugal dredging pump was put into service and the remainder of the excavation done thereby, sufficient water to render this operation possible being meanwhi.e admitted to the pit from the creek above. Bulkheads and transverse shoring were placed as the work progressed. The pulling of the piles was accomplished by the aid of a Yale & Towne 3-ton triplex chain block for starting and an ordinary pair of triple blocks with a 1-inch fall and a steady team of horses for the rest of the operation. A generous application of axle grease to both bulb and channel sides of the pile during the driving greatly aided the pulling afterwards. The greatest difficulty met with was the prevention of water coming into the trench from underneath the piling especially where the line led across lagoons as it did in a portion of the work.

The infiltration gallery terminates at its lower extremity in a main well circular in plan, 15 feet in diameter and 29 feet deep and constructed of concrete. An adjunct of this well is a valve chamber through which the water passes on its way to the well and admission to which from the gallery is controlled by a 16-inch gate valve operated from the floor above. This valve chamber is provided with a permanent metal weir enabling the operator at any time to determine the quantity of water being received from the gallery. The excavation for this well was done entirely by the dredging pump. Over the well stands the headworks pumping station.

Headworks Pumping Station

The headworks pumping station is a brick structure 48 x 36 feet in plan, with concrete foundations, base, floor and roof. The mechanical equipment includes two Fairbanks-Morse two cylinder,

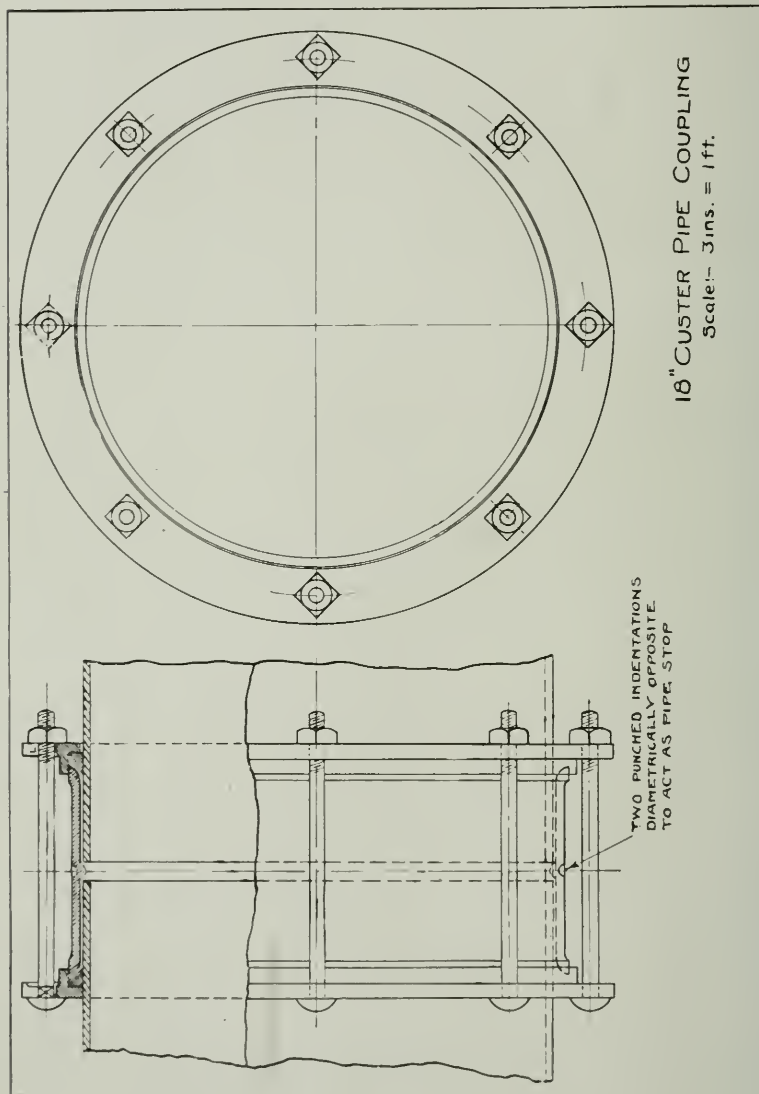

Fig. 2—Custer Pipe Coupling

four cycle 50 H.P. vertical oil engines belted through a line shaft of two Boving centrifugal pumps each of 600 gallons per minute capacity. The arrangement is such that either or both pumps may be operated by either engine. The nominal speed of the engines is 300 R. P. M. and that of the pumps 1450 R. P. M. The two discharge pipes join with the 18-inch pressure main in a special wye outside of and below the pumphouse wall. Each pump is protected by a check valve set in the discharge main and priming, when necessary, is done by a by-pass connecting the pressure main beyond this valve with the pump casing. In addition to the engines and pumps there is a 5. K.W. generator for lighting purposes, an air compressor and air storage tanks for starting, and oil and water pumps for fuel and cooling respectively. Ultimately when it is decided to install the deep wells for the purpose of obtaining the water in the low-lying strata of gravel, an air-lift equipment will be employed and the compressor capacity will be increased. Provision for such increase has been made in the lay-out of the station. The usual storage tanks for oil, gasoline and water are provided and complete the equipment.

The Pressure Main

As stated elsewhere, the pressure main has a diameter of 18 inches. It consists of welded steel tubes of thickness ¼ inch and of average length 17 feet. The ends are plain and the joints are made by the Custer method. A sketch of this joint is shown herewith in Fig. 2. The joint mechanism consists of a collar sufficiently large in diameter to slip over the ends to be connected, two followers or gland rings, two rubber gaskets and ten track bolts. The collar is ten inches long and on its interior are two projecting buttons which insure half the collar covering each of the two ends to be connected. A special Custer wrench is used for tightening the bolts. The advantages of this joint are that it is slightly flexible after being laid, that it can be made under water and that a change in direction equal to three degrees at each connection can be secured with 18-inch pipe. With 10-foot lengths it will be seen that a thirty degree curve could be followed if necessary. Experience has shown that if proper care be taken in the jointing, absolute water-tightness can be secured. The specification for laying required that as soon as the pipe was connected up, backfilling to a depth of one foot over the pipe, carefully rammed should be done. The objects of this were to avoid injury to the pipe in case of caving-in, and to prevent the pipe floating in wet situations where water could not enter the free or open ends of the pipe. Part of this pipe had to be laid at a depth of 14 feet and over owing to the regular nature of the ground through which it passed and the advisability of avoiding summits in the profile of the ripe.

Headworks Reservoir

The headworks reservoir is an all-concrete structure circular in plan, 75 feet in diameter and holding when full, 17 feet of water. The roof, which is of the girderless type, is supported by 9 columns placed in three rows of three each. Admission of water to the reservoir and discharge thereform are controlled by 18-inch gate valves. The admission valve is protected by an 18-inch check valv The roof is about 8 feet above the normal level of the ground. Back filling against the exterior walls and over the roof slab adequately protects against frost. The concrete was the equivalent of a 1:2:4 mixture thoroughly well mixed and carefully tamped. No other waterproofing precaution was employed and when after construction, the reservoir was tested full for 24 hours a leakage of less than ¼ of 1% occurred. The difference in level between the normal water in this reservoir and that of the storage reservoir at Moose Jaw is 57 feet. The infiltration gallery, headworks pumping station, pressure main and headworks reservoir were done by day labor instead of by contract, it having been felt that the many uncertainties to be anticipated rendered this procedure advisable.

The Gravity Main

The gravity main from the headworks or Caron reservoir to the city is of 18-inch welded steel with Custer joints of the type already described. The invert is laid at an average depth of 9 feet. To facilitate examination and repairs, it is divided by gate valves into sections averaging one mile and two-thirds in length. The entire pipe is laid on either a rising or a falling gradient, the objects being to permit entrapped air to rise to the summits where air valves are provided. At each air valve there is provided also a poppet inlet valve for the purpose of admitting air whenever a section of the line is drained. Six-inch drains are provided at all depressions and are controlled by six-inch gate valves. These will permit the main to be unwatered in sections when necessary.

Storage Reservoir

The storage reservoir at Moose Jaw has a capacity of 2,000,000 gallons. It is rectangular in plan and is divided transversely by a partition into two equal parts. The 18-inch gravity supply main from Caron divides at a point exterior to the wall and an inlet branch goes to each half. Each branch is equipped with a Mason, float-operated, balanced valve which controls the admission of water. Except at such times as the demand of the city services exceeds the capacity of the gravity supply, this arrangement will insure a full reservoir always. The reservoir is of reinforced concrete throughout, the floor having a thickness of 10 inches. The exterior walls consist of panels 18 feet high spanning between counterforts spaced 9 feet on centres. The partition wall is similarly constructed, except that it is designed to resist a full head of water in either direction. The roof is of the girderless type, supported on columns spaced 18 feet both ways, the slab proper having a thickness of 7½ inches. A five-ply felt and gravel covering overlies the concrete roof and on this, in turn, a filling of two feet of earth is placed.

The Moose Jaw Pumping Station

The Moose Jaw pumping station is of the same general style of construction as the headworks pumping station. Its equipment consists of two Canadian Boving centrifugal pumps direct connected to two Siemens 35 H.P. motors which receive their power from the supply mains from the city's central power station. These pumps lift the water to the elevated tank a height of upwards of 110 feet. They will ordinarily draw from the storage reservoir but the piping arrangements will permit water to be drawn direct from the Caron gravity main. In addition to this, either pump can draw from either side of the reservoir. Finally the piping system will permit of water being fed (without pumping) from the reservoir or from the gravity

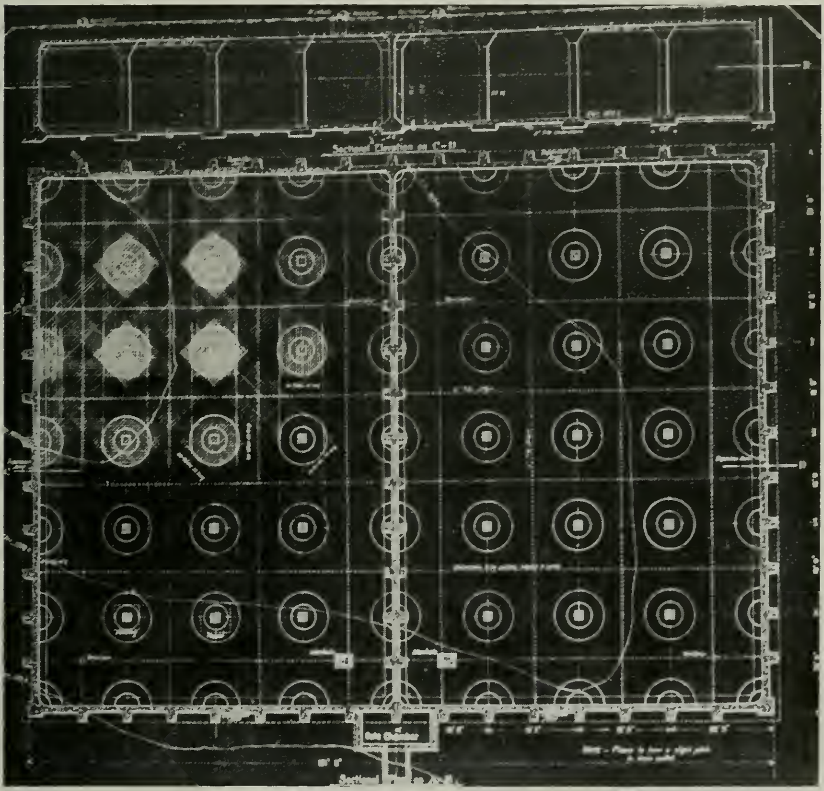

Fig. 3—Plan and Section of Headworks Reservoir.

main into the city's distributing system either of which would give a moderate pressure overall of the city except the highest parts. If desired, the elevated tank may be cut out and the pumps made to discharge direct into the mains. The motors are equipped with Cutler-Hammer switches operated by a float in the elevated tank. This is intended to keep the tank practically full at all times. The pumping station is supplied with a heating boiler with circuits through the reservoir and the riser of the elevated tank to provide against unusual frost conditions.

The Elevated Tank

The elevated tank is a steel structure of 75,000 gallons capacity, and is carried on four posts. It is provided with a riser 6 feet in diameter. The bottom is elliptical in section. The tank is provided with a mercury pressure indicating gauge and with floats operating the motor switches in the pumping station. The elevated tank, the Moose Jaw pumping station and the storage reservoir stand in close proximity on what is practically the highest ground in the vicinity of the city.

As stated previously, the infiltration gallery, the headworks pumping station, the pressure main and the headworks reservoir were all done by day labor. The Wm. Newman Company, Limited, Maurice S. Holmes, and the Moose Jaw Construction Company Limited, were the contractors for the laying of the gravity pipe line, the pipe itself having been supplied by the National Tube Company through the U. S. Steel Products Company. The storage reservoir and the Moose Jaw pumping station were constructed by the Moose Jaw Construction Company, Limited. George T. Horton, of Chicago, supplied the elevated tank. Drummond, McCall & Company, supplied all valves, fittings and specials. The mechanical equipments at the headworks and Moose Jaw pumping stations were supplied by the Canadian Boving Company, Limited, and the Canadian Fairbanks-Morse Company, Limited.

At the present time the infiltration gallery is laid for only about half its contemplated length, and the system of deep wells across the valley to tap the lower supply has not been constructed. The reason for this is that it was considered best to test out the supply this winter with only part of the gallery in operation. Then, if the conditions require it, the balance of the gallery and the deep wells are to be constructed next season. It is quite likely that the present works will be extended so as to include the whole of the development originally contemplated at the headworks.

Those members of the staff of Walter J. Francis & Company, from the Engineering Faculty of the University of Toronto, were Mr. R. L. Dobbin, '10, Mr J. C. Murton, '10, Mr. Ross Taylor, '11, Mr. R. E. Green, '11, and Mr. Angus Richardson of the present second year, with the writer in charge of the general supervision of the whole work.

F. H. Chesnut, '08, is resident engineer in charge of the construction of about sixty miles of freight yards for the C.N.R. at Port Mann and also of repair shops, round house, freight sheds and auxiliary plants.

W. G. Worden, '11, is with the Manitoba Hydrographic Survey at Lac du Bonnet, Manitoba.

A. H. Foster, '08, is manager of the Guelph Radial Railway Co.

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EDITORIAL

The School Dinner has its important place in the calendar of events pertaining to the University of Toronto. It is to be hoped that all opinions to the contrary are settled for some years to come. The success of the twenty-fourth annual dinner, held on February 13th, 1913, was due, in part, to the conscientious and well organized team work of the members of the Dinner Committee, but largely to their energies being directed along proper lines. It is sufficient to state that the number present exceeded the number arranged for in the plans to such an extent that more would have marred the successful working out of the programme. It remains for next year's executive to lay plans of considerably larger dimensions, if it would maintain the popularity of the policy so ably followed this year by Mr. Ritchie and his officers.

TWENTY-FOURTH ANNUAL DINNER

THE U. OF T. CLUB OF NEW YORK

The 11th annual banquet of the University of Toronto Club of New York, was held at the Hotel Astor on Tuesday evening, February 11th. Among the speakers were Dr. H. K. Clark, Dean of the Faculty of Medicine, University of Toronto; Mr. Robert Henderson, past president U. of T. Club of N. Y.; Mr. Ernest Thompson Seton, Mr. Edmund D. Fisher, Deputy Comptroller, New York City; Mr. John A. Stewart, Chairman, 100 Years of Peace celebration, and Mr. Andrew B. Humphrey.

For the first time, the assembly of University men had their annual banquet graced with the presence of ladies, and in all probability this precedence will be upheld in future.

Mr. T. Kennard Thomson, '86, Mr. E. W. Stern, '84, Mr. H. E. Ballantyne, '93, Mr. H. P. Rust, '01, and Mr. T. H. Alison, '92, are among the "School" men who were present.

After the occasion was over the party adjourned to a reception given by the Canadian Club of New York, at the Waldorf Astoria. Mr. Thomson, the President of the latter Club, officiated.

"Toike Oike" Club Dinner

The Montreal Branch of the Engineering Alumni Association, the "Toike Oike" Club, held a dinner on Tuesday, January 28th at Cooper's Restaurant, entertaining the School men who were in the city to attend a convention of the Canadian Society of Civil Engineers. Between 30 and 40 were present. Owing to the absence of the President, Mr. R. A. Ross, '90, the chair was occupied by Mr. Walter J. Francis, '93. With him at the head table were seated Mr. T. Kennard Thomson, '86, C. H. Pinhey, '87, C. H. Mitchell, '92, J. M. Robertson, '93 and D. C. Tennant, '99.

After short addresses had been delivered by Messrs. Thomson and Mitchell, the partakers of the festivities adjourned to the smoker held by the Canadian Society in its new building. Among the men who were present were the following guests from Toronto: T. R. Loudon, '05; T. H. Hogg, '07; H. W. Tate, '09; P. G. Cherry, '11; Others present were W. H. Sutherland, '02; M. C. Hendry, '03; J. P. Watson, '04; A. L. Harkness, '06; C. W. B. Richardson, '07; S. A. Marshall, '07; A. M. Bitzer, '08; F. H. McKechnie, '09; W. D. Black, '09; L. R. Wilson, '09; R. L. Dobbin, '10; H. W. Fairlie, '10; R. M. Walker, '10; H. M. White, '10; T. J. Farrelly, '11; E. H. Niebel, '11; C. A. Meadows, '11; R. O. Stewart, '11, and J. C. Martin, '11.

McGill Engineering Society

Mr. T. Kennard Thomson addressed the Engineering Society of McGill University on Monday, January 27th, the subject of his address being "Caisson Foundations." In the course of his remarks Mr. Thomson referred to his connection with the formation of the first engineering society in Canada in 1885 (one year before the formation of the Canadian Society of Civil Engineers), it being the University of Toronto Engineering Society.

DIRECTORY OF THE ALUMNI

Giving each month, in alphabetical order, the location of a number of the graduates. The entire list will be reviewed in the twelve issues beginning November, 1912.

The graduates will confer a favor by advising us of any and all instances where the list is not up-to-date. Addresses unknown, or no longer correct, are hard to eliminate entirely from our records. If graduates will see that the information given about *themselves* is exactly as it should be, and that that concerning their class mates is also correct to the best of their knowledge, the department will soon be most reliable.

C (*Continued*)

Charlton, H. W., '97, is on the staff of the Experimental Farm, Ottawa, as chemist.

Chase, A. V., '05, whose home address is Orillia, Ont., is with the Department of the Interior, Kamloops, B.C.

Cherry, P. G., '11, is circulation manager of the *Canadian Engineer*, Toronto.

Chesnut, A. W., '10, is in the office of the surveyor-general, Vancouver, B.C.

Chesnut, E. F., '11, is also in Vancouver.

Chesnut, F. H., '08, is at Port Mann, B.C., in charge of the construction of the Canadian Northern Pacific Railway company's shops, freight sheds, etc.

Chesnut, V. S., '09, is on general engineering and surveying with Murdock & Co., at Kamloops, B.C.

Chewett, H. J., '88, is mechanical engineer for the Evans Rotary Engine Co., Limited, Toronto.

Chilver, C. A., '04, is with the Canadian Bridge Co., at Walkerville, Ont.

Chilver, H. L., '04, is also with the Canadian Bridge Co., Walkerville, Ont.

Chisholm, D. C., '10. We do not know in what line of work he is engaged. He is in Winnipeg, Man.

Christie, W., '02, is engaged in engineering and land surveying at Prince Albert, Sask.

Christie, A. G., '01, is assistant professor of steam engineering, University of Wisconsin, Madison, Wis.

Christie, F., '06, is with the Algoma Central Railway in charge of construction.

Christie, U. W., '04, is in Ottawa, Ont., in the Astronomical Survey Branch, Department of the Interior.

Chubbuck, L. B., '99, is with the Canadian Westinghouse Co., Toronto, Ont., in the engineering department.

Clark, F. W., '11, is at Niagara Falls, N.Y. He is in the employ of the International Waterways Commission.

Clark, G. T., '06, is city engineer of Saskatoon, Sask.

Clark, H. J., '11, is in the city at present after spending the summer on engineering work at North Battleford, Sask.

Clark, H. S., '10, is instrument man on the new Welland Ship Canal, at Port Dalhousie, Ont.

Clark, J., '00, was, when last heard from, with the P. & L. E. R. R. at Pittsburg, Pa., as electrician. We do not know his present address or occupation.

Clarke, F. F., '03, is divisional engineer for the Canadian Northern Railway Co. His home is in the city.

Clarke, J. E., '11, is resident engineer for the city of Toronto on the Canadian Pacific Railway grade separation work at North Toronto.

Claveau, J. A., '10, Chicoutini Pulp Co., at Chicoutini, P.Q.

Cleary, F. S., '11. His home is in Windsor, Ont. We have no other address for him at present.

Clement, S. R. A., '05, was with the Hydro Electric Power Commission, but this is not his latest address.

Clement, W. A., '89, is city engineer of Vancouver, B.C.

Cline, C. G., '09, is on the staff of the hydrographic survey, railway belt, Kamloops, B.C. He is spending the winter at his home in Hamilton, Ont.

Clothier, G. A., '99, was, when last heard from, with the LeRoy Mining Co. as engineer at Rossland, B.C.

Coates, P. C., '04, was at Revelstoke, B.C., according to our last information.

Cockburn, J. R., '01, is lecturer in descriptive geometry in the Faculty of Applied Science and Engineering, University of Toronto.

Cockburn, L. S., '10, is a member of

the engineering firm of Wenger & Cockburn, with consulting practice in Regina, Sask.

Code, A. G., '10, is demonstrator in electrical engineering, University of Toronto.

Code, S. B., '04, is town engineer of Smith's Falls, Ont.

Code, T. F., '04, deceased October 29th, 1906.

Cole, C. R., '10, his home is in Woodstock, Ont.; we do not know what he is doing at present.

Cole, D. B., '11, is in charge of repair shops for the Canadian Copper Co., at Copper Cliff, Ont.

Cole, '08, deceased December 31st, 1909.

Coleman, R. M., '10, is at Deseronto, Ont.

Colhoun, G. A., '06, is draughtsman for the Hamilton Bridge Works Co., Hamilton, Ont.

Collett, W. C., '08, is in the city with Collett-Simpson Fibre Tire Works Limited.

Collinson, W. G., '09, has Seeley's Bay for his home address. He was, until recently, with the National Portland Cement Co., Durham, Ont., but is now chemist for the Carborundum Co., of Niagara Falls.

Colquhoun, G. A., '10, is with the Topographical Surveys Branch, Department of the Interior, Ottawa.

Coltham, G. W., '09, is carrying on an engineering and surveying practice at Aurora, Ont.

Conlon, F. T., '02, deceased, July 10th, 1912.

Connell, C. B. B., '07, who until recently was with Mirrless & Watson, Glasgow, Scotland, has no address with us at present.

Connor, A. W., '95. is a member of the engineering firm of Bowman & Connor (H. J. Bowman, '85) with offices in Toronto and Berlin, Ont.

Connor, H. V., '02, is with the Canadian Westinghouse Co., Hamilton, Ont.

Cooch, H. A., '09, is sales engineer for the Canadian Westinghouse Co., with headquarters in Toronto.

Cook, A. S., '11, whose home is in Ingersoll, Ont., is superintendent of the Saugeen Electric Light & Power Co., Southampton, Ont.

Cook, W. A. M., '06, is assistant engineer in the offices of the city architect, Toronto.

Cooper, C., '99, is with the Keokuk & Hamilton Water Power Co., Keokuk, Ia.

Corman, W. E., '09, is chief draughtsman for C. H. & P. H. Mitchell, Traders Bank Bldg., Toronto.

Cornell, C. W., '11, is in engineering and contract work, Exchange Building, Vancouver, B.C.

Corrigan, G. D., '90, deceased May 6th, 1907.

Corrigan, T. E., '05, when last heard from was chief electrician for the Standard Consolidated Mining Co., at Bodie, Cal. We have no address for him at present.

Cory, R. Y., '08, is in charge of the bond department of Baillie, Croft & Wood, Toronto.

Coulson, C. L., '03. His home is in Welland, Ont. We do not know the nature of his professional work.

Cousins, E. L., '06, is harbor engineer for the city of Toronto.

Coulthard, R. W., '99, is general manager of the West Canadian Collieries, Limited, at Blairmore, Alta.

Cowan, W. A., '04, is assistant to the chief engineer of the Canadian Pacific Railway, Montreal.

Cowper, G. C., '07, His home is in Welland, Ont.

Coyne, H., '08, is chief draughtsman for Thomas & Thomas, Racine, Wis.

Craig, J. A., '99, is engaged in civil engineering and surveying at Prince Albert, Sask.

Craig, J. H., '10, is a member of the architectural firm of Craig & Madill, Manning Chambers, Toronto.

Craig, S. E., '04, is engineer for Ritchie & Ramsay, paper manufacturers, New Toronto, Ont.

Creighton, A. G., '06, is a member of the firm of Creighton & Strothers, architects and structural engineers Prince Albert, Sask.

Crerar, S. R., '04, is lecturer in surveying, Faculty of Applied Science and Engineering, University of Toronto.

Crosby, N. L. R., '05, is contracting engineer with McClintic-Marshall Construction Co., Chicago, Ill.

Crosby, T. H., '09, is sales engineer with the Canadian Westinghouse Co., in the Vancouver office.

Crouch, M. E., '11, whose home is in Rochester, N.Y., was with Lang & Ross, Sault Ste. Marie, Ont., when last heard from.

Cruthers, W. M., '11, is with the Canadian General Electric Co., at the Peterborough plant.

Culbert, J. V., '07, is in the engineering office of the Toronto Iron Works.

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THE PANAMA CANAL [1]

By David A. Molitor, C. E.

Mem. Am. Soc. C. E., etc., Late Designing Engineer, Isthmian Canal Commission

The ancient world wonders, recorded in the history of man, mark achievements of engineering science. With the progress of civilization, the production of great works increased until the period of wonders apparently ceased. Engineering of to-day has assumed such enormous proportions of worldly activities, that it may well be said we are living in an age characterized by the continuous performance of wonders.

Nationally, economically and commercially the Panama Canal commands the attention of the world to-day as the vastest engineering undertaking in all history.

More than most great national undertakings, its chief purpose is for the general good of the American people and incidentally offers some advantages to nearly all the nations on the earth.

Isthmian Canal History

The Isthmus of Darien was discovered by Columbus in 1502 and the province of Darien known as Castilla del Oro, under Vasco Nunez de Balboa as govenror, was founded soon after.

Balboa, in Sept. 1513, crossed the isthmus with a considerable force of Spaniards and Indians and discovered the Pacific Ocean which he called the South Sea. Through the efforts of his enemies Balboa was soon superseded as governor of the Province by Pedro Arias de Avila, known as Pedrarias.

In 1517, Balboa was charged with treasonable conduct by Pedrarias and, after the form of a trial, was condemned and beheaded. "Thus closed the career of the brave and unfortunate man who first marked out a line of transit across the Isthmus."

The old City of Panama on the Pacific coast, was settled in 1517 and the Atlantic port Nombre de Dios, 40 miles east of the present City of Colon, was founded in 1519. Between 1517 and 1520 a trans-Isthmian route was established via the royal road to

1. Read before the University of Toronto Engineering Society, Feb. 12, 1913.

Cruces, from old Panama to Cruces on the Chagres River, using the river as a water route from Cruces to the Atlantic and thence to Nombre de Dios.

In 1597 the Atlantic port was moved westward to Puerto Bello, 21 miles east from the present City of Colon. Also a new road was built from Panama due north to Puerto Bello, which is still in existence.

During the century, the Isthmian commerce grew to such importance that it became the toll gate between Western Europe and Eastern Asia.

As early as 1520, Charles V. of Spain is said to have directed that a survey should be made to determine the feasibility of a canal across the Isthmus at Panama. "The governor, Pascual Andagoya, reported in 1534, that such a work was impracticable and that no king, however powerful he might be, was capable of forming a junction of the two seas or of furnishing the means for carrying out such an undertaking."

Old Pamana became a centre of wealth, and considerable trade was established with the Pacific coast of Central and South America.

Though well fortified, the city was sacked and burned by Morgan in February, 1671, and in 1673 the present city was founded six miles west from the original site.

In January, 1522, Gil Gonzales with one hundred men, explored the Pacific coast northward from Panama and landed in the Gulf of Fonseca, about 650 miles from Panama. He discovered an inhabited country under a chief called Nicarao, and found what he considered a great inland sea which he afterward named Lake Nicaragua.

Thus a maritime trade of some importance was established between Spain and Lake Nicaragua which reached its greatest activity near the end of the sixteenth century.

Although the feasibility of a canal across Nicaragua was recognized soon after the route was discovered, there is no evidence of any investigation having been made until 1779 under instructions of Charles III. of Spain.

In 1781, Galisteo reported that Lake Nicaragua was 134 feet above the Pacific Ocean and that high mountains intervened between the two bodies of water, making a canal impracticable. However, a company was subsequently formed to build such a canal but nothing further was ever done.

The English Capt. Nelson, in 1780, captured Fort San Juan but was forced to return to Jamaica without accomplishing any permanent results.

Panama achieved her independence from Spain in 1819. Later she became a member of the Granadian Confederacy and then joined the United States of Columbia.

During the three hundred years of Spanish occupation no actual progress was made toward establishing an Isthmian communication between the seas.

As a result of the extensive travels and accounts of Baron von Humboldt a new interest was revived among the nations of the world, and subsequently Spain, in 1814, passed a formal decree for the construction of an Isthmian Canal.

However, this never resulted in any actual work, for in 1823 Spain lost the last of her Central and South American provinces by secession.

Mr. John Baily made a survey of the Nicaragua route for an English Company in 1826 but, failing in his main purpose, he remained in Central America until President Morazin, in 1837, employed him to determine the best location for a canal.

President Bolivar of Panama in 1827, commissioned Mr. J. A. Lloyd to survey the Isthmus of Panama with a view to locating a transport line either by road or canal.

The republic of New Granada, in 1838, granted a concession to a French company, authorizing the construction of a road, railroad or canal with one terminus at Panama. After several years spent by this company in exploration, the French government was drawn into the matter and in 1843 a rather complete investigation and report was made favoring a ship canal closely approaching the present Panama route at a cost of twenty-five million dollars.

About the middle of the nineteenth century a succession of great events vastly increased the importance to the United States of a maritime connection at the Isthmus. The history now takes on such a broad aspect that it is beyond the limitations of this paper to give more than the few important incidents leading up to the present situation.

After a series of complications the American Atlantic and Pacific Ship Canal Co. in 1850, appointed Col. O. W. Childs, as Chief Engineer, to make a careful survey of the Nicaraguan route which he completed in 1852. A provisional route of stage and boat was established and used for several years but as no progress was made on the canal construction, the Nicaraguan government annulled the contracts made with the company and seized the latter's property.

The French Panama Company, in 1847, secured the exclusive privilege of building a railroad across the Isthmus, which road was completed in 1855.

General Grant in his first message to Congress, in 1869, "commended an American Canal on American soil, to the American people."

Congress promptly responded to this sentiment and accordingly authorized the President to appoint an Interoceanic Canal Commission to investigate the subject. Surveys of the Tehuantepec, Nicaragua and Panama routes were made between 1870 and 1875 and in its final report 1879, this commission favored the Nicaragua route.

The men who made these surveys were Captain R. W. Shufeldt, U. S. N., Com. A. F. Grosman, U. S. N., who lost his life on the work, Also Com. Chester Hatfield, U. S. N., Mr. A. G. Menocal, and Capt. Edw. P. Lull, U. S. A.

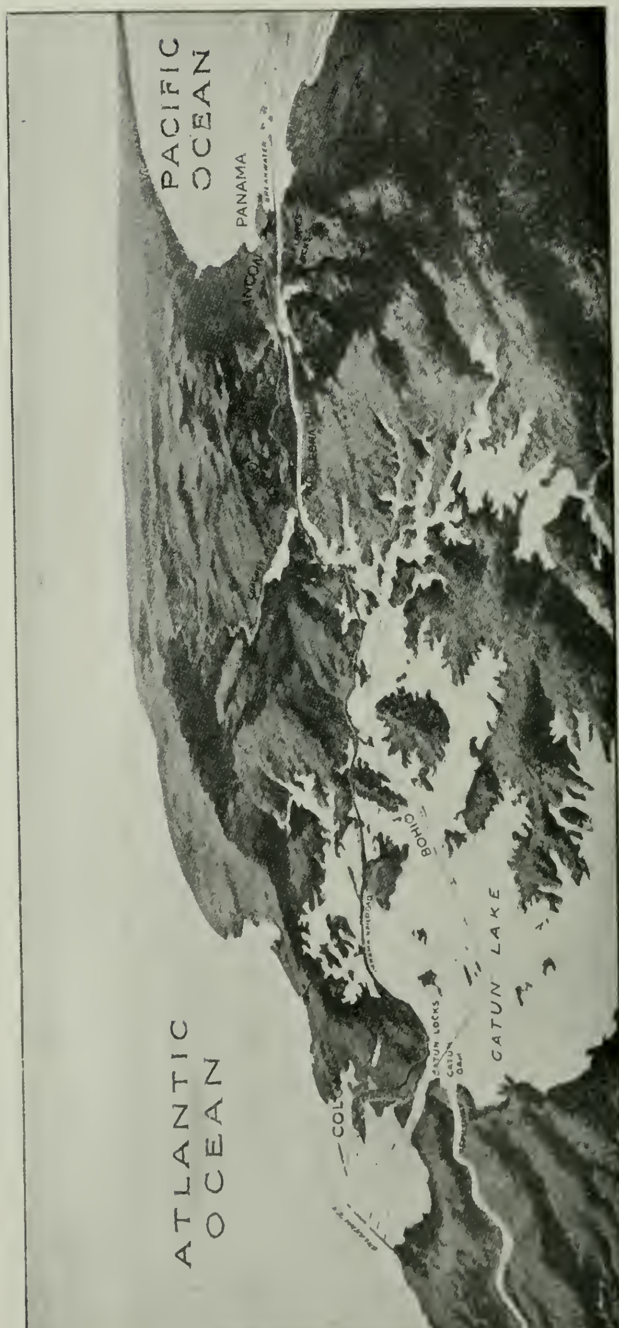

Fig. 1—Bird's-Eye View, Panama Canal, Lock Level Project

While the United States Government was engaged in makin these surveys and before any arrangement for a canal was com pleted, a provisional company was organized in France to investigate the feasibility of an Isthmian Canal. In May, 1876, Lieut. L. N. B. Wyse, as representative for this company, entered into contract with the Colombian Government by which, under a later modification, the Company obtained exclusive privileges for 99 years, for building a canal, the general route of which was to be determined by an international congress.

Such a congress met in 1879 and decided on a route which is practically the one now being built. F. de Lesseps, in 1881, formed the Panama Canal Co., which bought up the concessions obtained by Wyse, and proceeded to construct a canal between Panama and Colon.

This canal was to be of the sea level type, 72 ft. wide at the bottom, 29.5 ft. deep, 47 miles long and to cost $169,000,000.

The plan was soon changed to a lock canal and after expending $260,000,000, obtained from the sale of shares in France and finally by lottery, the work was abandoned, in 1889, for want of funds. A new Panama Canal Co. was formed in France, in 1894, with a ten year concession, which was afterward extended to 1910.

About twelve miles of canal was completed at the Atlantic end and some considerable excavating done in the Culebra cut amounting in all to about seventy-seven million cubic yards and costing about $267,000,000.

The new company continued work, between 1895 and the time the United States took possession, with a force of between 2000 and 3600 men.

During this time about five million cubic yards were excavated at a cost of about $7,000,000, which amounts are already included in the above.

The financial entanglement and exposures of fraud prevented the company from raising further funds though work was continued in a provisional manner.

In 1885 the Nicaragua route was again surveyed by Mr. A. G. Menocal after a treaty had been negotiated between the United States and Nicaragua, in 1884, to build a canal involving joint ownership by the two nations. Nothing came of this treaty as it was withdrawn by Nicaragua.

In 1887, Mr. Menocal and others were granted a concession from Nicaragua to construct a canal between Greytown and Brito. This gave rise to the formation of the Maritime Canal Co. of Nicaragua incorporated by Congress in 1889.

This Company had a sad fate and after the expenditure of considerable money, the Nicaraguan Government declared the contract forfeited.

Several bills were brought before Congress with a view of seeking governmental aid.

While such a bill was under consideration in 1895, an amendment to the Sundry Civil Appropriation bill was passed, by which a Nicaragua Canal Board was created to ascertain the feasibility and cost of completing the canal.

On this board were appointed Lieut. Col. Wm. Ludlow, Admiral Mordecai T. Endicott, U. S. N. and Mr. Alfred Noble. The investigation was made and a report submitted, setting forth the impossibility of properly concluding the work with the limited time and means allotted.

Accordingly the President, in 1897, was authorized to appoint a new board to continue this work. The second board consisted of Rear Admiral John G. Walker, Col. Peter C. Hains and Prof. L. M. Haupt. This body, known as the Nicaragua Canal Commission, submitted its report in 1899, and this indicated the desirability of a more general investigation with a view of examining all feasible routes across the Isthmus.

The Isthmian Canal Commission was thus created by Congress in 1899, and the President appointed the following members to this Commission: Rear Admiral J. G. Walker; Hon. Samuel Pasco; Mr. Geo. S. Morison; Mr. Alfred Noble; Lieut. Col. O. H. Ernst; Col. Peter C. Hains; Prof. L. M. Haupt; Prof. Wm. H. Burr; Prof. Emory R. Johnson; Lieut. Com. Sidney A. Staunton, Secy.

This Commission made a very complete investigation of all feasible routes of the entire Isthmus and in an exhaustive report, submitted to the President in 1901, presented their findings for nineteen different routes, four of which were particularly investigated by the Commission as offering the most advantageous conditions, and of these the Panama route was selected as being the most favorable.

As a result of the recommendations of this commission Congress passed an act, dated June 28, 1902, authorizing the President to acquire, at a cost not exceeding $40,000,000, the rights, franchises and property of every kind belonging to the New Panama Canal Company, including its shares of the Panama Railroad Company, provided a satisfactory title could be obtained. This same act contained other instructions relating to property rights to be acquired from the Republic of Colombia and directed the President to cause to be constructed a ship canal from the Caribbean Sea to the Pacific Ocean.

On January 22, 1903, Colombia proposed a treaty offering to lease the necessary canal land to the United States for 100 years. The following August Colombia rejected this treaty and on November 4th, Panama asserted her independence from Colombia, being almost immediately recognized by the U. S. and European powers.

On February 23, 1904, a canal treaty between the U. S. and Panama was signed by which Panama granted in perpetuity, a zone five miles wide on each side of the canal route, with exclusive police, judicial, sanitary and other control within this zone excepting the terminal cities of Colon and Panama, which were, however, to be controlled by the United States in sanitation and quarantine affairs.

For these grants the U. S. paid $10,000,000 on the ratification of the treaty and after nine years an annual rental of $250,000 is to be paid.

On May 4th, 1904, the United States purchased the Panama Canal property at a cost of $40,000,000, and thus came into possession of property and rights which cost the French people $267,000,000 and many thousand lives to acquire.

In the meantime the President appointed a new commission to carry on the construction of the canal and govern the canal zone.

The Commission consisted of Rear Admiral John G. Walker, Chairman; Major General George W. Davis; Mr. William Barclay Parsons; Prof. William H. Burr; Mr. Benjamin M. Harrod; Mr. C. E. Grunsky; Col. F. J. Hecker.

In May, 1904, Mr. John F. Wallace was appointed Chief Engineer and Major General Davis was made Governor of the Canal Zone.

Col. Wm. C. Gorgas of the Medical Department, U. S. Army, whose successful work in the sanitation of Habana was so commendable, was made Chief Sanitary officer of the Zone.

On November 16, 1904, the Walker commission resigned to take effect at the pleasure of the President and a new commission was appointed as follows: Mr. Theo. P. Shonts, Chariman; Mr. Chas. E. Magoon, Governor; Mr. John F. Wallace, Chief Engineer; Rear Admiral M. T. Endicott, U. S. N.; Brig. Gen. Peter C. Hains, U. S. A.; Col. O. H. Ernst. Corps of Engrs.; Mr. B. M. Harrod.

On June 13, 1905, Mr. Wallace resigned and was succeeded by Mr. John F. Stevens as Chief Engineer.

On June 24, 1905, the President appointed a Board of Consulting Engineers consisting of Gen. Geo. W. Davis; Mr. Alfred Noble; Prof. Wm. H. Burr; Mr. Wm. B. Parsons; Gen. Henry L. Abbot; Mr. Fred. P. Stearns; Mr. Joseph Ripley; Mr. Isham Randolph; Mr. Wm. Henry Hunter, by the British Government; M. Guerard, by the French Government; M. Quellennec, Con. Engr. Suez Canal; Herr Eugen Tincauzer, by the German Government; Herr Welcher, by the Dutch Government; Capt. J. C. Oakes, Secy.

This Board was appointed for the purpose of considering the various plans proposed to and by the Isthmian Canal Commission for the construction of the Panama Canal. Minority reports were requested in case of differences in opinions among the members of this Board.

On February 5th, 1906, this Consulting Board submitted two reports, a majority report favoring a sea-level canal and a minority report advocating a lock canal with an artificial lake and summit level at 85 feet above sea level.

The minority report was signed by Messrs. Noble, Abbott, Stearns, Ripley and Randolph, and this report was proposed for adoption by the following members of the Commission: Messrs. Shonts, Magoon, Hains, Ernst, Harrod and Stevens.

It is the plan of this minority report which is at present being arried out with some slight modifications which became desirable as the work progressed.

In November, 1906, President Roosevelt visited the canal in person. At this time an Engineering Board consisting of Messrs. Alfred Noble, F. P. Stearns and J. R. Freeman was sent to the Isthmus to investigate and report on the foundations of the locks and dams.

In March, 1907, Mr. Stevens resigned his connection with the Commission and the President then appointed Col. George W. Goethals, Corps of Engineers, Chairman and Chief Engineer, and turned the entire work over to the Corps of Engineers, U. S. A.

In January, 1909, the President appointed a Board of Consulting Engineers consisting of Messrs. Frederic P. Stearns; Henry A. Allen; Arthur P. Davis; James D. Schuyler; Isham Randolph; John R. Freeman and Allen Hazen, to accompany President-elect William H. Taft to the Isthmus with instructions to look into the condition of the work and especially to report upon the feasibility and safety of the Gatun Dam and also to decide whether, or not, there should be any change in the plans at present adopted by Congress.

This Board returned from its duties and submitted a report February 17th, 1909, approving unanimously the type and dimensions of dam being constructed at Gatun and commending the general canal plans as at present adopted.

Brief Discussion of Five Isthmian Canal Projects

The American Isthmus, connecting Mexico with South America and embracing the Central American Republics, is a mountain ridge between the Sierra Madre and Andes ranges.

There are many high peaks up to 12,000 feet above sea level, and the ridge has occasional saddles which have been located so far as possible with a view of finding suitable canal routes.

At Tehuantepec, Mexico, the summit is about 700 feet, at Nicaragua it is 400 feet, at Panama 365 feet, and at Caledonia and San Blas over 1000 feet above sea level.

Owing to the peculiar S shape of the Isthmus of Darien, now commonly called Panama, the continuity of the range is somewhat interrupted, giving rise to the Culebra Pass.

Rivers are very numerous and during seven months of rainy season, when the rainfall reaches 140 inches at Colon and 180 in. at Nicaragua, these rivers discharge immense quantities of water and any canal project, if it be practicable, must provide for disposing of this water or in some way regulating the same without detriment to the Canal or to navigation.

Of all routes investigated by the Isthmian Canal Commission there are only four which warranted making any complete surveys and estimates and the results of these studies are given in the accompanying table.

The Tehuantepec route may be discarded at once on the grounds of length, high summit level and excessive cost, besides offering no

ESTIMATES OF ISTHMIAN CANAL PROJECTS FOR CHANNEL 150 FT. WIDE AND 35 FT. DEEP

Route	Length miles	Mx. Cut feet	Sum. feet	Locks	Total Excava. cubic yards	Cost dollars	Remarks
Panama Lock level	45	275	85	6	95,000,000	184,233,000*	Gatun Earth Dam, 115 ft. high x 8,200 ft.
Panama Sea Level	45	365	0	1	266,228,000	290,000,000*	Gamboa Masonry Dam, 200 ft. high x 5,000 ft.
Nicaragua Lock Level	184	324	110	8	227,400,000	189,864,000	6 Spillways, 1 Dam 132 ft. high x 1,000 ft.
Caledonia Sea Level	56	1050	0	1	235,000,000	263,340,000	1 Tunnel, 1.6 miles long, 120 x 155 ft.
San Blas Sea Level	40	1070	0	1	289,000,000	289,770,000	1 Tunnel, 4.2 miles long
Tehuantepec Lock Level	120		700	40		400,000,000	No water for locks and power

All above locks are estimated as twin locks, 84 ft. wide, 800 ft. long, 35 ft. deep.
Above estimates do not include right of way, sanitation, zone government, etc.
*The Panama estimates include $40,000,000 for purchase of French Company's property.

natural water supply for the 40 locks which are indispensable. This route came into prominence when Mr. James B. Eads proposed the construction of a ship railway.

The Caledonia and San Blas routes are similar in their general characteristics, being short and requiring ship tunnels as the only possible means of passing through the high summit levels of over 1000 feet each. The tunnel feature must be regarded as highly objectionable and these routes are therefore, rejected as impracticable.

This reduces the choice to two routes, the Nicaragua and the Panama, of which the latter alone is feasible for a sea-level canal, though both are practicable and feasible for a canal with locks.

On the basis of a lock canal the Panama route offers very obvious advantages, being only one-fourth as long, requiring less locks and about half as much excavation thus involving considerably less cost. Both routes offer ample water supply. The estimated annual cost of maintaining and operating the Panama Canal is about $1,300,000 less than for the Nicaragua Canal. The time required for ships to pass through the canal is also greatly in favor of the Panama route.

The only obstacle in the way of making a choice was found to be the purchase price originally held by the New Panama Co., but this was finally settled on a very advantageous basis.

The question of territorial rights would be common to all routes and was concluded in a most satisfactory manner with the state of Panama.

Hence after much study and most painstaking and diplomatic negotiations the United States selected, and acquired by purchase, the best route for an Isthmian Canal and also the route which offers the greatest possibilities from an engineering standpoint.

The questions still remaining for discussion are the choice between the sea-level type of canal and the lock type.

Sea Level Versus Lock Level Plan, Panama Canal

A *sea level canal*, according to the popu'.r impression, is a waterway affording unrestricted navigation. The lock type of canal is assumed to be decidedly inferior to the former, owing to delays caused by mechanical appliances used in lifting and lowering vessels. These conceptions are quite inaccurate.

An ideal waterway would be a sea level canal of greater width than the length of vessels using it, since with less width such a channel could be easily blocked by the sinking of a ship transversely to the channel. This would require at least a 1000 ft. canal, which has never been proposed and could never be entertained. Hence, all who have seriously considered this question have been compelled to reduce the width to that strictly necessary for the largest vessels to pass at greatly reduced speed.

The original estimate by the Isthmian Canal Commission, in 1901, was based on a width of 150 feet, which is very far from furnishing unrestricted navigation. Large vessels, such as the Cunarders could not exceed a speed of say four miles per hour, nor could they pass inside this limit, even if there was sufficient depth of water to float them.

The lock type of canal can be so planned that for considerable distances, navigation may proceed, without restrictions, through artificially created lakes. The advantages thus afforded may by far outweigh the objections feared from the use of locks. Hence, it is quite conceivable that a lock canal might be better and offer greater facilities in ease and time of navigation, and be attended with less risk than a sea level canal.

However, there are many other features favoring the lock type of canal, in this particular instance, which are not understood by the layman until the more intricate engineering problems involved in both types are more clearly presented. See Figs. 1, 2 and 3.

The sea level canal will be a deep, narrow, tortuous, gorge, which no large ships can safely navigate except at very slow speed. A tide lock will be absolutely necessary on the Pacific end of the canal to take care of a fluctuation of about 22 ft. between high and low tides. The enormous flood waters of the Chagres River must be carried off or controlled and the extraordinary rainfall, amounting annually to 60 inches at Panama and over 140 inches at Colon, will cause dangerous silting-up of the excavated channels and this in turn will make the maintenance very costly.

The most serious of these factors, the control of the Chagres flood waters, invited many speculative schemes and formed the subject of much study and discussion. Either the canal itself must be made sufficiently large to carry off the maximum floods, or independent channels must be provided for that purpose.

As the canal was to occupy the lowest portion of the valley, the construction of such diversion channels would offer serious difficulties. The simplest solution would be to enlarge the canal prism sufficiently to carry the entire flood water; however, this proposition must be discarded at once on account of the extreme dimensions required, the swift currents produced and the silting-up of the channel from the various rivers emptying into the canal.

The most feasible plan proposed was to impound the flood waters from the upper Chagres valley behind a masonry dam at Gamboa, just off the canal line. This dam was to be 200 ft. high, over one mile long and to form a reservoir to be called Gamboa Lake, into which the upper Chagres water could be received and be gradually discharged into the canal prism at a maximum rate of 15,000 cu. ft. per sec. restricting the current to 2.6 miles per hour.

Other flood waters accumulating below this dam were to be diverted entirely from the canal and carried, by separate channels, to the sea. Some other tributaries and the Rio Grande, Gatun and Mindi Rivers would still remain to be taken care of either by similar dams or separate channels. The Rio Grande was to be diverted through a tunnel about one mile long. The Gigante River was to be controlled by a masonry dam 75 feet high and over one-half mile long.

The structures thus made necessary for flood water control, present

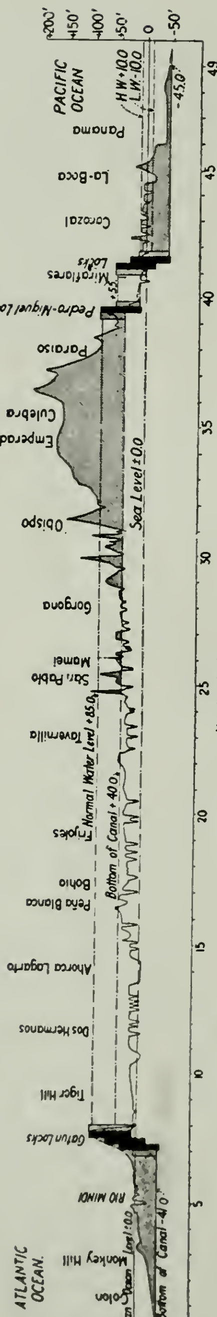

Fig. 2—Profile of Proposed Lock Level Canal

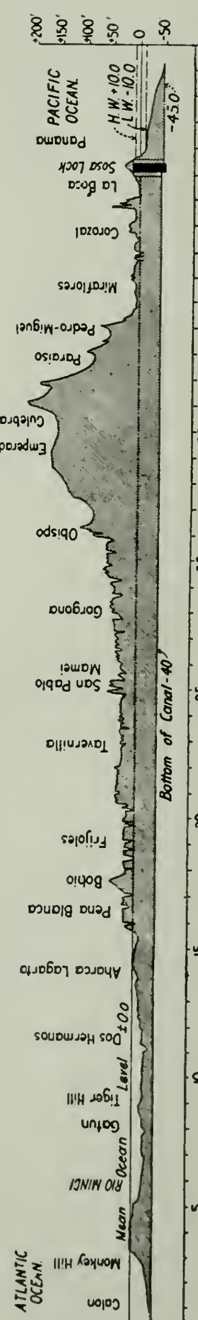

Fig. 3—Profile of Sea Level Canal

far more hazardous and untried features than any of the proposed locks and dams and would cost approximately as much to build and maintain.

The mere increased excavation is, therefore, only a comparatively small objection, easily measurable in money, contrasted with the engineering difficulties involved in the sea level project. The time for construction was variously estimated at from 16 to 20 years, and the cost including $40,000,000 for purchase, was estimated at $290,000,000 for the sea level canal 150 feet wide and 35 feet deep.

The Much Criticised Plan for a Lock Canal

The principal feature of this plan as finally adopted, is an earth dam at Gatun designed to close the Chagres valley at a point only 5 miles from Colon, thus forming an immense inland lake into which all the tributary rivers could empty. This lake, to be known as Gatun Lake, will store sufficient water to supply the needs for the locks and to generate electricity for operating the canal. It will be maintained at an elevation of from 80 to 87 feet above sea level, will have an area of about 164-square miles and will effecctually regulate all the flood waters north of the Culebra Cut without producing any measurable currents or silting in the navigable channel.

At Gatun the vessels will be raised 85 feet through three flights of twin locks and this level will be retained over the greater length of the canal to Pedro Miguel where a single flight of twin locks will lower the level to 55 ft. above the sea into Sosa Lake.

This is another artificial lake to be created by a dam at the Pacific end, which dam will close the valley of the Rio Grande and thereby regulate the flood waters from this river. The final descent into Panama Bay was then to be accomplished by two flights of twin locks at Sosa. By a change in plan the Sosa locks are now located at Miraflores for military reasons, but this does not affect the general features of the canal except to add something to the cost of excavation, though the Sosa dam disappears.

While the Culebra Cut was planned with a bottom width of 150 ft. as in the sea level project, nearly 70 per cent. of the entire canal would be 500 ft. or more in width, and include about 20 miles of lake navigation affording a width of 1,000 ft. and over, with a depth of 35 to 70 feet.

The estimated cost for this type of canal, including purchase of the French property, was figured at $184,233,000, or 5/8 as much as for a similar sea level canal with uniform width of only 150 ft. The time of completion was estimated as 10 years.

In conclusion then the very considerable differences in cost and time of completion, which speak so decidedly in favor of the lock type of canal, ought to afford a vastly superior waterway on the sea level plan if the added expenditure of time and money be justified. The choice should fall to that type which offers the greatest safety and ease to navigation within the limits of engineering and financial possibility. If the most costly structure be not also the best, then the result will be discreditable and scandalous.

The question of safety and ease to navigation depends both on the nature of the waterway and the crafts using it. Accidents to the waterway may stop traffic or merely retard it, or may not affect it at all, depending on the nature of the accident.

It has been demonstrated that the risk of serious injury to a well-equipped canal lock is exceedingly small and for the twin lock system with duplicate gates provided in the Panama lock designs this factor is practically eliminated except in time of war. At such time either form of canal would require efficient military protection which is equally practicable for either type of canal.

Experience on the world's great waterways has shown that ships are far more liable to delay and injury while traversing artificial channels at considerable speed than when passing locks where they move slowly and under perfect control. The narrower the channel the greater the danger of collision, groundings, blockades, and injuries to ships.

In consequence of the wider and better channel afforded by the lock canal, ships could pass through at far greater speed and with comparatively little danger to accident and this would greatly exceed the slight inconvenience and loss of time in passing the locks. The term "provisional" so commonly applied to the lock canal is, in reality, better suited to the sea level type of canal, a fact not known to the average readers of the daily papers.

To sum up the comparative engineering features we may add that a sea level project must include a tide lock at Sosa or Miraflores; a dam 200 feet high at Gamboa, where the site is so unfavorable that a masonry dam is unavoidable with foundation 50 ft. below the Chagres River bed; either spillway cuts must be provided through this dam, or long tunnels, larger than the new Swiss, double-track tunnels, must be built through unknown geologic formations; and about 40 miles of artificial and very costly diversion channels must be built in the immediate vicinity of the canal. All these items according to the most approved plans yet proposed must be added to the huge excavation through the continental divide, which of itself proved so disastrous to the French undertaking and forced that company to definitely abandon the sea-level construction many years ago.

By the lock type of canal these features are all removed, the tributary rivers are all transformed from formidable enemies into welcome friends, the amount of excavation is reduced to a minimum, and the only structures of any importance are the Gatun earth dam and the locks, all of which are absolutely feasible and now nearing completion.

In view of the apparent advantages thus to be obtained from the lock canal, Congress, on June 29, 1906, authorized the construction of the canal in accordance with this recommendation which was proposed by the Isthmian Commission of 1901, and more thoroughly discussed and again advocated by a minority of the Board of Consulting Engineers, in 1906, receiving the approval and support of the Commission, the Secretary of War, and the President of the United States.

Work is being prosecuted along these lines with very satisfactory results, and all former estimates relative to rate of progress and engineering possibilities are being realized beyond expectation.

The Lock Level Plan as at Present Adopted

In the interests of navigation it was found desirable to change many minor details as to dimensions of locks, widening the Culebra Cut successively from 150 to 200 feet and finally to 300 ft., also widening the ocean approaches, and deepening the entire canal to 41 feet, with 45 feet in the approaches, etc. All these changes, together with the cost of sanitation and canal zone government, in creased the original 1901 estimate from $184,233,000 to $375,200,000 as shown by the following revised estimate:

ESTIMATE FOR 85 FT. LOCK LEVEL CANAL 300 TO 1000 FT. WIDE AND 41 TO 45 FT. DEEP, JANUARY, 1909.

Original Board estimate for 150 ft. Channel	$144,233,000
Purchase of Canal property from French Co	40,000,000
Republic of Panama for Canal Zone	10,000,000
Sanitation and Canal Zone Government	27,435,000
Increase in locks to 110 x 1000 ft. x 41 ft. deep. 80,000,000 c. y. increased excavation. Increased cost of labor for 8 hr. day	97,250,000
Cost of plant, steamship line and 20 per cent. for contingencies	56,283,000
Total	$375,201,000
Credits from Panama R. R. Loans, etc	15,000,000
Net	$360,201,000

An estimate for a sea level canal, 300 ft wide and 41 ft. deep over the main portions would be about $563,000,000, and require until 1921 to complete.

It is confidently estimated that the canal can be completed on the revised and adopted plan by January, 1915, which would require the work of excavation to proceed at the rate of less than 2,000,000 cu. yds. per month, while in reality over 3,000,000 per month were excavated during the year 1908, and the maximum for any single month was nearly 3,500,000 cubic yards.

During the French occupation, a total of 78,147,000 cubic yards was excavated of which about 29,908,000 cubic yards are useful to the present project.

The work of excavating by the United States was necessarily slow at first owing to the lack of sufficient digging machinery which could not be supplied on short notice.

The number of steam shovels and dredges was gradually increased until Jan., 1908, since which time about 100 steam shovels and 18 dredges have been at work.

WORK ACCOMPLISHED TO FEB.1, 1913.

Excavation about 91% completed

Usable excavation by the French	30,000,000 c. y.

Excavated by the U. S.	190,000,000 c. y.
Required to complete	22,000,000 c. y.
Total excavation	242,000,000 c. y.
Fill in Gatun Dam, completed	22,000,000 c. y.
Concrete in Locks, Dams and Spillway, 96% completed	
In place	4,503,000 c. y.
Required to complete	167,000 c. y.
Total concrete	4,670,000 c. y.
Steel in 46 lock gates, 58,000 tons. Nearly all delivered and about 65% erected.	
Total estimated cost	$375,000,000
Disbursed to Jan. 1, 1913	277,000,000

When the canal is completed according to the above estimate and plan, the United States will own not merely the canal but also the Panama R. R., the steamship line and a construction plant which has cost about $30,000,000.

A few words regarding the "scandal-mongering literature" so current in the daily papers, may be added here. All the statements made and investigated have been traced to interested complainants or to a class of reformers who are not acquainted with the facts and who at the expense of truthfulness, are seeking notoriety. In the language of the former Chairman of the Commission, Mr. Theo. P. Shonts, "the only discredit inhering in these false accusations is to those who originate and give them currency, and who, to the extent of their abilities, thereby hamper and obstruct the completion of the great work in which both the honor and the interest of America are so deeply involved. It matters not whether those guilty of these false accusations utter them in mere wanton recklessness or folly or in spirit of sinister malice to gratify some personal or political grudge."

Ex-President Roosevelt in his message to Congress, dated Feb. 17, 1909, referring to the report of the recent Board of Consulting Engineers who visited the Isthmus, said, "I am happy to report to you that the accompanying document shows in clearest fashion that the Congress was wise in the position it took, and that it would be an inexcusable folly to change from the proposed lock canal to a sea level canal. In fact, this report not only determines definitely the type of canal, but makes it evident that hereafter attack on this type—the lock type—is in reality merely attack upon the policy of building any canal at all."

To this the writer would add that the navigator who, in the future, will use this waterway will be the first to protest against any scheme having for its object the change from a lock canal to one of the sea level type.

The Safety of the Canal

So much adverse criticism regarding the safety of the Gatun dam and the locks has appeared in the daily press, that a few words should be directed to this subject.

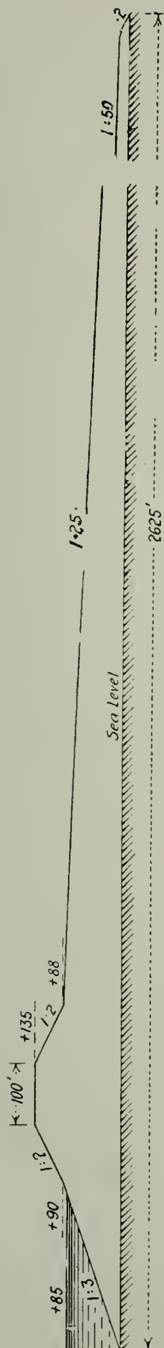

Fig. 4—Original Sketch, proposed by Board of Consulting Engineers, 1906

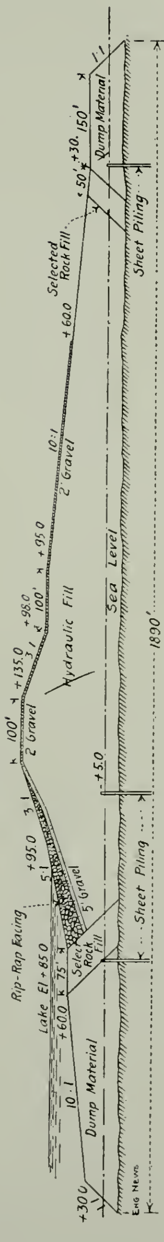

Fig. 5—Modified Section, proposed by Isthmian Canal Commission, 1908

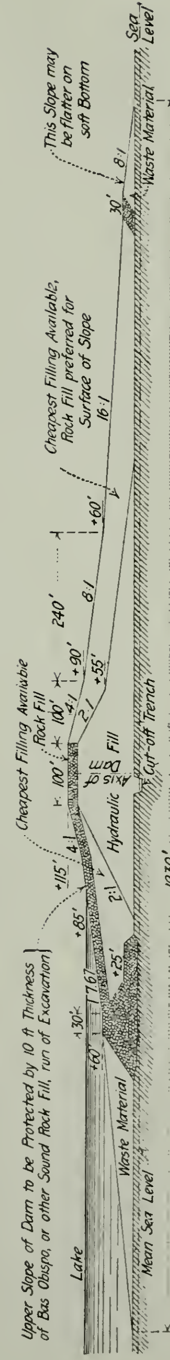

Fig. 6—Adopted Section, proposed by Board of Consulting Engineers, 1909

It is significant that all the pet schemes of certain individuals and many untried methods proposed by inventors of excavating machinery together with the objections of prospective contractors, should gain free advertisement by some 10,000 newspapers under the guise of pointing out dangers to be feared from the adoption of the present plans.

This condition has prevailed to such an alarming extent that when the truth is occasionally told by some responsible engineering authority, as the recent Board of Consulting Engineers who accompanied President Taft to the Isthmus, such facts are either ignored or ridiculed.

These pernicious practices have brought about a sad condition of affairs which, if directed against any private enterprise, would certainly have proven disastrous. It is only through the strenuous efforts of those in high authority that the good work has been permitted to continue.

No technical argument, worthy of serious consideration by the engineering profession, has appeared among the lately published criticisms concerning the Panama plans and work. Yet these alarmist reports have a wonderful influence in warping public opinion, and this is undoubtedly the underlying motive to which the public press has innocently become a party.

"A little word is not a little thing;
For it may make, and it may mar a King."

It is scarcely possible to find an example of engineering design which embodies such a high factor of safety throughout as do the designs for the locks and dams of this canal. So great was this conservatism on the side of safety, that the recent Board of Engineers recommended reducing the height of Gatun dam by 20 ft., leaving its crest 30 ft. above the level of Gatun Lake instead of 50 ft. as originally planned. See Figs. 4 to 7.

The increased width of the narrow portions of the canal from 150 to 300 feet and the greatly enlarged lock chambers were adopted to increase the safety to vessels navigating the canal. The deepening of the entire canal from 35 feet to 41 and 45 feet is another feature which will permit the larger vessels to proceed at greater speed.

The locks are all designed of most massive concrete monoliths and arranged in duplicate so as to separate up and down bound traffic and in case of necessary repairs one lock may be temporarily thrown out of commission without interfering with traffic. Duplicate gates are also provided for the case of local damage, should any occur. About five million cubic yards of concrete will be utilized in their construction.

As a further safety, the several lake outlets are all to be guarded by emergency dams of the movable type, so that in the remote possibility of any serious accident the summit level will be maintained while repairs are carried on. All this may never be needed but it is provided as an absolute safeguard against any possible contingency.

The possibility of an earthquake has also been erected by fancy into a threatening danger. If such creations of the imagination are to serve as a guide, then the earth is no place for any great work.

There are 116 volcanoes within a radius of 1200 miles from Panama, and half of these are active. Within a radius of 500 miles about Nicaragua, may be counted 43 extinct and 37 active volcanoes. One active volcano is situated within eleven miles of the proposed Nicaragua route and one within 200 miles of Panama, yet private corporations were prepared to venture investments in both localities.

The famous straight arch (26 ft. span and 7 ft. rise) in the ruins of the old Santo Domingo Convent at Panama, and the stone arch over a river near the old city of Panama, both of which have stood over two centuries, would certainly have collapsed during any serious manifestations of seismic disturbance. There was a more or less

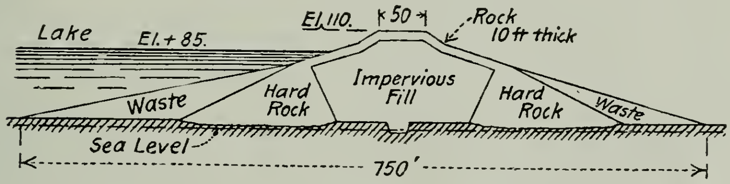

Fig. 7—Section proposed by "ENGINEERING NEWS" as Safe Design

destructive earthquake at Panama in 1621, but none of any importance were recorded since.

However, in the event of any such disturbances, the resulting damage to a sea level canal with a masonry dam at Gamboa, would be even more disastrous than that to any of the locks or dams now proposed in the present project.

Climatic, Sanitary and Social Conditions

Possibly the greatest danger which attended the Isthmian undertaking and which, to a high degree, brought about the failure of the French Company, was the danger to life. This fact was carefully considered by the Commission, and a most vigorous campaign was immediately instituted for the establishment of sanitary conditions especially in the terminal cities, Colon and Panama.

The department of health and sanitation was thus created and after adopting most stringest sanitary measures, has reduced Malaria to comparative insignificance, while Yellow Fever was stamped out on the Isthmus since May 1, 1906.

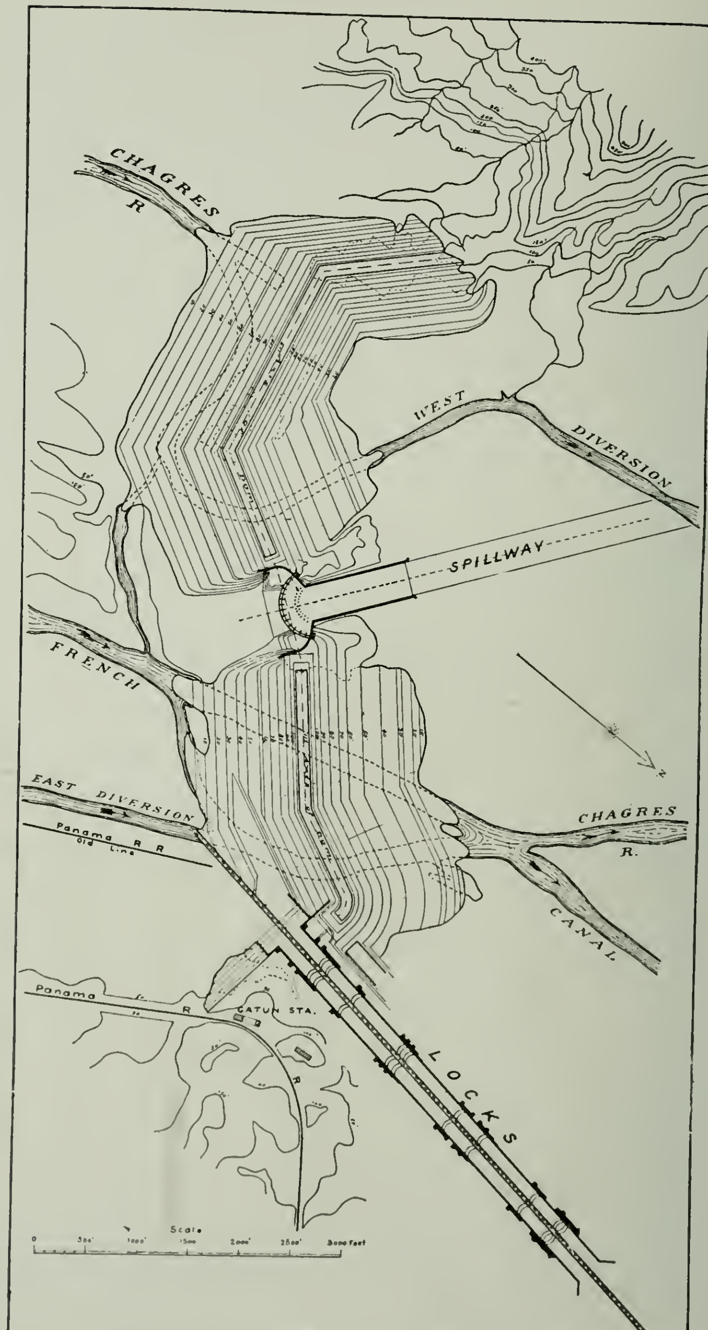

Fig. 8—Plan of Gatun Locks and Dam.

Considering the whole population of Panama, Colon, and the Canal Zone, we have the following health record:

YEAR	POPULATION	DEATH RATE PER THOUSAND
1904	35,000	52.45
1905	42,699	50.57
1906	66,011	51.89
1907	102,133	33.45
1908	120,097	29.17
1909	125,000	16.42
1910	145,000	19.00
1911	154,000	17.67

From 1881—9, during the French occupation, the average number of deaths per 1000 was 28.5 due to Yellow Fever and Malaria alone. During the past year, with a population of over 150,000, this number was reduced to 1.8 per 1000 due to Malaria and none due to Yellow Fever.

The mosquito theory regarding the transmission of these fevers is now generally accepted and through the discoveries of Ross,

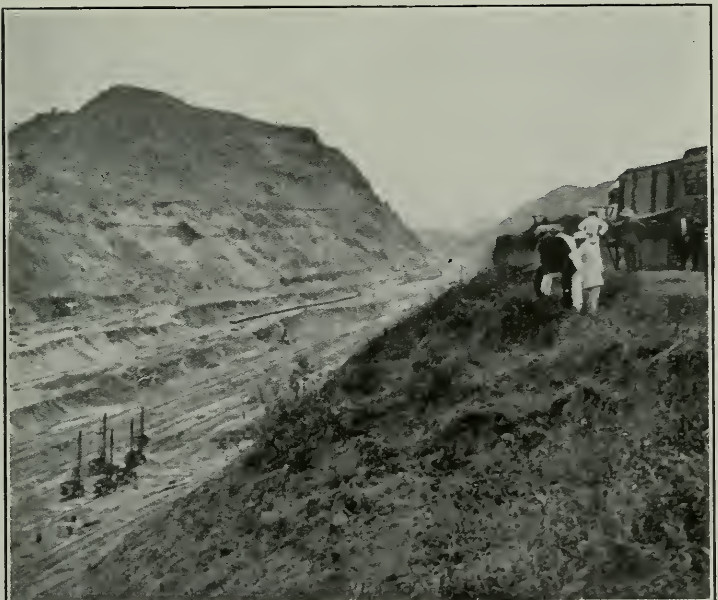

Fig. 9—View of Culebra Cut from Y.M.C.A. Observatory

Lavaran and Reed, a most valuable service was rendered to science. By this discovery the United States was enabled to overcome what seemed to be to the French an insurmountable obstacle.

By treaty the United States secured the right to enforce sanitary regulations over the entire Canal Zone and the terminal cities. An immense amount of labor and money has been thus expended in clearing the Canal Zone, exterminating the mosquito by applying crude oil to all the breeding places and providing the entire Zone with a good water supply. The cities of Colon and Panama were cleaned up, paved and sewered and are now as healthy as any of our northern towns.

The Isthmian climate is not at all unhealthy. Five months

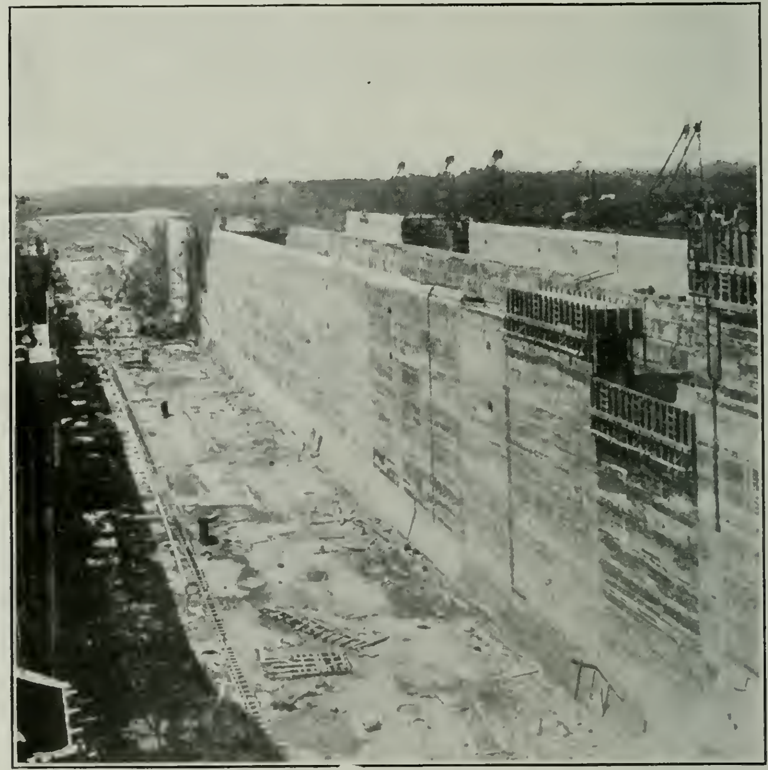

Fig. 10—Gatun Middle Locks, Panama Canal

of the year, including January, February, March and April, constitute the dry season, and the temperature never falls below 64° nor rises above 97° in the shade. The average daily range is from 75° to 84°, with little variation between summer and winter, wet and dry seasons. The high humidity, ranging between 80 and 87% exerts a very exhausting and oppressive influence on the white races. The negro races are not so seriously affected.

The average annual rainfall during a period of 33 years, between

1871 and 1904, was 64.7 inches at Panama, 94.9 inches at Gamboa and 137.2 inches at Colon.

The Canal employees are being well cared for, are provided with comfortable and sanitary quarters, and can receive all the necessary wants of life from the Commissary Department at practically the same prices as in the United States.

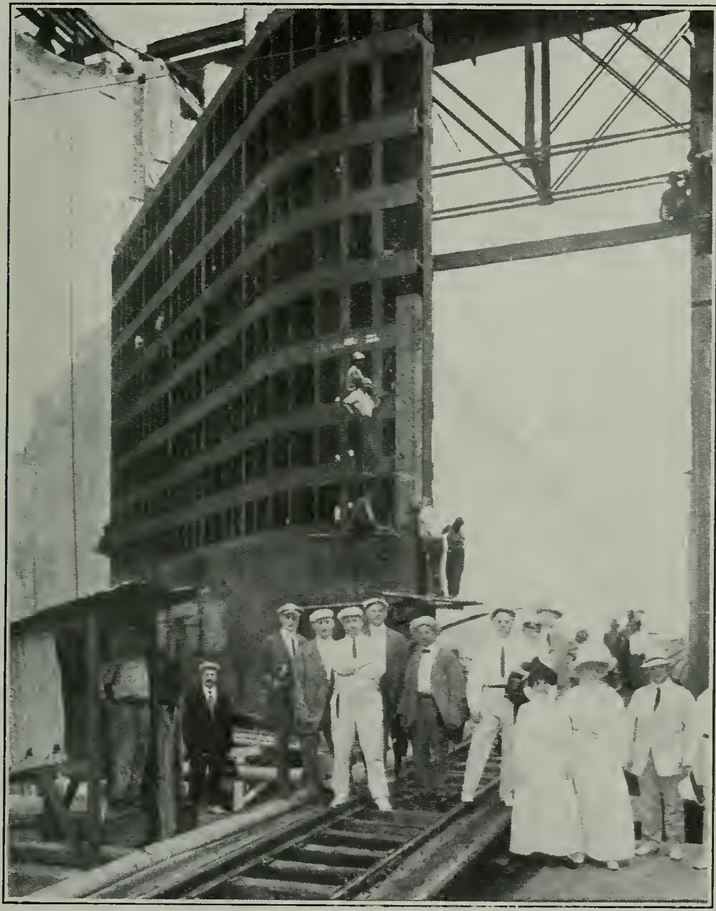

Fig. 11—Gatun Locks, Panama Canal

Artificial ice is produced at Colon and there are several steam laundries and bakeries, all owned and operated by the government.

Many Social Clubs now exist, though several years ago this feature was absent. Various outdoor sports such as baseball, tennis, etc., are indulged in.

Let us hope that this great work may continue without further impediments savoring of politics, scandals and investigations, and that the United States may win the prize among nations in demonstrating their ability to complete another "world wonder," which nearly crippled one of the foremost European nations, and is now on a fair way to successful completion.

Canal Statistics.

Length from deep water to deep water	50½ miles.
Length on land	40½ miles.
Bottom width of channel, maximum	1,000 feet.
Bottom width of channel, minimum, 9 miles Culebra Cut	300 feet.
Locks, in pairs	12
Locks, usable length	1,000 feet.
Locks, usable width	110 feet.
Gatun Lake, area	164 sq. m.
Gatun Lake, channel depth	85 to 45 feet.
Excavation, estimated total	242,504,000 c. y.
Excavation, by the U. S. to Feb. 1, 1913	190,000,000 c. y.
Excavation by the French	78,146.960 c. y.
Excavation by French, useful to present Canal	29,908,000 c. y.
Concrete, total estimated for Canal	5,000.000 c. y.
Time of transit through completed Canal	10 to 12 hours.
Time of passage through locks	3 hours.
Relocated Panama Railroad, estimated cost	8,866,400
Relocated Panama Railroad, length	47.2 mile
Canal Zone, area	about 436 sq. m.
French buildings, number required	2,150
French buildings, number used	1,537
French buildings, net value when acquired	$1,959,203
Value of utilized French equipment	1,000,000
Canal force, actually at work	about 36,000
Canal force, Americans	about 5,000
Cost of Canal, estimated total	$375,000,000
Work begun by Americans	May 4, 1904
Date set for official opening	Jan. 1, 1915

THE DIRECT DETERMINATION OF OXYGEN IN ORGANIC COMPOUNDS*

By Maitland C. Boswell.

Oxygen is one of the most frequently occurring constituents of organic compounds, and yet there is no direct method known for its quantitative determination. In the analysis of a compound the universal custom has been to determine the percentage of all the elements present with the exception of oxygen, subtract the sum of these from one hundred, and call the remainder the percentage of oxygen. Although this has presented no serious impediment to the development of organic chemistry, yet many instances have occurred in which a method for the quantitative estimation of oxygen would have been a great convenience. No doubt most organic chemists have in the course of their synthetic investigation work met with reactions involving considerable alteration in the oxygen content of a compound without changing to any appreciable extent the percentages of carbon and hydrogen present, as, for instance, in the

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replacement of the amino group by hydroxyl. Moreover, a direct method for oxygen is also needed for its determination in commercial products as asphalt, rubber, etc., and for following the course of reactions involving the fixation of atmospheric oxygen in compounds Several indirect methods have been worked out by Baumhauer,[1] Ladenburg,[2] Maumené,[3] Mitscherlich,[4] Persoz,[5] Strohmeyer,[6] Wanklyn and Frank,[7] Cretier,[8] and others. All of these suffer from the complications and consequent inaccuracies of indirect methods. None of them have come into general use, and many of them, such as the method of Mitscherlich for the determination of C. H. O. N. Cl., Br., I and S in one operation, have probably not been performed since the original experiments by the investigators themselves.

The method described in this paper consists in the determination of the amounts of water, carbon dioxide and carbon monoxide formed when a weighted amount of substance is heated in a quartz tube to a high temperature in a current of pure hydrogen, the products of the reaction being passed over a long layer of charcoal particles heated to a white heat. In the presence of the two strong reducing agents, hydrogen and carbon, at a high temperature, all the oxygen in the original compound is converted into the simple compounds water, carbon dioxide and carbon monoxide. The hot carbon also reacts with the water, forming carbon monoxide and hydrogen, and likewise reduces some of the carbon dioxide to monoxide. However, not only are both of these reactions reversible, but in the passage of the gaseous mixture through the hot tube they probably do not reach equilibrium. Hence water and carbon dioxide are always observed among the reaction products. The water is absorbed in conc. sulphuric acid, the carbon dioxide in soda-lime and the carbon monoxide determined by a modification of the method of Levy,* which consists in passing the gas from which the water and carbon dioxide have been removed through iodine pentoxide and the determination of the carbon dioxide formed in the oxidation by absorption in soda lime.

Description of Apparatus.

A is a quartz tube 13 mm. in internal diameter, and 980 mm. in length. Commencing 135 mm. from one end a layer of charcoal particles about 1 c. mm. in size, free from powdered charcoal, is packed tightly in the tube for a length of 400 mm. and held in place by asbestos plugs at each end. This tube is set in a "combustion furnace" of the usual form, except that the iron trough and tiling supporting the combustion tube are omitted, and the iron work

(1) *Ann.*, **90**, 228 (1854); *Jahresb.* **1855**, 768; *Z. Anal. Chem.*, **5**, 141 (1866).
(2) *Ann.*, **135**, 1 (1865).
(3) *J. prakt. Chem.*, **84**, 185 (1861); *Compt. rend.* **55**, 432 (1861).
(4) *Pogg. Ann.*, **130**, 536 (1841); *Z. Anal. Chem.*, **6**, 136 (1867); *Ber.*, **1**, 45 (1868); *Ibid.*, **6**, 1000 (1873); *Ibid.* **7**, 1527 (1874); *Z. Anal. Chem.*, **7**, 272 (1868); *Ibid.*, **15**, 371 (1876).
(5) *Ann. Chim. Phys.*, **75**, 5.
(6) *Ann.*, **117**, 243 (1851).
(7) *Jahresb.* **700**, (1863).
(8) *Z. Anal. Chem.*, **13**, 1 (1874).

(*) *J. Soc. Chem. Ind.*, **30**, 1437 (1911).

supporting the trough also, if possible, removed so as to avoid any transfer of heat to the substance during the preliminary heating of the charcoal. Two asbestos board protectors *a*, *b*, are cut so as to fit tightly across the furnace, one 15 mm. from the end of the charcoal layer, and the second 30 mm. from the first. If these are cut so as to fit tightly around the quartz tube and along the sides of the furnace, it is possible to heat the entire charcoal layer to a white heat in a rapid current of hydrogen, and thus clear the tube of all free oxygen and oxygen compounds, without warming in the least the silica boat *c* containing the weighed amount of substance, which rests 60 mm. from the nearer asbestos protector. The remainder of the tube *A* is empty.

The *Hydrogen Generator*.—The hydrogen is produced electrolytically in the generator *B*. This consists of a heavy outer glass vessel, *e*, 600 mm. in height and 130 mm. in diameter, containing

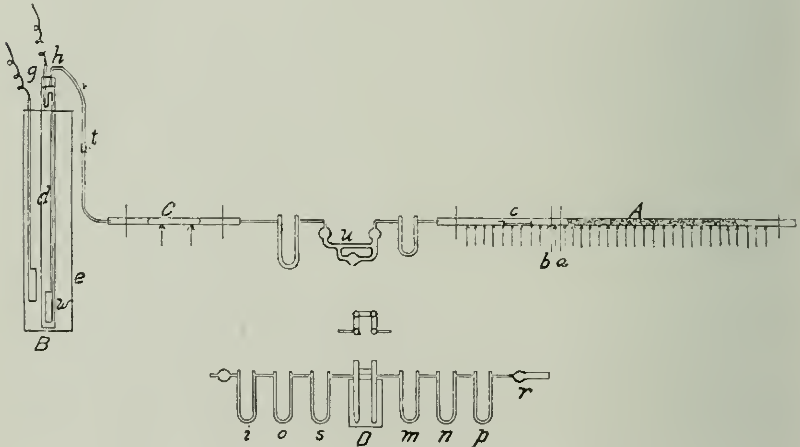

Fig. 1—Apparatus for the Direct Determination of Oxygen in Organic Compounds

dilute sulphuric acid (1:6) and having an inner glass tube *d*, 690 mm. in length and 35 mm. in diameter, open at the lower end and reaching almost to the bottom of the containing vessel. Both electrodes are of heavy lead, the anode being in the outer vessel and raised 60 mm. from the lower end of the inner vessel containing the cathode *w*. The cathode tube is closed by a rubber stopper with two holes, through one of which passes a bent glass tube, *h*, to conduct away the hydrogen, and through the second passes the **U** tube *g*, full of mercury and carrying the insulated conductor to the cathode. A current of cold water is made to circulate through a lead tube wound around the cathode vessel. This generator is connected up with a lamp rheostat and an ammeter to the street current of 110 volts. The hydrogen so generated contains an appreciable amount of oxygen which is removed by passing the gas through a quartz tube, *C*, 360 mm. in length and 13 mm. internal diameter, containing a tightly wound coil of copper gauze 130 mm. in length, which is heated to white heat in a small furnace of two flat, wide flames. The hydrogen from this passes first through a **U** tube containing calcium chloride, then through a sulphuric acid dryer *u*, of special form,[1] which causes very thorough contact of gas with acid with very small friction and pressure head, and finally through a **U** tube containing phosphorus pentoxide from whence it passes into the main tube *A*.

Absorption Apparatus.—This consists of three parts—that for the absorption of water, that for the absorption of carbon dioxide, and that for the oxidation of carbon monoxide to dioxide and absorption of the dioxide thus formed. For the reasons given by Benedict[1] it is advisable to use conc. sulphuric acid on pumice for the first absorption. An ordinary calcium chloride **U** tube, *i*, with a bulb is filled with small pieces of pumice about 1 c. mm. in size, and so much conc. sulphuric acid is run in that a seal is just made at the bend, after impregnating the pumice. The carbon dioxide is preferably absorbed by moist soda lime made by the method of Benedict[2] and cut into pieces about 1 c.mm. in size and held between asbestos plugs in a **U** tube with limbs 120 mm. long and 11 mm. in diameter. A **U** tube *s*, of pumice moistened with conc. sulphuric acid, follows to retain the moisture carried over from the soda lime. The method of determining the carbon monoxide is a modification of that devised by Levy. The iodine pentoxide apparatus *D* shown in elevation and plan in the figure, consists of two **U** tubes 14 mm. diameter joined together on one side about 110 mm. from the bottom by a tube of about the same diameter. One **U** is filled with rolls of copper gauze, the other is filled with iodine pentoxide on asbestos made by impregnating enough asbestos to fill the tube with a solution of 25 or 30 grams of iodine pentoxide or iodic acid in water, evaporating to dryness on the water bath and heating in a vacuum at 250° C for several hours. The ends of the **U** tubes are then carefully sealed and the entrance and exit tubes carefully stoppered when not in use. During the analysis this is heated in an oil bath at 160°—170° and connected with the tube *s*. The carbon monoxide is oxidized to dioxide completely while the methane, ethane and hydrogen are unacted on, provided the gas is dry and no ethylene or acetylene hydrocarbons are present. The iodine liberated condenses for the most part in the wide connecting tube, the last traces being removed by the copper. As it is very difficult to completely free iodine pentoxide from iodic acid,[3] provision must be made for removing the moisture liberated when any iodic acid is reduced by the carbon monoxide. This is effected by a **U** tube *m*, containing sulphuric acid on pumice. The gas is then led into a **U** tube *n*, containing soda-lime, similar to tube *o*, and this is followed by a **U** tube *p*, of sulphuric acid on pumice similar to *s*. The absorption train is completed by a straight calicum chloride tube *r*, to prevent absorption of moisture from the air.

(1) *Trans. Farady Soc.*, **6**, 10 (1910).
(2) *American Chemical Journal*, **23**, 323 (1900).
(3) *Compt. rend.*, **153**, 1226-9; *C. A.*, **6**, 721.

Method of Conducting the Analysis

Approximately three-tenths of a gram of substance is carefully weighed out in a silica boat, which has been cleaned, heated in the blast flame, and cooled in a desiccator. The five absorption vessels are weighed, care being taken to rub each vessel to constant weight with clean dry cheese cloth. The necessity for this must be emphasized because the analysis involves ten separate weighings. The boat containing the substance is now inserted in the tube *A*, care being taken that it is not closer than 60 mm. from the nearer asbestos board *b*. The hydrogen apparatus is connected to the tube by means of a rubber stopper and the apparatus tested for any leak under the full head of acid in the generator *B*. The flames under *C* are now lighted and when the quartz tube is glowing under the entire portion holding the copper gauze, the hydrogen is allowed to pass in a very rapid stream by regulating the screw pinch cock *t*. In a couple of minutes the burners extending from the asbestos board *a*, to the end of the furnace are lighted and turned full on. In three or four minutes this part of the tube is glowing. The rapid current of hydrogen is continued for four or five minutes longer. The rate is then considerably diminished and the absorption tubes connected by means of a tightly fitting rubber stopper. The remainder of the absorption apparatus is then connected in the order described above and the temperature of the oil bath *D* raised to 165°—170°. The rate of hydrogen is now still further diminished so that there is an actual but very small movement of gas through the apparatus. The burners at the other end of the furnace are now lighted, and very gradually the substance is warmed and finally heated with the full flames. The hydrogen current is continued for 15 minutes after this, the rate being somewhat increased during the last ten minutes in order to drive over all the gaseous products of the reaction. The success of the determination depends largely on the very gradual heating of the substance. The heating of the tube from the first lighting of the flames under the charcoal till the complete sweeping over of the reaction products requires about 1½ to 1¾ hours. The absorption apparatus is then detached from the apparatus *D* and the tube *m*, and dry air free from carbon dioxide passed through the five vessels for ten minutes. The tubes are then detached, allowed to remain in the balance room for an hour, observing the usual precautions, and weighed, care being taken to wipe each to constant weight.

Results

In calculating the amount of oxygen in the substance from the increase of weight of the absorption vessels, it must be borne in mind that although the increase in the tubes *n* and *p* following the iodine pentoxide apparatus represents the weight of carbon dioxide absorbed, yet one half of the oxygen present in this carbon dioxide has come from the iodine pentoxide and not from the substance. The substances analysed were thoroughly purified by repeated crystallizations of each from two solvents and where possible, by sublimation.

The purity was verified in some cases by constancy of melting point and where this was incapable of determination, by an analysis of the compound for carbon and hydrogen.

Substance	1	2	3	4	5	6	7	8	9	10
Cane Sugar.........	.3020	.0775	.0700	.1008	.0689	.0509	.0366	.1564	51.8	51.5
Succinic Acid........	.2864	.0532	.0506	.1772	.0473	.0441	.0644	.1558	54.4	54.2
Dimethyl Oxal......	.2978	.0292	.0477	.2752	.0259	.0347	.1001	.1607	54.0	54.2
Phthalic Anh........	.3024	.0262	.0187	.1721	.0233	.0136	.0626	.0995	32.9	32.4
Vanillin.............	.2893	.0132	.0100	.2015	.0117	.0073	.0733	.0923	31.9	31.6

Column (1) gives the weight of substance taken,
Column (2) gives the weight of water formed,
Column (3) gives the weight of carbon dioxide formed,
Column (4) gives the weight of carbon dioxide formed by oxidation of monoxide,
Column (5) gives the weight of oxygen corresponding to the water in Col. (2),
Column (6) gives the weight of oxygen corresponding to the carbon dioxide in Col. (3),
Column (7) gives the weight of oxygen corresponding to the carbon dioxide in Col. (4),
Column (8) gives the weight of total oxygen, the sum of (5), (6) and (7),
Column (9) gives the percentage of oxygen found,
Column (10) gives the percentage of oxygen calculated from the formula.

It is seen on comparison of the oxygen percentages calculated from the formulas with the percentages actually found, as shown in columns 9 and 10, that the method is capable of about the same degree of accuracy as the combustion method for determining carbon and hydrogen, when this latter is very carefully conducted This is considerably better than at first sight would seem possible, judging from the nature of the process. It might reasonably be expected that even though all the oxygen of the compound analysed should appear in the reaction product in the form of water, carbon dioxide and carbon monoxide, that stable compounds of carbon and hydrogen might be formed which might partly condense in the absorption apparatus and thus vitiate the result. It would be very surprising if in the application of this method to a great variety of compounds some cases of this kind are not encountered. However, under the conditions of the determination as described above (the very slow distillation over the very long and very hot carbon layer in a current of hydrogen) this objection does not apply, at least, to the compounds analysed, and these are fairly representative. Should this objection, however, in any case be observed, it could very probably be eliminated by the use of a small weighed amount of pure oxidizing agent of definite oxygen content, as potassium permanganate, intimately mixed with the substance in the boat.

It is the intention to proceed in this laboratory with the investigation of this or other means of obviating this possible source of error, and also with the application of the method to compounds containing nitrogen and other elements.

THE ANNUAL DINNER

All biased enthusiasm might be expected to have quite subsided during the past six weeks, and since in that interval none but optimistic tone has commented upon the twenty-fourth annual dinner of the Engineering Society, the event, like the Engineering Dance, must have been a success, truly. The dinner committee centered its efforts upon introducing into the affair a variety of enjoyment and amusement. The result was a capacity attendance—a most encouraging turn-out of undergraduates and a fine representation of graduates.

President Ritchie had many distinguished guests on either side and their short and pithy speeches were ably interspersed with instrumental selections by the "Toike Orchestra," the "Symphony Orchestra," and Mr. Evans, violin soloist, while Mr. E. F. McGarvey, baritone, and the Science Octette, under the leadership of Clayton Bush, '07, furnished the vocal music. Mr. "Rube" Dickenson, from a local theatre, also contributed to the program.

The toasts were those to the King, the Profession, Canadian Industries, the Faculty of Applied Science, and Kindred Societies. After that to the King, Mr. T. V. McCarthy presented the toast to The Profession. It was well responded to by Mr. David A. Molitor, C.E., whose presence at the dinner was most warmly delightful to those who had listened to his lecture to the Engineering Society on the previous day. Mr. Molitor's engineering experience was not confined to America, but it was partly gained in Germany, Austria, Switzerland, Italy and the Isthmus of Panama. In addition he occupied the chair in civil engineering for three years at Cornell University. His remarks in response to Mr. McCarthy's toast are gems of inestimable value to young engineers, and are, in part, as follows:—

The Engineering Profession

The broad definition of engineering is so comprehensive in its scope as to include practically all applications of the pure and natural sciences to the uses and convenience of man. This is necessarily an ideal conception and includes as many fields of activity as to preclude the possibility of accomplishment by any one individual or class of professional men.

Ideals are beautiful and stimulating, but can never be achieved, for no sooner do we carry an undertaking to successful completion than it becomes a thing of existence, and thereby ceases to be an ideal. Thus human ambition is constantly creating new ideals soaring above the realm of actual achievement.

What, then, are the prequisites of an engineer within the bounds of individual possibility? What are the useful tools, the command of which distinguishes an engineer from other individuals, professional or otherwise? What are the relations of the engineer to the general community? To answer these questions requires thought and experience.

When we further consider, that only four years of university work are allotted to the young man in which to acquire these prerequisites, then it becomes highly important to weigh most carefully the matter of efficiency in education.

It is possible for the average student to do a certain amount of work in a four years' course and do it well. An extraordinary student might accomplish more while one of inferior caliber could possibly cover the ground less thoroughly, or perhaps fail to attain the required standard.

Some technical schools have gone as far as to offer specialized courses leading to such degrees as mechanical, civil, hydraulic, sanitary, electrical, chemical engineer, all in the brief period of four

J. E. Ritchie, who presided at the Annual Dinner

years and with practically the same entrance requirements as for any baccalaureate degree.

Practically the only difference in these several courses consists in the introduction of a few specialized subjects usually in the line of practical applications, at the expense of some of the fundamental sciences not directly bearing on such specialization, covering about the same sum total school hours for each degree.

If each young man could determine in advance precisely what his future field of activity is to be, such a procedure might be expedient, but few persons are so fortunate as to be able to read their horoscope with such accuracy.

There is still another very important factor not to be disregarded.

It is that young men are not allowed to do those things requiring highly specialized knowledge until they have first gained several years of experience along more general lines of engineering and have demonstrated their ability to grow and to become specialists by virtue of accumulated experience and judgment.

Why, then, seek to administer practical experience along special lines when school time is measured by a few hours and when the young graduate must work for many years before he can hope to apply such special knowledge which can only be satisfactorily acquired in actual practice.

In other words, if a man is going to practice engineering, he must first of all be an engineer, and finally becomes a specialist if his career leads in that direction.

But how is an engineer to become a specialist? By climbing the long ladder, experience; by studying; by availing himself of opportunities when they present themselves.

Considerations of this nature will suggest answers to the first and second questions. The prerequisites of an engineer are thorough knowledge of the fundamental sciences, mathematics, physics, mechanics, surveying, chemistry, astronomy, botany, bacteriology, geology, physiology, materials of construction, and a thorough course in English, including reading, writing, rhetoric and composition. These, also constitute his most useful tools by the aid of which he can continue his studies along any line of special science or engineering. In the course of acquiring this knowledge, the young man may have learned how to study and have the making of an investigator.

The man who has learned how to study, possesses the greatest asset which any university can bestow.. To him, no field of science, no walk of life need offer an impassable entrance. This distinguishes the technically trained engineer from the one who grew up in practice alone; it also marks the man of broad training who can work out his own difficulties as against the man of specialized training who has nothing to fall back on except his specialty.

We come now to the question of standing of the profession in the community. How does engineering compare with the other learned professions? What have we engineers done to warrant the admiration and esteem of our fellow men? To answer this we must first see ourselves as others see us.

We have erected bridges and buildings, built tunnels, railways, waterways, and constructed machinery which has made the civilization of the day. To those who give us our just dues, we stand as masters of the industrial world, others liken us to locomotive or stationary engine men.

This is not surprising, for the advancement in civilization has not affected all men alike and the rank and file of our race may not be aware of who or what profession is responsible for the creation of the things they see.

The average engineer is a modest man. He rarely mentions his achievements; his name is often omitted from the works of his labors, and instead we see the names of politicians and money-men. It is a common occurrence to forget sending invitations to the engineering staff, when dedicatory celebrations are held at the successful completion of a great work. The engineers are the hired help, a sort of necessary evil.

Here we ourselves and the technical schools share the blame, We are no more than we make of ourselves, for the price we ask is all we can hope to get.

We have no particular standard of professional ethics; we do not look to our personal appearance in public as do members of the other learned professions and public men; and we are often afraid that our services are overpaid. While there are able and incompetent men practising the profession, there is no stamp of quality and competency by which we stand or fall individually, except in the case of colossal failure, and then the profession receives the blame usually because the money-man or politician hired a cheap engineer.

The time is ripe that our noble profession should receive the recognition which it justly deserves from the general community, and the first step in that direction must come from the combined efforts of the engineers and the universities who give them the stamp of recognition. It is a matter of mutual aid. The university must label its graduates accurately, and confer honors after graduation which are commensurate with their achievements. The alumni must do all in their power to further the interests of their alma mater.

A doctor of engineering will certainly enjoy the same distinction from the general public as is now accorded a doctor of law, medicine, or divinity. The university is the only tribunal to confer this honor on the leading members of our chosen profession and failure to do so means failure of recognition by the community.

From among his guests, Mr. Ritchie called upon Mr. J. L. Morris, the earliest graduate of the "School." It was especially pleasing to have him as one of us and his address was listened to with interest.

Mr. Morris found an incentive to say a few words to the students in Applied Science in response to the toast, "The Profession." As students and future graduates in Applied Science of the University of Toronto we have reason to feel proud of the course of instruction which you are receiving. For a member of years, engineers of all grades and branches have been coursing to us from Great Britain and the continent of Europe, some with creditable practice and others without.

Engineers whom we will call "hypochlorite engineers," because of their knowledge of the treatment of water for typhoid bacteria, are recommended to a municipality for this purpose, and often take upon themselves the construction of waterworks systems without having any previous experience and knowledge of this class of engineering. I am here reminded of an engineer, recommended by the Provincial Board of Health to report on the quality and treatment of water as a supply to prevent the recurrence of a typhoid epidemic, who agreed to engineer the construction of an intake pipe. It was a three-sixteenth inch plate eighteen inches in diameter, and his specifications actually called for rivets one inch in diameter spaced six inches apart for rivetting the three-sixteenth inch plate.

Notwithstanding what any foreign engineer may presume, I will say that you are receiving a training in engineering, suitable to the conditions of this country of ours, and there is no reason why any of you, when you go in to the practice of your profession, should submit to any outside engineering talent. The Canadian of to-day has institutions of learning preparing him to meet any others in professional competition.

Two other representatives of the earlier days of the School were also in attendance, Mr. J. W. Tyrrell, '83, and his brother, Mr. J. B. Tyrrell, M.A., '80. The latter is not a graduate in engineering, although his lectures were received in what was at that

J. L. Morris, '81, the School's
earliest graduate.

time the home of engineering, i. e., the north wing of the present building. Mr. Tyrrell is quite a School man, nevertheless, and his remarks were warmly received.

"It gives me very great pleasure to be here this evening and to see around the tables so many students of a School which was founded while I was attending University of Toronto, and which I regard as the proper type of school, not only for this new country with its vast undeveloped resources, but for any country. From the time you enter, it furnishes you with a definite aim and purpose in all your studies and enables you to spend those splendid formative years, which are, perhaps, the most valuable years of your life, in acquiring suitable knowledge, and proper habits of thought, so that you may become efficient members of the community, prepared to perform your own individual duties, and also to contribute most fully and perfectly to the happiness and welfare of others. The courses in engineering prepare you not only to be good, helpful citizens, but also to be efficient and resourceful men capable of undertaking the development of enterprises of any magnitude, and of carrying these enterprises to successful issues with the least possible expenditure of energy and loss in friction, at the same time making you nobler and stronger men in consequence of your exertions and of your success.

"When I was an undergraduate, between the years 1876 and 1880, there were no engineering courses, or shall I call them purposeful courses, at the University of Toronto. If there had been I would certainly have taken one of them. As it was, the lectures which I attended during my last two years at college were given in the old engineering school which had just been built, and was being prepared for you, so that while I cannot claim to be a graduate in engineering, I can claim to have taken my college course at the same school from which you have graduated or will shortly graduate.

"Thirty-three years, which is the length of time since I graduated from the University, does not seem long when it has passed, but nevertheless as I look around this hall I see that there are only two of us here who were at the University at that time, Doctor W. H. Ellis as a professor, and I as a student. Since then many engineering courses have been established, but even yet the university authorities have not decided to grant a degree to the members of the profession which I am following, namely, that of geological engineer, though it will probably be recognized by them before many more years have passed.

"In their speeches, some of the students have shown that they have a high appreciation of the value of the education that has been taught to them, and that they look forward with interest and enthusiasm to the work which they hope to accomplish in after years. But I would like to urge on all here the necessity for a fuller appreciation of the work done by one another. As yet there is no large and full *esprit de corps* among Canadian engineers, and it is usually necessary for a Canadian to go outside of his own country to gain recognition for the work that he may have done in it. This is not as it should be. Canadians should support one another, and if they do so the world at large will also recognize their merit.

"Just one other point before I conclude. At the present time engineers of any kind have very little to say in the general management of Canadian national affairs. They may be in control of large industries, but they have not as a rule entered public life, and they have taken no part in the framing of the laws which govern and control these industries. This omission needs to be corrected. Engineers who know the resources and possibilities of our country are the men most capable of directing the legislation for the development and control of those resources, and I would urge you, as you value the welfare of your country, to do your utmost to see that proper, just, and intelligent laws are passed for its development, and if necessary, to lay party politics aside, and by offering a determined and undivided front in the elections, to make sure that some of your own engineers shall be elected to the House of Commons, and appointed to the Senate, in order that the nation may receive proper and competent advice not only in its ordinary every day legislation, but also in cases of emergency such as may arise at any moment. In connection with the great engineering enterprises on which the government of Canada is at present engaged, it would surely be wise for it to have some engineers, who understand the conditions limiting or controlling those enterprises among its members. As good citizens, the obligation devolves on you to arrange for a supply of such competent and high-minded engineers to undertake this public duty."

Mr. F. C. Mechin, '14, proposed "Canadian Industries," and the toast was jointly responded to by Sir Edmund Walker, chairman of the Board of Governors, University of Toronto, and president of the Canadian Bank of Commerce, and by Mr. J. S. McCannel, president and managing director of the Milton Pressed Brick Co. The remarks of the former were largely based upon the financial crisis with which the University was contending at the present time, expressing the hope that increased aid would shortly be forthcoming from the government, not only to assist in establishing courses to afford needed instruction in many channels of industry, but to prevent the otherwise necessary decrease in the present courses of instruction.

Mr. McCannel emphasized the need of technical training in the clay working industry. He expressed the hope of the Canadian Clay Products Manufacturers' Association that the University of Toronto would soon be in a position to train young men to scientifically cope with the problems met with in the manufacture of brick, tile and ceramic ware.

The toast, "The Faculty of Applied Science," was introduced by Mr. D. A. S. Mutch, '13, and President Falconer briefly responded. The president also dwelt upon the scarcity of funds which handicapped the University, and trusted to the early future to bring relief before drastic changes in the curriculum became unavoidable.

Dean Galbraith spoke for a short period upon the gradual development of the Faculty of Applied Science and Engineering into the institution which it is to-day. To those who listened to his remarks and searched among them for some admission of the many years of indefatigable exertion and monstrous responsibility to which he has been so consistently a devoted servant, in the interests of the engineering profession, no semblance of such accompanied his historical sketch.

Before the close of the event Mr. W. D. Black, '09, of Montreal, a past president of the Society, voiced the sentiments of the gathering in complimenting Mr. Ritchie and his executive upon the success of their dinner.

APPLIED SCIENCE

INCORPORATED WITH

Transactions of the University of Toronto Engineering Society

DEVOTED TO THE INTERESTS OF ENGINEERING, ARCHITECTURE AND APPLIED CHEMISTRY AT THE UNIVERSITY OF TORONTO

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EDITORIAL

FOREWORD REGARDING EMPLOYMENT

During the winter months we have had many enquiries for men, and some of them pertaining to positions of a very desirable nature. We have had few requests from graduates seeking to be put in touch with new and better fields. The inference is that of the two parties, the latter estimates the less the service of our employment bureau, although practically every application from them received satisfactory response. We make the assertion with the belief that not all our School men are employed just in the shadow of their ideals; that some are on the lookout for something better, not contented with the present state of things, considering all in all. It is they to whom our employment bureau might be of service during the months in which our undergraduates are in academic work, and out of the market for positions.

During the past year we have received nearly five hundred applications for technically trained men. Over half of them went a-begging. As in labor circles, the unskilled workman is in excess and the skilled in demand, so it is in the higher plane. In the profession of engineering the supply of efficiently capable young men is more in demand to-day than ever before in Canada, and to our Faculty of Applied Science and Engineering falls the heavy responsibility of properly equipping the men who yearly depart from it, with the proper knowledge and training. That it is doing its work well, is evidenced by the demand which the above figure indicates to have been created.

THE STUDENTS' SUMMER

The time is at hand when the employment bureau will be thoroughly taxed. It is the aim this year to make it more successful than ever, especially in the matter of speedily bringing together the two contracting parties. To the undergraduates who will be our chief applicants until well into the month of May, APPLIED SCIENCE would tender a few suggestions which, if followed, will be of assistance.

(1) Let your application be in writing. Nothing is to be gained by taking a whole morning to describe the kind of position you would like.

(2) Embody in your application a summary of all previous engineering or business experience.

(3) Mention the nature of employment preferred, and where. If a second or third choice be added, it may be advantageous.

That is not all. Co-operation is needed. If you are aware of a vacancy that is unsuited to your needs, put one of your classmates on the trail. Endeavour to select the best man for the work; or, bring it in and permit us to assist in having the position filled.

Graduates who require the services of others, or who are in a position to recommend others for vacancies on engineering work can be of invaluable assistance, and their favors in this direction will not pass unappreciated.

FOR CLASS EXECUTIVES

The re-union of class '09 shows what a very little effort (our apologies to the secretary) will do toward bringing together a class after nearly four years in pursuit of livelihood and laurels, and toward record breaking as well. Before its members experienced the stimulus of graduation they elected a president, a secretary and a cavalcade of councillors, appointing also a time when they would endeavor to re-unite. On the evening following the School dinner nearly sixty '09 men met at the St. Charles, and, under the direction of Mr. W. D. Black as toastmaster, enjoyed themselves with their companions of college years. Dean Galbraith and Dr. Ellis sent their regrets, being unable to attend owing to previous arrangements necessitating their appearance elsewhere, and the members of the class keenly felt their absence.

Professor Wright gave the banquet the required touch of academic tone, and during the course of the evening his remarks concerning the School and the class were most warmly received.

ENGINEERING ALUMNI ASSOCIATION

The Pittsburg Branch

The S.P.S. men in Pittsburg held an informal dinner on the evening of February 26th. M. L. Miller, '03, presented an interesting paper on the Panama Canal. Due to the removal from the city of Mr. G. Alison, the club's president, the election of officers took place at this meeting. The executive for the coming year consists of: President, H. O. Hill, '07; vice-president, E. B. Graham, '10; secretary-treasurer, M. L. Miller, '03, 206 Suburban Ave., Pittsburg.

The annual dinner of the branch is scheduled for April 2nd. Doubtless all University of Toronto men in that city and vicinity will communicate with the secretary and turn out to make the event the usual success that characterizes "School" dinners, no matter where held.

EXCURSIONS OF THE CHEMISTS

During the present session, a number of visits have been made by the chemists to manufacturing plants.

The industries which involve a knowledge of chemistry are very diverse, and demand a wide acquaintance with manufacturing processes—an acquaintance which is formed most rapidly and surely by a personal inspection of factories in operation.

A visit was paid on October 22nd, to Messrs. John Taylor & Co.'s soap factory on Front Street East. The manufacture of toilet and laundry soaps was followed through in detail, and the plant for the recovery of glycerine from the spent lyes was carefully inspected. The presentation to each man of a cake of soap or a tube of tooth paste is an indication of the courtesy and good will displayed by the officers of the company to the visitors.

On November 4th, an excursion was arranged to Messrs. Marlatt & Armstrong's tannery at Oakville. Mr. Kenneth Marlatt, one of our own graduates, received the party which numbered 20, and after discussing the main points in the tanning process, conducted the men over the factory. The splitting machine attracted a great deal of attention. This is a band knife—on the same principle as a band saw—and of about six feet effective length, by means of which a hide can be cut into as many layers as is desired. Our thanks are due to our hosts for kindly providing a 'bus to transport the party to and from the station, over some roads which need a highway engineer very badly.

A party of 18 left Toronto on November 16th, and spent the day at Berlin. Heuther's Brewery was first visited, and one of our own men, Mr. J. C. Heuther, was our guide. The various steps in the process were followed out, and the new cold storage and ice plant was inspected. After dinner, the party spent the afternoon at the Dominion Sugar Co.'s factory, where the campaign was in full swing. The process from the receipt of the beets to the shipping of the finished sugar was explained by the chemist in charge, and the mechanical equipment afforded excellent illustrations of the desiderata in chemical engineering.

A small party of senior men went up on November 30th to Longford to see the plant of the Standard Chemical Co. at that place. This is a wood distillation plant handling 48 cords of hardwood per day, and turning out wood alcohol, acetone and charcoal as products. The various types of large-scale stills and fractionating columns were studied with profit, and the partial construction of some new ovens permitted an inspection of their design and setting. The autone plant was also interesting, and it was learned that the entire output is marketed in England for the manufacture of smokeless powder.

On February 19th the works of the Gutta Percha and Rubber Mfg. Co. were visited, and a very profitable afternoon was spent in this large and very ably conducted establishment. The plant has recently been enlarged, and a new reinforced concrete building houses the automobile tire department, and the machinery for producing hose in continuous lengths. The washing, compounding, frictioning, cutting, boot and shoe making and hose manufacture were attractive and interesting, while one carried away an ineradicable impression of the mechanical methods of handling plastic materials. The well equipped laboratories were also very interesting, and two of our men, Messrs. Klotz and Eckert, are in charge of some of the work performed there.

During all the visits mentioned above, the parties were most kindly and hospitably entertained, and the chemists are very grateful to all those who have put themselves to so much trouble and inconvenience in arranging personally conducted tours through their factories.

THE REUNION OF '09

Class '09 held a reunion in Toronto during the second week in February. The School dinner, on the evening of February 13th, served as a formal opening for the convention, and a good representation of the class was in attendance.

On the following morning, at frequent intervals, groups of them passed through the buildings, and numerous old acquaintances were renewed. Changes in staff and equipment were noted. It surprised a good many to find the old red building still in commission, it having been pronounced unsuitable for further use, and a new one having been talked of, about the time the class were experiencing the sensations of graduating. The visitors recollected many incidents, not recorded in any minute book, that endear the old engineering building as the nucleus of the activities of the class during undergraduate days, and it will be cherished as a monument to such very heartily, although the baneful thought arises as to how some of the courses taught within, manage to flourish, practising in their own home so little of what is preached.

At noon on the fourteenth a luncheon was given at the Engineers' Club. Mr. Ross Workman, the secretary, was in charge of ceremonies, and presided over the smokes at a little business meeting afterwards. The discussion centered upon the practicability of a few minor changes that would add substance to the usefulness of the class organization. It was decided to compile a geographical map, illustrating the distribution of the class and to organize subsidiary committees in localities where a few could assemble frequently.

It was also decided to approach:

(1) Members of former years who ultimately became members of the class before graduation; and,

(2) Members of the class of '09 at its initial stage whose names appear in the graduating lists of more recent years; and,

(3) Members of the original class, who drifted into other walks of life prior to the final examinations.

Upon definite knowledge of the desire of each to retain connection with the class, the executive can outline its course. As soon as the membership of the class has been clearly defined, some important feature or movement is likely to be brought forward.

The afternoon was spent at one of the theatres, a good bill serving to dispel the atmosphere of business, in preparation for the evening ceremonies.

At the St. Charles, by eight o'clock, half a hundred chorused the "Che hee" and the "Toike Oike," which were as ready as ever at the tip of the tongue, and half a hundred countenances beamed with satisfaction as "Dolly" Black accepted the premier position at the dinner table.

And the toastmaster was never in better form. Seated at his right and left hand were those whose attempts were futile to suppress the effervescence of long pent-up School-day demeanor, and our worthy chairman failed to display the mediative characteristics which we had expected to witness in a husband and father, and we cannot claim that he differed materially from Ross Harstone, Bill Tate, Dave Harvie, Eric Ryerson, or Sandy Sanderson, in the matter of being in best of form.

When the speeches were in order some well selected subjects brought forth sterling remarks about the School, the Class, and the event itself. Some whose oratory has continued to blossom every season since our knowledge of its quality was formed—Lew Rutledge, who fought a good fight for the electricals and mechanicals during our senior year; Bill Tate, the chaplain and advisor, and Professor Wright, whose interest in the class '09 is unparalleled among the potentates of the University, and whose presence was as highly appreciated as at any athletic, social or academic function in the olden time,—they were the proposers.

The Dean and Dr. Ellis, from whom a treat was anticipated by way of response to Tate's toast, "The School," were prevented from attending owing to meetings elsewhere requiring their participation. The menu prescribed that every man should make a two minute response to the toast, "Class '09," well proposed by Rutledge. In that time he was supposed to summarise the important events of his career as a man of the world. Early in the course of this phase of the proceedings the toastmaster and the secretary framed up an appeal that it was all a typographical error, and as the press reporters were one by one sliding into lethargy, the exploits of some half dozen sufficed as reply to the exhaustive demands of the proposer.

Professor Wright, in proposing a toast to "The Future," was conservative and reasonable in his prophecies, and the members of the class unanimously pronounced the climb as not too steep. He touched upon the acquisition of telegraphic, telephonic and illuminating facilities, mentioning as well the aerial, marine and rail transportation developments, as largely belonging to the past twenty years, and the advancement during the next two decades would be accelerated manifold by these one-time innovations. The next twenty years marked the lapse of time during which class '09 would give to the world its best service. Already members of the class had begun to win success and to court renown and others had chosen branches of the profession not conducive to precipitant distinction but worthy and pointing to substantial advancement before a great while.

Replying to the toast, H. Irwin referred largely to the pleasure and profit the class might derive if it adhered closely to the principles laid down at the first meeting it ever held as an undergraduate body. The voice of the meeting was, "Stick together"; and its final undergraduate meeting had come and gone with the same watchword unsullied and as potent as before. If the class upheld its ideals as a class, solid and self-sustaining, it would be a pleasure, in years to come, for its members to recollect the many reunions supplementing its journey through the halls of learning. It would not require too much sacrifice, or be too prodigious a task to compile a log, "The Last of the Noughty-Oughts-School" containing between its covers what of interest may be printed of the doings and sayings of the fellows, as chapter after chapter is breathed out. At any rate something more beckoning than a reunion every two or three years was necessary, and if the committee could select an acme of interest in which every member might indulge, it would form a bond in itself.

Letters were read by the toastmaster from absent members regretting deeply their inability to gratify their strong desire to be present—from Morton in Calgary, Sara in Winnipeg, Crosby in Vancouver, Danks in Sherbrooke, Woodley in Virginia, Palmer in Mexico, and others.

As a satisfactory close to such a successful event, W. D. Black was unanimously chosen president of the year until the next regular meeting three years hence, while G. R. Workman retains the office he has so admirably filled, as secretary to the Class.

DIRECTORY OF THE ALUMNI

This department began in November, 1912, and the entire list of graduates will be reviewed before the end of the year.

A number of corrections have been received bearing upon the "A" "B" and "C" of the directory already published, and our list of addresses is thus becoming more authoritative. If those whose names will appear during the next several months will assure themselves that our record of their location and employment is correct before publication, it will be improved still more, as there are some addresses upon our files that are long standing and hardly to be depended upon.

C (*Continued*)

Culbert, M. T., '02, deceased March 14th, 1911.

Cumming, J. D., '08, is at Copper Cliff, Ont., with the Canadian Copper Co.

Cumming, R., '02, is a member of the contracting firm of Miller, Cumming & Robertson, Toronto.

Cummins, O. F., '11, whose home is Chepstow, Ont., has no business address with us at present.

Cunerty, T. J., '11, is with the Westinghouse Electric and Manufacturing Co., East Pitsburg in the publicity dept.

Cunningham, C. H., '11, is designing engineer for Thor Iron Works, Toronto, of which firm he is a director.

Cunningham, R. H., '09 [illegible] Windsor, Ont. He is sales engineer for the Hoskin Manufacturing Co., Detroit.

Currie, W. M., '04, is a member of the staff of the Canada Steel Co. Hamilton.

Curzon, J. H., '11, is with the Canadian Pacific Railway at Moose Jaw, Sask., as chief draughtsman.

D

Dahl, A. D., '08, has Midland, Mich., for his address. He is chemist for the Dow Chemical Co.

Dallyn, F. A., '09, is with the Ontario Board of Health as consulting expert, in charge of the experimental station at Toronto.

D'Alton, F. K., '11, is taking an apprenticeship course with the Canadian General Electric Co., in the Peteroboro plant.

Daniels, W. N., '06, is in Philadelphia, Pa., in the employ of the John R. Wiggins Co.

Danks, F. A., '08, whose home is in Toronto, has no business address in our directory.

Danks, C. N., '09, is with the Jenckes Machine Co., Sherbrooke, Que., as engineer.

Dann, E. M., '09, is assistant engineer on hydrographic survey work in B. C. for the water power branch, Department of the Interior.

Darling, E. H., '98, is with the Hamilton Bridge Co., as engineer and manager of the east end plant of that firm in Hamilton, Ont.

Darroch, J., '08, has no address with us at present. When last heard from he was with the Autoparts Mfg. Co., Detroit, Mich., as draftsman.

Davis, J., '09, is sales engineer for the Canada Foundry Co. in connection with the Ottawa office.

Davis, H. W., '09, resides in Kingston, Ont., where he is in charge of the power department of the Davis Tanneries, Limited.

Davis, H. C., '09, until recently with the Hamilton Bridge Works, is at present in Bangalore, India.

Davis, R. S., '07, is manager of the Calgary office of the Canadian Westinghouse Co.

Davis, W. B., '11, is at Maple Creek, Sask., and is engaged in land surveying.

Davison, J. E., '00, is in the engineering department of the Canadian Northern Ry. Co. at Fort William, Ont.

Davison, A. E., '03, is with the Hydro Electric Power Commission, as engineer, with Toronto as headquarters.

Dawson, J. H., '09, is resident engineer for the T. C. R., at Cochrane, Ont. St. Catharines is his permanent address.

Deacon, T. R., '91, is president and general manager of the Manitoba Bridge and Iron Works. He is Mayor of Winnipeg, Man.

Dean, C. D., '10, has Sarnia, Ont., for his home address. We do not know his business address.

Death, N. P. F., '06, is a member of the firm of Death & Watson, electrical engineers and contractors, Toronto.

DeCew, J. A., '96, is in Montreal, Que., where he has a consulting practice in chemical engineering.

DeGuerre, F. C., '11, is in the engineering department of the British Columbia Electric Co., at Vancouver, B. C.

Delahaye, W. H., '09, is in the employ of the National Manufacturing Co., Brockville, Ont.

De Laporte, A.V.'10, is taking a post graduate course in chemical engineering, University of Toronto.

Depew, H. H., '04, was for some time superintendent of the Crow's Nest Pass Electric Light and Power Co., Fernie, B. C. We do not know if this is still correct.

Derham, W. P., '09, whose home is in Ottawa, is engaged in power house and switchboard in that city.

Dickson, G. W., '00, is with the Laurentide Co., Limited, Grand Mere, Quebec, paper manufacturers, as assistant superintendent of the ground wood mill.

Dickenson, E. D., '00, is with the General Electric Co., at Schenectady, N. Y.

Dill, C. W., '91, is general manager of the National Paving Co., Winnipeg, Man.

Dixon, H. A., '00, is at Resplendent, B. C., as district engineer for Mackenzie Mann & Co., on the C. N. P. Ry.

Dobbin, R. L., '10, is with Walter J. Francis & Co., on water power installation work at Moose Jaw, Sask.

Dobson, W. P., '10, is research fellow for the University of Toronto Engineering Alumni Association.

Dobie, J. S., '95, resides at Thessalon Ont., he is engaged in O. L. S. and D. L. S. work.

Dodds, W. A., '09, is chemical engineer for the Penman Littlehales Chemical Co., of Syracuse, N. Y.

Doorly, H. C., '08, is in St. Catharines, Ont., in the employ of that branch of the Jenckes Machine Co.

Douglas, R. H., '08, for some time since graduation, in the employ of the Department of Public Works, at Edmonton, has no address with us at present.

Douglas, W. E., '02, is secretary-treasurer of the McKnight Construction Co., Toronto.

Downing, F. H., '11, whose home is at Lucan, Ont., is with the Manitoba Bridge and Iron Works, Winnipeg,

Duff, A. R., '09, is chemist for the Dunlop Tire and Rubber Goods Co., Toronto, in the rubber department.

Duff, J. A., '90 (deceased), March 13th, 1902.

Duff, W. A., '01, is assistant bridge engineer for the Transcontinental Ry., Ottawa, Ont.

Duggan, G. H., '83, is vice-president and chief engineer of the Dominion Bridge Co., and chief engineer of the St. Lawrence Bridge Co., Montreal.

Dunbar, W. B., '11. whose home is in Dunbarton, Ont., is engaged in surveying practice in the West.

Duncan, J. M., '10, is marine engine draftsman with the Collingwood Shipbuilding Co., Collingwood.

Dundass, C. S., '06, is at Lachine, Que., with the Dominion Bridge Co., as draftsman.

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ENGINEERING SOCIETY EXECUTIVE, 1912–13.

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Applied Science

INCORPORATED WITH

TRANSACTIONS OF THE UNIVERSITY OF TORONTO ENGINEERING SOCIETY

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PONTOON BRIDGES

An Economical, Though Much Neglected Type. Suitable for Both Fixed and Moving Spans.

By Henry Grattan Tyrrell, Evanston, Ill.

Pontoon bridges are not so often used for moving spans as are trusses with their greater rigidity under loads, and yet they may sometimes be quite satisfactory, especially for highway service.

Types

Floating bridges are capable of development in several directions, and the moving spans may be classified under the following headings:

(a) Those in which a floating span is drawn out from the line of roadway.

(b) Those which revolve about hinges at the shore end.

(c) Those which revolve on a centre buoy, the vertical axis of which does not change position.

The first includes all those, whether supported on barges or on separate pontoons, which are towed or otherwise drawn clear of the structure, examples being those over the Golden Horn, and across the Hooghly at Calcutta. It also includes those bridges with only a single platform, such as that over the canal at Dublin, which was a fixed bridge when in place, but which could be removed to open the channel.

The second class includes a large assortment of swings, revolving about pivots at their rear ends, and supported at the outer end on a barge or float, examples being those at Aalborg, and the temporary ones at Chicago. This class should also include those bridges with double leaves, such as the frame bridge over the Kaiser Wilhelm Canal and that at Nebraska City, Iowa, over the Missouri River.

The third class has rigid trusses with equal arms, supported at their centre on a floating buoy, which revolves inside a ring of guide piles, on top of which is a balance track which supports only enough load to hold it in position. This is illustrated by the bridges at Spencer Dock, and over the Weaver River at Northwich, England.

Movable pontoon bridges might also be classified according as they are supported on barges or on separate buoys or floats, and also as they are wholly or only partly floating.

Bridges which are supported throughout their fixed part on pontoons, may have opening spans of other types such as bascules or direct lifts, examples of hinged bascules being built about ten years ago in India, where double pontoons were used beneath the hinges or the somewhat similar one proposed a few years ago for Seattle.

Suitability of Movable Pontoon Bridges

These bridges are most suitable where the current is small and where ice can easily be broken. Their unsuitability in heavy ice was proven at Budapest between the years 1837-47, when a bridge was removed every winter, and for six months of every year, travel was taken over on the ice, involving heavy risk. They are appropriate on water with small change in elevation, but not for tidal basins. Scows covering a large water area, such as those used at McGregor and Reed's Landing, are better suited for railway service than individual buoys, which at Maxau would sustain only a light 18-ton locomotive. Mr. D. J. Whittemore, under whose direction several of these bridges were built, reported in 1884 that pontoon bridges with double leaves 500 feet long, making a total opening of 1000 feet, would be quite practicable and could be opened or closed in four minutes.

Provision for River Travel

The decks of pontoon bridges may be built up on trestle bents, high enough above the water to leave space under the platform and between the boats or pontoons for the passage of river craft, an example being the bridge at Calcutta over the Hooghly River, the deck of which is 27 feet above the water, Owing to established street grades, this is often impossible, as for example at Dublin over the Royal Canal, where the street is only 16 inches above the water.

Vertical adjustment of a railway track on a floating pontoon, to compensate for variations in water level, when the pontoon lies between trestle work or other approaches, the grade of which is at a fixed elevation, may be made by blocking up the track between side supports, as was done on the first bridge at McGregor. The track could in this way be maintained at a fixed level regardless of the rise or fall of water. In deciding upon a clear width for river travel, if the pontoon span revolves in the usual way about one corner, and when open, lies parallel to the stream, the width of the open channel will be decreased by the width of the barge, and provision must be made for this obstruction by making the opening and the barge just that much longer.

A method of clearing the floor before floating out the moving span, is illustrated in the Hooghly bridge where two sections of the platform, 20 feet long, one at each side of the moving span, are revolved over the adjoining roadway while being supported from beneath by hinged struts. In other cases, a simple floor apron can be thrown back by hand, leaving the movable section free at each end.

Long bridges with very light travel, when only small funds are available for a bridge of any kind, may have their decks wide enough for only a single carriage track, and occasional extensions in the width where vehicles can pass. One or more lines of light chain can sometimes be used for railings where bascule or other movements would prevent the use of riveted or stiff sections.

Advantages and Disadvantages of Pontoon Bridges

The chief advantage of pontoon bridges is their economy in foundation over deep water, and the possibility of floating them away to another location when no longer needed at their original site. A disadvantage is that they are suitable only for comparatively low levels and cannot be opened quickly. The pontoons are liable to leak and settle in the water, and they are seriously affected by its rise and fall, by ice formation and river drift, and may sink more or less under heavy moving loads. In the following pages, examples are given of how some of these objections have been overcome.

The Pontoons

Floating military bridges, which had been used ever since the days of Cyrus, had boats or pontoons five to fifteen feet apart in the clear, supporting a platform ten to twelve feet wide made of plank on stringers, but pontoons for many old Roman bridges were of wicker work covered with hides. In succeeding centuries, the armies of other countries made their pontoons with wooden frames covered with plank, sheet copper, india rubber, or canvas, waterproofed with tar or paint. The Germans, in the seventeenth century, used timber pontoons covered with leather, and the Dutch, similar ones covered with tin, while the army of Napoleon preferred copper. For ease in transporting, they were sometimes made in two or more pieces which were fastened together before being launched. Recent ones have watertight compartments, so a single leak will not cause them to sink, and the platforms usually lie on trestles standing in the bottom of the floats. Floating piers have also been made of an assemblage of casks or logs lashed together, with sufficient buoyancy to sustain their loads, closed casks being floated on their sides and open ones on end. Empty barrels in the Hertford bridge in Carolina, remained in service for fifty years.

The United States army in the Phillipines made floats of ten to fifteen bamboos, 25 feet long, tied together, and lying in the water 10 feet apart. They were buoyant enough to sustain wagons and light artillery. A very crude and unscientific method of floating the deck was that used at Lynn, where the whole timber platform was laid upon the water, and as the timber became water soaked and settled, other timber was laid over it, till the thickness had finally increased to 17 feet. Rafts 30 feet square made of flattened logs and connected by platforms, as in the bridge at Port Hope, were an improvement on the last and yet very defective.

Open top boats are used at Cologne, and wood barges for most of the pontoon bridges in America, including all those for railway service in the Middle West, the latter ones being divided into four separate compartments by three longitudinal walls. Barges with large bottom area have the advantage of small depression under live load, that at McGregor, 408 feet long and 30 feet wide, sinking only 8 inches under a locomotive. The pontoon 400 feet long at Reed's

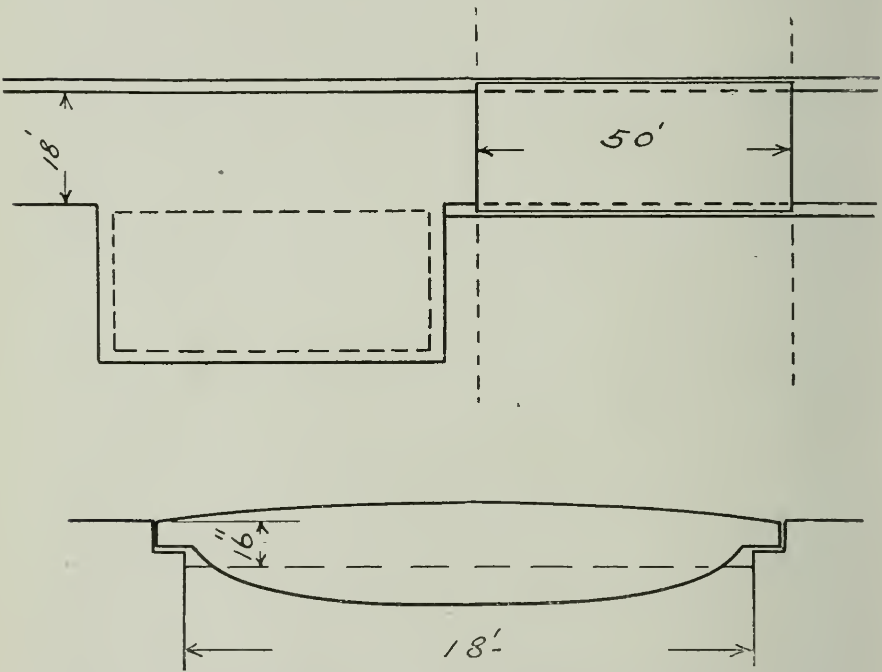

Fig. 1—Pontoon Bridge over the Royal Canal at the Broadstone Terminus of the Midland Great Western Railway, Dublin (1847)

Landing, is similar to that at McGregor, excepting that the depth is 7½ feet at the ends, while it is only 6½ feet through the central 320 feet, thus adding to its buoyancy at the ends under an approaching load.

Wooden boats are used at Toulon, but metal floats are the general rule in Europe and Eastern countries. Those for the Calcutta bridges are made of ¼-inch metal, and are 160 feet long, 10 feet wide and 8 to 11 feet deep, standing 3 to 4 feet above water, each one being divided into eleven compartments. Other examples are those at Riga and Coblenz. Scows and tugs beneath the outer end of revolving spans are used at Aalborg and Chicago, and Mr. Kinniple's submerged caisson bridge was partly supported by a buoy.

Centre Pontoon Under Double-Arm Swings

The benefit of this method of supporting a span is that it is independent of the shifting river bottom and the height of the deck can be adjusted by admitting or withdrawing water ballast. The buoy is held in position by a circle of piles, on top of which is a track for the balance wheels. The pontoon should be made in four to six parts bolted together, forming a cylinder and sections could then be replaced without removing the bridge superstructure. Hand pumps should be installed to remove water from leakage or condensation. The pontoon of the Weaver river bridge is 12½ feet deep and 30 feet in diameter, with the bottom slightly dished or spherical, and all metal 3-8-inch thick.

Buoys might be placed in regular bridge piers to reduce the pressure on the piles or foundation, but their lack of stability and durability has prevented such use. At Northwich, the buoys sustain 85 per cent. of the whole load, while on the earlier ones of 1873 at Spencer Docks, they carry 95 per cent. of the load.

Spacing of Pontoons

The distance between centres of buoys or pontoons is usually 30 to 50 feet, being 35 feet at Maxau, 40 at Attock, and 48 at Calcutta, but it may be regulated to suit the length and size of floor joist, the relative cost of floor and boat, and the required buoyancy. In the Attock bridge, 14 feet wide, boats 48 feet long and 12 feet wide, cost $286 each. Flotation may be regulated by water ballast, and the buoys can be anchored with chains or wire rope, the former being almost exclusively used until thirty years ago.

Details and Cost

Since water offers greater resistance than air to movement, floating bridges have a slower operation than bascules or swings, and should generally open with the current and close against it. One of the quickest moving pontoons is that at McGregor, on the Mississippi River, which opens with the current in one minute and closes against it in three minutes.

The kind of power and its method of application should be governed by circumstances. An old locomotive on shore was used for operating the bridge at Rouse's Point, while the double leaf bridge at Nebraska City is swung open by the force of the current. Temporary swing bridges in Chicago, supported at one end on a pontoon, were formerly operated by an electrically driven double drum, carrying two chains with their outer ends anchored on shore, but the more recent one in that city has electrical paddle wheels on the pontoon.

Floating bridges have frequently been assembled either up or down stream from their final location, in a place sheltered from the rapid current or from the enemy, and afterwards towed or swung around into position in either one piece or several sections. This plan was followed by Napoleon for a bridge over the Danube the day before the battle of Wagran. The quiet water around an elbow of the river on the inner side is convenient for this purpose.

The time occupied in building pontoon bridges depends on the degree of permanence required, the preparation which has previously been made for such work, the skill and experience of the builders, and the availability of materials. Military bridges put up by men practiced in such manoeuvres and from parts which are carried by the army, have often been built in a few days, and one which was constructed during the American Civil War, over the Potomac at Harper's Ferry, was completed in eight hours. The Nebraska City bridge which is over 2,100 feet long, was built in twenty-eight days, while that at Maxau took twelve months and another at Calcutta, twenty months, delay being caused in the last case by waiting for materials from another country.

Timber pontoons such as those on the Mississippi, when built of creosoted timber, will last twelve to fifteen years, or at least half as long as steel, and if the pontoons are of metal, the duration of pontoon and swing bridges will be about the same. Their cost does not usually exceed one-third to one-sixth of the cost of metal bridges with swing spans.

Assyrian and Persian Bridges

The earliest pontoon bridges were probably those used by ancient armies, since they were mentioned by Homer as common in his time, about 800 B.C. The writings of Lucarus, Herodotus and Xenophon, state that pontoon bridges with casks as floats were used for military purposes. The earliest bridge of this kind of which definite records are extant is one made by Cyrus, King of the Persians, for transporting his army in the year 536 B.C., stuffed skins being used as floats. Babylon was taken 538 B.C. by the Persian army under Cyrus, diverting the course of the Euphrates and entering the city at night under the water gates of the river. The people in those days knew, therefore, both how to bridge the rivers and to dam them.

Darius Hystaspes, fourth King of the Persians, who began to reign 521 B.C., built a bridge of boats across the Danube River (510 B.C.) when engaged in his Scythian warfare. In 493 B.C., the same King, on a Scythian expedition, when about to invade Thrace, constructed a bridge of boats over the Bosphorus at a place where it was 3000 feet in width, over which he marched his army of 600,000 soldiers. His head bridge builder was Mandrocles of Samos.

In 480 B.C., Xerxes, King of the Persians, who succeeded his father Darius, built a double bridge of boats at Abydos, between Sestos and Madytus, over the Hellespont (or Dardanelles) which separates Europe from Asia. The strait varies from one to four miles in width, and the bridge is believed to have been at least 5,000 feet long. Herodotus says that the first bridge was destroyed by a violent storm, and in great anger, Xerxes ordered the engineers or builders to be executed and the water of the Hellespont to be scourged with rods and blasphemous words. Xerxes then built two other pontoon bridges, one of which on the side adjoining the Euxine Sea, was supported on three hundred and sixty, and the other on three hundred and forty anchored boats of the largest size used by the ancient navies. The first were placed transversely, and the others parallel with the current, to diminish the strain on the cables. The boats were connected by six large cables of white flax, extending the whole length of the bridge and fastened to piles on either shore, the cables being drawn tight with wooden capstans. The platform, which was protected by a railing at each side, consisted of trunks of trees laid across the cables and covered with flooring and a layer of earth. When the work was completed, Xerxes ordered fetters to be thrown into the sea, signifying that he had conquered the turbulent waters. One authority states that at three places in its length openings were

Fig. 2—Bridge of Boats over the Rhine at Cologne.

left for the passage of ships. The work was done by Egyptian and Phoenician artisans. Over these bridges Xerxes marched his army of 2,000,000 men across into Europe when on his way from Sardis to conquer Greece, and seven days and nights were occupied in making the passage.

Roman, Grecian and Chinese Bridges

At a later period, the young Emperor, Alexander the Great, built a pontoon bridge over the Ganges, about 330 B.C., for the purpose of transporting his soldiers, and in crossing the Oxus, 327 B.C., he used rafts made of hides stuffed with straw, as all the available boats had been burned. He was accustomed to carry with his army a kind of boat in sections, which could be joined together when required for use. Pyrrhus, King of Epirus (318-272 B.C.), also had a bridge of boats on the Adriatic Gulf. Caligula's bridge (see Tyrrell's History of Bridge Engineering) is thought by some historians to have been constructed chiefly on boats. It was three miles long, in the form of a crescent across the bays of the Puteoli and Baiae, or Tyrrhene Sea, and was supported over the water on a double row of boats or pontoons. The roadway was made of plank, covered with earth and gravel, and the deck was lined on either side with shops and houses, and was illuminated at night with torches. Caligula's boast was that he would turn sea into land and night into day, and when it was completed, the Emperor had great festivities lasting for several days, which teminated by his ordering a large number of the citizens to be thrown into the sea. The date of completion was in the latter part of his reign, about 40 A.D.

Movable boat bridges were common in China, and one in the province of Chausi at the junction of two rivers, was made with one hundred and thirty barges, chained together and so arranged that two or three boats were removable for the passage of vessels. In the fourth century, A.D., the Greeks under Emperor Julian, used boat bridges for crossing the Tigris and Euphrates rivers in their retreat from Persia.

Modern European Bridges

The Servians used a pontoon bridge for crossing the Danube in the fourteenth century, to assist in the defense of Nicopolis, and a bridge of boats over the Rhine between Cologne and Deutz, Germany, was constructed in 1674, and was replaced by a new one in 1822. It is 1400 feet long and carries highway and pedestrian travel, and has a wooden floor which is renewed occasionally as required. The Rouen bridge of boats, prior to 1810, was 900 feet long and paved with stone, and was very firm under heavy travel, the boats being anchored with chains. A bridge over the Neva at St. Petersburg prior to 1845, admitted ships at night through one opening.

A removable platform supported on a pontoon, was, in 1847 placed over the Royal canal at the Broadstone terminus of the Midland Great Western Railway at Dublin. Water in the canal was only 16 inches below the street and there was little vertical space for framing. The bridge is 50 feet wide, only 18 feet long, and can be removed by withdrawing water from the chamber by means of a syphon which is exhausted by a jet of water issuing into the exhaust pipe at an acute angle. The platform then rises from its bearings and is drawn into a recess in the approach at one side. The pontoon is made of half-inch iron plate and its total weight is 18 tons. It was designed by Robert Mallet and at the time, was a new departure in bridge construction. The cost was $6,375. Two parallel swivel bridges, each with a road 25 feet wide, were at first intended for the place but were not used.

The bridge of boats over the Danube at Budapest, which existed previous to 1837, was removed in the winter seasons because of danger from ice, and travel was taken over the river either in ferries or on the ice, which, in 1838, was 6 to 8 feet thick. For several months of each year, travel had been accompanied with much uncertainty and risk, and as these conditions were not satisfactory in 1847, the new suspension bridge was erected. The pontoon bridge over the Rhine at Maxau near Carlsruhe, Germany, had a portion 768 feet long, supported on thirty-four pontoons, though the total length with approaches is 1,200 feet. It is 40 feet wide, with a single line of rail track in the middle and a highway on each side, but only light train loads and an 18-ton locomotive are permitted on the bridge. The wood pontoons are each 12 feet wide, 4½ feet deep and 65 feet long. It was opened in 1865 after twelve months in construction. One set of pontoons near each side of the river is, in summer time, moved three or four times per day to allow boats to pass. It replaced an ancient bridge a few hundred yards further up stream, and was designed by Messrs. Becker & Basler, Engineers. A bridge over the same river at Ehrenbreitstein also has a movable section.

The pontoon highway bridge over the Mangegarry Canal at Toulon is in two parts, hinged together. The roadway is 16½ feet wide supported on four wooden boats, which gives a passage of 30 feet when partly open and of 85 feet when fully open. Another bridge, 500 feet long, over the Havel at Spandau near Berlin, differs from previous practice by using wire ropes instead of chains for anchorage. It is supported on eighteen pontoons and the footway is elevated high enough that boats can pass under at two places, while a movable section at the centre on two pontoons, permitted the passage of masted ships. It was completed in 1883 and cost $5,250.

Floating bridges with hinged aprons at the ends are convenient for crossing small channels with varying water level, for the apron permits the central part to rise and fall. One of this kind for foot travel, crossed a small channel at Coblenz in 1888, the deck being supported on two metal pontoons, 1½ meters in diameter and 7 meters long, placed 10 meters apart. Above the floats were small towers, from the tops of which were ropes leading out to support the aprons at their outer ends. Another highway bridge over the Dunastrom at Riga is supported on buoys 3.2 meters in diameter and 26 meters long, spaced 19½ meters apart, with a deck 14 meters wide.

The Prame bridge over the North East Sea Canal (Kaiser Wilhelm Canal) at Holtenau is in two parts with a 15 meter road and two narrow walks, the total width being 20 feet. Each half is carried on boats and revolves about a pivot on shore. When closed, the two leaves meet in the centre of the canal forming an obtuse angle with each other. The main pontoons are made with ¼-inch plate and the whole bridge cost $30,000. It was originally worked by hand but was afterwards equipped with petroleum motors. The design has proved satisfactory in water with only small variation in level, but would be useless in tidal basins. Other interesting ones cross the Diena at Riga and the Weaver River at Northwic , England, the latter being supported on a floating centre pier, while still others at Presburg, Coblenz, Mayence, Seville and Portsmouth might be described.

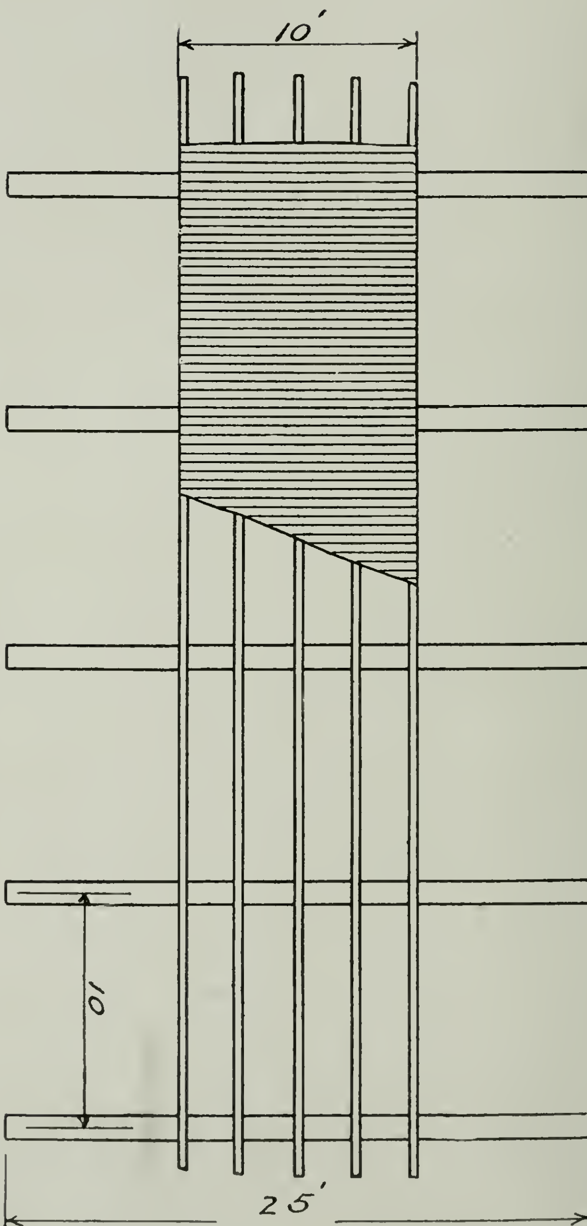

Fig. 3—Floating Bridge used by the United States Army in the Phillipines (1899).

Asiatic and Eastern Pontoon Bridges

Many of the finest and most interesting pontoon bridges are to be found in Asiatic countries, some of them the designs of English engineers. An early one of the last century is the Victoria bridge at Colombo, Ceylon, over the Kelani River at Grandpass, completed in 1825, and in use for more than forty years. The river is 450 feet across and rises 9 to 12 feet during flood seasons.

Bridges over the Golden Horn, that busy watercourse leading out from the Bosphorus to the north, and separating Constantinople from the suburbs of Galata, Topana and Pera, have long been maintained, one being erected in 1837. The deck of this bridge was 36 feet wide and most of it was near the water, but in two places were elevated platforms reached by grades, leaving openings at all times for small river craft. It was wholly of timber and was supported on floats, being divided into sections which could be removed for the passage of ships. Gables and anchors held it laterally in position. This old wooden pontoon bridge was replaced in 1872-75 by a new one at Karakeni, a contract having been made between the Turkish government and Mr. George Wells, a civil engineer of London. The original contract price for a bridge 1350 feet long was $475,000, to cross between Azap-capon and Oun-capon, but after the contract had been made, the government officials changed the location to a place which was 100 feet longer than the first, and they agreed to pay an additional sum of $30,000. But on receiving the iron from Newcastle, England, it was found to be 9 feet longer at each end than was provided by the abutments, and the grade level was therefore raised by discharging a portion of the ballast from the pontoons. The contractor demanded and secured damages for several months' delay, in the amount of $500 per day.

Another bridge over the same channel was completed in 1907, But the latest one from Constantinople (Stamboul) to Galata, which was begun in September 1910, was completed in the autumn of 1912, and replaced the one built in 1872-75. The other bridge, half a mile further up the channel, on account of its position, has only light traffic compared to that over the last one, which required an 82-foot roadway. The moving span at the centre has two passage ways 39 feet wide and 17½ feet high under it, through which small water craft can pass without removing the opening span, but when it is withdrawn, the clear channel is 205 feet wide. The new bridge is 1542 feet long, and contains 8,000 tons of steel, which was manufactured in shops at Mayence, Germany. Water in the channel is 130 feet deep, and as there is no tide, the greatest variation in level, caused by wind blowing continuously for a long time from one direction, is only one foot. The pontoons are arranged in two rows parallel to the bridge axis. In consideration of its population of a million, and the harbor facilities for 1200 ships in the Golden Horn, it would seem that Constantinople, the capital of the Turkish Empire, the harbor of which is used by not less than 37,000 ships annually, was poorly supplied with bridges.

Another large pontoon bridge, erected in 1873, crosses the

Hooghly River at Calcutta, India. It is 1530 feet long, and the deck is supported on twenty-eight rectangular iron floats coupled together in pairs, and held in position with 1¾ inch chain cables, fastened to anchors weighing three tons each. The anchors are placed on the up-stream and down-stream sides, and each pontoon is divided into eleven separate compartments, with the top three or four feet above the water. The pontoons are 10 feet wide, 8 to 11 feet deep, and 160 feet long to prevent their oscillating or tipping sideways. The deck is 63 feet wide and 27 feet above the surface of the river, which has a current of six miles per hour. An opening for the passage of boats can be made by removing a central section 168 feet long, resting on four pontoons, which operation is performed about twice per week. Before floating the section out, a portion of flooring 20 feet long at each side of the removable part is thrown back over the adjoining roadway, and when the moving part is withdrawn, there remains a clear opening of 200 feet. It is worked by hand power, and fifteen minutes is required to open the bridge, and twenty to close it again. It connects Calcutta with Hawrah, and at the time was the longest floating bridge in the world. Sir Bradford Leslie designed it in 1868, but it was not completed until five years later, after twenty months of actual construction. The quantities of material are as follows, the iron work being sent from England.

Iron in pontoons................	1600 tons.
Iron in girders..................	875 tons.
Timber	1500 tons.

It cost $1,000,000, which was only one-third the estimated cost of a fixed bridge of the same width.

In recent years, the need for a more commodious bridge at Calcutta has become evident, and in the early part of 1912, competitive designs were received for a new one. Since the river bottom is soft mud and silt to a great depth and quite unsuitable for piers or foundations of any kind, transporters and floating bridges were the only types seriously considered. Two designs with floating piers, submitted by Head, Wrightson & Company, of Thornby, differed only in the piers, for in one case. buoys were to float on the surface of the water which had a maximum rise and fall of 20 feet, and in the other design, the buoys were to be anchored below water and remain stationary regardless of the water elevation. The clear distance of 1408 feet between abutment faces was to be crossed by a 500-foot shore span at each side, with a double leaf swing in the center, leaving a clear space of 200 feet between the floating piers. These plans showed a deck 98 feet wide with three lines of trusses, which is 50 per cent. greater than the former one. Each pier consists of eight buoys, 15½ feet in diameter and 228 feet long, spaced 18 feet apart on centers, the buoys being divided into five separate bulkheads.

Pontoon bridges have been extensively used in other parts of India, such as those at Dera Ismail Khan, Attock, and Khushalgarh. The bridge at Attock was 1200 feet long supported on boats 48 feet long and 12 feet wide, placed 40 feet apart on centres and costing $286 each. Over the boats were trussed joists and a plank roadway 14 feet wide. The bridge over the Indus at Khushalgarh was recently replaced by a cantilever. Small bridges of this type are also common in India, five of them with lengths of 310 to 558 feet having been built from 1900 to 1902. Pontoons 6 feet in diameter and 30 feet long of 3/16-inch steel plate are placed 31 feet apart on centres and anchored with chains 100 feet apart. Narrow roadways about 10 feet wide, guarded at each side by a fence of light chain, are carried by two lines of 10-inch steel joists. Each of these bridges contains a hinged bascule supported on double pontoons, which can be opened by two men in fifteen minutes and closed in six minutes.

Floating military bridges used by the United States Army in 1899 in the Phillipines, had floats 10 feet apart and 25 feet long, made of fifteen bamboos tied together, over which was laid a deck of bamboo mat, 10 feet wide, no nails being used in any parts. One of these bridges 290 feet long, over the Iloilo River at Molo, was completed in four days by ten men at a total cost of only $125.

American Pontoon Bridges

One of the earliest floating bridges in the United States and probably the only one of its kind, was built in 1802 near Lynn, Mass., over a pond which was believed to have no solid bottom. It was built by Moses Brown, and was 511 feet long in three sections. The platform was of timber 5½ feet thick, but it had so often been refloored, that its thickness in 1904 was 17 feet. It was then so water-soaked that light loads passing over it caused it to sink below the surface, and it was replaced by a modern bridge, though the old one was allowed to remain. A somewhat similar one crossed Dexter Pond in Maine. One at Hertford, North Carolina, was supported on empty barrels and was used for fifty years. A bridge similar to that at Lynn, was made by George Steward of Port Hope, Ontario, who many years ago built a floating bridge like a corduroy road, three-quarters of a mile long, between Sturgeon and Scugog Lakes. Rafts 30 feet square, of flattened timber, were connected by six or seven longitudinal beams on which a platform was laid.

Pontoon bridges were largely used by the American armies during the civil war, of 1862-65. One over the Potomac at Harper's Ferry, Va., containing sixty boats, was built February 1862, in a period of only eight hours. The river was in freshet condition, 15 feet above summer level, and was filled with ice and drift, but when finished, safely carried the heavy army wagons, cavalry and artillery. The Rapidan, Rappahannock and other rivers were similarly crossed.

One of the most important commercial bridges of the kind was that which was built in 1851 over the outlet to Lake Champlain near Rouse's Point. The principal part of this structure was a pile trestle 1800 feet long, but it contained a pontoon draw 300 feet long, which was operated by an old locomotive engine on shore. It was built by Henry R. Campbell, and gave good service until removed in 1868. It was 30 feet wide, and 7 feet high, drawing 2 feet of water. The experience with this bridge was valuable, for it served as a model or prototype for several others in the Middle West in later years, including those over the Mississippi at McGregor and Reed's Landing. The bridge between Prairie du Chien, Wisconsin, and North McGregor, Iowa, built in 1874, carried the Chicago, Milwaukee and St. Paul Railroad over the Mississippi River. It was the work of John Lawler, who first examined that at Rouse's Point before putting this one into execution, which he afterwards patented, prior to his death in 1891. Before building it, cars had been taken over the river on a ferry. The river is divided by an island into two parts, the west channel being 1500 feet wide and the east one, 2,000 feet. Excepting for the two removable parts, the remainder of the bridge was a pile trestle. As first built, the pontoons were 408 feet long, 28 feet wide and 5 feet deep, drawing 10 inches of water, which depth was increased to 18 inches when loaded with cars. As the range from low to high water is 22 feet, the track was blocked up between stiffening trusses on the deck, and it could be lowered during high water to suit the grade of the approaches. It was operated by a 20 h.p. steam engine, and could be opened with the current in one minute, and closed again against the current in three minutes. When open, the channel width of 408 feet was reduced by the width of the pontoon, the remaining distance being 380 feet. Log rafts in the river were usually 320 feet long or wide, and experience showed that the river men liked this bridge and found it easy to pass. Therefore, in later years, as renewals were needed, it was replaced by structures of the same kind, which were found to cost only one-sixth as much as the cheapest swing span on the river. Renewals were made in 1882 and 1888, and a new pontoon was placed in the east channel in 1898, and another five years later in the west channel, the new floats being made 30 feet wide on the bottom and 41 feet at top. They were divided by three longitudinal walls into four compartments, and each one contained 600,000 feet, B.M. of timber. These bridges are suitable in gentle currents only, and where ice can be easily broken. When built of good material, they should last twelve to fifteen years. This one is opened on an average about five times per day, and is in service about 250 days of each year, which time represents the whole open season.

The Chicago, Milwaukee, and St. Paul Railway maintains another pontoon bridge at Reed's Landing near Wabasha over the Mississippi River, 1½ miles below Lake Pepin. The main part of the bridge is a pile trestle 3,500 feet long, but it contains a 400-foot pontoon which, when open, leaves a clear channel of 350 feet. It was first finished in 1882 and was rebuilt in 1891, much of the trestle being filled in with rock. At low water, the river is 2,400 feet wide, and the variation in level is 15 feet, with a swift current. The barge is 6½ feet deep through 320 feet of its central part, and 7½ feet at each end, and altogether, it has given such good service, that it was rebuilt again in 1907 with creosoted timber.

The Missouri River bridge at Nebraska City, finished in 1888, has a length of 1074 feet over the navigable water, with 1050 feet of causeway on cribs over a back channel, when completed was the largest of its kind in the world. The moving part, 528 feet long, is a triangle in two leaves with apex down stream, and to open it, the connection at the centre is loosened when the current swings the halves apart, the services of only one man being needed. The width is 24½ feet for highway and pedestrian travel. It was built under the direction of Colonel S. N. Stewart of Philadelphia, and the whole structure, including approach, was completed in twenty-eight days at a cost of $18,000.

John Lawler also built a highway pontoon over the Illinois river at Lacon, Illinois, in 1889, though it was designed by George F. Wightman, of Lacon, in 1879, and afterwards built under his direction. The pontoon is 200 feet long, 24 feet wide and 6 feet deep, but the remainder of the bridge is a pile trestle. It cost $17,000, and as

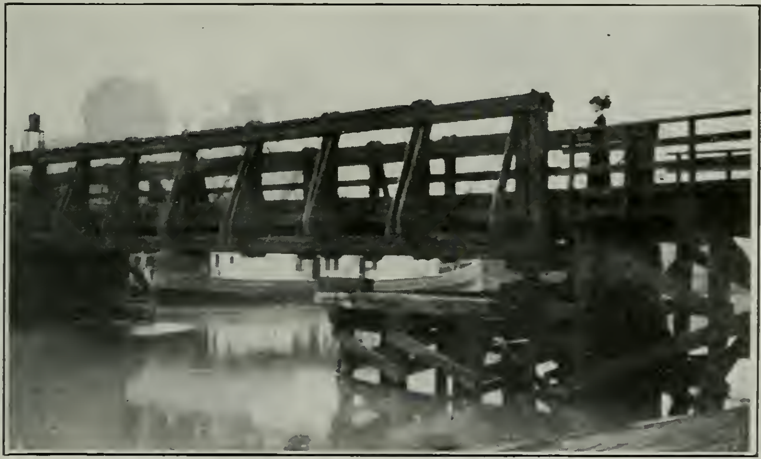

Fig. 4—Old Bridge on Chicago River, from Goose Island to East Bank, one end on Pontoon

the toll received is $4,000 per year, it was renewed in 1905 by another one, of the same kind, but 50 feet longer than the original. It is operated by two men. The river is 38 feet deep at low water and has a maximum rise of 18 feet, 40 feet of the deck on each approach being movable to connect with the pontoon on the water with varying elevation.

The competition of 1892 for a moving bridge over a 250-foot channel at Duluth, brought forth three designs for a single leaf swing bridge supported at the outer end on a pontoon and mounted on a turntable on the other shore. These were made by Messrs. Bates, La Rue and Stebbings, and in all cases a recess was left in the dock, adjoining the turn-table, to receive the pontoon when the bridge was open. In Mr. Bates' design, the bridge was lifted from its bearing by pumping water from the pontoon, and then turning it by means of a screw in the water. The estimated cost was $80,000. Mr. La Rue's design was similar, excepting that the outer end of the bridge rested on a steam tug 20 feet wide and 70 feet long with 15-foot draft, the total cost being estimated at $108,000. Mr. Stebbings' design was to cost about $135,000. All of these were quite similar to a bridge erected at Aalborg, Denmark in 1867. (See Heinzerling's Bridges). The following year (1893) when the bridging of the Detroit River was being discussed and opposed by the river interests, a patent was granted to Mr. E. Fontaine, of Detroit, for a so-called "winter bridge," consisting of girders supported on hinged bents, the intention being to float the spans away on barges or pontoons, and to revolve the bents down on a submerged platform well below the reach of ships. But it is now well known that opposition to the bridge was so severe that a tunnel was driven under the river instead.

The pontoon highway bridge over a harbor on Curazoa Island, in the Dutch West Indies, 46 miles north of Venezuela, is 700 feet long with pontoons 30 feet long and 20 feet wide, spaced 30 feet on centres. It was designed by L. B. Smith, and the removable section 400 feet long is worked by cables from an engine on shore.

A bridge, the length of which is 3638 feet, containing unusual features, was built over Chemong Lake near Peterborough, Ontario, in 1900. The fixed approach is 913 feet long, and the pontoon portion 2620 feet, which contains a draw of 105 feet. At five places the road is 24 feet wide to permit vehicles to pass, but the remainder of the deck is only 18 feet wide. Its cost was $26,000.

A bridge over Salmon Bay at Seattle, Wash, was proposed in 1902, the total length of which, including the approach would be 1,200 feet. It was intended to be 60 feet wide for a highway and two railway tracks with the deck 20 feet above water. The floating part would consist of eight scows 20 by 50 by 5 feet, resting on the bottom at low water and connected by several short spans, and the draw would consist of two counterweighted lifting spans 50 feet long, on scows 60 by 100 by 6 feet, giving a clear opening of 100 feet.

Temporary swing bridges supported at one end on a pontoon, have frequently been used at Chicago during the construction of permanent bascules, a design for one at State Street having been made in 1902, though not then used. It was quite similar to a bridge built at Aalborg, Denmark, in 1867, and to those proposed for Duluth, ten years before. The design for State Street was intended for pedestrian travel only, with a clear width of 10 feet, between trusses 117 feet long and 12 feet deep. One end was to be pivoted on a pile pier, while the other end was bolstered up on a timber pontoon, leaving an underclearance of 16 feet, 60 feet wide when closed, and 100 feet wide when open. The pontoon was 20 feet wide and 7 feet deep, 38 feet long on top decreasing to 20 feet at the bottom, carrying three lines of timber trusses which supported the outer end of the bridge. But the first one of the kind actually used in Chicago, was at Northwestern Avenue, where the trusses of the moving part were 100 feet long with 8-foot panels, carrying a roadway and two lines of car track over a clear channel of 72 feet. Floor beams were

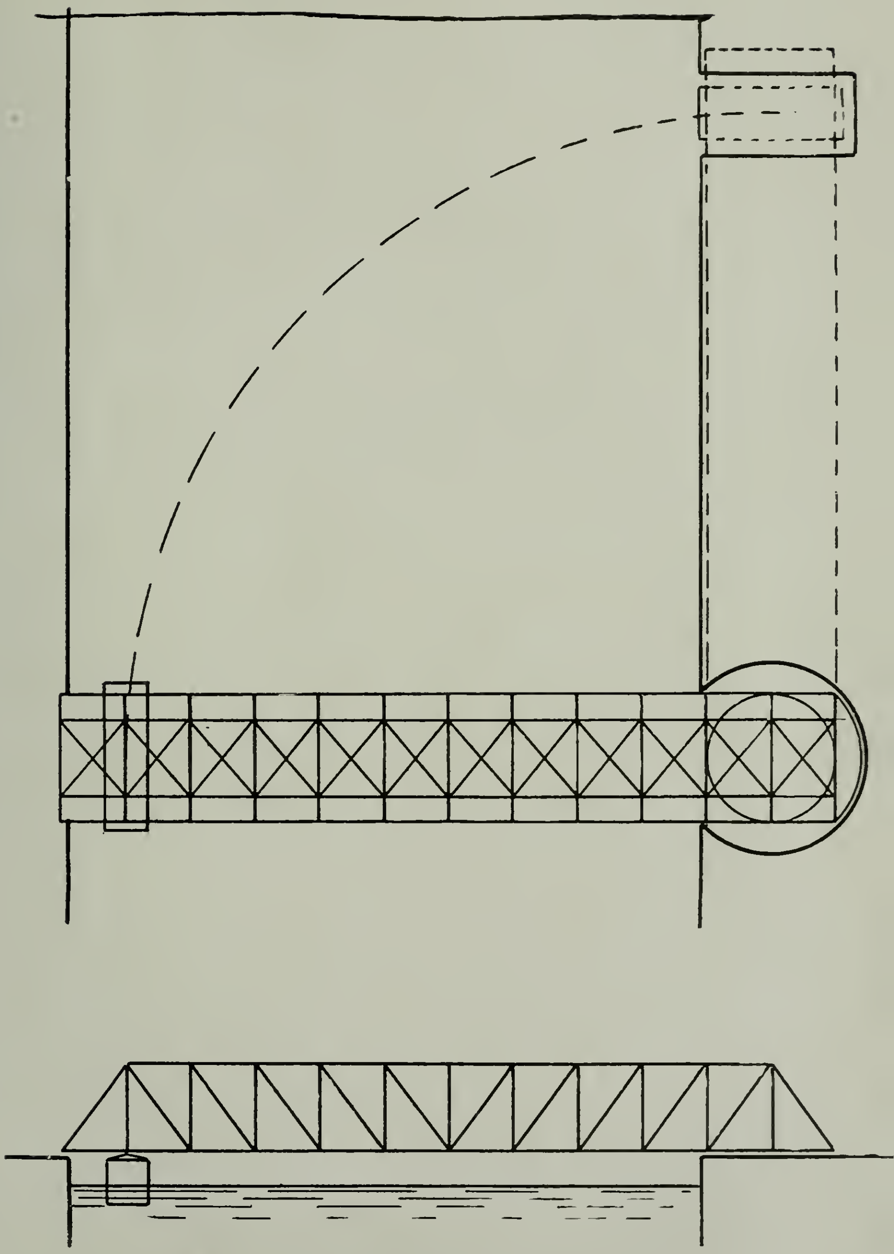

Fig. 5—Mr. Onward Bates' Design for a Bridge to cross the Channel at Duluth (1892)

two feet apart, and the total dead weight was 100 tons, or 2,000 pounds per lineal foot, 85 per cent. of which was supported by the scow. The whole bridge 212 feet long with the approach trestle, cost $10,000, but the moving span with pontoon and machinery cost only $5,600. The scow was propelled by electrically driven double drums, carrying two chains with their outer ends anchored on shore. Other similar bridges were used in Chicago at Archer and North Avenues. The North Avenue bridge, where the river is 195 feet wide, was similar to that just described, excepting that the scow, 15 feet wide and 40 feet long, was equipped with electric paddle wheels instead of drums with chains.

A railroad bridge over the Missouri River at Chamberlain, North Dakota, completed in 1905, has a pontoon 360 feet long similar to that at Prairie du Chien, leaving a clear opening of 300 feet.

M. H. Baker, '06, until recently the city engineer of St. Thomas, Ont., is now city engineer of Prince Albert, Sask.

E. H. Phillips, '00, and A. P. Linton, '06, presented very interesting papers at the annual meeting of the Saskatchewan Land Surveyors in Regina.

At the annual meeting of the Association of Ontario Land Surveyors, J. S. Dobie, '95, was elected president for the coming year.

A. A. Kinghorn, '07, for seven years connected with the works department of Toronto, and for the past several years superintendent of roadway construction, is now manager of the Asphaltic Concrete Co., Limited.

J. Hutcheon, '90, civil and municipal engineer, Guelph, has accepted a position in the Department of Lands, Forests and Mines at Toronto.

H. Gall, '10, until recently with the Canada Foundry Co., is now assistant engineer to Frank Barber & Co., Toronto.

M. Pequegnat, '08, for several years demonstrator in drawing, leaves the staff at the close of the term to assume the duties of engineer of Berlin, Ont.

A. Schlarbaum, '09, is hydro-electric engineer for the Riordan Pulp and Paper Co., at Merritton and Hawkesbury, Ont.

V. C. Thomas, '08, has accepted a position with the Ontario Power Co. at Niagara Falls, Ont.

F. C. Rust, '11, is in the engineering department of the Vancouver Island Power Co., Limited, at Victoria.

G. P. Stirrett, '08, is resident engineer for the Canadian Northern Pacific Ry. at Spence's Bridge, B.C.

J. E. Grady, '09, is instrument man for the Transcontinental Ry. at Cochrane, Ont.

C. K. Nixon, '11, is engineer of tests, with the Edison Illuminating Co., of Detroit, Mich., in charge of the testing of isolated steam, gas, etc., plants for the benefit of consumers about to install electric power.

THE MAKING OF GOOD ROADS

By W. B. Dunbar, B.A.Sc.

The construction of roads, or artificial ways, is one of the first steps taken with the spread of civilization in the opening up of a country for the accommodation of travellers and the carriage of commodities. Road builders may be looked upon as pioneers in the material advancement of a nation, the condition in which the roads are maintained being a fair indication of the progress or prosperity of an age or people. Canals and railways have, no doubt, in modern times superseded, to some extent, the common highways; yet, these retain their importance, if only as essential auxiliaries.

The natural resources and manufactures of a nation can only be developed by communication between towns and rural districts, or, in other words, the road is so necessary an instrument to social well-being that in every new colony it is one of the first things thought of. The new country as well as the old can only be effectually opened up by roads, and until these are made it is virtually closed.

The evolution of the modern road can only be adequately understood by reference to the practice from the time when the great military roads of the Romans were built to the present time.

The Romans were undoubtedly the greatest road builders of ancient times. Owing to the situation of their vast possessions and their desire for conquest, it was very important that they should have a rapid and satisfactory means of travel. Except where some natural barrier made it impossible, the Roman roads were almost invariably in a straight line, probably because the chief means of transport then in use were beasts of burden and not wheeled vehicles, which made the preservation of the level of less consequence. Investigation proves that the Romans were masters of the art of road building. The substantial character of their roads is perhaps best demonstrated by the fact that they have, in some instances, borne the traffic of two thousand years without material injury. A good example of this is the Appian Way, one of the earliest and most famous of roads.

The reputation of many of the pioneers in civil engineering was, to a large extent, based upon their success as road builders. It is well known that the art of road-building in Europe has practically disappeared with the Roman Empire, and from one hundred and fifty to two hundred years ago the arteries of commerce were so defective in these lands that freight had to be transported, to a large extent, by pack trains, the apologies for roads being almost impracticable for wheeled traffic.

The pioneer of modern methods of road-building seems to have been M. Tresaguet, who was appointed inspector-general of the French department of roads in 1775. He was followed by Telford and Macadam, in England, the former's splendid road from London to Holyhead being one of the greatest engineering feats of his day. Not only was the road better than the track it replaced, but it effected a large saving in distance over the old, and still more important, the total height up which loads had to be lifted was reduced.[1]

It is well known that the great movement for better roads set on foot by Telford and Macadam received a set-back with the introduction of railways. As these become more and more evident, traffic fell away from the country roads, except such as acted as feeders to the railways. The principles of Telford and Macadam were forgotten, or at least set aside, and the condition of the roads fell into a deplorable state.

However, with the popularization of wheeled vehicles for pleasure purposes in the early eighties, complaints as to the dangerous and defective condition of many of the roads were rife. The introduction of motor cars has, without doubt, revived the dust problem, of which little has been heard since the passing of the stage coach. But the dust problem is not the only one to be faced. The increased use of motor vehicles for pleasure and commercial purposes, and the use of steel studs, chains, and other non-skiding devices have called the attention of the country at large to the unsatisfactory construction of the roads.

In the early days of Canada, when the only means of traffic by land was on foot, the roads, or trails as they were called, were only distinguishable from the surrounding bush by blazes on adjacent trees. But as the country became settled, the desire for a better means of communication was manifested. The settlers, banded together, cut paths through the forest, and cleared them so that wheeled vehicles could travel. These served for a number of years, but were replaced by the turnpiked earth roads. As years went on, and the condition of the country improved in many ways, the roads experienced a corresponding improvement, and the construction of highways was given over to associations which financed the improvement by a system of toll-gates. There a toll was collected from all except pedestrians, who passed along the road. Soon, however, municipalities took over their own roads, and the days of corduroy roads, log culverts and fords, passed into history.

In regard to the advantages of good roads, nothing has as yet been said, but it is a question which cannot be overlooked. Good roads bring progress and prosperity to the community. Not only do they increase the value of the adjoining properties, but they aid greatly in the social and educational welfare of the community. In regard to cities, it is acknowledged that good roads go a long way in the solution of the question of the high cost of living. They allow the farmer, by reducing the cost of transportation, to market his goods at a lower price, and still make a substantial profit. Well paved city streets and country roads make habitations along them desirable and encourage pleasure driving. Noiseless and comparatively dustless pavements are being recognized as essential elements in maintaining the health of a community, and not the least of the good results is the bringing of country and city into closer relation with one another.

1 Roads and Road Making, Eng., July 15, 1910.

The direct benefits to country districts are many:

1. Decrease in cost of haulage.
2. Better facilities for marketing. For those living near cities advantage of market gardening.
3. Marketing of produce at most favorable time.
4. A wider choice of market.
5. Equalizing of railway traffic and mercantile business between different seasons of the year.
6. Promotion of social and intellectual intercourse between members of rural communities, also between rural and urban populations
7. Consolidation of rural schools and the increase in their economy and efficiency.
8. Facilitation of rural mail delivery.
9. Increase in value of rural properties.

Cities derive their benefit in the following ways:—

1. Decrease in cost of transportation.
2. Increased fire protection.
3. Improvement of appearance of streets.
4. Improvement of standard of sanitation and health.
5. Facilitation of social intercourse and pleasure driving.
6. Enhanced value of property.

Many advantages are common to both city and country. Thus, seeing what is offered by a system of good roads, is it any wonder that the country, as a whole is being aroused into action for the betterment of their condition?

Width of Country Roads

In laying out country roads, there are many conditions which have to be considered. The traffic on a road is one of the main points defining the width. Will the traffic always remain light, or is there a chance in the future, of the road becoming part of a village or town, or of a main road leading to a town or city? The greater the width of a travelled roadway, the greater the cost of construction, and in this country of frost and sunshine, the greater the difficulty of maintaining a satisfactory surface. An earth road of greater width than twenty-four feet cannot be efficiently drained. When such a road of greater width is crowned sufficiently to shed the surface water to the ditches, a vehicle driven along the side is necessarily tipped to an inconvenient or uncomfortable angle, and hence the tendency to keep traffic in the middle of the road. The result is that frost and rain destroy the road surface to such an extent that, when the frost disappears in the spring, it leaves the crown so uneven that it holds water over its entire surface and makes the road practically impassible. When this surface, so rutty and broken, finally dries out, the roughed-up material is ground to dust by traffic, and is either blown away, or remains to form mud when frost and wet return.

The average carriage which traverses a country road occupies from five to six feet of road surface and it is hence, able to pass another comfortably on a roadway from fourteen to sixteen feet in width. The widest vehicle in use is, perhaps, the wagon loaded with hay. This will cover, in extreme cases, a width of not more than twelve feet, and hence could pass another comfortably on a road twenty-four feet wide.

The question of roads on hills must also be considered. An excessive width of road (especially on steep hills) is in danger, in times of heavy rainfall, of being washed out by water using the wheel tracks instead of the ditches as a means of run-off. With a narrow road the danger is not so great, since sufficient crown can be obtained without making the side slopes too steep for this to occur.

The regulations respecting highways, published by the Provincial Government of Ontario, call for a width of roadway on cuts and fills of not less than eighteen feet. Main roads should be graded to a width of twenty-four feet, and roads of least travel should not be less than eighteen feet.

The engineer, in laying out the roadway for surfacing, must use his own judgment as to the width which would be most suitable for

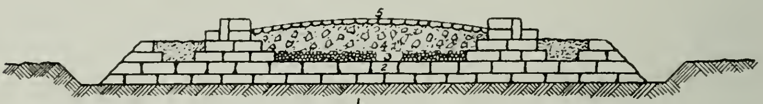

Fig. 1. Cross-section of The Appian Way—1, Solid subsoil; 2, Flat stone laid in mortar; 3, Well beaten Rubble; 4, Gravel or broken stone and lime; 5, Stone blocks fitted into place

the particular traffic for which the thoroughfare is intended, but an average width seems to be twenty to twenty-four feet on the level, and sixteen to eighteen feet on heavy grades.

Width of Town and City Streets

In considering town and city streets, the main elements which determine the width are traffic, cost, and, in built-up sections, the proximity of buildings. Before commencing the discussion, however, we must classify the streets according to the traffic they must carry, or the district they are intended to serve. The three main districts are wholesale, retail and residential, but in laying out streets for these considerable foresight has to be used, as it is often difficult to tell to which class a new street may belong.

As a rule, a wholesale street is not a thoroughfare, and consequently, a width that will satisfy local conditions will be sufficient. But one tier of trucks can be loaded in front of any building at one time. The largest trucks, when in position for loading, occupy from ten to twelve feet. If the opposite side of the pavement be so occupied, twenty to twenty-four feet in all will be blocked to transient travel on the street. In general, the width of the roadway should be sufficient to allow trucks to load on both sides without impeding the lines of traffic each way. If a width of forty feet be assumed, a width of sixteen feet will be open to traffic. It is probable that both sides of the street will be occupied most of the time by the largest trucks, so that traffic could move fairly well in both directions under these conditions.

Retail streets are governed by different conditions. The street is used by a large number of both vehicles and pedestrians, hence, a larger sidewalk has to be provided, and this will necessarily decrease the width allotted to vehicular traffic. In general, since the majority of vehicles will not occupy more than eight feet of roadway, a width of thirty-two feet will be ample allowance for vehicles standing at the curbs, and a line of traffic each way in the centre.

Streets with car tracks should have a width sufficient to allow a team to pass between the car and another team standing at the curb. To accomplish this, a width of forty-four feet would be required. However, existing conditions must be taken into consideration, and the sidewalk not made too narrow.

For residential streets, or any streets not in the business section, allowance for three lines of traffic will be sufficient. To accomplish this, there will be required a width of twenty-four feet. This leaves room for boulevards, which add much to the appearance of a residential street. But on such streets used as thoroughfares, and on those with car tracks, a width of thirty feet will better satisfy the conditions.

Drainage—Surface and Subsoil

Good drainage is the first principle of road-building of any kind. The life of a pavement depends on the foundation which is really the underlying earth. The ability of earth to sustain a load depends almost entirely on the amount of water it contains. Most forms of earth make good foundations when kept dry, but when allowed to become soaked with water, are soft and soggy, and utterly unfit to withstand pressure.

Efficient drainage should consist of two kinds, surface and subsoil. The former provides for the speedy removal of water coming in contact with the surface of the road, and the latter for the removal of water from the subsoil, without which the life of the road is materially shortened.

Surface drainage is provided for by making the surface convex, thus running the water to the sides, and the subsoil drainage by a system of drains. A road built on a wet foundation will soon be destroyed by action of water and frost, and while it lasts, will be troublesome and expensive to maintain.

Different kinds of earth hold water to a different degree, and hence, require different forms of drainage. A sandy or gravel foundation will require little or no drainage, being sufficient in itself, but one of clay retains the water, and must be drained.

The centre of all roadways should be higher than the sides; the difference in elevation depending to a large extent on the road material, the longitudinal grade and the traffic it must sustain. Hence, rules for the proper crowns to give roadways can only be used as limited guides.

Many formulæ have been compiled with the view of reducing to a certainty the proper crown to give roadways, but if all elements are to be considered in the determining of street crowns, it will become too complicated a production to express in any formula that would be useful for designing purposes. What is wanted is a shape that will drain rapidly and easily, and at the same time, be as nearly flat as possible in order that it may not interfere in the freighting of heavy loads.

The forms of crowns are many and varied, among which the most prominent are—circular arcs, two straight lines joined by the arc of a circle, compound curves, elliptic and parabolic. The most suitable forms, however, seem to be the circular arc or parabola. These give the maximum fall at the gutter, which is a desirable feature.

A universal practice is to express the height of the centre above the gutter as a proportion of the width of the roadway. The following gives a very satisfactory rule for constructing crowns on country roads.

Kind of Surface	Rise in centre in prop. of width.
Earth	1 : 40
Gravel	1 : 50
Macadam	1 : 60

It is considered a good rule to establish ⅞ of the total rise at ¼ the width from the centre to the side, and ⅝ of the total rise at ½ the width of the roadway.

City streets are, as a rule, constructed of paving material other than the above, and do not require as much rise at the centre. The most suitable proportions for the different paving materials are given in the following:

[1]For pavements having a smooth surface, such as asphalt, creosoted blocks, grouted stone blocks, and brick, and having grade of two per cent., or less, with no car-tracks, make the crown one inch to each six feet width between the curbs.

For pavements having more secure foothold, such as stone blocks and brick with bitumen filled joints, Macadam and bitulithic, on streets having a two per cent., or less grade, make the crown one inch to each four feet of width.

If the street has car-tracks, deduct the total width outside to outside of rails from the width between curbs, and divide the difference (double width between track and curb) by six and four, respectively.

For grades between two per cent. and four per cent., use one-half the crown provided by the above computation.

For grades above four per cent. provide a crown equal to one-third that of above computation.

Provide one-third of the lateral fall between the crown and the quarter, and two-thirds of it between the quarter and the curb. By "quarter" is meant the point midway between the centre of the

1 Roadway Crowns—Warren—Can. Eng.—April 29, 1910. Page 420.

roadway and the curb, or, in the case of car-tracked streets, the point midway between the outside rails and the curb.

With regard to fixed formulae for road crowns, many have been devised, but all, in some manner or other, fall short of the desired attainment.

Under Drainage

Wet subsoils on country roads should be drained by a system of transverse drains, constructed of three-inch terra cotta or burnt clay tile, laid in V-shape with the point directed slightly up-grade. This point should be at least eighteen inches below the subgrade of the road, and the drains should have sufficient fall to run the water away readily. The distance between such drains may vary from fifteen feet to forty feet, according to the character of the soil, and the amount of water it contains.

The practice of putting these transverse drains at right angles to the direction of the road is not a satisfactory one, on account

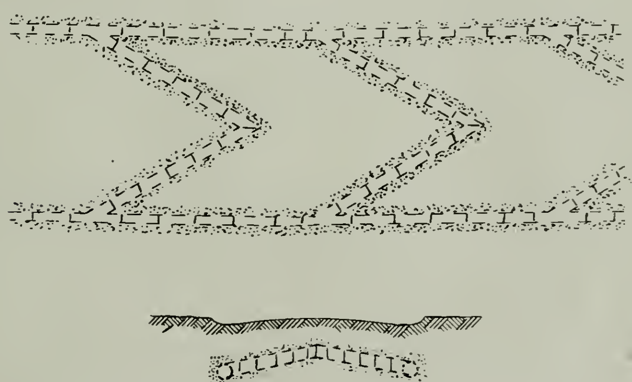

Fig. 2. Plan and section of V-shaped Drainage System

of the comparatively small area served by each of the drains. These transverse drains may empty into longitudinal drains under the curbs, and thence into the ditches, or directly into the ditches, in which case the outlet should be protected by a small wall of stone, brick, or other material from action of frost, and precautions should be observed to prevent choking up of the outlet.

In city streets where a practically water-proof pavement is laid, no transverse drains are necessary. Since no water enters the subgrade through the surface, the only source of danger is from percolation underneath the curb, or leaking water mains or sewers. This, however, is taken care of by placing a tile drain at a distance below the curb in order to lower the water line of the surrounding earth to a proper level below the pavement.

Curbs and Gutters

When the water has been drained from the surface of the road, it is caught in the gutter at the sides, and thence run through gullies into the sewers.

Closely associated with the gutter is the curb which forms a side for it to carry away the water, as well as defining the lines of traffic and improving the appearance of the roadway. As a factor in defining the street, the curb has to resist a great many disturbing forces, which may be classified as follows:

1. Pressure of earth behind, often augmented by piles of merchandise and building materials, tending to overturn it, break it transversely, or move it bodily from its base.

2. The pressure due to expansion of freezing earth behind and beneath it, especially where the sidewalk is partly sodded, and the ground is accordingly moist, tending to thrust the curb forward.

3. Concussions and abrasions caused by traffic, the defacement and injury caused by fires built in the gutters, and the breaking, displacing and destruction resulting from posts and trees set too near the curb.

The materials employed in the construction of curbs are: natural stone, such as granite, sandstone, etc.; artificial stone; concrete; iron, and vitrified clay blocks. Great care has to be exercised in the placing of the block forms, due to the tendency to displacement. However, if set in concrete, they form a very satisfactory curb. On account of the ease of construction, and the fact that it can be built in place, the concrete curb is coming into general favor, and in connection with the higher forms of pavement, the continuous curb and gutter. The attention of the reader is called to the city of Toronto specifications for concrete curb, as being essential to a more thorough knowledge of the subject of curbing.

From the gutter, the water is led through gullies into the sewers. They should be placed at intervals of two to three hundred feet along the gutter, the grade of the latter being such that the water will run away readily. A plan employed with much satisfaction in many cities is to locate the sewer under the centre of the street to which connection can readily be made with the gullies.

In country roads the water may be led directly into the ditches from the gutters, or drains may be placed below the gutter and filled with cobble stone and gravel, through which the water can percolate.

Gullies may be of brick, stone, iron or concrete, covered at the level of the pavement with cast or wrought iron gratings, or they may be let into the curb. The essential points of a street gully are:—

1. Area of open gratings and outlet drain should be sufficient to cope with heavy or sudden rainfall.

2. The grating must be so constructed as to permit of least possible obstruction or choking on its surface by road detritus, paper, straw or leaves.

3. Gully must be of adequate capacity to retain road detritus below the outlet pipe, and so prevent its entrance to the sewer.

4. It should be so constructed as to be easily cleaned out and readily cleared, should a stoppage occur.

5. Grating should be such that it will form the least possible obstruction to traffic.

6. It should be constructed of material not likely to be injured by tools used for cleaning. It should be strong and thoroughly water-tight, and extend far enough below the pavement to prevent damage by frost.[1]

Ditches and Culverts

Side ditches are provided on each side of the traveled roadway in the country, to carry away water from subsoil drains, and also that which falls as rain and snow on the surface of the road. They also intercept and carry away water from side hills and cuttings which would, otherwise, run upon the road.

The size of these ditches is determined by the drainage area, the amount of rainfall and the condition of the surrounding earth. The side slopes of ditches should be in the proportion of one and one-half feet horizontally to one foot vertically. The bottom, wherever practicable, should be at least twelve to eighteen inches wide, and the tops of the ditches should seldom be less than four feet wide. The depth should be such that the water will have the least possible chance of attaining the height of the road-bed.

The grade of the ditches should be great enough to drain the water rapidly away instead of allowing it to soak into the road-bed. In many cases, the natural grade of the adjacent ground will be sufficient, but in nearly level territory, an artificial grade will have to be provided. For this case a fall of two feet in each 500 to 800 feet will usually suffice. The ditch should have a free outlet to some stream or artificial waterway to keep the water moving, and the bottom should be free from pockets or depressions which would tend to hold the water.

On heavy grades, the bottom and sides of the ditches should be protected from the scouring action of the current created. A velocity of twenty-four feet per minute will loosen and transport particles of clay and sand. To overcome this, the ditches may be paved with cobble-stone, or small stone wiers may be constructed across the stream, thus slackening the current, and causing it to deposit suspended material.

Culverts

Wherever it is necessary that water should cross the road, whether it be that from side ditches or from small streams, a culvert should be built. The first essential in culvert construction is the size, which depends on the amount of water to be carried away. If made too small, and not specially protected at times of heavy rainfall there is a danger of the water damming up and causing a

1 Road Making and Maintenance---Aitken---Page 385.

washout; while, on the other hand, if too large, the construction is more costly than necessary.

The factors which enter into the problem of run-off are the area of the drainage basin, maximum rainfall per hour, the slope of the surface, the character of the soil, whether porous or compact, and whether or not it is wooded. Many tables have been prepared giving the size of culvert for any drainage area for a given rainfall. The following gives the area required in the locality where the average rainfall is thirty-five inches, which is approximately that of Ontario.

Column D Areas of drainage in square miles.
Column W Areas of waterway in square feet.

D	W	D	W	D	W
.01	2.0	.25	38.00	3.0	300.0
.02	4.0	.50	66.00	4.0	388.0
.04	7.5	1.00	100.0	5.0	455.0
.10	16.0	2.00	200.0	8.0	601.0

The efficiency as a waterway of a culvert of any size depends on the rapidity with which the water is carried away. This may be increased by so arranging the upper end that the water may enter

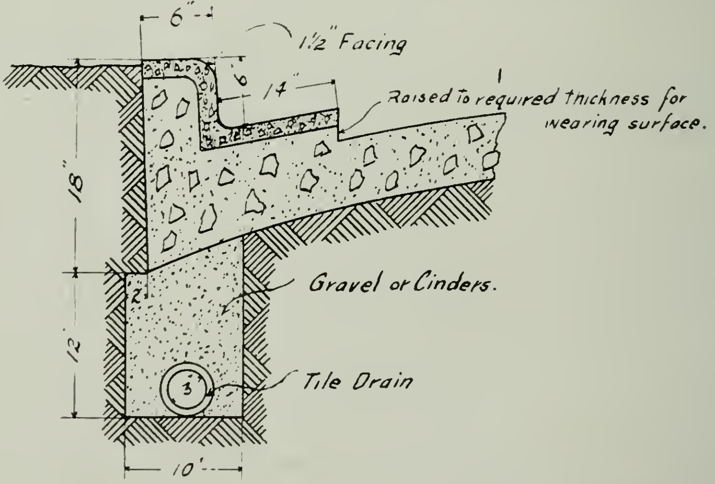

Fig. 3. Cross-section of a continuous Curb and Gutter

without retardation, and by increasing the inclination of its bed as much as the channel will allow. If constructed so that it may act under a head, the discharge will be greater, but this is impracticable for ordinary highway culverts.

Culverts should always, when practicable, be constructed at right angles to the direction of the road, Oblique structures are objectionable as being longer than if set at right angles, and also by reason of acute and obtuse-angled abutments and coverings necessary. In every case, they should extend the full width of the road, and should be protected by strong guard rails at the ends.

The materials used in the construction of culverts are stone, brick, vitrified earthenware and concrete pipe, iron pipe and concrete. Wood should be avoided as much as possible because, though its first cost is small, it lasts only for a comparatively short time, and is liable to cause accidents through failure when the wood becomes decayed.

Concrete and vitrified earthenware pipe are very satisfactory where the flow is small. In many places one line of pipe is sufficient to cope with the water, but when larger areas are required, two small pipes laid side by side are preferable to one large one, since, to utilize the full capacity, the water need not rise so high in the former as in the single pipe.

When laying the pipes, care must be taken to have the bed rounded to conform with the proper depressions for sockets. The top surface of the pipe should not be less than eighteen inches below the surface of the road, and all joints should be carefully caulked to prevent water oozing through and washing out the bed. In all cases, the upper end or entrance should be protected by a masonry wall to prevent the water working in and around the pipe and washing it out. This wall should extend below the frost line to avoid heaving. The lower or discharging end of the pipe should be laid in such a position as to overcome the scouring action of back-water, and the pipe must have sufficient inclination to drain freely, since any freezing of water in the pipes is liable to burst them.

Iron pipe has, of late years, come into prominence for culvert construction. There are two kinds, the cast iron pipe and the corrugated galvanized iron pipe, both obtainable in all sizes up to six feet. Both are in general favor, the latter more so on account of its ease of transportation in knock-down form, and of erection into place by means of bolts. Iron pipes, however, have a great tendency to corrode under the action of water, and by reason of this, care must be taken in selection to secure a sufficient heavy gauge of metal free from impurities.

The process of laying such pipe is similar to that of concrete and earthenware pipes.

Stone and brick culverts are usually constructed in the form of an arch, and are provided with wing and apron walls on both ends.

For large and small culverts, nothing can excel concrete for endurance, efficiency and comparative ease of construction. It can be built in any form desired and almost any size. If properly placed, concrete requires little or no attention after construction, hence, practically no cost for maintenance.

Some of the forms adapted to concrete are circular (built with collapsible forms), box or rectangular, arched and I-beam construction. In excavating for concrete culverts, the footings should be carried to a solid bottom, and the apron walls should be carried to a sufficient depth to avoid any chance of water getting underneath the culvert.

Earth Roads

The term "earth road" is applied to that form of road in the construction of which earth alone is used. This class of road is probably the most common in country districts, and is, no doubt, the cheapest in first cost. Earth roads are at their best during the dry seasons, but with proper construction and maintenance may be considered good in any season.

The first step in the construction of an earth road is that of defining the centre line over which a system of levels should be taken. The problem of drainage should then be solved, for no road will endure that is not properly drained.

The work of construction should begin by ploughing up the surface and removing all sod from the roadway, it being undesirable because, though seemingly good material, the vegetable matter soon decays and forms, with the earth, a soft muck. The subsoil along the sides of the road should then be ploughed up parallel with the centre line, and the depth of the required ditches established. By means of a grader or scraper, it is thrown into the centre of the road, and worked into the required shape. It should then be finished off with a roller, until all hollows are filled and the work presents a smooth and even surface. When this is completed, the road is ready for traffic.

To keep the road in good condition is an easy matter, provided the right method is employed. When it shows signs of cutting into ruts, a split drag should be used. Greatest success will be achieved just after a rain, when the earth is soft, but not sticky enough to roll into clogs. The drag should be drawn up one side, and back the other until all ruts are filled. If holes have been made which are too deep to be filled by this method, earth of the same nature as that of which the road is made should be shovelled in, and tamped to an even surface. In no case should stones be used to fill up an earth road, as they will not wear off even with the rest of the road, and will form a hard ridge or a bumpy surface.

In the fall the road should be dragged to put it in good condition for winter. Gutters and ditches should be cleaned and culverts freed from rubbish. If this has been properly done, the road should be in a fair condition in the spring, when, under action of wind and sun, it will soon become hard and dry.

Sand roads are almost the opposite of earth and clay roads. They are at their best when wet. When dry, the sand has not sufficient stability in itself to sustain a load.

In constructing sand roads, the ditches and gutters should be made only large enough to carry away the rain water, as otherwise, they would have a tendency to dry out the road. Vegetation should be induced along the sides to conserve the moisture and to tend to prevent picking up of road material. Sand roads may also be improved by rolling, and it is possible by the addition of clay to the sand to make a road which, under moderate traffic and favorable conditions of climate, will be fairly serviceable.

Gravel Roads

Gravel roads are usually constructed on an earth foundation with gravel as the wearing surface. Gravel, unlike earth and sand, is not a simple material, but is a mixture composed of pebbles, broken fragments of rock, and sand or clay. Gravel for road-building must be carefully selected, so as to contain properly graded constituents. Too coarse a gravel will, undoubtedly, leave too many voids for entrance of water, thereby ruining the road; and again, gravel containing too much clay or sand makes a muddy road during wet weather, and is easily rutted even by moderate traffic. For best results in general, considering ordinary gravels, all stones that will not pass through a two and one-half inch mesh should be screened out. At least fifty per cent. by weight should consist of pebbles or fragments which will not pass through a one and one-quarter inch mesh; at least eighty per cent. should not pass through a one-half inch mesh, and the remainder should consist of small fragments of pebbles and sand from less than one-half inch in diameter to an impalpable powder. Although such gravel as this is very rarely or practically never found, it is offered as an ideal to be approached as nearly as possible.

In the construction of gravel roads, the bed is prepared with earth or clay shoulders at the sides leading to the gutters. The

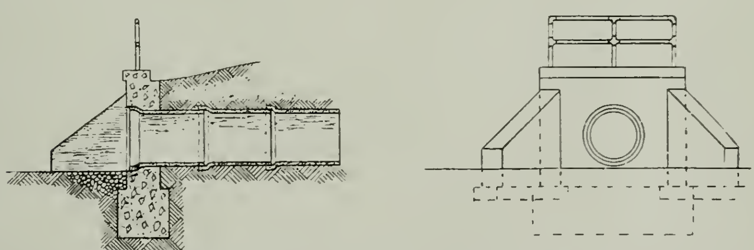

Fig. 4. Section and Elevation of the Concrete Head and Wing Walls protecting a Tile Culvert

subgrade should be well rolled, preferably with a steam roller, to the same crown as if desired on the finished road. The gravel should then be applied in thin layers, each layer being rolled before the next applied, until the required thickness of wearing surface is obtained. The process of consolidation will be aided by the addition of a little water. It should be continued until the pebbles cease to rise or creep in front of the roller. In applying the gravel, care should be taken to have a uniform mixture from top to bottom. Large stones, if placed in the bottom, have a tendency to rise under the action of frost, and vibration caused by traffic, and tend to disrupt the surface.

To maintain gravel roads, all that is necessary is to rake the loosened pebbles into the centre of the road where they can be consolidated by traffic. In the case of ruts and holes appearing, a thin layer of gravel should be tamped in, and then another, and so on, till the even surface is restored. When great thicknesses of gravel are added at one time, the surface becomes compact, while the body is comparatively loose. This, under action of traffic and water, will soon destroy the road.

Macadam Roads

The process of macadamizing a road consists in compacting together, on a prepared subgrade, a number of layers of broken stone, which forms a surface to carry traffic. This form of pavement has been used to a great extent on main roads of travel in the country, and as a secondary paving in towns and cities. Macadam roads are suited to varying conditions. They have stability to withstand fairly heavy traffic, furnish good foothold for horses, and do not become slippery when wet. But the macadam road has one great objection, namely, it is very dusty in dry weather.

The qualities required in good road stone are toughness, hardness and ability to resist the disintegrating action of the weather. The fine dust made from powdering the stone should have more or less cementing action when mixed with water. Scrap rock forms a very durable and hard surface, but must be bound with limestone, dust, or some other agent. The stone should be uniform in quality, as otherwise, one place in the road will wear down quicker than another, thus forming holes and ruts to hold water, and assist in the destruction of the road surface.

The size of the stone depends, to a great extent, on the character of the rock. Hard rock should be broken finer than soft. It should be broken into pieces as nearly cubical as possible, since experiment shows that this shape binds best. When crusher broken, the stone should be screened by a rotary screen into grades as follows: dust, No. 1, ¼ to ½ inch; No. 2, ½ to 1 inch; No. 3, 1 to 2½ inches and tailings. The smaller the pieces used in the road, the smaller the percentage of voids, the more easily compacted and the smoother will be the surface of the finished road. The thickness of the wearing surface depends on the traffic, varying from six to twelve inches.

The essential points in the construction of a macadam road are:—

1. Proper drainage and rolling of the earth foundation.
2. The use of machine broken and screened stone.
3. Well sprinkled, but not over-flooded, with water.
4. Thorough consolidation with a steam roller.

The earth foundation should be carefully constructed, the subgrade thoroughly rolled until it presents a smooth and even appearance. Hollow places will gradually collect water, becoming soft and undermining the road. On this prepared subgrade, a layer of No. 3 stone and tailings should be spread, and thoroughly rolled. (When the subsoil has a tendency to be wet, a layer of large, flat stones may be laid in the bottom, forming what is known as a Telford foundation). A layer of grade No. 2 is then applied and rolled as before. Then a layer of No. 1, sufficient to bring the surface to the desired crown, is added and rolled until the stones cease to creep before the roller. As it stands at this juncture, the road will contain from thirty-five to forty per cent. of voids. To fill these and also act as a binder, a coat of screenings is applied. This should be watered and rolled until a wave of grout passes along in front of the roller (brushing with large street brooms aids in working the grout into voids). At this stage, rolling should cease, and the road blocked to traffic for a sufficient time to allow the grout to set. In the last process care should be taken not to add too much screenings. They, when dry and ground to powder, form dust and mud when wet, and in frosty weather are likely to aid in the destruction of the pavement. A road constructed after this method is called a water-bound macadam, and is the kind in general use.

In many places at the present time, tar is being used as a binder. It eliminates the dust problem in dry weather, prevents the absorption of water which under action of frost disintegrates the macadam. It also serves to keep the aggregate together under the action of motor traffic. The methods of applying the tar to the stone are very numerous. Almost every company putting binders on the market has a different method of laying the pavement. The chief methods are: (1), penetration, where the binder is sprayed from a cart or applied with a hose under pressure, and (2) mixing the stone with the binder previous to laying. In both cases, the stone should be perfectly dry and the tar applied hot. The stone is laid in layers, and, as in the case of water-bound macadam, each layer is thoroughly rolled.

To maintain a macadam road in good condition, the surface should be kept free from any substance which will tend to make mud. In wheel tracks during heavy rains, will develop streams that soon wash out the binder. Loose stones, or any other substance which would cause any unusual impact, should be kept off the road. The use of water to lay dust should be limited. Traffic should be distributed over the entire surface. Free drainage should be provided at all times. In case of a rut or a hole appearing, the dirt should be cleaned out, the material in and around it loosened, and a sufficient quantity of new material added, so that when thoroughly tamped, the smooth surface will be maintained. If a considerable portion of the road is to be repaired, the old surface should be loosened up with a scarifier, graded off, new material applied and rolled down, as in the construction of a new road.

O. T. G. Williamson, '09, is engineer for the Canadian Stewart Co. at Princess Louise Embankment, Quebec.

Alan Fraser, '10, is assistant engineer with the Toronto Iron Works, Limited.

L. W. Klingner, '07, is resident engineer for the Crow Lake branch of the Canadian Pacific Railway.

W. O. Boswell, '11, has taken a position as electric-chemical engineer for the Tivani Electric Steel Co., of Belleville, Ont.

CLASS '13 GRADUATING DINNER

The Fourth Year held a final re-union as an undergraduate body on the evening of March 11th, in which eighty-four of its members participated. As guests, Dean Galbraith, Dr. Ellis, Professors Wright, Angus, Haultain, and Mr. Young were present. The evening's proceedings were well interspersed with a variety of entertainment. Mr. Blain furnished several violin solos and showed his ability as a trifler upon the strings to be of no small calibre. Mr. Goodman recited Drummond's "Stove-pipe Hole" in the precise manner the author would have prescribed, and Mr. Holden's exemplification of "Casey at the Bat" was likewise delivered as superbly as superbness may be applied to humor.

Dean Galbraith made a very hearty response to a toast proposed to him by Mr. Black. He referred to the building-up process which the School had undergone since its inception. He emphasized the need, among other things, of the curriculum undergoing a pruning operation. He felt that the lengthy list of subjects taught should be curtailed, as superfluity of instruction prevented, in a measure, the proper treatment of the most important parts of the course.

The toast to the Faculty, proposed by Mr. Rous, was replied to by a number of the members of the class, their remarks bearing largely upon the pleasant associations between staff and students during the past years, and a hope that the end of the undergraduate trail did not mean a severance of the many friendship ties formed within that time.

"The Future"

Professor Haultain responded to Mr. Mutch's toast, "The Future." His remarks summed up the chief requirement of the future in an evolutive review of the past.

"The whole existence of mankind is generally assumed to have lasted not less than 240,000 years. It may have lasted much longer, it cannot have lasted less. If this period be represented by a day of twelve hours, then each hour would represent 20,000 years, each minute 833 years. If we imagine that we of the present are living at noon on that protracted day the startling fact comes out *that for over eleven and a half hours there is nothing to record*. At twenty minutes before twelve the earliest vestiges of Egyptian and Babylonian civilization begin to appear. Greek literature is seven minutes old. At one minute before twelve the Advancement of Learning makes its appearance. The steam engine is only half a minute old.[1]

"Yes, the engineer as we know him is only a matter of a few seconds. That is a long back-sight and if this story of the geologists is true, what was happening during those eleven and a half hours? and what sort of a line does it give us for the future? No doubt if our sight were clear we could read here much of the riddle

1 John Adams: The Evolution of Educational Theory, p. 86.

of existence. Though little apparently has been recorded, much was accomplished during that quarter of a million years. Very enduring foundations were being laid, very definite trails were travelled, and it may be taken as an axiom that the earlier the foundation, provided that it has survived, the more enduring is it to-day. What more surprisingly constant than our blood temperature of normal health? With no other reason than their ancient origin, how persistent are some of the likes and dislikes; tendencies that are called instincts, our disgust at the smell of putrefaction, our delight at fresh rain on dry earth, our instinctive following of a leader. Everybody, old and young, black, yellow, and white, likes the open fire. It was the first luxury of our own commanding. For long it was almost our only luxury. It may have been that it was for the sake of the fire that we left the tree tops.

"The beginnings of the foundations of our modern civilization go back a long way. Organized co-operation and language are at the base of things. Organization we had without language—that came with the fighting animal. Language grew at the fireside; grew for and with the story-teller. As the luxury of our fire brought us to our feet and set our backbone upright, so story telling led us by psychic ways still further from the mere animal. The physical champion was the great man of the tribe, but the story teller was the advanced man and was a leader in all things other than war. Later he became a scriber on bone, a teller of stories in picture. Mimicry and song had helped his meagre language, and thus we find the story teller laying the foundations of all that we understand by art, wherein we are to-day furthest removed, in our activities, from the animal. The story teller has been in the vanguard of all progress since the beginning. The story teller to-day commands the attention of the tribe and of the individual as nothing else. The physical champion without the story is but little. It is the moving picture rights that bring the money. Roosevelt received $350,000 for his services for seven years as president of the United States, but he received a million for the story of his African holiday.

"The story draws and holds as does the fire. Without the hearth there is no home, and without the story there is no hero. This is one of the trails that has been trodden since first we had a trail. A psychic trail it is, a nerve path but none the less definite. Man now treads unconsciously but surely this much trodden trail of two hundred thousand years. We engineers, we of the last few seconds, are so busy with our work that we think we have not time to tell the story, much less time to learn how to tell it. And our trail is so new, pushed ahead so far and so rapidly, that the professional story teller is left behind; he can neither follow nor understand. We achieve, but the story is lacking, and the public does not recognize the greatness of the achievement. Gentlemen, you are going out into the finest work of the world, the finest opportunities for your activities that have ever presented themselves to the young man. The engineer is doing the world's work to-day, but he is not recognized nor paid accordingly. We must learn to

FOURTH YEAR EXECUTIVE, 1912–13.

Standing: R. L. Hearn, Sec'y-Treas.; G. J. Mickler, Rep. Mech. and Elect.; W. K. Thompson, Rep. Chem. and Mining; D. Blain, Rep. Civils and Arch.
Seated: H. A. Hawley, President; Dean Galbraith, Honorary President; B. S. Black, Vice-President.

tell our own story. And remember—the story teller is not merely the translator of events into words or pictures. He is a keen student of man, of the peculiarities and needs of the listener, because a story is not really a story without the interest of the listener. What the engineer needs more than anything else to-day and to-morrow is something of the art of the story teller. Without the story our achievements are nought: we are merely hewers of wood and drawers of water."

The Average Man

Mr. C. R. Young's congratulatory remarks to the year contained special emphasis on the place of the average man in engineering. Paradoxical though it might seem, the average man very frequently out-distanced his brilliant competitor in life's work as a result of certain qualifications of a modest, and perhaps of an almost commonplace, character. His better appreciation of relative values, his business sense, his balance and normality, brought him into positions of trust and large responsibility, while the man of outstanding ability often confined himself to narrow fields of special investigation, little known and less appreciated by the employers of engineers. The average man derived success, too, from his ability to get along with others—a rare qualification of the genius. Friendly intercourse and pleasant relationships between men were, the speaker held, an asset of very great value to the engineer.

Another factor which he claimed to belong to the ultimate triumph of the average man was the fact that he carried a greater reserve of energy than the man of spectacular attainments. When the latter, through extraordinary labors and disregard for Nature's limitations, had worn himself out, the man of no future moved steadily onward and carried vast enterprises to successful completion.

The Electrolytic Cell

Dr. Ellis, when called upon for a few remarks, spoke of the School, and in the following estimable manner:

"This School is a great electrolytic cell—a contrivance for transmitting intellectual energy to supply the needs of the world. Some of this intellectual energy, like coal, has been stored up during the ages of the past, and must be obtained by digging and delving among the deposits of bygone learning. Some, like flowing water, is pulsating with the life and movements of the past.

"In this cell we, the teachers, are the anodes. Whether we be of expensive platinum or of cheap retort carbon, our function is the same, to collect this energy brought to us by cables of many kinds, by books, by journals, by conversation, by experience—to bring it into the cell and to give it up to the ions—to you, the students, whose function it is to carry each his own charge of intellectual energy to the cathode, to the place where it is wanted, to the negative electrode representing, as I have said, the needs of the world. Your capacities for carrying intellectual energy are not all the same. Some are mono-valent, some di-valent and some poly-valent. It is enough if each of you carries his proper charge—he can do no more, and he ought to do no less.

"You carry your charge to the cathode and you give it up, and take your place in the world as free elements, some as polished silver, some as brilliant copper, some as useful nickel and some, possibly, as bubbles of gas.

"But what about those ions whose charge of intellectual energy is negative? They go back to the anodes and are removed from the cell.

"Experience has discovered an interesting law with regard to these negative ions. The number of them discharged from the cell varies inversely as the square of the time. If there are twenty of them in the first year there will be five in the second year, 2.2 in the third year, and only 1.25 in the fourth year.

"I am sure, gentlemen, that those negative ions are not with us here to-night. They are either at home vainly trying to crowd a tri-valent charge on a mono-valent ion, or they are elsewhere taking part in secondary reactions tending to impair the efficiency of the cell."

An important part of the proceedings, the election of officers for the next three years, resulted in Mr. E. R. Gray as president, and Mr. C. C. Rous as secretary-treasurer. The executive committee consists of the following men in addition: Messrs. R. L. Hearn, civils; W. K. Thompson, miners; F. R. Sims, mechanicals; F. W. Beatty, railways; H. D. Livingston, architects; and H. L. Seymour, for the sanitary engineers. The executive has already assumed its duties to the extent of calling the attention of the class to essential points in its organization proceedings. A careful compilation of the home and business addresses of each member, together with his occupation and other interesting news regarding him is in preparation, and a class fee of $1.00 for the next three years has been arranged to defray the expenses which the next reunion will incur. The enthusiastic manner in which the class as a whole is launching itself as a graduate organization is worthy of compliment and the old adage concerning things well begun comes to mind. APPLIED SCIENCE wishes the class great success, not only in its organization, but in the professional welfare of its individual members.

G. H. Wilkes, '11, is with the Massey-Harris Co., Toronto, as draftsman.

G. Kribs, '05, is chief engineer of the Texas Power and Light Co., at Dallas, Texas.

TREASURER'S REPORT

Owing to the pressure of examinations throughout the month of April, and also to the fact that a number of accounts have not, as yet, been received, the final report of the treasurer for the financial year of the Society ending March 31st, 1913, has not been presented. It will be published in the May number of this journal.

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EDITORIAL

THE NEW DEGREE

The Calendar for 1913-14 has been out for several weeks. Its earlier appearance makes it much more useful to the undergraduates, who can better equip themselves with an idea of their next year's work, while they are still at hand to discuss it with each other and with members of the staff. Every year the Calendar is an indication of the activities at the School, and gives in plain facts the improvements which the year has brought to the curriculum. The 1912-13 calendar announced the addition of a new department, that of Metallurgical Engineering, prepared to provide instruction throughout the four years to those students desiring to enter that branch of the profession, the academic work before graduation to be supplemented by at least eight months' experience in metallurgical work.

This year a new degree has been announced. A graduate who has attained the degree of Bachelor of Applied Science (B.A.Sc.), may spend an additional year in attendance as a student in the Faculty of Applied Science and pass an examination and prepare a thesis upon a course of study approved by the Council, and thus be eligible for the degree of Master of Applied Science (M.A.Sc.)

A new degree has been the subject of discussion for some time in the Faculty Council and in the Senate Chamber of the University, and its establishment at this time marks an important advancement in the Faculty of Applied Science. In all probability many graduates who have had the benefit of several years in the pursuit of various branches of the profession, and who feel a need of further study and instruction in some special branch, will avail themselves of this long felt want, now at their disposal.

HIGHWAY ENGINEERING

If the subject of a fourth year man's thesis is an indication of the branch of engineering in which he is most interested, highway construction and maintenance is an exceedingly popular branch among those who have gone up for the degree of B.A.Sc. during the past several years. The percentage of men specializing in this work during the fourth year is increasing in accordance with the development of the popular good roads movement in Canada and the United States. The engineer is rightly busying himself in the cause of better thoroughfares. Being specially fitted for the work he should apply his capabilities toward improving existing roads and constructing new ones. He will thus enhance to an interesting degree in the community the profession which he follows.

Frequently an engineer is criticized because he remains aloof from discussions affecting municipalities in general. To him such considerations may at times appear to be matters beyond the horizon of his work. Highway improvement, however, is a subject before municipal associations and similar bodies into which the engineer should enter without hesitation. The public needs and will welcome his advice and co-operation. The construction of a good road is a problem for the engineer.

In the civil engineering course in the Faculty of Applied Science the fourth year men are afforded a lecture and laboratory course of about eight hours per week, dealing with the design and construction of highways and pavements, and with the study and testing of various materials used in such work. The course is associated with a similar course in sanitary engineering, as one of the options of the final year. The work in highway engineering has been in charge of Mr. A. T. Laing, B.A.Sc. This week Mr. Laing goes to Europe, where he will study the roads of England, France, Italy and other countries, and will also attend the International Road Congress to be held in London, June 23rd to 28th. The information and road data which will be accumulated during this investigation will be an added asset to the course, which, as one of the youngest in the Faculty, is already making a fine showing.

THE ANNUAL ELECTIONS

This yearly event was marked with the usual enthusiasm and few are the events in the college year that equal it in importance. Candidates did not enter the field as early as usual and very little excitement prevaded the atmosphere of the studious month of March until the appearance of the election daily, the "Toike Oike," on the morning of the day of nominations. This is the third year for the publication and, given over entirely to the policies, platforms, qualifications and advertising data of the would-be office holders, it very efficiently fulfilled its purpose. It appeared at eleven a.m. on the Wednesday, Thursday and Friday of election week, filled to the farthest corner with anticipation and advertising. Mr. N. L. Somers, '14, and Mr. G. G. Macdonald, '15, were the editors this

F. C. MECHIN
President of the Engineering Society, 1913-14

year, with Mr. J. A. P. Marshall, '14, and Mr. W. S. Steel, '15, as associates. They are to be congratulated upon the paper, neat in appearance, impartial in its editorial policy, prompt in distribution, and successful as a venture.

The presidential chair was contended for by Messrs. F. C. Mechin and G. M. Smythe. The latter entered the contest upon nomination day, which typifies, generally, the spontaneous action common among many of the candidates. The offices, however, were exceptionally well contested, and the shortening to several days of the election fever did not detract from the general excitement of the occasion, but rather stimulated the candidates and their supporters with promptness and alacrity in covering the entire filed.

The voting was divided between afternoon and evening sessions. The examination hall afforded an excellent accommodation for the evening's sports and final reckoning. Wrestling, boxing, roller hockey, etc., formed a programme of amusements, while the Toike Orchestra furnished a good musical programme throughout the entire evening. One of the important events among the former was a chariot race which will long be remembered for its uniqueness and for its close finish, taxing the capabilities of the judges to the elastic limit. The returns were completed before eleven o'clock and as the sports had continued uninterrupted until that time, a great deal of credit must be given to Mr. W. T. Curtis for his excellent floor management. The results of the voting is as follows:—

President, F. C. Mechin.

1st vice-president, F. S. Rutherford.

2nd vice-presidents—civils, R. E. Laidlaw; mechanicals and electricals, K. A. Jefferson; miners and chemists, C. K. Macpherson (accl.)

4th Year representative, R. G. Matthews.
3rd Year representative, W. R. McGie.
2nd Year representative, H. B. Little.
1st Year representative (to be elected).
Corresponding-secretary, A. W. Sime.
Treasurer, W. G. Millar.
Recording-secretary, N. R. Adams.
Curator, C. Smythe.
Jun. Varsity representative, J. F. Young.
Senior Varsity representative, G. J. Mullins (accl.)

C. F. Szammers, '11, has gone to Hudson Bay as assistant to J. G. McMillan, '00, who has charge of the harbor and river survey work for the Ontario Government.

H. O. Hill, '07, until recently with the Riter-Conley Mfg. Co., has accepted a position with the Blaw Steel Construction Co., of Pittsburg. Mr. F. M. Bowman, '90, is vice-president of this company, and head of the structural department. Their new structural plant, with a capacity of 50,000 tons of fabricated steel per year, is near completion at Hoboken, Pa.

F. V. Seibert, '09, is carrying on a surveying and engineering practice in Regina and Edmonton.

J. W. R. Taylor, '08, is erecting engineer for the Canadian Westinghouse Co., Hamilton.

J. C. Murton, '10, is resident engineer for the city of Moose Jaw, in charge of the construction of a dam for a high pressure supply in connection with the city's fire system.

A. B. Mitchell, '08, is in Montreal, employed with N. McLeod & Co., on the city's harbor development.

DIRECTORY OF THE ALUMNI

This department began in November, 1912, and the entire list of graduates will be reviewed before the end of the year.

A number of corrections have been received bearing upon the part of the directory which has already been published, and our list of addresses is thus becoming more authoritative. If those whose names will appear during the next several months will assure themselves that our record of their location and employment is correct before publication, it will be improved still more, as there are some addresses upon our files that are long standing and hardly to be depended upon.

D (*Continued*)

Dunlop, R. J., '02, is a member of the National Refining Co., dealers in dental supplies, Toronto.

Dunn, T. H., '93 is at Winchester, Ont., in civil engineering and land surveying.

Duthie, L. J., '09, is surveyor and assayer for the McEnhanney Mines, Porcupine, Ont.

Dyer, F. C., '08, is demonstrator in mining, University of Toronto.

E

Eagleson, F. M., '08, is engaged in civil engineering, surveying, and municipal work at Winchester, Ont.

Eason, D. E., '01, is division engineer on the construction of the Trent Valley Canal, at Peterborough, Ont.

Eckert, C. H., '11, is with the Standard Chemical Co., at Longford, Ont., as chemist.

Edwards, W. M., '02, is a member of the firm of Duff & Edwards, engineers and surveyors, Lethbridge, Alta.

Edwards, C., '08, is with the Standard Chemical Co., Toronto.

Elliott, C. F., '11, is enrolled at Osgoode Hall, supplementing his engineering course with one in law.

Elliott, G. R., '11, is with the Department of the Interior at Calgary, on irrigation work.

Elliott, H. P., '96, is a consulting engineer with offices in London and Toronto.

Elliott, J. A., '11, is engaged as chemist with the Castner Electrolytic Alkali Co., of Niagara Falls, N.Y.

Elliott, J. C., '99, whose home is at Kelso, Ont., has no other address with us.

Elder, A. J., '04, is with the Department of the Interior, at Ottawa, in the Topographical Surveys Branch.

Elwell, W., '02, deceased Sept. 3rd, '09.

Emery, V. H., '10, is at the McIntyre Mines, Porcupine, Ont., as assistant engineer.

Empey, J. M., '02, is with the Department of Public Works, Calgary, as district engineer and surveyor.

English, A. B., '90 (deceased).

Evans, S. D., '07, has no other address than his home at Leamington, Ont., upon our lists.

Evans, S. L., '08, has Corinth, Ont., for his home address. We have no record of his professional work.

Evans, W. J., '10, is in the employ of the Canadian Westinghouse Co. at Hamilton, Ont.

Ewart, J. A., '94, resides in Ottawa, Ont., where he has an architectural practice.

Ewart, F. R., '07, is in Toronto, with the Toronto Hydro Electric System.

Ewing, E. O., '08, is in Toronto. He is engaged in surveying and structural engineering.

F

Fairburn, J. M. R., '93, is with the Canadian Pacific Railway as assistant engineer, located in Montreal.

Fairchild, C, '92, is connected with the Dominion Government, Department of the Interior. His home is in Brantford, Ont.

Fairlie, H. W., '10, is in the employ of the Northern Electric & Mfg. Co., Montreal, as sales engineer.

Falconer, F. S., '09, is with the topographical survey branch, Department of the Interior, Ottawa.

Fargey, T. A., '09, is electrical engineer for the Scott Bros. Electric Co., Detroit, Mich.

Farrell, K. A., '11, is assistant engineer with Speight & Van Nostrand, Toronto.

Farelly, T. J., '11, is with the Bell Telephone Co., Montreal, in the transmission department.

Fear, S. L., '06, is in charge of the gas engine department of the Canada Foundry Co., Toronto.

Fensom, C. J., '03, is conducting a consulting practice in mechanical engineering, Toronto.

Ferguson, G. H., '05, is assistant engineer to the Commission of Conservation, Canada.

Ferguson, J. B., '09, was in Chicago when last heard from. We have no address for him at present.

Ferguson, J. W., '10, until recently with the Dominion Bridge Co., Montreal, is now in Toronto.

Ferguson, A. T., '09, is a member of the firm of G. T. Fergusson & Co., stock brokers, Toronto.

Fierheller, H. S., '05, deceased, June, 1910.

Fingland, W., '93, is engaged in architecture. His office is in Winnipeg, Man.

Fisken, J. B. K., '10, is a demonstrator in the department of architecture, University of Toronto.

Flanagan, O. L., '08, is resident engineer on the Prince Albert hydro-electric development at Prince Albert, Sask., for C. H. & P. H. Mitchell, Toronto.

Fleck, J. G., '04, is a member of the firm of Fleck Bros., Vancouver, B.C.

Fleming, G. R., S., '07, is with Atwell Fleming Printing Co., as superintendent.

Fletcher, A. W., '10, is in Calgary, Alta., with the Department of Public Works.

Fletcher, F. L., '10, is also on the staff of the Department of Public Works, Calgary.

Fletcher, J. A., '10, is with E. W. Robinson, D.L.S., Fisher River, Man., as assistant.

Flint, C., '08, is in the employ of the Canadian Pacific Railway on lines west of Winnipeg.

Flint, T. R. C., '10, has just completed a post-graduate course in engineering, University of Toronto.

Flook, S. E., '11, whose home is in Willowdale, Ont., is in the employ of W. S. Gibson, '04, surveyor.

Flynn, C. C., '11, is in Chicago, with the Western Electric Co., Limited.

Follett, R. C., '10, has no address upon our records except his home address, Oakville, Ont.

Forbes, D. L. H., '02, is a consulting mining and metallurgical engineer with offices in Toronto.

Ford, A. L., '04, is government inspector and engineer, Department of Railways and Canals, at Prince Rupert, B.C.

Foreman, J. M., '10, whose home is in Lucan, Ont., has no business address with us.

Forman, W. E., '99, was in Pittsburg, with the Westinghouse Electric & Mfg. Co., construction department, when last heard from.

Forrester, C., '93, had Indian Head Sask., as his address until recently. We do not know his present address.

Forward, E. A., '97, is engineer in charge of St. Andrew's lock and dam at Lockport, Man.

Forward, C. C., '06, is assistant analyst, Department of Inland Revenue laboratories, Ottawa.

Foster, A. H., '08, is manager of the Guelph Radial Railway Co. and Guelph Waterworks, Guelph, Ont.