No. 7 1893-4

PAPERS

READ BEFORE THE

ENGINEERING SOCIETY

OF THE

SCHOOL OF PRACTICAL SCIENCE

TORONTO

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CONTENTS.

PREFACE.

Early in the year 1885 the students then in attendance at the School of Practical Science organized the Engineering Society, with Professor Galbraith as president, the objects of the Society being the encouragement of original research in the science of engineering, the preservation and dissemination of the results of such research among its members, and the cultivation of a spirit of mutual assistance among the members in the profession.

Meetings of the Society are held in the School every alternate Wednesday during the session, at which papers on engineering subjects are read and discussed.

This year most of the papers have been presented to us by graduates and members of the profession, and for this kindness the Society desires to thank these gentlemen, and hopes that in the future they may continue to favor us even more than before, as by this means the student is able to gain some information as to the practical execution of work and the means of overcoming the diffculties therein met. But the Society has felt that more papers from its undergraduate members would not only be of great assistance to these gentlemen themselves, but also of great interest to the Society. To encourage this, the council of the School has decided to consider papers read by the students before the Society in the granting of honors at the annual examinations, and we therefore hope to have more undergraduate papers in our next pamphlet.

Hereafter the discussion on papers read will be published along with the papers, which will add greatly to the value of the pamphlet.

At the suggestion of Mr. T. K. Thompson, the dates of graduation of our members are given.

The present edition consists of 1,500 copies, which will be distributed among the members and engineers.

NOVEMBER, 1894.

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ENGINEERING SOCIETY

OF

The School of Practical Science

TORONTO

PRESIDENT'S ADDRESS

GENTLEMEN,—I have this afternoon to thank you for the honor you have conferred upon me in electing me as President of this, the representative society of the School of Practical Science. It is an honor of which I am indeed proud, and I am inexpressibly grateful to you for having placed me in the position, which I trust I may be preserved to occupy for the ensuing year.

I feel, gentlemen, that I can hardly fill the office of president as well and ably as my predecessors; but, having the very able and energetic committee that you have elected to assist me, I am confident that the affairs of the Society will be well and zealously guarded.

But, gentlemen, I would have you remember that the success of the Society does not depend solely upon the efforts of the president, or on the work done by the committee, but on the hearty co-operation of the members themselves.

It was my privilege last year to be a member of this Society, while ably presided over by Mr. Lea, and as a freshman I looked up to our friend, Mr. R. W. Thompson, as a gentleman possessed of great executive ability, and envied him the popularity he enjoyed, and so well merited.

Under the presidency of these two gentlemen we have had two unquestionably successful years, due largely to the generalship they displayed in conducting our meetings, and to the lively interest manifested by the students; and I hope, gentlemen, that you will this year take a still greater interest in the welfare of the Society.

On behalf of the Society I welcome those of you who are here for the first time, and to whom a word or two in regard to the working of the Society will not be amiss.

The officers consist of President, Vice-President, Corresponding Secretary, Recording Secretary, Treasurer, Librarian, Graduates' Representative, and one representative from each of the four years.

Meetings are held every second Wednesday during the academic year, at which papers, chiefly on engineering subjects, are read, these papers being published at the end of each year in the form of a pamphlet.

Leading engineering papers and magazines are subscribed for by the Society, and are on file in the library. A large quantity of drafting paper is bought each year and sold to the members by the librarian at cost price. Drawing covers, school colors, etc., will also be supplied by the librarian at the minimum cost.

These, gentlemen, are but insignificant privileges compared to the benefit that accrue to each member as a regular attendant at these meetings.

The object of the Society, according to the constitution, is: (1) The encouragement of original research in the science of engineering; (2) the preservation of the results of such research; (3) the dissemination of these results among its members; and (4) the cultivation of a spirit of mutual assistance among the members of the Society in the practice of the profession of engineering.

In speaking under this head, I think I cannot do better that quote from the speech of a gentleman with whom you are all familiar. Mr. J. A. Duff, a past-president of this Society, in his inaugural address said that, were he called upon to define the great object of this Society, he would say, "It was to afford facilities for and to encourage the development in the minds of its members of habits of reading and observation, and the cultivation of the ability to communicate information thus received by means of writing and speaking."

In previous years, as all the former members of this Society are aware, the fee was $1.00 yearly, collectable by the treasurer in the regular way. Prof. Galbraith, watchful of the best interests of our Society, and anxious as to its prosperity, suggested that it be made compulsory for each regular student to pay a library fee of $1.00 into the school treasury, and each member so doing to be exempt from further dues to the Engineering Society; the greater part of the money so collected, or at least as much as we have ever before raised in a single year, to be handed over to our treasurer to be expended as your committee may deem wise, and the balance to be spent in providing books for the library—the books to be selected by your committee, subject to the approval of the council of the school.

This suggestion met with the approval of your representatives, and a library fee of $1.00 was accordingly inserted in the new calendar, and is being collected with the ordinary fees of the school.

In former years any surplus there was at the end of the year, after the publishing of the pamphlet and paying of current and incidental expenses, was used, if spent at all, to replenish the library shelves.

Therefore, gentlemen, you will easily see that we have everything to gain and nothing to lose by the change just brought about. We will have full control of the library, and must keep it in order. I think, gentlemen, this has been a wise move on the part of your committee, and before many years are passed this Society will possess a well-stocked library and be in a position to profit by the action just taken.

Many of you, no doubt, would like to know why this meeting was not held on Tuesday, as in former years, instead of to-day. During the summer months, when your committee were not here to be consulted, Prof. Galbraith asked me, as the representative of the Engineering Society, if I would consent to allow the day of meeting to be changed from Tuesday to Wednesday, saying, at the same time, that Wednesday would suit the convenience of the majority of the students. After consulting the article relative to meetings in our constitution I readily agreed to his request, and my decision has been sustained by your committee.

I would like to say something in regard to the relation between the Engineering Society and the school itself. Our meetings here, although we control them, are quite part of the work of this institution, and shall, I understand (from good authority), always be regarded as such so long as part of a working day is devoted to them. This Society was instituted eight years ago by Prof. Galbraith, who, for four years, was its very esteemed president, the object being to acquaint the students with the practical side of their chosen profession. I say again, gentlemen, and I cannot impress it upon you too forcibly, our work here as members of this Society is not the least important factor in the curriculum, and I think that students who take the proper view of the matter will appear here as regularly as at lectures.

The success of our Society depends largely on the papers read at these meetings, and the larger the stock your committee has to choose from the better the quality of those selected. As a rule, the papers read here have been written by graduates of the school and outside engineers, and turned over to the corresponding secretary to read. In a few cases have the writers themselves been here to explain points of difficulty, or to answer the numerous questions that may be asked regarding the work covered by the article.

Now, gentlemen, the point which I want to bring out is the advisability of students themselves writing papers. No man who has spent his summer in an office or on construction work has, so far as I can see, any laudable excuse for not writing something for this Society. In fact, gentlemen, I think it is his duty as an active, honest member of this Society to help to supply it with working material. I believe more benefit is derived by the majority of members from a paper written and read by a student than from one by an outside engineer who is not here to take part in any discussion that may arise from the reading of such. Do not misunderstand me, gentlemen; I do not say that students' articles contain as much solid information, or are more cleverly written, than those of outside contributors, but I do say that I sincerely believe that more instruction is gained from them on account of the discussions which are likely to follow their reading. For these reasons, gentlemen, I trust that every member, who can at all, will write a paper for the Society this session. I am not in favor of long papers. I would say, let them be short and to the point, so that we may have several read at each meeting. We have not hitherto confined ourselves strictly to articles on engineering subjects, nor do I think it would be wise to do so, although if we adhere closely to the constitution we shall be prevented from discussing any papers that do not bear on work connected with our profession. I think papers descriptive of a canoe trip, a yachting cruise, or a shooting expedition wedged in with an article on a heavy scientific subject serve to make our meetings more attractive and interesting.

The council of the school are anxious that students should write articles to be read at these meetings. In fact, I may say that they are about to consider the advisability of holding out inducements to encourage men in work of this nature.

This Society has advanced steadily since its formation. Let us this year, by united effort, make the session of 1893-94 famous in its history.

What we want is enthusiasm. Let every man be an enthusiastic member, and our Society will be a success. Do not come here and be satisfied to listen to others take part in discussions and debates. Join in them yourself. If you have an idea you would like to make known, do not be backward in expressing it. If you have a question you would like to ask, ask it. It is in this way that discussions, which add so greatly to the usefulness of our Society, are brought about. Every one of you has ideas which, if imparted to the rest, might be interesting and beneficial. It is in open debate that matters sometimes difficult of comprehension are made clear, and when you have a Society such as this, where the sole object is our mutual benefit, and where our motto should be, "One for all, and all for one," you should not be slow to forward its interests, but do all in your power to enhance its value to yourselves as students.

Our corresponding secretary, Mr. W. A. Bucke, has been alive to the interests of the Society during the summer months. Last spring, before vacation commenced, he obtained permission from your committee to have a circular letter printed, and a copy of this was mailed to all graduates of the School of Practical Science and to the prominent engineers of the province. Several of these gentlemen thus addressed have promised to write us an article on some engineering subject as a result of your corresponding secretary's work in this direction.

I would like to draw attention to a subject which, although not directly concerning the Society, is of interest to students generally, for which reason I feel justified in speaking on it here. I refer, gentlemen, to the Athletic Association of Toronto University, the directorate of which has taken the place of the gymnasium committee of last session. Since this time last year a gymnasium has been established, and has been equipped more fully, perhaps, than any in Canada, and is probably second to none on the continent. For this we have to thank the old gymnasium committee, on which the school was represented by Messrs. Goldie and Rolph, who devoted considerable time to the work in our interests, and the energy and ability that these gentlemen displayed in this connection cannot be overestimated by the students of this institution, and should meet with the thanks of all interested in athletics. As most of you know, when the University authorities erected the gymnasium building, they did so on condition that the students would equip and maintain it. In order to do this a large amount of money had to be subscribed, and I must say, and I am proud to say it, that the students of the School of Practical Science responded generously to the call for funds. I think the gentlemen of the first year may congratulate themselves in being able to enjoy the privileges of the gymnasium provided for them, and should encourage the Athletic Association by giving it their substantial support. We are all aware of the advantages arising from physical culture, and it will not be necessary for me to expound the hackneyed arguments with which you are all so familiar.

Gentlemen, I hope that this may be marked as a most successful year in the history of our Society, and trust that we will not only strive to maintain the reputation of our Society, but shall endeavor to increase its usefulness to ourselves as students.

JAMES D. SHIELDS.

October 17th, 1893.

PROFESSIONAL PROSPECTS

An address by ALAN MACDOUGALL, Vice-Pres. Can. Soc. C.E., M. Inst. C.E.

It affords me much pleasure to accept your invitation to address you this afternoon in an informal manner. The intercourse between us will be more readily encouraged, and the stiffness which unconsciously creeps in between junior and senior will be relaxed by your custom of inviting some of your professional seniors to visit you. I have tried to exercise my powers of persuasion on Professor Galbraith to have your Society attached to the Canadian Society, but without effect, and from the professor's point of view I daresay he is right, for the existence of this Society leads to closer intercourse amongst all of you who are in daily communication with each other, and from the opportunities afforded by the meetings of your Society many subjects common to you in several parts of your scholastic work can be more freely discussed than if you were part of a large society.

Looking round the country just now, the prospects for the engineer are not particularly bright. Of all professional men the engineer is the first to feel the effects of bad times, for public improvements are classed as luxuries, to be delayed as long as the purse is light. Nevertheless, there is in the country work which is increasing in magnitude—increasing in its ramifications more than in directness of any individual undertakings, and which will, I hope, call for the services of many of you. The work of building up a practice and making a living will be beset by many disappointments, the temptation to pull up stakes will come very often, and there will be many cases in which this may have to be done, whilst in others the race may be for the one who " stays."

Commencing your professional career together, as members of this Engineering Society, you have the foundation of a thorough *ésprit de corps*, which is strengthened to you by your diplomas and degrees. Through this agency you will be able to uphold with befitting dignity the honor of the profession, and each one of you will have to undertake it as a special duty to impress upon the public by your conduct and practice that you thoroughly respect yourselves and the profession you belong to. Our profession has not received the same notice and appreciation from the public which other professions have, but this may be accounted for by the conditions of society and the country. During the early days of settlement every bushwhacker had to be his own road maker and bridge builder; he had to frame and erect his own buildings; as his prosperity increased he became set in the habits learned in early life—self-dependence, and possibly the outcome of it, economy. If he were not a Scotsman, he took to the alleged inherited spirit of that nationality and kept a firm grip on the "bawbees." It was almost beyond his comprehension that a man who only looked through a spy glass should claim higher compensation than one who, with his axe, could possibly build a bridge or a barn. Looking back over a quarter of a century's practice in this country, I see immense advances made in the recognition of our profession, which has risen immensely in public estimation since the foundation of the Canadian Society of Civil Engineers, and I am most hopeful of the future, which I believe will be guided and nurtured by concerted action on the part of all members of the profession through the Society.

The main channels of employment in the past have been railway construction, or the public works' service of the Dominion and Provincial Governments. Of later years other branches have opened up, in one of which I am directly interested at present, and which will be one of those cases of "staying" I have already referred to. A movement is spreading through this province for the improvement of our public highways, which is really an extension of the movement so successfully accomplished amongst our neighbors, where the movement for better roads has taken hold of the whole nation from Atlantic to Pacific, and has already caused large mileages of mud roads to be turned into highways passable at all times of the year, and as a consequence raising the values of adjoining lands.

It is the intention of the Canadian Institute, of which body I am the secretary, to call a convention to consider road reform early next February, about the time of the meeting of the Central Farmers' Institute. I am sanguine of the success of that convention. I do not look for immediate improvements in road construction, but I am confident that in the near future there will be work for some of you on the construction and improvement of our highways.

With the advancement of prosperity and the enlightenment of the public, we find the capitalist commencing to lean on the judgment of the engineer for advice in the prosecution of large public works. The professional standing of the engineer is now a guarantee and one of the best recommendations he can have; it is therefore incumbent on him to make himself perfectly familiar with all the details of that special branch in which he practises. This opens up the field for the exercise of individual energy. The mechanical engineer must study out the various methods to obtain the fullest value from raw material. The prime factor of all our mechanical energy—heat—has many an unexplored field. We are still unable to utilize to its fullest development the heat unit of one pound of coal. The steam boiler and steam engine have not arrived at a condition of finished perfection; on land in the stationary and the locomotive engine, and on water in the marine boiler, with its intensely overheated and exhausting stoke hole, a field for improvement and invention is yet open.

In the applications of our newly acquired force—electricity—we have to depend on some other power for its generation, as we have not yet succeeded in abstracting it from the rays of the sun or the atmosphere. The recent discoveries by which electricity can be transmitted to great distances with but trifling loss—I think it is possible to do so now with the loss of only one per cent.—call for thought and attention in its generation. We have an untold amount of power lying idle, and we can say, truly, going to waste, in our magnificent inland rivers. We have in the various chains of lakes which dot our province ample and ready opportunities to store water, which can be let down as required, to maintain any given amount of head; and it does not need much argument to point out to any of you how readily one water power can work in connection with another, generating electricity at this point and sending it so far, till it reaches the current developed at the next point. The discoveries in the field of electrical science follow each other with a rapidity never attained in any other branch of pure or applied science.

These are some of the fields in which your energies have to be developed. I do not wish you to carry away an impression that I have come to speak pleasantries, and make you believe the country is full of work at present. The outline I have given you is a correct statement; the success which will attend you will depend on your individual effort. Let me say one word of warning: let not your youthful elasticity of spirits tempt you to undertake work beyond your powers, for the world has a most uncharitable habit of writing men's failures deeply into its memory.

I doubt not many of you will be anxious to hear a few words from me on the subject I have so much at heart, and on which I have had the pleasure of addressing you on a former occasion. I refer to the position the movement for professional status and close corporation has reached. During the year the committee appointed at the last annual meeting of the Canadian Society of Civil Engineers has been hard at work. As chairman of that committee, I have been in correspondence with a number of leading men in the United States, who are in warm sympathy with the movement, and have received material assistance from members of the profession in the Dominion. There are many obstacles in the way, which will only be overcome by patience and careful consideration of the interests of the profession. Without anticipating the report my committee will make, I may say to you that the proposals outlined in my paper on "Close Corporation," read before the Canadian Society of Civil Engineers, will have to be modified. The movement will be strengthened and established on a firmer basis by prudent action on the part of the profession just now.

THE REMOVAL AND DESTRUCTION OF GARBAGE

By J. H. Chewett, C.E., A.M. Can. Soc. C.E.

Garbage may be said to consist of (1) House Refuse, made up of ashes, tins, and broken crockery (technically known as "*hard core*"), with animal and vegetable matter, and waste paper, etc. (known as "*soft core*"). (2) Street Sweepings, comprising horse droppings, road grit, pieces of paper, fruit peelings, etc. (3) Trade Refuse, which includes rotten fish, meat, and vegetables, together with waste matters from slaughter houses and markets.

Its satisfactory and sanitary disposal is a question which is at present receiving a great deal of attention in England, and which is most important to large towns like Toronto.

The present mode of disposal widely adopted, filling up hollows and spreading over land, is most condemnable. The future results of this practice are not pleasant to contemplate. Houses built upon such sites will probably be distributing centres for diphtheria and other zymotic diseases. Authentic cases, almost without number, in which this course has proved prejudicial to the health of the locality, are before our eyes. One which might be mentioned is the outbreak of yellow fever in New York at the beginning of this century, and described in the following extract, which is taken from *Scribner's Magazine* of May, 1881:

"The character of the filling, in the extension beyond the water line, is described in an account of a severe epidemic of yellow fever as being a sufficient (and the probable) cause of the outbreak. The slip east of Whitehall was filled with dirt and garbage, and spoiled provisions—even whole carcases of horses and swine were half buried there from time to time, and left to rot under the summer sun. This condition was reformed after the first outbreak, and such excessively foul deposits were confined to the upper end of Front street. The next year the fever made its appearance near this new dumping-ground, and the region of the

Battery was exempt. A very large portion of the river border of the city which has been considerably extended on both sides to about 40th street has been built up with a mixture of sewage deposits, garbage, street dirt, and the composite product of the ash barrel."

There are many records of similar cases, where private houses have been built upon "made ground," containing garbage, and in which sickness and death have resulted, only attributable to the unhealthy emanations that have found entrance to the dwelling.

Most houses are practically ventilators for the subsoil, especially in cold weather, when the inside is at a comparatively high temperature. The tendency of the hot air is to rise and escape through the chimneys and other openings near the roof, and thus when doors and windows are carefully shut to keep out the cold then the new supply of air is drawn through the cracks in the cellar floor. This air has given up a part of its oxygen to oxidize organic materials in the subsoil, and is laden with mephitic gases, which contaminate the foods, and spread disease through the house. These facts emphasize the necessity for concrete or air-tight basement floors, and ventilators to bring pure air from above ground into the cellar.

Dr. Parsons, in his report for 1892 to the Local Government Board of London, enumerates the following diseases, which have been thought capable of being produced by town refuse:

1. General malaise, vomiting, and diarrhœa.
2. Sore throat (follicular tonsillitis).
3. Diphtheria.
4. Enteric fever (in presence of human excreta, especially where water is contaminated).
5. Other infective fevers.
6. Septicæmia.

The substances comprising garbage are practically of no commercial value as garbage, and are such that they cannot safely be trusted in the sewers; nor do they in this thrifty age pay for the disgusting operation of sorting. The days of the "golden dustman" are past.

The collection should, if possible, be made daily; the periods at which it must be removed from private houses must never exceed one week. This work is preferably performed by the municipality, though in some English cities it is still done by contract. The latter course has not, however, given the same satisfaction as the former. The systems of collection adopted vary in different localities. In many of the London parishes each householder is provided with a card upon which is printed a large letter D, and when the dust-bin is full this is exposed in the window of the front room to attract the attention of the scavenger as he passes along the street. In other places calls are made periodically; this is much more satisfactory on account of its being much more systematic.

There are many forms of dust-bins, some of which have the merit of being clean and neat, and at the same time comparatively inexpensive.

Street garbage consists essentially of *horse droppings* and *road grit*, together with other substances of accidental occurrence. The amount of "grit" will depend largely upon the character of the roadbed. Macadam yields a large quantity, stone block and brick less, while wood and asphalt pavements produce practically none. In the main streets the collection and removal should be made two to three times a day, as the constant traffic performs a grinding, and at the same time a stirring-up action, which keeps the fine particles floating in the air. Breathing such an atmosphere is supposed to produce sore throat, and must be highly injurious in any case.

In the crowded thoroughfares of the city of London it would seem almost impossible to keep the streets clean, but the difficulty is very successfully overcome by the employment of boys, who, with a dust-pan and brush, are constantly collecting the horse droppings, etc., in their own particular section. They place these materials in tall cast-iron receivers, which are fixed at intervals along the side of the street, and which are emptied periodically by carts. The boys receive for this work about $4 per week, nd the men employed as carters $5 to $6 per week.

Thirty-four carts are used, and, on the average, collect three and a half loads each per day. The number of miles of streets served in this way is, roughly, thirty-eight. The collected refuse is delivered at Lett's wharf in Lambeth, where it is sorted, and part sold to the brick makers and part burnt in destructors.

There are a number of different designs of carts for carrying the garbage to the points of disposal. The usual form adopted is a four-wheeler, some provided with covers, and drawn by one horse.

As before stated, spreading over land has proved most unsatisfactory, so much so that at present there are about fifty towns in England, besides continental cities, which have erected destructors in order to deal with the matter without nuisance.

The form most universally used is that designed by Mr. Fryer, and constructed by the firm of Manlove, Alliot & Fryer, of Nottingham. I have seen several of these in operation, and one in the course of construction, and have selected that of Battersea as typical. The plant, for purposes of description, may be considered as consisting of the destructor, the flue, and the chimney shaft.

The destructor proper is a group of twelve cells, built of brick work and strengthened by iron tie-rods and beams. The number of cells necessary is estimated beforehand by the quantity of garbage to be disposed of. An even number is chosen and placed back to back, with the flue in the middle below their upper ends.

Each cell is twelve feet long, five feet wide at the level of the fire-bars, and three feet three and a half inches high. The top of the cell is a semi-circular reverberatory arch, lined with fire bricks. At the back there is a hearth upon which the materials to be consumed are placed, and from which they pass into the furnace proper. The fire-bars slope forward at an angle of about 20° with the horizontal, in order to facilitate the passage of the clinker and heavy substances to the front. The doors are of boiler-plate and counterbalanced. The top of the destructor forms a flat platform with an opening over the hearth of each cell, into which the refuse is dumped from the collecting carts.

This opening is divided from the opening provided for the exit for the furnace gases by a wall and bridge, built of solid fire brick, to prevent anything falling into the flue immediately beneath. There are also special openings provided for the introduction of infectious mattresses, diseased meat, etc., which fall directly on the burning mass. The platform is approached by an inclined roadway, at the bottom of which is the office, where each load is weighed and where all records are kept.

The flue is semi-circular, being about ten feet wide, six feet high, and fifty feet long. That part between the destructor and chimney is really a double flue, both of which are provided with a Jones' fume cremator. This consists of a reverberatory arch with rings of fire brick placed in the direction of the gases. Ribs of fire brick projecting from the arch serve to deflect the gases upon a mass of red hot coke, which maintains a temperature of from 1000° to 1500 F. This has the effect of breaking up any organic gases which might otherwise be offensive to the neighborhood. Another most interesting feature of the flue is a tubular boiler, twelve feet long by eight feet in diameter. This is capable of producing a pressure of about sixty pounds, sufficient to drive an engine of fifty horse power. The power is used for grinding clinker and other purposes about the works. If the power is not required, it is only necessary to arrange the dampers in such a way that the heated gases pass through the other flue.

The chimney shaft rises 180 feet above the ground level, and rests on a foundation twenty-two feet below the surface, extending five feet into London blue clay. The foundation consists of a bed of Portland cement concrete thirty-five feet square and twelve feet deep, equal to about 900 tons. The base of the footings is twenty-nine and a half feet square, and diminishes to seventeen and a half feet square, which is the size of the shaft at its commencement above the ground level. The shaft is circular, with an outside batter of about one in fifty. The inside, to a height of forty-six feet, is lined with fire brick, with an air space between this lining and the ordinary outside brick. The inside diameter at the bottom is seven and a half feet, narrowing at the top to six feet. Its total weight is 1,850 tons of 2,000 lbs.

In their haste to begin operations this chimney was unfortunately used before the mortar and cement had properly set. The effect of the heat upon it in this state produced a crack, which had to be protected by placing iron bands round it.

As regards the working of the destructor, I cannot describe it better or more concisely than by repeating the rules formulated by Chas. H. Lowe, surveyor to the vestry of St. John, Hampstead. The following are the rules:

RULES FOR WORKING.

1. Each fireman is required to feed and clinker two furnaces, and run away all ashes and clinkers from same.

2. The fires to be always the same thickness, viz., from twelve to fifteen inches, and the drying hearth to have as much refuse as it is possible to get on to it, care being taken that it is pushed as far into the furnace as possible when charging, and before filling in fresh refuse. The fires must not be in a heap on the side where the gases pass to the main flue, as it is necessary to allow a free draught.

3. Clinkering is necessary when burning the lighter class of refuse, in from half an hour to one hour, and when burning wet refuse a longer time is required.

4. The charging should be done immediately after clinkering, and after the filling in is completed the hopper should be filled up and well trodden in, to prevent the cold air getting into the flue.

5. When the fireman leaves work at the end of his shift, his ash pit should be left free from ashes, and the fires in good condition. At all times the dead plates at the furnace mouths should be kept from hot fire and refuse.

6. The changes in night and day work to take place every fortnight. The night men to clean out the flues and clinker their fires on the

Sunday previous to changing their shifts, instead of working on the Saturday night, and to commence their day shift on Monday; the day men to bank up their fires on Saturday before leaving; on the remaining Saturday night, between the shifts, the night men to work all night and to bank up their fires before leaving on Sunday morning.

7. Nos. 1 and 2 furnaces to be in the exclusive charge of the leading fireman. Each other fireman to take his two furnaces consecutively; that is to say, the man who takes Nos. 3 and 4 furnaces for one week will take Nos. 5 and 6 the following week, and so on.

8. The fires to be clinkered consecutively; that is to say, ten minutes after the clinkering of No. 1 cell the fireman at No. 5 cell is to clinker his fire, and after another interval of ten minutes the firemen at Nos. 3 and 7 cells may clinker their fires. The firemen working Nos. 3 and 4 furnaces, and the firemen at Nos. 7 and 8 furnaces, may clinker both at the same time.

9. The cremator to be kept working night and day by the fireman having charge of Nos. 1 and 2 cells.

By order,

November, 1890. CHAS. H. LOWE, Surveyor.

Having discussed the construction and working, it will be interesting to notice some of the results achieved by destructors.

Each cell will burn from five to six tons per day, without the addition of any carboniferous matter whatever, there being enough of such material in the garbage itself to make it self-consuming. The residue in the shape of clinkers and ash varies from twenty per cent. to thirty-three per cent. This makes an excellent road material, and has been used with great success and profit in tar paving, concrete paving, and silica paving. Battersea realized $3,815 on clinkers sold for paving purposes in 1892. In this connection it may be said that the population of Battersea is about 150,000. The total cost of collection and disposal amounted to the remarkably low sum of from 35c. to 50c. per ton; and there is no doubt but that this method of disposal could be made self-supporting by careful management; in fact, in Nottingham, Oldham, and Newcastle, the cost was reduced to 10c., 12c., and 15c. respectively.

In Ealing, a town of 45,000, a novel and successful process has been worked by Mr. Jones, the town engineer, and inventor of the fume cremator. The sewage is treated in tanks by the lime and ferrous sulphate process; the precipitated sludge is then mixed with the town garbage and burned. It might be assumed that this would cause a nuisance, but such is not the case. I visited the works twice while the work was in operation, and could not detect any worse odor than that to be found round the average precipitation works.

The steam power is one of the most striking features in connection with the destructor. It is estimated that each cell will burn enough in twenty-four hours to keep a five horse power engine going. The power is used for grinding clinker and supplying electric light in nearly all the works. At Southampton, in addition to this, a thirty horse power boiler pumps 500,000 gallons of sewage effluent for working one of Shone's pneumatic ejectors. At Blackpool it is used for driving electric tram-cars; at Hastings for pumping sea water. Thus we see what valuable work may be extracted from an apparently useless and undoubtedly offensive material.

In conclusion, I would say that it is by some such means as this that garbage should be disposed of. The present mode of spreading over land is a wasteful one; wasteful not only in the loss of work and useful materials, but also of human life, which it is our object and duty as engineers, and especially as sanitary engineers, to preserve by all the means which we have in our power.

THE BEETON WATERWORKS SYSTEM

By J. R. Pedder, O.L.S.

Mr. President and Gentlemen,—In dealing with this subject, it is my object not only to take it up from a truly engineering standpoint, but also to relate some of the preliminary steps the village took before consulting an engineer, thus forming wrong opinions which the engineer found he was forced to fight against.

Beeton is a village situated in a considerable valley. A little over a mile from the village is a small spring creek with an average flow of about sixty gallons per minute. This creek, being over 160 feet above the village, was considered the best available source of supply, the only obstacle being a range of hills lying between the creek and the village.

In the summer of '92 the question of waterworks was first taken up. The village, thinking they would save the cost of employing an engineer, advertised asking contractors to make an offer to put in a system of waterworks, they to furnish their own plans.

Contractors, of course, like this way of doing work, as the plans they furnish with their contract are generally in such a form that the corporation have not much to hold them by; and as there is not an engineer to inspect the work, the contractor is sure to come out ahead.

In the case of Beeton in the summer of '92, several contractors put in tenders. The most favorable one offered to build a dam at a point where the creek is only 143 feet above, and at a distance of one mile from the village; the dam to be fifteen feet high, and from this the supply mains were to consist of 10″, 8″, 6″, and 4″ pipe, the 10″ not being of any great length.

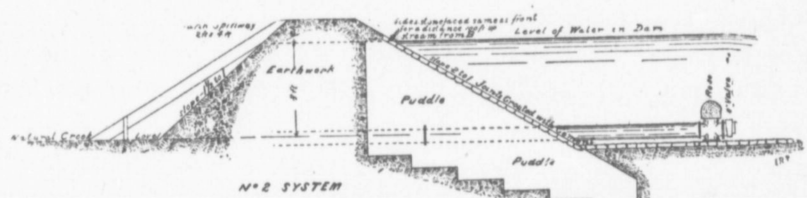
The by-law for this work was carried; but some of the citizens, upon thoroughly investigating the matter, found that the system would not give the service that was desired. A petition was then raised and the by-law quashed.

Shortly after this a very destructive fire occurred, burning out most of the business blocks of the place. This, of course, was a clear proof that they needed an efficient system of waterworks.

The question was again taken up and several engineers communicated with as to the probable amount of their fees, should they be retained. Mr. Galt was finally asked to pay the village a visit to enable him to make a preliminary report, in order that they could have the voice of the people as to whether they wanted waterworks or not. Mr. Galt investigated the probable cost and efficiency of the proposed works as nearly as could be done from the preliminary information which he obtained. He saw from the natural situation of the village that there could be two schemes, which he called No. 1 and No. 2.

His No. 1 scheme proposed having a small coffer dam at the springs in order to collect the water; then to gravitate this water through small pipe into a reservoir or tank on one of the hills near the village.

The No. 2 scheme proposed to build a large dam at the springs, as



N° 2 SYSTEM
SECTION OF DAM

had been the intention of the village the previous summer; but in Mr. Galt's scheme the pipes were of a larger size, and of a more extended service; the dam also was to be at a point where the creek is 165 feet above the village.

In comparing the two systems, Mr. Galt considered No. 1 the more favorable, as it was the more sanitary, and, if anything, the more efficient; its cost, with a steel tank, being somewhat less than of No. 2.

The two systems were discussed in public, but the idea of the large dam had been so thoroughly ground into the people that they could not see the advantages of the No. 1 system.

The council then passed a resolution accepting the No. 2 system. The by-law was passed, and Mr. Galt engaged to prepare plans, etc. Nearly a week was taken up in acquiring the necessary information in regard to the question of levels and distances. When this information was plotted, it was at once seen that the No. 1 system was to be favored more than ever, especially as a ground reservoir could be formed 2,500 feet nearer the village than the dam would be, and without any appreciable loss of head.

The time was now so limited that it was too late to argue any further with the corporation, and, although it was somewhat irregular for Mr. Galt to do, plans, specifications, and forms of tender were prepared so that the contractors could figure on both systems.

When the tenders were opened, no further argument was needed, as the No. 1 scheme was shown, as Mr. Galt had held from the first, to be the better system by over $2,000. The council then rescinded their former resolution, and decided to accept the No. 1 system.

The tender of McQuillan & Co., of Toronto, for $12,000, was accepted.

Thus, after trying nearly a year to obtain their desired object without professional advice, *the people* were at last put right by retaining an engineer and following his advice.

In the meantime they had paid for taking three votes on the matter, publishing and drawing up the by-law twice, and lost half of the village by fire.

The system as constructed consists of—

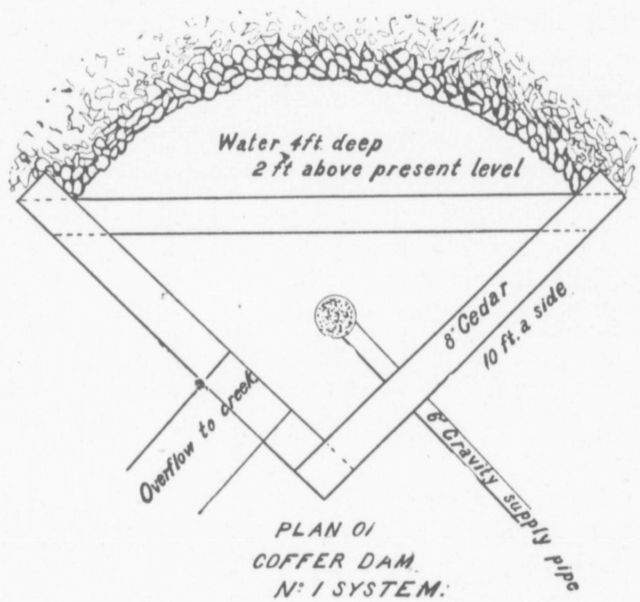
A—Supply System.

One small coffer dam.
500 ft. of 6″ C.I. pipe.
2,000 ft. of 4″ pipe.
2—6″ valves.

B—Distribution System.

One storage reservoir—capacity, 140,000 gals.
100 ft. 12″ cast iron pipe.
600 ft. 10″ " " "
5,500 ft. 8″ " " "
5,000 ft. 6″ " " "
800 ft. 4″ " " "
16 hydrants.
1—12 inch valve.
1—10 " "
2—8 " "
3—6 " "

The coffer dam, as shown, is a simple piece of V-shaped cribwork, built of 8″ x 8″ x 10 ft. cedar; the bottom of the dam being two feet lower than the present creek level, and the overflow so placed as to give a depth of four feet of water. On the upper side of the dam a pile of coarse gravel is placed to serve the purpose of arresting any floating substance; a screen is also placed over the end of the pipe to further prevent leaves, etc., entering it.



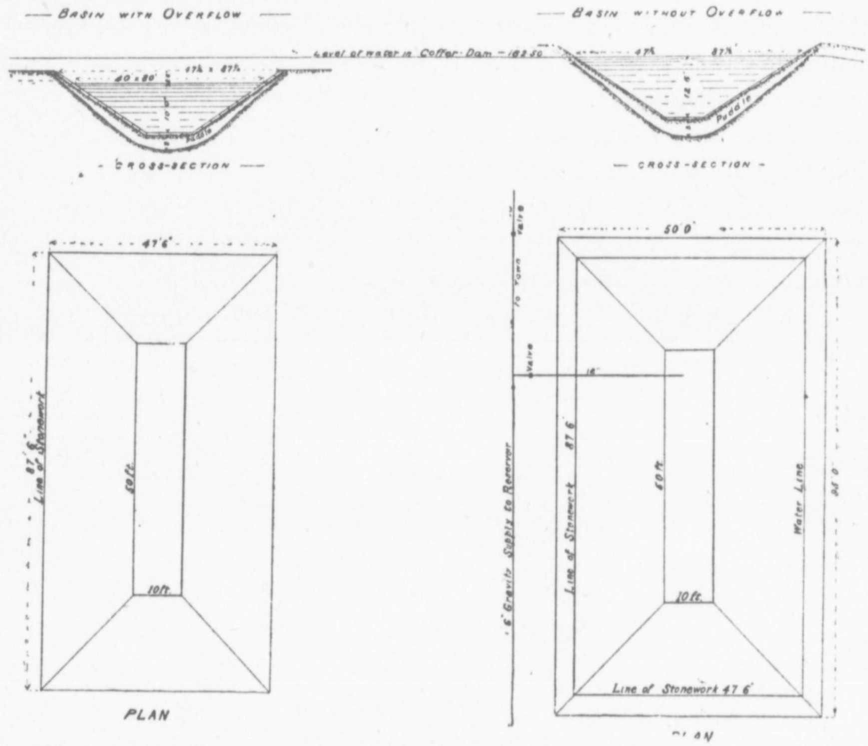
The 6″ and 4″ supply pipe to the reservoir is laid to a grade sufficient to discharge not less than fifty gallons per minute up to a depth of eight feet of water in the reservoir, which, after that height is reached, gradually fills until the level of the coffer dam is reached.

From this it will be seen that after there is eight feet of water in the reservoir, the coffer dam being full, a slight waste of water will occur at the dam, which gradually increases until the water in the reservoir is level with the water in the dam, when the full discharge of the creek will go out the overflow.

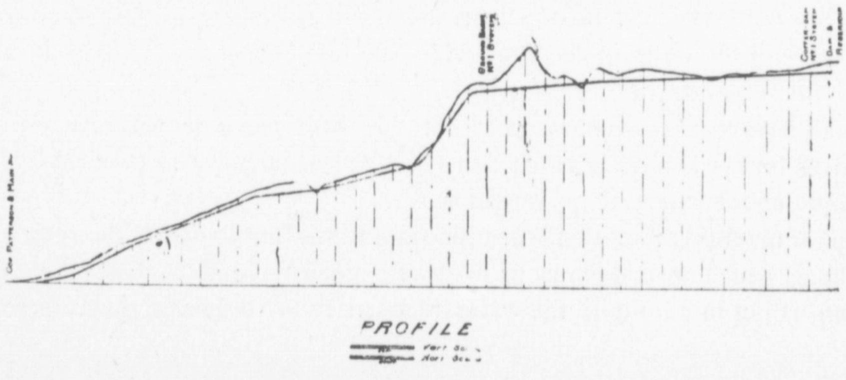
Having any overflow occur at the dam prevents property owners below from claiming as much damages for loss of water as they otherwise would should there be no overflow.

I might here say that when the system was first designed the reservoir was placed low enough so as to have sufficient head to take the fifty gallons per minute until the water reached the overflow of the reservoir.

This, however, has been changed, as is shown on the drawing, the water in the reservoir now rising to same height as water in coffer dam, so that any overflow that will occur at the coffer dam, and the waste water, will go down its natural channel.



The ground basin, or reservoir, has its sides and bottom faced with flat stones grouted with cement. The area of the water surface, when at the same elevation as the water in the coffer dam, is 47½ feet by 87½ feet, with a depth of 12½ feet, the slope being 1½ horizontal to 1 vertical. The basin is located so that one end and part of the two sides are partly embankment, the remainder being excavation. After the proper excavation was made and the embankments built up, the inside of the whole basin

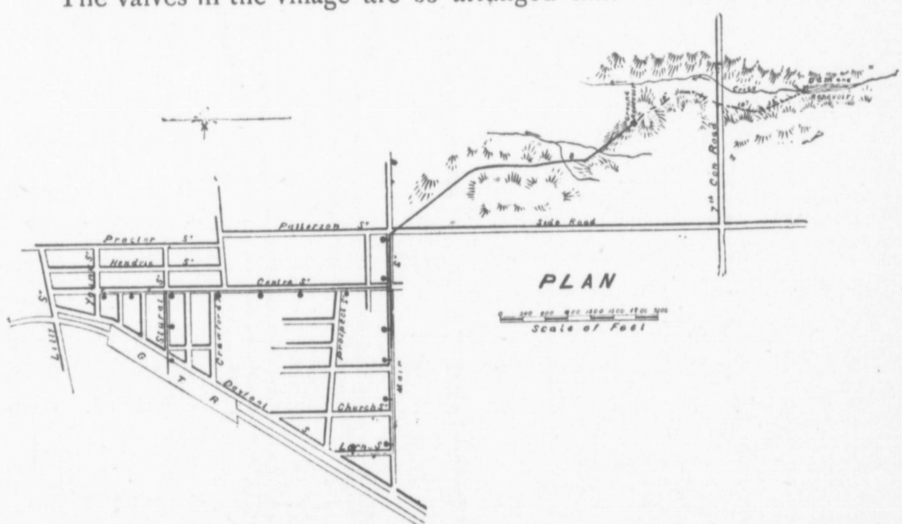


was well puddled before any stones were laid. The elevation of the reservoir above the main part of the village is 162 feet, which will give an hydrostatic pressure of 80 lbs. per square inch, or with three streams, each through 100 feet of 2½ inch hose, one inch nozzle, a hydraulic pressure of 60 lbs. per square inch; or four streams under same conditions, a hydraulic pressure of 55 lbs. per square inch; or five streams under same conditions, a hydraulic pressure of 42 lbs. per square inch, which is ample, considering the possible needs of the village. In fact, this service is about double what is called for by the regulations of the Fire Underwriters' Association; but Mr. Galt considered it would not be wise to design the system to barely pass the above regulations, as the pressure will be greatly reduced during any heavy draw upon the system.

The supply from the reservoir to the village is through 100 feet of 12 inch, 600 feet of 10 inch, and 3,000 feet of 8 inch pipe; these large sizes being necessary in order to lessen the friction as much as possible. As the pressure on the mains can never exceed to any extent 80 lbs., the contractors were allowed the privilege of using pipe a little lighter than the standard weights where pumping is resorted to.

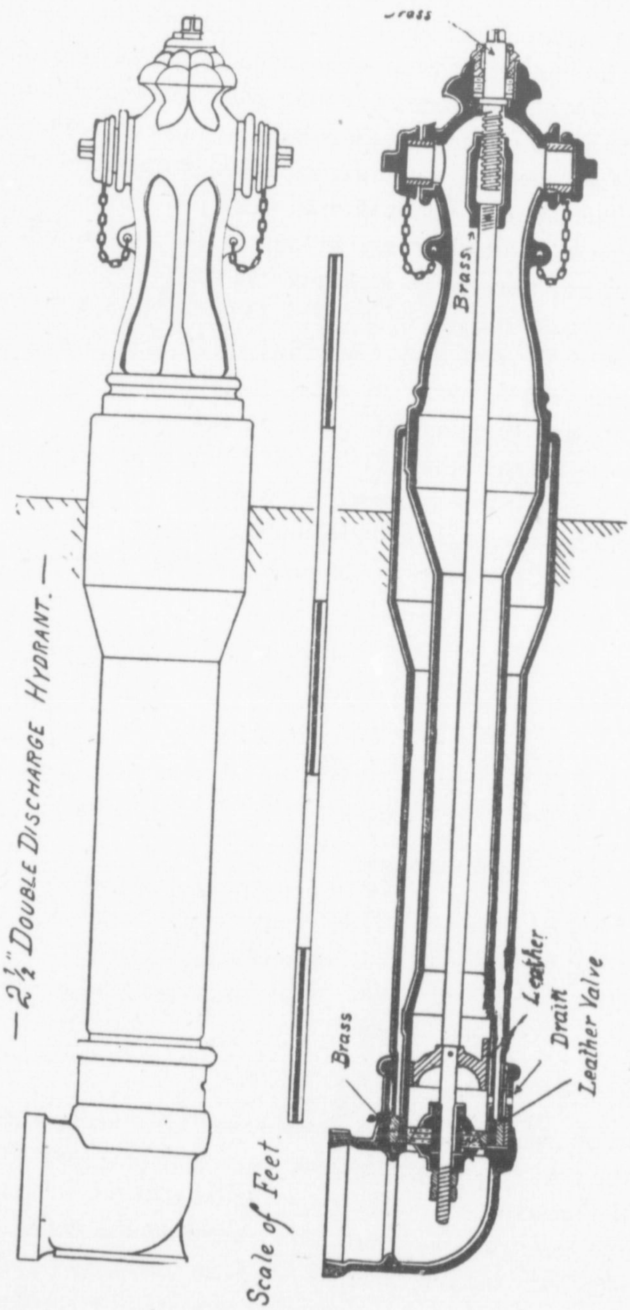
The pipes used were made at Hamilton.

The valves in the village are so arranged that in case of a break as



small a portion of the village as possible will be inconvenienced. The valves on the reservoir supply system are so arranged that in the event of emptying the reservoir the coffer dam can be shut off, and in cleaning or repairing the reservoir the water can run from the coffer dam to the village, which, although not being of any great utility, will keep the village from going dry. All valves are provided with cast-iron covers.

The hydrants, as shown in the drawing, are 2½ inch double discharge hydrants of the best Toronto pattern and make, and are all provided with frost-proof jackets.



— 2½" DOUBLE DISCHARGE HYDRANT. —

The trenches have an average depth of five feet, the soil being a sandy clay, easily handled, seventeen men making an average run of 500 feet per day on six-inch main, including refilling. The Provincial Board of Health, in reporting on the quality of the water, classed it as A1, saying it was the best they had examined for some time.

Waterworks may be considered by some an expensive undertaking for a village the size of Beeton, but I think they must be congratulated for the enterprise they have shown, especially as by an arrangement they have made the G.T.R. pays for water to supply their engines a sum annually equal to the interest on the debentures.

I am unable to describe the test, as the works are still under construction, but the system is supposed to be completed before the end of 1893.

THE CRAWFORD GOLD MINE

J. McAree, B.A.Sc., O.L.S., D.T.S.

This mine, or rather prospect, as it should perhaps strictly be called since it is as yet only in process of development, is situated on the east half of lot 20, in the first concession of Belmont, near the edge of the road allowance on the north side of the lot. The mining property consists of this half lot, together with the mining rights over east half of lot 21, in the first concession, which must be crossed by the vein, as shown by the strike of the latter. The vein has been traced eastwards almost to the county line, a distance of about 1,200 feet; two openings have been made in this part of the vein to the depths of 27 feet and 21 feet, respectively, and the rock assayed, as well as that at the main shaft, at corresponding depths. Five other quartz veins have, I believe, been discovered on the property, all showing more or less gold; and, on one of them, a shaft has been sunk 33 feet. The previous owners of the Crawford have secured the mining rights over lot 20, concession 1, Marmora, lying across the eastern extension of the vein.

The Crawford Mine, as I will designate it, is about 115 miles east of Toronto, and 6 or 7 miles from the village of Marmora, with which there is communication by wagon road. During the past summer, however, the Ontario, Belmont & Northern Railway was laid out and graded from the west half of lot 19, concession 1, Belmont, from the extensive deposit of magnetite there—about three-quarters of a mile from the Crawford—through Marmora township and village, to connect with the Central Ontario and Canadian Pacific Railways, a distance of about 10 miles in all. This road has been bonused by the local government, and, if the bonus be utilized, the road will, of course, be opened to general traffic—and probably will in any event—and then there will be little to desire for the Crawford mining property on the point of facilities for transport, which is, of course, a most important consideration in the cheap working of a mine.

Although Belmont was surveyed so long ago as A.D. 1822, and has had settlements for very many years, yet, owing to its generally rocky character, at least in the eastern part, much of it is still covered with forest, so that wood for fuel, and even timber for construction purposes, is still fairly abundant at reasonable prices; and, as the price of ordinary labor, as well as of provisions, is comparatively low in this as in other rural parts of Ontario, it is not hazarding too much to say that, perhaps, on no part of the continent could be found a more favorable location for a gold mine.

Regarding the geological system in which the rocks of this section of the country should be classed, there appears to be some diversity of opinion among geologists. By the Geological Survey, it was at first, although provisionally, placed in the Laurentian; subsequently, however, it was held by some to belong to the Huronian, rather than Laurentian. In a note to Mr. Thomas Macfarlane's report on the geology of this region (see Canadian Geological Survey Report, A.D. 1866), the late Sir W. E. Logan said:—

"The rocks of Marmora, Madoc, and other townships in Hastings, have, provisionally, been classed with the Laurentian series, with which they seem conformable. . . . These Hastings' rocks may be a higher portion of the lower Laurentian series than we have met with elsewhere. It is not to be inferred from the presence in them of a schistose conglomerate that they are therefore Huronian."

In the presence of such eminent geologists who have considered the question, it would perhaps be presumptuous to offer any opinion; but one thing I would like to remark, without knowing whether the point has already been brought up or not, viz., that the *surface features* of the region, as far as it came under my own observation, resemble those of a Laurentian tract rather than a Huronian. As a rule, the Huronian produces a landscape that is much more rugged, broken, and uneven, with steeper slopes and less flowing outlines, than is presented by a Laurentian landscape.

A notable feature of Belmont is the lake of the same name, in the eastern part of the township; it receives the waters of Deer River at the north and discharges at the south, being a portion of the system of the Trent. The surface of the lake is about 200 feet below the general level of the country to the west, but on the east the land slopes more gradually. On the west side of the lake, some half mile from the shore, and about half way up to the general level of the country, on lots 20 and 21, in the 4th concession, are some slaty beds, dull green in color, evidently chloritic, standing at high angles, but dipping towards the lake, and with their strike apparently parallel to the general direction of the lake. Some fifty rods higher up the slope, and on lot 21, Mr. Purdy, in digging out the foundation for his barn, took out a considerable quantity of a thin-bedded, dark-gray limestone, in practically horizontal stratification. No fossils were to be seen, but the strata evidently belong to the Cambrian or to the Lower Silurian.

The rock in which the Crawford vein occurs is a moderately coarse and even-grained diorite, consisting normally of a dark-green hornblende with a pale plagioclase. The hornblende is generally in plates and tabular masses, and in prisms which appear to be imbedded in the felspar, as if the latter had crystallized out subsequently to the former. Under the microscope the plagioclase was seen to have been largely altered to epidote. In addition to the two essential constituents, the microscopic section showed masses and lath-shaped crystals of apatite, specks of pyrite and of magnetite, a little biotite, and some grains of titaniferous iron, with borders of leucoxine. I am unable to give the geographical limits of this field of diorite, but may mention that I came across it some three-quarters of a mile south of the mine, also over a mile to the west, and, from information which was given me, I believe it extends a considerable distance to the north and east. The surface is gently rolling, hummocky in places, but nowhere rising into hills; the general appearance being that of a glaciated surface, although no striæ were seen.

THE VEIN.

The exploration of this property was begun in A.D. 1891, and, besides the work already referred to, consisted in the commencement of the shaft where work is now going on, and which constitutes the mine. There is erected here a shaft house, and alongside a building containing the steam plant, rock breaker, quartz mills, etc., while conveniently situated are an assay office, blacksmith shop, boarding house, etc. The supply of water is taken from a well sunk near at hand, and there are two reservoirs, one being a large tank placed close beside the smoke stack, and the other one placed close to the other side of the mill house, and half underground. These tanks contain a reserve supply that can be drawn upon in case of a temporary stoppage of the supply from the well. The water is pumped up from the well by a small engine. The water in the reservoir alongside the smoke stack can be heated by an arrangement which applies heat generated by the furnace, and can be substituted in very cold weather for the ordinary water, when there is danger of the formation of ice that would interfere with the proper working of the mill. Up to the time of my visit, however, in the middle of February, it had not been found necessary to draw upon this reserve store of heat, although during the winter there had been some exceptionally severe weather.

The steam plant and machinery, not including the quartz mills, however, came from the establishment of the Waterous Co., Brantford, Ont, and consists of a set of boilers of 65 horse power, with engines of 35 horse power, together with steam pump, hoist in the shaft house, and engine for pumping water from the well.

The ore is conveyed from the shaft house down a slope a distance of about thirty feet to the upper floor of the mill building, and when broken to suitable size is shovelled into a Gates rock crusher, the top of the hopper of which is level with this floor, whence it descends through a spout to the hopper of the Crawford quartz mill, firmly erected on the ground beneath.

The Crawford mill for extracting gold from quartz by wet crushing and amalgamating with mercury was patented by Mr. Middleton Crawford, the proprietor of the Crawford mine, and the following description from the *Engineer and Mining Journal*, July 23rd, 1892, may be of interest:

"The Crawford mill is a new invention, and one which is attracting considerable attention from mining men. As will be seen from the illustrations, it is a variety of the common Ball mill, but one in which the disadvantages of that pulverizer are completely eradicated. It is, in addition, an exceedingly good amalgamator. This mill undoubtedly possesses several novel features, and as a fine crusher has given good results. To pretend that any mill will crush and treat every kind of material is a mistake that has been often made, and in many instances blame has been laid on the machine where it was really due to those employing it. To attempt to crush material finely in one operation is also a great mistake, and wherever attempted has invariably ended in failure. The Crawford mill is pre-eminently a fine crusher, and in order to obtain the best results the material fed into it should be previously reduced by a rock breaker, which is the most economical form of coarse crusher for reducing material down to, say, half-inch to quarter-inch in size.

"The special features of the Crawford mill are: The feed is central, not to one side, thereby insuring an even wear of the roller path. No screens whatever are employed, and a constant source of expense and trouble was thus removed. The crushed material, instead of being discharged at the periphery of the machine, where the swirl is great, passes out in a steady flow near the centre, so that there is no danger, it is claimed, of any particles of gold being carried over with the tailings. A current of clear water is admitted at the centre, passing over the surface of mercury, and rising up through an angular slot below the crushing path of the balls. The action of this rising current of water is to carry off all the material as fast as it is sufficiently finely reduced, and is light enough to pass out at the centre of the machine. Any gold freed from the quartz, or from sulphurets, owing to its greater specific gravity, cannot be lifted by the rising column of water, and sinks down, it is claimed, through the slot below the roller path and becomes amalgamated with the quicksilver in the annular well.

"Further, as the mercury well was out of the swirl of the pulp, and as the water flowing over it keeps any base mineral from coming in contact with it, there is no loss due to 'sickening,' and it is possible in these mills, say the patentees, to treat refractory ores, which could not be treated in an ordinary stamp battery, with copper plates. The mercury is easily withdrawn from time to time to remove any amalgam, and fresh mercury added to the machine by means of the pipe and funnel. In many ores, the ore is so exceedingly finely disseminated that no amount of pulverizing in an ordinary stamp battery can eliminate it from its surrounding matrix. For such ores the Crawford mill is suitable, since by it there is no difficulty in reducing the ore so that it can pass a 120-mesh sieve. Stamps seldom pulverize finer than 40 to 45 mesh. The wearing parts of these machines are rough castings, which can easily be renewed, and at less expense than the dies of ordinary roller mills. These machines are self-contained, easy of transport, and on arrival at the mine can be erected and put to work in a day or two. Clayey ores, which are difficult to treat in a stamp battery owing to the slimes produced, have been very successfully reduced by these mills, little or no gold being carried over with tailings. The following advantages are claimed for the mills :

"1. Minimum outlay in capital.

"2. Great economy in transport and erection.

"3. Low consumption of water.

"4. Small power required for driving.

"5. Extreme fine grinding.

"6. Simplicity of construction.

"7. Ease of management.

"8. Greater efficiency than any other mechanical process.

"The cost of crushing and amalgamating is stated by representatives of the company to be from 60c. to $1.00 per ton, according to the hardness of the ore."

A table is then given showing a comparison of results obtained with this mill with those from stamps, from which it appears that the mill extracted over 30 per cent. more of the gold from ores of certain mines in Canada, the United States, and Queensland than did the stamps; and then the writer continues:

"In addition to this table, which shows the efficiency of the mill, other tests have been made with like results. Thus, at Helena, Mont., the mill extracted $46.00 per ton from an ore where a stamp mill extracted but $21.00. The mill at present is made in two sizes—8 in. and 12 in.—and with a capacity of 2½ tons, and from 8 to 10 tons respectively. The cost of the smaller size is $1,000; of the larger, $2,500. When working, the machine is under lock and key, and one man can attend to at least 12 machines, capable of dealing with a minimum quantity of 100 tons a day."

At the late International Mining Convention in Montreal, Capt. G. Macduff, of Waverley, N.S., presented a paper on this mill, speaking very highly of it. I append two or three extracts from his paper.

"It will not only, as we believe, make mines remunerative which are now abandoned, but it will provide the means for the profitable recovery of gold contained in the large deposits of tailings which have accumulated, and in many instances remain as a bequest from the use of stamps, ordinary mills, or chlorination. . . . In regard to the amount of gold which is obtained by the Plattner process, recently there has been occasion to treat a small amount of slimes sent to the metallurgical works in New York from a large chlorination establishment in Nevada, and the Crawford mill was still able to recover from one sample gold to the value of $8.27 per ton, and from the other $6.20, which had not been saved by the chlorination."

Some failures, however, are recorded against the mill in which it was not able to take out more than a small percentage of the gold from the ore submitted to it. One of these instances occurred in the United States during the past winter, and is referred to in an issue of *The Egineering and Mining Journal* of a few weeks ago. The other instance occurred at the Ogema mine, Black Bay, and was discussed in a Port Arthur newspaper last autumn. In this case the mill extracted all the *free* gold, amounting to about $1.50 per ton, but failed to obtain the portion, amounting to several dollars a ton, that was held by the "sulphurets." The ores of the Black Bay region of Lake Superior are, however, I believe, of a very complicated and refractory character, an example of which is afforded by the Enterprise mine—not working at present. It must be noted also that a subsequent issue of the same Port Arthur newspaper announced that the Crawford mill had been so very successful in some tests made in the Rat Portage country that a quite a number of mills had been ordered for mines out there.

It remains but to add that the larger size of mill weighs but about one ton, and, when taken apart, the heaviest piece can readily be loaded upon an ordinary lumber wagon.

There were two of these mills at the Crawford mine at the time of my visit, a larger and a smaller, only the larger one being running, however. Another large mill is about to be put in.

The shaft, which is ten feet by ten feet, was down 120 feet at the time of my visit, and has, at present, reached a depth of 140 feet. I believe it follows the dip of the vein, which is toward the south, at an angle of about 12° from the vertical. The strike of the vein is about south 72° degrees west. No more stopping was done than just enough to furnish sufficient rock along with that coming from the bottom of the shaft to keep the mill going. The mill puts through about 10 tons in the 24 hours. The water coming into the shaft amounted to about 50 gallons in the hour.

The vein is about four feet wide at the surface, and is somewhat broken up, but becomes well defined as depth is attained. At the bottom of the present working it is about 6 feet wide, and is much more strongly impregnated with the pyrite, being, in fact, about half gangue and half pyrite. The gangue is a white, opaque, vitreous quartz. The pyrite is chiefly massive, but also in grains and in crystals, the larger cubes often showing striated faces, with the striæ on adjacent faces at right angles to each other. Besides the ordinary iron pyrites, there is also a little chalcopyrite occasionally. In the deeper parts of the shaft there is found associated with the pyrite grains and scales of a reddish-brown mineral, which, upon examination, turns out to be iron oxide, or, more properly, jasper. In thin sections, under the microscope, these brownish masses are resolved into aggregations, more or less compact, of minute spherical concretions of ferric oxide and silica, or jasper. The individual sections generally show a system of alternating concentric rings of jasper and quartz, with a quartz nucleus at the centre, the rings of jasper gradually approaching each other towards the circumference of the section, and finally coalescing to form a solid rim, the whole suggesting the idea of a nodule formed on a nucleus of a quartz granule, which received layers of jasper and quartz alternately, the quartz at first predominating, but gradually becoming weaker, and finally giving place entirely to the jasper. The pyrite does not show any definite mode of occurrence in the vein, but will be massed, now towards the foot wall, now towards the hanging wall. The pyrite contains a little magnetite, as is shown when a magnet is passed through a finely pulverized sample.

The hanging wall appears to be simply the diorite changed a little by penetration of quartz, etc., from the vein; a description of a microscopic section is given in the appendix. There seems to be no intermediate layer or selvage between the wall and the gangue; there is therefore no "let go" to the vein, but it is "frozen" to the wall. The foot wall, however, has generally a layer of a chloritic character, which the miners denominate slate, but which has only a very imperfect fissile structure. It consists mainly of chlorite, with quartz, and some calcite. Several "horses" have already been met with in the shaft.

The gold occurs chiefly in the pyrite, but also, to some extent, in the quartz, and "good shows" are constantly being found in both; altogether, however, not much gold is visible, the ore being only low grade.

The average of a number of assays made by me gave about $24 to the ton of 2,000 pounds in gold, the lowest being $10, and the highest $54. A large number of assays, made by a firm in this city, gave about the same average result as the above. A sample of tailings, assayed by the same firm, yielded only a little over a pennyweight of gold to the ton. This does not necessarily prove that the mill is saving all the gold except this small amount, for in the case of the precious metal held by the pyrite a large waste might result from the amount of gold in such a form and fine state of division that it would be carried off in the current of water before it had time to subside and come in contact with the mercury; some recent experiments having shown that gold may exist in such a state of division as to take from five to ten minutes to settle down to the bottom of a beaker of distilled water. I believe the mill extracts about $10 per ton from all the rock put through. The difference between the value indicated by the assays and that actually attained from the mill must be largely due to the mills treating a large amount of poor rock quartz, *e.g.*, which was not represented in the mass that furnished the sample for the assays. A certain allowance must, of course, be made for loss, for it is not even claimed for the mill that it saves *all* the gold. The indications of an assay are valuable for ascertaining the value of a given quantity of rock, only so far, of course, as they represent an average sample of that rock. In the present instance I could not sample the whole mine, but I have obtained sufficient evidence to enable me to say that there is no doubt about this being a valuable property. Even with only one mill running, I understand, it is clearing $40 a day, and when the work is carried on upon a larger scale the profits will naturally be proportionately greater. At present the cost of mining and treating the ore is about six dollars a ton, including all expenses. The gold carries only a small amount of silver—some few pennyweights per ton.

It might be added here that a strong vein of quartz showing free gold was discovered last autumn about three-fourths of a mile south of the Crawford vein, near the south side of lot 19, in the 1st concession. The vein carries pyrite, and very much resembles the Crawford vein; the dip is towards the south, apparently at about the same angle, but the strike, as far as could be ascertained, was about north 70° west; it also is in the diorite.

The deposit of magnetite already referred to as occurring on the west half of lot 19, concession 1, is a very valuable mass of iron ore. Numerous analyses have shown it to be very high in metallic iron, very low in sulphur, and remarkably low in phosphorus. It has been extensively explored with the diamond drill, and it has been estimated that that there are one million tons of ore within one hundred feet of the surface.

In conclusion, attention may be called to the rather noteworthy circumstance that the veins hitherto discovered in the locality that has been under discussion are entirely free from arsenic, which is so prominent a constituent in the veins of the territory immediately to the east, as in Marmora, Madoc, etc.

APPENDIX.

Containing an account of the examination under the polarizing microscope of the slides, or thin rock sections, made from the Crawford vein, the foot and hanging walls, and the country rock.

NO. 1.—SECTION OF GANGUE CONTAINING QUARTZ AND PYRITE AND OXIDE OF IRON.

Under the microscope, the above substances occupied the field, the iron oxide being resolved into masses of concretionary nodules, as already explained in describing the gangue; often two or more nodules were seen partially to coalesce.

NO. 2.—FOOT WALL.

(*a*) Plagioclase, largely changed to epidote.
(*b*) Biotite, dichroic, with inclusions, probably iron oxides.
(*c*) Quartz.
(*d*) Apatite.

(*e*) Specks of magnetite.

(*f*) Chloritic matter.

(*g*) A little orthoclase.

(*h*) Some calcite.

NO. 3.—HANGING WALL.

(*a*) A good deal of chlorite in fibrous masses, dichroic, green to greenish yellow.

(*b*) Biotite.

(*c*) Quartz.

(*d*) Whitish mass, probably decomposed plagioclase.

(*e*) Plagioclase, changing to epidote.

(*f*) A little magnetite.

NO. 4.—COUNTRY ROCK.

(*a*) Green hornblende in plates and crystals.

(*b*) Plagioclase, almost entirely altered to epidote.

(*c*) Some pyrite.

(*d*) Apatite.

(*e*) Magnetite.

NO. 5.—QUARTZ FROM VEIN.

(*a*) Massive quartz with some inclusions; also shows masses and crystals of apatite in colonies.

NOTES ON CEMENT

By T. Kennard Thompson, C.E., A.M. Am. Soc. C.E.

Gentlemen,—The writer, having graduated before the cement testing laboratory was added to the School, found himself put in charge of some masonry construction a few years later with a decidedly limited knowledge of cements, and thinks that he might save the beginner some trouble by giving some of the information he eventually collected from more or less inconvenient sources. To make these notes easier of access, they will be numbered and divided under different headings.

1. KIND OF CEMENT.

The first question the writer had to decide was whether Rosendale (or natural) or Portland (an artificial cement) was the better adapted for the work he had on hand. We know, of course, that Portland cement, with the same quantity of sand, will attain its strength quicker, acquire much greater ultimate strength, be less injured by frost, and cost more than Rosendale cement. So it is often a question of economy whether to use Rosendale with a small amount of sand, or Portland with a larger proportion. If the masonry or concrete is to be laid in freezing weather or under water, or where early strength is required to avoid shocks, etc., Portland will be preferred.

2. AMERICAN OR EUROPEAN PORTLAND.

The next question is whether it is better to use an American or a higher priced European Portland. At present large quantities of European Portland are imported, but there is no reason why our manufacturers cannot supply us with an equally good material at a much lower price. The writer is confident that if the engineers could always deal directly with the manufacturers there would be much less trouble. Foreign cements are often tightly packed in barrels before being properly seasoned, and we have not the time nor facilities for seasoning cement on the field, though it is often so treated in England, on important works, for ten days or so.

3. AIR-SLACKING OR SEASONING.

In Europe cement is sometimes air-slacked by spreading it on the fourth or fifth floor of a building for a few days, then allowing it to fall to the floor below for a few days, and so on until it reaches the ground. This is required where the proportion of clay in the cement is not sufficient to take up all of the lime—a very little free lime is very dangerous—for it will eventually absorb water, expand and crack, or distort the mortar or masonry, and may crumble to dust. If the proportion of free lime is very small it may not take effect for years, but then will have disastrous results.

To illustrate this, the writer knows of a Portland (of course, a bad brand) which has frequently given good results on all the tests, except the hot test, which had not been tried, up to two years, after which the briquettes, both in air and water, suddenly crumbled away to powder. This shows how unreliable is the old method of testing Portland for checking or cracking.

Cement with an excess of free lime is liable to gain its strength very rapidly, and give high tensile tests on a twenty-four-hour test, and ultimately lose their strength instead of increasing it.

4. BAGS VERSUS BARRELS.

Paper bags have many advantages over barrels for shipping cement, as they are much cheaper in first cost and are destroyed after using once —as barrels often are, too—and they give the cement more chance to be properly seasoned than barrels. They also afford an easy and accurate means of measuring the proportion of cement to sand, and can be handled more cheaply in many places than barrels.

5. TIME OF DELIVERY.

The cement should be delivered on the ground as early as possible, so that ample time will be had for testing, and if it is necessary to reject the first lot the work will not be delayed by waiting to have it replaced.

6. NUMBER OF SAMPLES.

There is much difference of opinion as to how many samples should be taken; but if in a carload a sample taken from every fiftieth bag or tenth barrel is found satisfactory, the carload may be safely accepted. But if some samples turn out good and some bad, it would be necessary to test every package to be sure of the quality. The writer does not believe in mixing a poor cement with a better one to strike an average, as mechanical mixtures are never thorough. These samples should be taken from different parts of the bag or barrel, and not exposed to air or moisture until tested. Four or five pounds will be ample for one sample.

7. EXPERIMENTER.

Much practice is required before the student's tests are of any value, as the skill and exactness required can be obtained in no other way. It is important that the tests should be made in a room where the temperature can be kept uniform; otherwise the results will vary greatly. Briquettes made at a low temperature will take longer to harden and acquire a higher ultimate strength than those made at a higher temperature.

The samples should be tested as soon as possible after being taken from the original package; otherwise the results may be entirely different. For instance, the writer once rejected a carload of Portland because it set hard in five minutes. It also gave a very low tensile strength in twenty-four hours. A few weeks later he retested the same samples, about ten, which had been standing in paper bags in the laboratory, and found that the time of setting was then about one and a half hours, and the tensile test in twenty-four hours was much higher. This was an English brand, which had evidently been barrelled before being properly seasoned, and was air-slacked in the laboratory. The writer has had the same experience with other brands.

8. TESTS.

The samples should be tested for fineness, checking or cracking, and for tensile strength, both neat and with sand. *The Engineering News* advocates replacing the tensile tests by transverse tests. This is certainly worth looking into, but the writer has not had an opportunity lately to experiment in this line.

9. TEST FOR FINENESS.

Not more than eight per cent. should be retained on a No. 100 sieve (10,000 meshes to the square inch) made of wire, No. 40, Stubb's gauge, as recommended by the American Society of Civil Engineers. Coarse cement tested neat gives a higher tensile test than when more finely ground, but when tested with sand (as it always ought to be) gives much lower results. Thus an artificial stone made of cement and a small proportion of sand would probably be stronger than if made of neat cement. These requirements for fineness are those of the American Society of Civil Engineers, and would be important if the cement were only tested neat; but it is so well recognized that the finer the cement the higher the sand test that, as a rule, the cement is ground much finer than this specification calls for.

10. CHECKING OR CRACKING TEST FOR ROSENDALE.

At present the best test for free lime, etc., we have for Rosendale or natural cements is that suggested by the American Society of Civil Engineers, viz.: Make two cakes of neat cement, two or three inches in diameter, about one-half inch thick at centre, and with thin edges; place one in water as soon as set and keep the other in air. Observe from day to day. If the cakes are cracked at the edges, or distorted, or show blotches, the cement should be rejected as unsound. This test, however, may pass a poor cement, but will not reject a good one. For Portland cement the hot test should be substituted.

11. HOT TEST FOR PORTLAND.

All Portland should stand the following hot tests before being accepted: Make three pats or cakes, as before, of neat cement on a piece of glass, leave the first in damp air until set, the second for about six hours, and the third for twenty-four hours, after which place each in a steam bath of 200° Fahr. for three hours, and then in water of the same temperature for twenty-one hours each. If any of the pats show cracks, distortion, or swelling, the cement should be rejected, as it probably contains too much free lime or is underburned.

12. TENSILE TESTS—NEAT.

The cement, when made into neat briquettes with a section of one square inch in the neck, should stand the following tensile tests:

Test.	Time in Air.	Time in Water.	Breaking strength in pounds per sq. in.	
			Natural or Rosendale.	Portland.
1 day.	1 hour, or till set.	23 hours.	40-80.	100-150.
1 week.	1 day.	6 days.	60-100.	250-550.
1 month.	1 day.	27 days.	100-150.	350-700.
1 year.	1 day.	1 year.	300-400.	450-850.

In the case of a well-known and satisfactory brand, the cement may be accepted on the first and second tests, but the month and year tests should be made wherever possible, even if only for record. If the 1 day and 1 week tests give higher results than the above, the cement should be rejected unless the monthly and yearly tests are known to give correspondingly higher tests for that brand.

13. SAND TESTS.

The cement, when mixed with sand and made into briquettes as before, with a section of one square inch, should stand the following tensile tests :

Test.	Time in Air.	Time in Water.	Breaking strength in pounds per sq. in.	
			Natural Cement. 1 Cement, 1 Sand.	Portland. 1 Cement, 3 Sand.
1 week.	1 day.	6 days.	30-60.	80-125.
1 month.	1 day.	27 days.	50-80.	100-200.
1 year.	1 day.	1 year.	200-300.	200-350.

As before, the cement will be accepted on the 1 week test, if the brand is known to conform to the other tests.

As a general rule, it is impossible to wait for a longer test than the 24 hours, or, at the outside, the 1 week test. For a strange brand these tests would be absolutely useless ; but if we know that a certain brand has been proved to stand all tests up to one year or more, and we have a sample, of which the short-time tests agree with the established tests of the brand, the assumption is that the long-time tests would also agree.

14. SECTION AND NUMBER OF BRIQUETTES.

The briquettes should break in the smallest section, which should be one square inch, and four or five briquettes should be made at one time.

15. PROPORTION OF WATER.

The amount of water required in mixing the cement will vary with every brand, and even with every lot of the same brand, and should be accurately determined in each case, for a very small difference in the proportion of water will greatly affect the short-time tests, and will also affect the long-time tests, but not to the same extent. A very slight excess of water will greatly decrease the tensile strength of the short tests, but eventually the cement may attain nearly as much strength as if mixed with less water.

The approximate amount of water required is as follows :

For neat Portland, 25 per cent. of the weight of cement.

For neat Rosendale, 30 per cent. of the weight of cement.

For 1 Rosendale to 1 of sand, 15 per cent. of the weight of cement and sand.

For 1 Portland to 3 of sand, 12 per cent. of the weight of cement and sand.

16. SAND.

For testing purposes a crushed quartz should be used of such fineness that it will all pass a No. 20 sieve (400 meshes per square inch, wire to be of No. 28, Stubb's gauge) and caught on a No. 30 sieve (900 meshes per square inch, wire No. 31, Stubb's gauge).

17. MIXING.

The proportion of cement and water should be accurately weighed, the cement placed in the form of a trough on a glass, or other impervious material, and all the water poured in at once, and rapidly but thoroughly worked, the mortar, which should be thick and plastic, being then pressed firmly into the moulds with a trowel without ramming. All working must cease before incipient setting commences.

18. MIXING SAND TESTS.

The sand and cement having been carefully weighed and thoroughly mixed dry should then have the water added as before.

19. REMOVING FROM MOULDS.

As soon as the briquettes are hard enough they should be removed from the moulds, and kept covered with a damp cloth until placed in water. This is especially important with Portland cement.

The moulds should be kept clean, slightly greased (using as little grease as possible), for if they are not properly greased the cement will stick to the moulds, and in case the grease is too thick it is liable to affect the strength of the cement.

20. SLOW SETTING.

Portland cement which is not to be used under the water (where a quick-setting cement is a necessity) should be slow setting, that is, take at least one hour to set hard.

As a general rule, a slow-setting cement will acquire a greater ultimate strength than a quick-setting cement of *the same brand.* Cement takes much longer to set when mixed with sand.

21. THE TESTING MACHINE.

The testing machine should be so arranged that the strain will be gradually applied at the rate of about 400 pounds per minute. Dropping water answers very well.

22. MOULDS AND CLIPS.

The moulds and clips should be of such shape that the briquettes will always break in the smallest section. The forms adopted by the Cornell University are the best that the writer has used.

23. HAND VS. MACHINE.

These results are all based on the assumption that the briquettes are made by hand and placed in the moulds by hand, the simplest method, and one which cannot be done away with entirely. Unfortunately, it is almost impossible to eliminate the "personal equation" and make all operators get the same results.

If good and economical machines for doing this work could be universally adopted much more uniformity could be obtained, and all of the above figures, etc., would be more or less modified.

24. TESTING EACH PACKAGE.

In a case where some of the samples taken from the same lot are satisfactory and some are not, whether as regards strength, setting, or cracking, the entire lot should be rejected unless the contractor agrees to pay for the cost of testing each bag or barrel. No mixing of good and bad cement should be allowed.

25. FREEZING CEMENT.

Cement mortar should not be laid in freezing weather, unless absolutely necessary. In the first place, the cement itself, especially if Rosendale, would be more or less injured by being frozen before or while setting. Again, the freezing and thawing of the mortar, even if it does not injure the cement individually, would probably crack or otherwise injure the masonry in which it was used. In this respect the laboratory test of a small briquette would be of very little use. Salt should not be used.

26. RE-SETTING.

No mortar should be allowed in the construction under any circumstances after it has once set.

The above requirements can easily be met by the cement dealers, but unfortunately the engineer often has to take a very strong stand to secure the cement he wants. He should send very clear and liberal specifications to the dealers, and then absolutely refuse what does not come up to them, and after a while he will be understood and have less trouble.

The writer once called for a slow-setting Portland, and he got a carload that set in ten minutes, and on the twenty-four-hour test broke at from 30 pounds to 40 pounds, which was at once rejected. His chief had instructed him to accept or reject on the twenty-four-hour test, but for his own satisfaction he continued the tests after rejecting, and found that samples taken and made at the same time as the twenty-four-hour tests in three months acquired a strength of 500 pounds, which was very good. Also, that samples which had remained in the laboratory for some time before being made into briquettes took over one hour to set, and broke at over 100 pounds in twenty-four hours.

In the meantime, however, another carload of the same brand had arrived, been tested and rejected, because half the samples set in ten minutes and half took much longer, and the contractor would not pay the expense of testing each barrel. The manager of the works where this cement was made explained that the agent had not informed him that a slow-setting cement was required, otherwise he would have sent it. He further added that he used two kinds of limestone—one for a slow and one for a quick-setting cement, and that when the time of setting was not specified he mixed the two together. Naturally, his mechanical mixture was not thorough.

The next carload, much to my regret, came from an entirely different place, and as it set hard in five minutes it was at once rejected. It should be explained that the writer had to give his instructions to the contractor, who, in ordering the cement, was probably careless about repeating his instructions, to his subsequent loss. After this, however, every carload was fully up to the mark.

This recalls a contractor who once wanted to use a very fine but clean sand, for the sake of economy, on the writer's work, and asked permission to do so. As the only objection to the sand was its extreme fineness, the contractor was informed that he could use it, provided he added sufficient cement to make the resulting mortar as strong as that obtained from using the coarse but dirtier sand as before. He declared that such was his intention, and ordered a number of loads. On the arrival of the first load, the writer took a sample to his testing room, and in due time informed the contractor that he would require about twice as much cement as before, which rather staggered him. He then declared that he did not agree to have the proportion of cement decided by a laboratory test, but by mixing a little in his hands. The writer informed him that he might as well enter a bet as regards the respective beauty of two girls, and after the bet had been fully arranged turn around and declare that the girls should only be viewed from the back. The contractor dropped the subject at once, and sold his sand to some one else.

ASPHALT AND ASPHALT PAVING

By F. N. Speller, Grad. S.P.S.

Mr. President and Gentlemen,—This subject brings us into the province of roadway engineering, which has of late years grown to be one of the most important departments of our great profession, and therefore commends itself to the discussion of our Society.

Crude asphalt is closely related to the well-known compounds of hydrocarbons known as naphtha, petroleum, etc. It is regarded as the ultimate result of a series of changes, probably due to a chronic distillation of organic matter buried at great depth in the earth's stratified crust.

The operations which resulted finally in asphaltum produced the following compounds in order: (1) Naphtha; (2) Petroleum; (3) Mineral Tar; (4) Asphalt. These merge into one another with insensible demarcations, the heavier ones being produced from the lighter by evaporation and oxidation.

This is, necessarily, only a brief sketch; hence it will be impossible to go into scientific details as to the origin and chemistry of this interesting and useful mineral, except in so far as they come in in practice. I will therefore briefly mention the localities from which it is chiefly produced, and its treatment for paving.

SOURCES OF COMMERCIAL SUPPLY.

Among the earliest records* which we have of the use of asphaltum is when the Egyptians, recognizing its good preservative qualities, used it in embalming their dead by saturating the linen in which the body was to be enclosed in liquid asphaltum, supposed to have come from the region around the Dead Sea, where it is to be seen to-day oozing up from the ground and saturating all local porous rocks.

*Ancient history affords us numerous examples of the use of this material, chiefly as a cement, and its worth is well shown on examining these great structures after the ravages of 3,000 years, in many cases the cement being as good as when first laid.

The so called "European asphalt" is really a limestone impregnated with asphaltum. The chief supply is from Val de Travers, in Switzerland, and Seyssels, in France. It is of these bituminous limestones that the first European asphalt pavements were constructed in Paris in 1850.

A German rock asphalt gave 8.8 per cent., and a Sicilian b. limestone, used in paving, 11.5 per cent. bitumen.

American asphalt is derived from four principal sources :

(1) *Cuba.* This is of fair quality, and occurs in veins or fissures. Analysis : Bitumen, 70 per cent.; inorganic matter, 24.5 per cent.; water, 5.5 per cent.; total, 100 per cent.

(2) *California.* In the southern part of the state there occur extensive deposits, including all varieties of bitumen, from the light oils to malthas and hard asphaltum. A large and important deposit of bituminous sandstone also occurs there. The asphalt contains 80 per cent. of bitumen, together with other organic and mineral matter, and water.

(3) *Venezuela, South America*, produces Bermudez asphalt, which is by far the purest—in fact, so pure that it is difficult to transport, due to a shifting of the viscous cargo. Analysis (estimated on dry material): Bitumen, 94.97 per cent.; inorganic matter, 5.03 per cent.; total, 100 per cent.

It was only lately introduced, and has only been laid to a limited extent ; but its high degree of purity and other valuable properties, which will be pointed out later, should bring it successfully to the front.

(4) *Trinidad deposits*, and especially the *Pitch Lake.* These have supplied by far the largest per cent. of American asphalt.

The pitch lake is situated on the west side of the island of Trinidad, half way between its northern and southern promontories, near the village of La Brea. Geologically, the island is intimately related to the mainland. More than two-thirds of its area is of tertiary formations, and consists of loose sands, clays, limestone, etc., with deposits of pitch and lignite here and there.

The strata is highly disturbed and contorted, showing it to have been the seat of violent disorders at no very remote date. In fact, the island lies on the line of volcanic activity extending through the Windward Islands to South America, and although no sign of volcanic action is now found on Trinidad many vents are found on the other islands.

Back of La Brea the land rises quite rapidly until we reach the pitch lake, which appears to occupy the highest point in the locality, the ground falling in nearly every direction from it.

It has an area of 115 acres, is three-quarters of a mile from the sea, and is at an elevation of 138 feet above it.

In shape it is roughly circular, a half mile in diameter, and is nearly surrounded on all sides by a wall of palms and other tropical plants, forming a picturesque background.

The lake itself is not level, nor is it liquid, except in a few places near the centre. It appears to be made up of spherical or polygonal masses separated by star-shaped pools of water three to four yards wide at the top, and from four to twelve feet deep. From the nature of the pitch, if it were motionless, the entire annihilation of these pools would be only a question of a few days, for, although the pitch is almost as brittle as ice when struck, it will flow quite readily if given an opportunity. These areas are slightly convex, and vary from thirty to two hundred feet in diameter. The appearance of the lake, with these watercourses and dark masses, has been described by travellers as resembling marbled paper.

The above-mentioned masses owe the preservation of their form to a curious revolving motion in the pitch itself, by which the lower part in the centre is slowly rising *en masse*, displacing that which was originally there, and forcing it towards the circumference, where it is turned under, to reappear at some future date. The evidences of this motion are abundant. The surface is contorted into concentric wrinkles, the numerous gas cavities in the pitch are elongated into lines as they reach the surface, and the interior presents a laminated appearance. Another curious proof is found in the numerous sticks of wood which are involved in the pitch, and are seen obtruding inclined at all angles. On reaching the surface they generally assume an upright position, due to one end being retained in the pitch, and by the lifting of the middle. The cause of this motion has been ascribed to the expansion and contraction due to the great variation in temperature, which is sometimes as great as 100° F. in a day.

Although the pitch is as hard as gypsum, yet a person standing in one place would sink a few inches in a space of time, depending on his distance from the centre of the lake. Near the centre is an area of more or less liquid pitch occupying a few hundred square yards, although a report of 1837 places the area at three and a half acres. Much of this has, no doubt, undergone a change, making it like the remainder of the lake. The fluidity is in no wise due to high temperature, for the temperature of the soft spot is only about 95° F., which is the usual temperature of the locality.

At the soft spot the evolution of gas is apparent to the ordinary observer, but it, no doubt, occurs to a lesser extent all through the lake, causing the pitch to possess that peculiar appearance of Swiss cheese.

The land all down the slope to the sea, and on either side of the lake, is covered with pitch, which forms three miles of coast. It is generally covered by a foot or two of soil, and, except when very near the lake, is of a varied inferior quality. The land pitch has evidently been largely derived from the lake by overflows, but has subsequently undergone a change in its constitution. It occupies about 12,000 acres. As late as 1854 there has evidently been an overflow, as reports of that date describe numerous streams issuing from the circumference and extending down the slope, sometimes jostling one another in their course. These evidences are now covered with earth and grass, showing that there has been no overflow since. This is, no doubt, due to the large quantity of pitch removed during the last twenty years; in fact, by levels taken in 1892, compared with permanent bench marks established years ago, the surface has been shown to have sunk about one foot.

The supply is, from all appearances, not being replenished, and its extent is unknown, owing to the fact that an excavation fills up rapidly by the moving in of the sides and rising of the bottom.

The general appearance of the pitch from the lake is the same, except that from the soft spot. The great uniformity is well shown in the following results obtained by the United States Government chemist at Washington from a large number of samples collected from different parts of the lake :

	Average.	Highest.	Lowest.
Water	27.85	30.65	25.77
Inorganic matter	26.38		
Organic " (non-bituminous)	7.63		
Bitumen	38.14		
Which when calculated for the dry substance becomes :			
Inorganic matter	36.56	37.02	36.27
Organic, not bitumen	10.57	11.75	9.96
Bitumen	52.87	53.77	51.68

On the other hand, the land pitch varies greatly in composition with the locality, and does not exhibit that peculiar porous structure which the lake pitch possesses, except when found near the lake.

The commercial land pitch, which is carefully picked over and extracted near the lake, does not vary in composition perceptibly from the above lake pitch, but its actual difference is striking, even to a mere novice, and experience has shown that the average quality is unfit for paving. It therefore becomes important to distinguish between the land and the lake pitch commercially.

DISTINCTION BETWEEN LAND AND LAKE PITCH.

As stated above, the difference is not revealed in an ordinary chemical analysis. It must therefore depend on some change in the character of the constituents; and as the non-bituminous organic matter and inorganic matter does not change, something must have affected the bitumen.

All the bitumen of the Trinidad pitch is soluble in CS_2, but only a portion is soluble in gasolene. The latter has been called by Boussingault *petrolene*; it is a sticky substance, and is the life of the asphalt, giving it its cementitious value. When extracted, it leaves a hard, cokey residue, containing the residuum of the bitumen called *asphaltene*.

The presence of a larger per cent. of petrolene causes lake pitch to possess a greater softness and utility than land pitch.

Owing to the difficulty of removing the water on the small scale without affecting the lighter oils, systematic investigation of the two asphalts has been carried on with the refined product.

Refining asphalt commercially consists in heating the crude material in an iron still to such a temperature as will evaporate the water without sensibly altering the light oils. The light organic matter rises to the top and is skimmed off, while some of the mineral matter will subside to the bottom. The product drawn off is refined asphalt, and renders the bitumen in a more available form for investigation and use. It is of great importance that the stills should be uniformly heated, and to this end the products of combustion are carried around them before going to the chimney.

I will here note a few of the principal tests employed to distinguish a poor asphalt from a good one, taking, for example, a few of the results obtained at the Toronto city engineer's laboratory last summer.

Different asphalts can be compared as to their relative usefulness as cements by estimating the amount of total bitumen which is petrolene in each.

For example, a Venezuelan sample, containing 97 per cent.* bitumen, of which 68.49 per cent. was soluble in naphtha, compared well with Trinidad lake asphalt. For, calculating in each case the per cent. of bitumen petrolene, we obtain figures in which the excess of inorganic matter in the Trinidad has no effect: Venezuelan, 70.5 per cent.; Trinidad, 70 per cent.

*These figures were obtained by Clifford Richardson, U.S.Gov. Chemist for D.C.

The solubility seems to depend on the specific gravity of the naphtha largely, so that the same solvent should be used for comparative tests. In distinguishing between land and lake pitch from Trinidad, however, an analysis is seldom necessary, as the difference is sufficiently well brought out in certain physical tests, a few of the principal of which are given :

(*a*) *Softening* and *flowing* points. These are obtained by placing a small angular fragment of each sample on a bath of mercury contained in a small beaker. It is slowly heated by the small flame of a Bunsen burner placed underneath, the temperature being noted by a thermometer suspended in the mercury. At the softening point the particle will be seen to form a little black globule. On raising the temperature slightly, this will be seen to flatten out into a little disc. This is the point of flow indicated on the thermometer. The following are the extremes :

	Soft.	Flow.
Refined lake asphalt........	180°-192° Fahr.	189°-210°
Refined land asphalt	190°-237°	210°-255°

(*b*) *Per cent. of flow.* A piece of glass (5 x 8 in.) is taken with a scratch ruled across it near the top, behind which samples of the material to be tested are stuck, weighing about two grammes each.*

The glass is placed in an inclined position, at about 30° to the horizontal, in an air bath, heated uniformly to about 110°C., until the asphalt has flowed some distance, when it is removed, cooled, and the flow measured. Calling that of the standard 100, most refined lake asphalts range between 70 and 100, while a "land" will run as low as 28.

(*c*) The *specific gravity.* This affords a good test when Trinidad asphalts have been properly refined. Lake asphalt will usually fall below 1.39, and land always above it.

The following results, obtained from two asphalts being used in our own city, afford a good example of the utility of these tests :

Series No., Refined Asphalt.	10	11
Bitumen	53.32 p.c.	56.20 p.c.
Inorganic matter	38.55 "	36.77 "
Organic matter, not bitumen.......	8.13 "	8.80 "
Bitumen soluble in gasolene†......	28.90 "	33.8 "
Per cent. of total bitumen soluble in gasolene	54.01 "	60.14 "

*All these tests should be made at the same time on a standard sample kept for that purpose.

†Very light gasolene was used.

Series No., Refined Asphalt.	10	11
Specific gravity	1.4428	1.4010
Softens	230° Fahr.	188° Fahr.
Flows	275° "	200° "
Per cent. of flow	38.6 p.c.	85 p.c.

PREPARATION OF ASPHALT FOR PAVING.

The question of road surfacing has been threshed out with characteristic thoroughness by the engineers of the great cities of the old world. In London, Berlin, and Paris, the asphalt surface has been received as a welcome substitute for stone and block pavements, and it has the reputation from eminent engineers of being the best general surface for city streets.

In Paris the first asphalt roadway was laid about 1850. About 1880 it fell into disrepute, through mismanagement in laying, and wood paving, for a time, was encouraged. However, in London and Berlin asphalt continued to grow in popularity, until to-day it is found on the majority of the principal streets in the above cities.

Léon Malo, the foremost of French experts on asphalt, pointed out to the Society of Engineers of Paris, in 1886, the causes of the above-mentioned temporary failure of asphalt there, and also, on account of the great quantity of wood paving which was being contemplated, the place which wood should occupy along with asphalt in the city paving, viz., that wood should, if used at all, be confined to the broad boulevards, while asphalt should be always used on the narrower streets and lanes.

It would be hard for an American to understand the progress which wood has made in Europe as a paver, in view of the disastrous experiments some of our large cities have made with it, without knowing something of the construction of these pavements in Europe. In the first place, only the *best* selected wood is used—usually white pine, cut into blocks six inches deep. They are often impregnated with a preservative, and are always laid on a foundation of concrete eight inches deep. The cost in Paris is about $3.75 per square yard, and 40 cents per square yard per year for maintenance. It is evident that few of our municipalities could stand such a luxury.

European asphalt pavements differ essentially from the American in being constructed of bituminous limestone, which has already been described. The one essential condition for any satisfactory street surface is a good foundation, and none is better than concrete.

Its advantages over others are threefold:

(1) It excludes moisture entirely.

(2) It is unyielding—perfectly solid.

(3) It facilitates resurfacing.

In Europe not less than eight inches is thought sufficient. The sub-grade is prepared so as to conform with the finished surface; then the foundation is laid, and, when thoroughly dry, is ready for the surface mixture.

The latter is prepared as follows: The bituminous limestone is first ground fine, and heated in revolving cylinders to about 300° F. It is then spread over the foundation to the requisite depth, and stamped down to about two to two and a half inches in thickness. It will not stand rolling, as it runs into hills and hollows.

It is much more slippery than the American pavement, as it contains no gritty sand in most cases, but the latter is now being mixed with it to some extent.

The principle of all good surfaces should be to provide a durable, healthy, soft, and reasonably smooth cushion between this hard foundation of concrete and the wheels of the vehicles.

The first American asphalt pavement was laid in 1870 in Newark, N.J., by E. J. DeSmedt, the inventor of it.

It was constituted essentially the same as our asphalt pavements of to-day, viz., an artificial sandstone in which the grains of sand are cemented together with asphaltic cement.

Refined asphalt itself is too hard to make a desirable binding material, so it is tempered with residuum oil from the distillation of petroleum, for the lack of a better substitute. The adaptability of asphalt as the basis of this cement is unquestionable, as it (when good) combines the properties of elasticity and strength to a high degree. To demonstrate this fact, I have made a few experiments on the tensile strength of a few of these substances, and quote a few figures from the same below:

Refined "lake" asphalt,	525 lbs. per sq. in.	Temperature about 60° Fah.
Refined "land" asphalt,	330 " " "	
Asphaltic cement (lake),	370 lbs. per sq. in.	Temperature 57° Fah.
" " (land),	300 " " "	

The above figures are averages of a large number of tests.

Various attempts have been made to substitute artificial material, as coal tar, for asphalt, but one only needs to see such a sample of this as the city of Washington possesses, when in the hot summer days the horses have to struggle through it, carrying away a portion of the surface on the tires of the wheels, to be impressed with its uselessness.

I will now speak briefly of the construction of this pavement in our own city. The surface mixture, when ready for laying, consists of asphaltic cement, 10-15 per cent.; sand and stone dust, 85-70 per cent.; carbonate of lime, 5-15 per cent.

Generally a sand is found which contains the requisite amount of lime.

The refined asphalt is melted in large rectangular wrought-iron tanks, the temperature being kept at about 325° F.

The residuum oil is pumped in hot, and the whole is agitated by air forced through wrought-iron pipes, sunk into the liquid mixture.

Owing to the considerable difference in specific gravity between asphalt and the oil, and because the former is insoluble in the latter, a great deal of agitation is required—about ten hours. The consistency of the cement should be tested from time to time by a penetration machine, and should run about 80°.

The quality of the oil is of next importance to that of the asphalt itself. The most particular requirements are that (1) it shall not flash below 325° F.; (2) it should not lose more than 4 per cent. when distilled at 400° F. for seven hours; (3) it must not contain cokey granular particles or hard scaly paraffine.

PREPARATION OF THE FOUNDATION.

Before the pavement is started, all drains, pipes, underground wires, etc., which are necessary, are attended to, the proper parties being notified.

The sub-grade is carefully prepared, levelled, and rolled, if found necessary, for solidification. The kerbs are placed in position, either being set in concrete or gravel. The subsoil is drained by four-inch tile drains running parallel with the kerb in three rows, one under each kerb, and one under the devil's strip, or centre of the roadway, the former making connections with the catch-water basins.

If electric car tracks are to be laid, the sub-grade must be excavated to twelve inches extra in the track allowance, this being then filled in with six inches of ballast and compacted.

Girder rails six and one-half inches deep, weighing seventy pounds to the yard, are now universally used for electric railroads, and they require a very carefully prepared roadbed, owing to the great weight of the motors and the way in which it is concentrated.

The rails are laid on cedar ties, twelve by six inches, by seven feet long, perfectly sound. The grade is indicated by stakes every fifty feet, and the centre line of one of the tracks is run in carefully by the transitman.

Proper gratings to catch surface water are placed between the rails at intervals, and are directly connected with the sewer.

The roadway is now ready for the concrete foundation, which should be six inches deep.

The laying of the concrete must be done systematically, and as quickly as possible. The mixing is done on a movable square platform the width of the track allowance (16 feet).

The proportions are one part of cement (Portland) to three of sand, and sufficient broken stone—about eight parts—to give excess of mortar when rammed.

Mixing :—One-half the quantity of sand is spread upon the platform and one-half the cement spread over it, then the remainder of the sand, and, finally, the remainder of the cement. The whole is now thoroughly mixed in the dry state. Water is then added by a fine sprinkler, and thoroughly mixed with the sand and cement. The broken stone is now dumped on and the whole mixture turned over once or twice, and quickly shovelled on to the roadbed and carefully rammed by wooden rammers. The finished surface must show excess of mortar, and conform strictly to the line of grade. It is necessary to note a few points essential to the life of concrete : (1) The Portland cement should be repeatedly tested, and for this purpose a laboratory is necessary. (2) The sand should be clean and sharp, and may contain some gravel. (3) The broken stone should be of approved quality, and be broken to pass through a two-inch ring. (4) The most skilful workmen should be employed.

We are now ready to lay our asphalt.

The sand and lime are heated in revolving cylinders of sheet iron, and raised by belt elevators to the mixing floor, on which are situated the "cement tanks" and mixing machinery.

The machine in which the mixture is made consists of a cast-iron trough with a trap bottom. Running through the trough are two parallel shafts to which are attached blades, which, when the shafts revolve, work in and out between one another, causing the most perfect mixture. The hot sand and limestone are dumped in from carriages suspended from a track overhead. After a slight agitation, the asphaltic cement is poured in and the whole agitated for about one minute. By pulling a lever the bottom swings open, and the thoroughly mixed contents fall into a cart placed below, in which it is conveyed hot to the roadway. It is rare, even in twenty to thirty analyses of this mixture, taken from any one street, to find a variation of more than 1 per cent. in the bitumen present.

The mixture must arrive on the street at a temperature of not less than 250° F., and is quickly spread out, raked even, and rolled, first with light rollers, then with the heavy seven to ten-ton steam rollers, until no further impression can be made on it. When nearly finished, Portland cement is swept over the surface dry, and later receives its finishing roll. It is usual to lay the pavement in two layers, first, the cushion coat, one-half inch thick, and then the surface mixture proper, two inches thick.

Too much importance cannot be placed on the experience of the workmen, as every detail requires skill and care of a very high degree.

ADVANTAGES OF SHEET ASPHALT COMPARED WITH OTHER PAVEMENTS.

The properties which an ideal city pavement should possess are well known, but, owing to the variety of local conditions, it is not always easy to compare, in a general way, one pavement with another. I will therefore briefly endeavor to show the advantages which this pavement possesses for a city such as our own.

The different systems will be placed in order of merit under each head.

1. *Durability*. (*a*) Granite setts for very heavy traffic. (*b*) A good asphalt surface is equally durable for moderate traffic; in fact, the more traffic it gets, up to a certain limit, the better. Some asphalt pavements show signs of disintegration for want of traffic. (*c*) Brick. Results are, however, uncertain; and owing to the variation in quality, it is risky to subject it to heavy traffic as a rule. (*d*) Wood.

2. *Healthfulness*. Including noiselessness and cleanliness.

Noiselessness. (*a*) Asphalt produces a minimum of noise, which is much less noticeable in summer, when the pavement is softer than in winter. (*b*) Wood pavement, when new, is about equal to asphalt in this particular, but, when worn, falls decidedly to second place. (*c*) Brick. (*d*) Granite setts.

Cleanliness. (*a*) Asphalt. Its merit here is unquestionable, as there are no cracks to retain putrefying matter; the nature of the surface facilitates cleaning and removal of surface water, and the surface is absolutely impermeable. (*b*) Brick. (*c*) Stone. (*d*) Wood. The latter two are probably at par except when the wood is new, when it might be placed first.

3. *Traction and safety.* I here quote the results of a series of tests made to determine the resistance to traction on roads:* "If one horse can just draw a load on a level road on iron rails, it will take one and two-thirds horses to draw it on asphalt, three and one-third on the best Belgian block pavement, five on the ordinary Belgian pavement, seven on good cobblestones, thirteen on bad cobblestones, twenty on an ordinary earth road, and forty on a sandy road." But there is evidently a limit to the ease of traction caused by, with most materials, increased slipperiness. This brings us to what many consider the great weakness in asphalt. The various forms of block pavement certainly have an advantage in having cracks in which the horses may gain a foothold, but the surface of these blocks invariably wears very smooth, while asphalt wears down naturally with a gritty surface. Under certain conditions, *when the asphalt is kept wet by a fine sleety rain*, it is slippery as is everything else, but it is dry in a couple of hours after the heaviest storm, while most other pavements, under the same conditions, retain the evidence of it in the form of mud and water for as many days.

4. *Popularity.* This must ever be one of the most vital influences in the existence of any system of paving, as well as that of a good many other engineering and architectural constructions.

There are at present in the United States and Canada fifty of the largest cities in which asphalt has been adopted, in some cases almost to the total exclusion of other systems, as at Washington.

Between 1880-1890 there was laid in the United States 6,803,054 square yards of asphalt, representing 446 miles 26 feet wide, and since then it has received a great impetus.

The asphalt laid in Europe during the above decade was about one-fourth of that laid with Trinidad asphalt in the United States.

5. *Cost.*† Including first cost and maintenance.

This varies, of course, with the locality. In Toronto the order of cheapness is: (*a*) Wood, (*b*) asphalt and brick‡ (about equal), (*c*) stone setts.

Maintenance. The contractors are required to keep the pavement in order for five years, and some experts say that if an asphalt pavement is going

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*By Rudolf Herring, C.E., Philadelphia.

†The costs of these systems of paving in Toronto in 1893 were:

(*a*) Wood (cedar, six inches in depth), on sand, per square yard 70 cents.
" on concrete (six inches), $1.60 per square yard.
(*b*) Asphalt (two and a half inches), on concrete (six inches), $2.60 per square yard.
(*c*) Brick, single course on six inches of concrete, $2.50 per square yard.
(*d*) Granite setts, on six inches of concrete, $3.80 per square yard.

‡So far, we have had to import our brick, and the first cost of the material is doubled by duty and freight.

to go to pieces during its natural life it will manifest this during the first six months of the same.

It is evidently impossible for one pavement to embody all the good properties of an ideal pavement, but our object should be, under the existing conditions, to choose that system which will approach it most closely.

In many cases, undoubtedly, asphalt may be replaced with advantage by some other system; but for all general requirements in our large cities it approaches the ideal, if not perfectly, at least as well as any which has so far been brought forward.

Toronto, January 17th, 1894.

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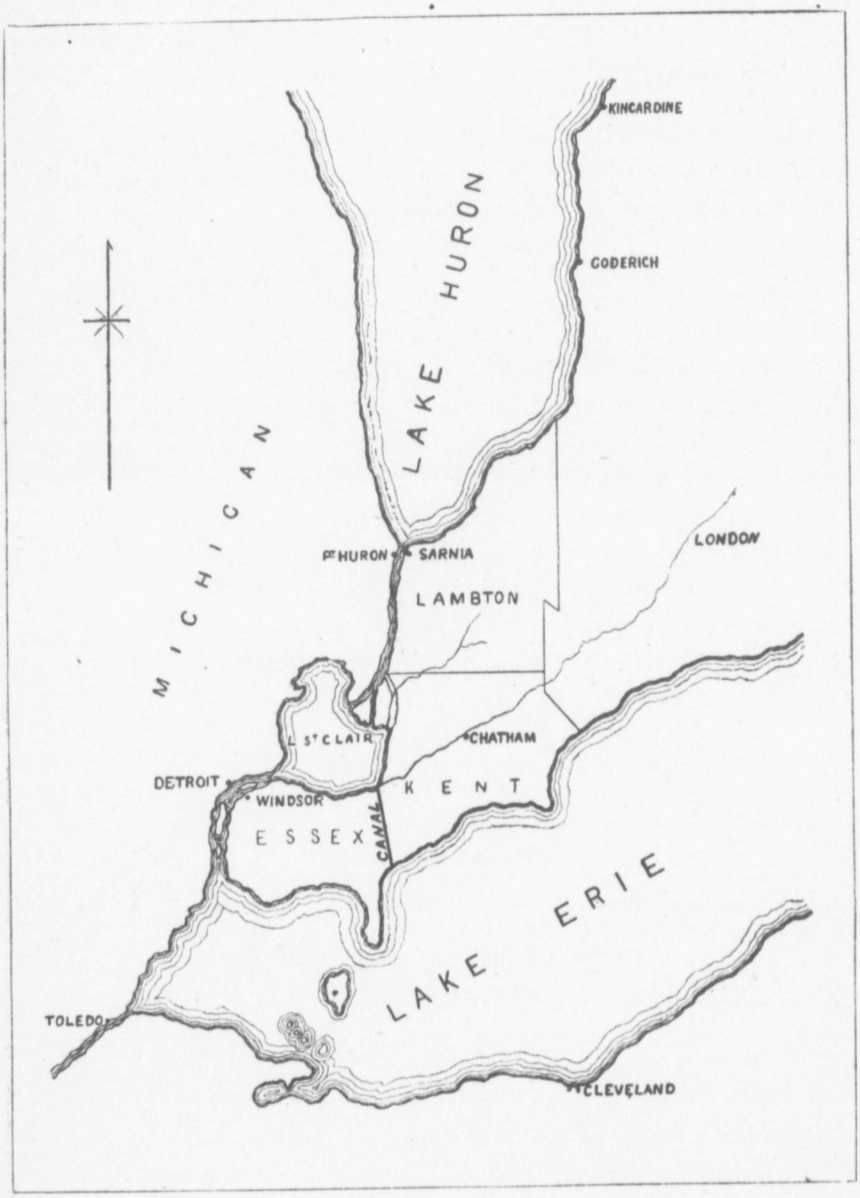
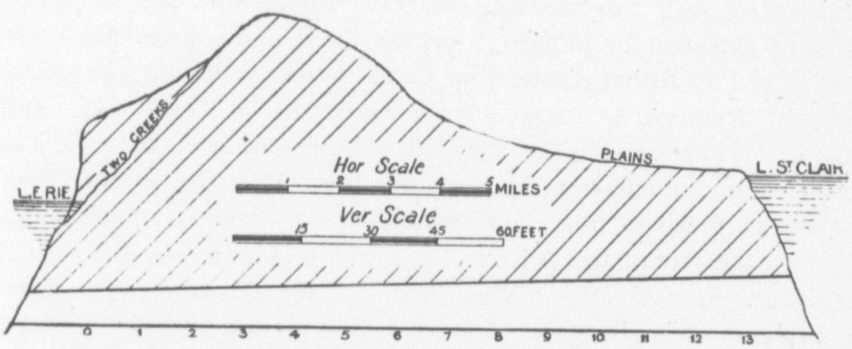

LAKE HURON
KINCARDINE
GODERICH
MICHICAN
P^T HURON
SARNIA
LAMBTON
LONDON
L. S^T CLAIR
CHATHAM
DETROIT
WINDSOR
KENT
ESSEX
CANAL
LAKE ERIE
TOLEDO
CLEVELAND

PROPOSED ST. CLAIR AND ERIE CANAL

J. C. MACNABB, O.L.S.

The present St. Clair and Erie Canal scheme is the revival of an old project that was talked of fifty years ago by the early settlers who were seeking some means of relief in the matter of drainage, and it has been before the public more or less prominently at intervals ever since, though the requirements of the times have changed the character of the proposed work, and now a canal is contemplated instead of a drain.

Three surveys have been made by different engineers at different dates with practically the same results, which show a difference of level between the surface of Lake St. Clair and that of Lake Erie of five feet ten inches. As is shown in the accompanying plan and profile, the route



of the canal would be about from the mouth of the Baptiste Creek southerly, taking advantage of the low levels of Baptiste, Trembly, and Two Creeks to the mouth of Two Creeks on Lake Erie, and this line gives almost a straight run between Lakes Huron and Erie, effecting a saving of sixty miles, as compared with the line at present travelled.

The physical characteristics of the route do not involve any engineering difficulties, as the thirteen and one-half miles of cutting consists of clay and clay loam, with possibly some sand in the neighborhood of the summit. The deepest cut necessary to give eighteen feet of water would be about forty-five feet, or an average cut of about twenty-two feet throughout.

At the St. Clair terminal there are large tracts of fen lands extending three and four miles inland from the shore of the lake; it is expected that these lands will be brought into cultivation by being drained by the canal. At the southerly terminal on Lake Erie, the estuary of Two Creeks presents an almost land-locked harbor of sufficient area to accommodate all the shipping that would meet at that point.

The development of the lake traffic of late years has been receiving greater attention from carriers and engineers than was usually devoted to it, as the annual rate of increase has been enormous. During the year 1890 twenty-two million tons passed between Lakes Erie and Huron, and during the year 1891 the tonnage passing through Detroit River exceeded by ten million tons the tonnage of the two ports of Liverpool and London. This is probably due to the opening up of the north and west and increased carrying facilities presented by the new type of freighter, named the *Whaleback*, by which a ton mile can be made by the expenditure of 1.8 pounds of power at a cost of 0.0018 cents, which compared with the power and cost to make a ton mile on an average railway, viz., 9 pounds and 0.009 cents, leaves a very large balance to the credit of the waterway as a means of transportation. Canada possesses a natural highway to the seaboard of over two thousand miles in length, with but seventy-two miles of detention by lockage; whereas the United States route from Duluth or Port Arthur *via* the Erie Canal to tide water has 352 miles of constant detention by lockage. As a writer on the "other side" aptly puts it: "Canada retains the key of the carrying trade of the great lakes to the ocean, not only from her own, but from American, shores. From Duluth as much as from Port Arthur, from Chicago as much as from Toronto, the way to the Atlantic for wheat and minerals is by the St. Lawrence. It will form a great bee line for the commerce of two hemispheres which, by reason of its few obstructions and detentions, its freedom from the necessity of breaking bulk, and its minimum cost of transportation, is destined to control a business which no imagination of man can picture or estimate." Whilst lessening the distance materially, the proposed work would also avoid the dangerous navigation met with at Grosse Point, Bar Point, Limekiln Crossing, Colchester Reef, and Point Pelée. The company now applying for a charter from the Dominion House is composed of American capitalists in Duluth, Buffalo, and New York, and their representatives on the grounds state that they will make the canal eighty feet bottom width, with eighteen feet of water; and give, as a rough estimate of the work, between four and five millions of dollars. This is roughly approximate, as no location surveys have been made by them.

The canal would be a great improvement on the present route and to the territory through which it would pass, so that it is to be hoped that the present company may not prove a bubble like its predecessors.

MOUNT BROWN AND THE SOURCES OF THE ATHABASCA.

By Prof. A. P. Coleman, M.A., Ph.D.

If the camel be the "ship of the desert," the cayuse pony is the "canoe of the mountains." To the inexperienced rider he is as cranky and tottish as any birch bark in a rapid, but with certain virtues as well as vices.

Our nine ponies were awaiting us at my brother's ranch in Morley on the 8th of last July (1893), and all that remained to do was to capture them and endow them with their loads. Some had not come under the hands of man since the summer before, and to lasso, saddle, and pack them required the efforts of all four of us, as well as the hired man on the ranch. One of them, the pinto, was hunted in the large field for more than an hour by three men on horseback before being coralled and caught. Soon after noon, however, all was ready, and we commenced our three-hundred-mile journey through the mountains to Mount Brown.

Our outfit was the usual one for the mountains, except for a canvas boat, the "Athabasca," most inconvenient to pack, but, as we soon found, quite indispensable in crossing rivers.

The party consisted of Mr. Stewart, Mr. L. Q. Coleman, and myself, with Frank Sibbald as cook and packer. Last summer's experience had shown that Indians, though picturesque additions to a party, are more trouble than they are worth when once beyond their own hunting grounds; so we set off without guides, and found no reason to regret their absence.

As far as the Kootenay plains, on the Saskatchewan, our route was the same as in our former expedition, following the well-travelled Stony trail through the foothills to the Red Deer, then into the mountains, over a pass to the Clearwater, over another pass to White Rabbit Creek, which we followed down to the Saskatchewan.

Chief Jonas, with his family and one of his braves, kept pace with us day by day, and not long after we camped every evening we saw a white cone, with a smoke-browned top, rise among the trees a few hundred yards off. Then the chief and his young man would come nonchalantly into our camp, following the odor of frying bacon, and sup with us. The chief was dressed in shabby white man's clothes, but with moccasins to show his race, and black ostrich plumes in his felt hat to show his rank. The young man wore the usual blanket costume, with fringed leggings, which parted company with his upper garments when he squatted on the ground, leaving a broad expanse of bronze thigh for the pestilent mosquitoes to pasture on.

The chief is a sinewy, graceful, dignified man, rather under medium height, speaking in a suave, well-modulated tone, with agreeable gestures. Sibbald was brought up with the Stonies, and is one of the few whites who understands their guttural language, so that he got a good deal of useful information for us from Jonas. One evening the chief borrowed a pencil and piece of paper from me, and next morning brought a map of the rivers, lakes, and trails of the region as far to the northwest as he was acquainted with it. This proved of value at least once in our journey.

The women and children we saw only on the march. The chief and his man rode gaily ahead with their guns, while a lithe, well-built girl of eighteen looked after the pack animals, riding astride her pony as erect as a guardsman.

Owing to the unusually heavy snowfall of the previous winter, and the sunny weather of the summer of 1893, the rivers were much higher than usual, and, as Chief Jonas and other Indians foretold, the Saskatchewan was unfordable. At the usual ford its strong, muddy current would have swept away horse and man. Jimmy Jacob, last year's guide, who was hunting sheep in the neighborhood, had promised to show us a ford for $5, but, deeming discretion the better part of valor, did not arrive at the time agreed upon to earn his money.

Without waiting for Jimmy, we proceeded a few miles down the river to a point where it flows in a single channel, and, unrolling the "Athabasca," ferried across, first driving the horses in and making them swim over.

To our astonishment, we found, camped near the ferry, a blue-eyed, stubble-bearded prospector, named McGavan. He was alone, except for a bright little spaniel and three ponies, and had met no one since leaving Laggan a month before. He was sawing boards to build a boat when we arrived, but was happy to secure a passage in the "Athabasca" next morning. It was midnight before we finished ferrying and got our camp made; and the first thing we heard in the morning was McGavan's cheerful whistle and the jangling of his cow-bell, as he sat by his bundles and his ponies on the mud of the bank, waiting for the ferry. He informed us that he was on his way to the most northerly tributaries of the Saskatchewan, in search of the quartz reefs which he believed to supply the gold of the placer mines near Edmonton. During the past few seasons he had prospected every stream entering the Saskatchewan from the mountains except the ones he was now going to; and since he had found no gold in any of the others, he was convinced, in spite of the geological survey, that these most remote tributaries must hold the treasure. It was too bad to see so much energy and courage spent in a perfectly hopeless quest.

After crossing the river our ways parted, McGavan leading his ponies eastward, and we turning westward to the Hahasigiwapta, or Cataract River, as it may be translated, one of the larger tributaries of the Saskatchewan. We followed the valley of the Cataract River westward, from the foot of Sentinel Mountain to its source, a distance of about fifty miles. It is a very rapid, blue-green river, heading, 1,500 feet above its mouth, among striking mountain peaks, in a charming lake, clear, cold, and trout-haunted, fed by a magnificent spring forty feet wide. We ascended a tableland, which rises to about 7,000 feet beyond the lake, and, after a tramp of eight miles to the southwest, looked down upon the Saskatchewan, already a respectable river, though within thirty miles of its source.

Turning to the north, we crossed a divide, which we named Cataract Pass, at 7,550 feet above the sea, and made our way down the Brazeau. The pass is not a very easy one, since snowslides have mowed down the forest for half a mile in width at one place, leaving an almost inextricable tangle of fallen trunks; and at the summit we found so much snow on July 24th that we had to make a wide detour up the mountain side to get safe footing for our horses. Several glaciers come down to the level of the pass, feeding an indigo-colored lake amidst the snows of the summit. Peaks of a very bold and rugged type rise close at hand; and at the highest point no trees can be seen, nor scarcely any other green thing, so that the whole effect is wild and severe.

A sharp descent of 1,200 feet leads to the headwaters of the Brazeau, where we camped for a few days to explore the neighborhood, and, particularly, to find a pass over to the Sunwapta, which Chief Jonas had marked on his map. The mountains here are of the inclined plane type. We climbed one which rises 9,600 feet above sea level, and another rising to 10,150. The latter, which faces the head of the valley, gives an admirable view down the Brazeau, as well as over the upper Saskatchewan, with its splendid mountain surroundings. To the northwest, we could see the blue valley of the Sunwapta and its far-off junction with the Athabasca, the limit of our journey last year.

The pass mapped for us by Jonas enabled us to avoid a long detour by Brazeau Lake and Poboktan Creek, the route we had followed the summer before. The trail climbs quickly up from the Brazeau into a narrow desolate side valley, treeless for seven or eight miles, and, when we crossed it, clammy with half-melted snow from a storm the night before. The descent towards the Sunwapta led over muskegs, past beaver ponds, and through horrible burnt woods where the soil had been consumed, leaving sharp stones that rolled under the feet of the horses on the steep side of the gorge. Two beasts rolled over, load and all, till they reached the creek below. We named the pass, which reaches 7,700 feet, and the creek which flows into the Sunwapta, in honor of the chief, Jonas' Pass and Jonas' Creek.

To explore the upper part of the Sunwapta valley, we rode seven miles up the river through dreary burnt woods, and climbed a mountain, stopping at 10,000 feet, several hundred feet beneath the highest summit. A wonderful view spread before us. Five thousand feet below lay the river branching into a hundred narrow, interlacing channels, looking from our perch like a ravelled skein of silk flung upon the ground. This spreading into numberless channels is a common feature of glacial streams near their headwaters. The mass of fine "rock flour" and pebbles with which the glacier burdens them is dropped at the first level reach of their bed, and the stream is perpetually seeking new channels through the loose materials it has deposited in its own path.

To the south of us near the head of the valley rose sharp and steep mountain points, and across the valley there was a huge dome-shaped mass of snow brooded over by heavy clouds, and sending long glacier tongues between black precipices into the valley. We probably saw the same dome-shaped mass over which the clouds hovered from a mountain top thirty or forty miles farther away the previous summer.

We estimated that the higher points in the group rose some thousands of feet above us, probably to 13,000 feet, but not more than 14,000 feet above sea level. So far as we have observed, these are the highest mountains in Canada. As the river is here about 5,000 feet above the sea, and the mountains rise abruptly 7,000 or 8,000 feet higher, the effect is very impressive.

Turning down the river from our camp at the mouth of Jonas' Creek, we were presently stopped by a rock slide impassable for horses. A huge slice of quartzite and conglomerate, a mile wide and hundreds of feet thick, must have loosened itself high up near the crest of the mountain and slid down into the valley, burying square miles of its surface with gigantic blocks of stone, damming the river, which now rushes over the obstruction in a series of rapids, and hurling great masses half a mile up the opposite slope. The yellowish scar from which the avalanche slipped can be seen distinctly on the mountain, so that the event took place probably not more than a century or two ago. What a tremendous sight it would have been from the opposite mountain !

Fording the river, we circumvented the rock-slide and made our way, often by dint of much chopping on tree-encumbered trails, past the falls of the Sunwapta, past its junction with the Athabasca, to the falls of the latter river, where we camped within sound of its thunder. The Athabasca falls, though only about sixty or seventy feet deep, are very striking. The river here, nearly a hundred yards wide, and too deep and swift to ford, gathers itself together, swerves suddenly to the left and plunges as a chalky green flood into a black chaldron, out of which steams a rainbow-haunted spray cloud. The canon into which the river disappears sweeps a semi-circular curve, and its walls close in so much at one point that some daring man, years ago, flung six small spruces across it to make a bridge. It would need a cool head to cross them now, half decayed from the dampness of the spray.

Our way down the river grew still more difficult after this, and the axes had to be in constant use. It is evident that no one has used the trail for some years. One very hard day's work advanced us only three or four miles. We came out at last upon a well blazed and beaten trail through the widened valley, with here and there stretches of prairie, delightful to behold after weeks of battling with burnt forest. One evening the half bark, half laugh of coyotes came to our ears, rejoicing the heart of Frank, who is a true plainsman. "It's a decent country where there are coyotes," said he, and looked more cheerful than for a long time before. To camp on a meadow of soft green grass beside a brook shaded with densely growing willows, where everything is clean and peaceful, has indeed a wonderful charm after days of burnt woods, where all day long you have been smeared and smudged by charred branches and tree trunks, until everything about man and horse is foul and sooty before the evening camp is pitched between shadeless black trees on a soil of ashes and sand. We began to think we were getting into "God's country" again, to use a westernism.

We had now reached nearly the latitude of the mouth of Whirlpool River, according to Mr. Stewart's observations, but no marked valley opened up on the other side of the Athabasca, and we were in doubt where the river entered. As it happened, we passed through a bit of woods cutting off a bend of the Athabasca at the critical point, missed Whirlpool River, and passed on to the Miette, a few miles farther down. This we took for Whirlpool River; and it was a day or two before the difference of latitude, the wrong direction of the valley, and the finding of railway survey pegs, convinced us that we had entered the Yellowhead Pass (Tete Jaune), where a survey was made a number of years ago for the Canadian Pacific Railway.

On the maps, Henry House, a trading post, is placed opposite the mouth of the Miette, but we found no trace of any house in that position. It has, perhaps, been destroyed by fire, and the site covered with second-growth trees. The law of the map-maker seems to be that of the consistent Calvinist, "Once in grace always in grace." A name once installed on a map, whether rightly or wrongly, stays there forever. We found that the Yellow Head Pass is still in use. A party had gone over it a week or so before us with horses much larger than our little cayuses, to judge by their big hoof-prints.

We ferried back across the Athabasca, and retraced our steps for a few miles, anxiously looking out for the mouth of Whirlpool River. Our first hint of its presence was given by the clearer green of the water on the opposite side of the Athabasca, which may be noticed a mile or two below the entrance of the Whirlpool.

At the mouth of the Miette, according to the railway survey, the Athabasca is 3,329 feet above the sea, but its descent is rapid, and we found the mouth of Whirlpool River about 300 feet higher.

We ferried across the Athabasca once more, and followed up the impetuous, sea-green Whirlpool River to its source. It is fordable with difficulty in its lower reaches, and my brother, on the tallest horse of the outfit, had to swim in exploring for a ford.

The Athabasca Pass was a thoroughfare for the Hudson Bay Company more than half a century ago, their voyageurs crossing it summer and winter; and it was used by hundreds of ponies and dog teams during the explorations for the Canadian Pacific Railway about eighteen years ago, so that we expected to find a good trail. In this we were disappointed. The pass has apparently not been used for a number of years; portions of the trail have been undermined and swept away by the river, and other portions were so tree-encumbered that we had a great deal of chopping to do.

The scenery along the way is often fine. A glacier, comparable to that of the Rhone, sends its blue ice-front down almost to the level of the valley at one point, and supplies a third of the water of the river. Still higher up the pass other large glaciers provide the rest of the flood, until, as one approaches the watershed, the Whirlpool dwindles into an insignificant rivulet rising in a pretty little tarn at the head of the pass. This pond is the Committee's Punch Bowl, which masquerades on the maps as a lake eight or ten miles long, sending a river southward as well as northward. By careful searching, we found a rill trickling between the stones at the other end of the Bowl and flowing south—a tributary of the Columbia—so that this little pool divides its snow-fed waters between the Arctic and Pacific Oceans.

The Punch Bowl is about 150 by 100 yards in dimensions, sufficient, one may be permitted to suppose, to brew punch for a large committee, even of well-seasoned Scotchmen such as one finds in the employ of the Hudson Bay Company.

Moberly puts the elevation of the Punch Bowl at 6,025 feet, but we found its height to be only 5,710 feet above sea level.

If the Punch Bowl was a disappointment, Mount Brown, which we had come so far to see, was much more so. Keith Johnson refers to it as 15,990 feet high,* and Reclus as 4,875 metres, or 15,980 feet high.†

The botanist Douglas, who went through the pass in 1826, has the credit of naming Mounts Brown and Hooker for the two great English botanists. Whether he gave them the heights we are accustomed to see in works on geography I do not know, not having been able to obtain copies of his papers on that part of his travels.

On the maps Mount Brown stands a little northwest of the Punch Bowl, but the only mountain answering to this position in nature is not particularly striking as seen from the valley. We passed several far handsomer and loftier peaks on our way up, so that we were deeply disappointed. Owing to a severe accident to my knee, I was unable to walk more than a few hundred yards when we camped at the summit of the pass; but when I surveyed the mountain, which I had toiled so long to see, it no longer seemed so great a privation not to join in its ascent. Mr. Stewart and my brother, with Frank as companion most of the way, made the ascent on August 21st. They met with no very serious difficulty, except a mile of steep snow field, until just beneath the summit, where a

*Physical Atlas of Natural Phænomena, p. 26.

†Nouvelle Géographie Universelle, p. 261.

cornice of snow proved unscalable. They estimated this cornice, which covers the crest of the mountain, at less than one hundred feet in thickness. Readings of the aneroid barometer and of the boiling point thermometer show the height at which they stopped to be 8,950 feet, giving about 9,050 feet as the full height of the mountain, which rises only 3,340 feet above the pass.

There can be no mistake as to the mountain, for no higher point rises beyond it west or northwest of the Athabasca pass, so far as could be seen from the summit. Mount Brown must descend, therefore, from its undeserved reputation as the highest mountain between Mexico and Alaska. There are hundreds of peaks higher than it towards the east and south, though probably none reaching within 2,000 feet of its reputed height. If Mount St. Elias proves to be within Canadian territory, instead of being the corner stone of Alaska, as claimed by Americans, its altitude of nearly 18,000 feet puts it far in advance of any other Canadian peak, and it has no rival in North America, except Orizaba in Mexico, which, according to some accounts, is a few feet higher.

During our return journey we asked ourselves again and again how the height of Mount Brown could have been so enormously overestimated as 6,000 or 7,000 feet, and we have found no answer to the question. Scores, if not hundreds, of men, many of them well-trained engineers, have made the pass a thoroughfare on the business of the Hudson Bay Company, or of the railway surveys. How did they fail to slice off some of the undeserved thousands of feet?

I should mention here that Dr. George Dawson, in a private letter on the subject, expressed the opinion that Mount Brown would turn out to be not more than 12,000 feet high when climbed.

The case of Mount Hooker we found less easy to settle. Johnson makes it lower than Mount Brown, Reclus higher.* The point nearest in position to that on the map is only about 8,000 feet high, as determined by Mr. Stewart and my brother, but a handsome, glacier-covered mountain, just east of the Punch Bowl, probably reaches 11,000 feet, and there are summits a few miles southeast that perhaps surpass 12,000 feet. Unfortunately, lack of time prevented our climbers from ascending any of them.

The Punch Bowl suggested no ideas of conviviality when we visited it last summer, for we had not even a flask of brandy with which to celebrate the end of our journey. The little meadow of matted sedge, surrounded by stunted spruces on three sides, and by the limpid pond on the

*_Loc. cit._, Johnson says 15,700; Reclus, 16,979 (5,180 metres).

other, was the type of the sober and restful. Whistlers, or marmots, inhabited every rock heap around, and piped warningly whenever a tree was cut for fuel, or any other unusual sound aroused them. In revenge for this surveillance two of them, pursy as aldermen in their handsome gray fur waistcoats, fell to Mr. Stewart's rifle, but, to our sorrow, proved as rank in the pot as even porcupine. Caribou left their large hoof-prints on the river flats not far away, but we failed to get sight of them.

One day, when only the packer and my crippled self were left in camp, a full-sized cinnamon bear strolled leisurely down to our meadow and stopped suddenly fifty yards from where we stood at the tent door, apparently catching the scent of our footprints where we had gone for wood. The crest of coarse hair rose on his shoulders, he looked round at us, and then strolled as leisurely as ever into the woods again, with a courteous air of not wishing to intrude on our privacy. Frank mounted his pony, and, taking the gun, rode after our friend, the bear, but the pony stopped short, trembling, when he scented the cinnamon, and could not be forced to go any farther.

The black bear is much more cowardly than the cinnamon or grizzly. Two which we came upon galloped off as fast as their clumsy legs could carry them, and one never stopped till he had swum the Athabasca.

Fortress Lake is only ten or twelve miles from Punch Bowl, and it had been our intention to strike across to it; but, finding no route possible for ponies, we turned back the way we came, following the Whirlpool River to its mouth, ferrying across the Athabasca, and retracing our steps up that river to the junction of the Sunwapta. This we forded near its mouth, and then made our way, with some chopping of trails, to Fortress Lake, travelling eighty or one hundred miles to advance a dozen. Most of the way from the mouth of the Sunwapta we followed the trail made by Job Beaver, who led seven lodges of Stonies to the lake several years ago, the only visitors, so far as we could discover, who had looked upon Fortress Lake before us.

Job Beaver was, perhaps, the most enterprising man among the Stonies, a sort of unlettered Stanley, who opened up many new trails in the mountains, chopping his way with an axe as keen as if wielded by a white man. We had followed his footsteps for many a mile, and had blessed him for his enterprise. Last winter his eldest son died of consumption, and Job was so much affected by the loss that he committed suicide. At least that is stated by the whites at Morley, though the Indians will admit only that "he was wrong in his head before he died."

In honor of this intrepid explorer, we named the western fork of the Athabasca, which is somewhat smaller than the main river, though more than fifty yards wide where we crossed it, and difficult to ford, Chaba River—Chaba being Stony for Beaver. The name is a memorial in another sense also. Many and immense beaver dams exist along this river, though the race seems now extinct, whether exterminated by Job and his comrades, or, as Chief Jonas avers, by some contagious disease.

Passing the poles of the seven teepees, we came out upon the shore of Fortress Lake, and feasted our eyes once more on its opaline blue-green waters, set in dark forests untouched by fire, and reflecting splendid ruddy cliffs and rock pinnacles, and the far-off whiteness of immense snow fields.

We had cherished a hope of launching our boat, the "Athabasca," on the waters of the Punch Bowl, until we found that pond too small to make it worth the trouble; but now we quickly had her afloat on the beautiful lake beside our camp. After hard pulling in crossing swift and dangerous rivers, it was a delightful contrast to float idly on the lake, or to row furiously after the half-fledged ducks, which seemed so little afraid of man.

One disappointment awaited us. After promising ourselves trout as a relief from the monotony of bacon, we trolled and still fished and set night lines, we displayed the charms of a silver spoon, of grasshoppers, of flies, and of pork rinds, and had never a bite as reward. The lake looks the very home of mountain trout, but is apparently void of fish.

We had discovered the summer before that Fortress Lake has a subterranean outlet into a small tributary of the Athabasca, and we now found that a canal, half a mile long and six feet deep, would drain it into that river. At the opposite end of the lake, which is eight miles long, we found a beautiful clear stream, nearly as large as the Miette, flowing west into a turbulent river coming from the north, undoubtedly Wood River, an important tributary of the Columbia. Thus Fortress Lake, like the Committee's Punch Bowl, sends its waters to the Pacific as well as the Arctic Ocean. As the Punch Bowl is represented on the maps about the size of Fortress Lake, one might almost suppose they had been confounded. Fortress Lake lies east and west, instead of north and south, however, and no trail leads past it down Wood River.

The lake stands 4,330 feet above the sea, so that the pass is nearly 1,400 feet lower than Athabasca Pass; 950 feet lower than the Kicking Horse Pass, followed by the Canadian Pacific Railway; and only 610 feet higher than the Yellow Head Pass.

We had intended to do some exploring and mountain climbing about Fortress Lake to complete last year's work, but smoke from some distant forest fire drifted over us, reducing the mountains, in a day or two after our arrival, to colorless ghosts, and destroying all chance of distant views.

After a few days of idleness, the only real holiday of our summer, we began a rush for home, leaving the lake on September 4th, following the Athabasca down to the mouth of the Sunwapta, ascending that river, crossing Jonas' Pass to the Brazeau, and following the Cataract Pass and River down to the foot of Sentinel Mountain on the Kootenay plains.

Here Mr. Stewart made a sudden resolve to run down the Saskatchewan in our canvas boat, and, failing to dissuade him, we divided to him one-fourth of all our sadly diminished goods and bade him farewell. Five minutes after he was out of sight beyond a bend, and had commenced his lonely journey, at first rushing through the rapids of the mountains, then sweeping more gently through the plains, till he reached the end of his voyage at Edmonton, 300 miles from his starting point.

The rest of us trotted our lightened ponies briskly over the Kootenay plains to the mouth of White Rabbit Creek. Here we occupied our old camp ground, and found that some one else had been there not long before, for a teepee had been pitched close by with only three poles, the minimum number possible. There was only one man in the outfit, as was shown by his narrow bed of boughs; and he was a white man, for his hob-nailed shoes had left their imprint on the mud when he filled his kettle at the creek; and he smoked, for a tiny heart-shaped bit of tin glittered on the earth beside the dead embers of his camp fire; and he had three ponies, for three tethering pegs stood a little way off on the yellow prairie. It must have been McGavan on his way home from the most northerly tributary of the Saskatchewan, disappointed in his search for the source of the Saskatchewan placer gold. He had, very likely, pitched his lodge close to our old camp for company; and I can imagine his gloom as he smoked by the fire, little cheered by the wag of his spaniel's tail, or the homely music of the cow-bell on his grazing pony.

Once more we crossed the pass to the Clearwater, and then to the Red Deer, and as we descended to the mountain park on September 12th we at last came once more upon human beings. Below us were twenty-one lodges of white or smoked-brown canvas planted on the prairie, and a couple of squaws with faggots of dry poplar looked curiously at us from the bushes as we passed. A hundred particolored ponies grazed near by or far away, a hundred dogs barked vociferously, and almost a hundred women and children came out to watch our approach. At this reception our ponies, so unused to metropolitan life, took fright and dashed to one side, sweeping a wide curve on the yellow turf, until yelling boys and yelping curs were left far behind.

Two days later we trotted into Morley, glad that the ten days' ride of three hundred miles, over wild valleys and passes and prairie, was over.

The general physical features of the region were described in a paper read before the Canadian Institute last year, and not much need be said in addition. The valleys, with their park-like bits of meadow, and their gloomy woods of spruce and pine; the mountain flanks clothed with forest up to 7,300 feet, the summits, bare of trees, often rising into the snows and necklaced with glaciers; the tumultuous rivers, and still more headlong torrents; the gem-like, placid lakes; all unsullied by man, except where swept by his runaway slave—fire—this continued for weeks, without the sight of a human being, outside of one's own party, gives one a most vivid sense of wild and lonely majesty, of virgin solitudes unconquered and unconquerable by man.

A CANOE TRIP ON THE SASKATCHEWAN

By L. B. Stewart, D.L.S.

About a year ago, when in discussing our proposed expedition for the coming summer to Mount Brown we decided to make a folding canvas boat a part of our equipment, it occurred to me that it would make a very pleasant termination to the trip to paddle down the Saskatchewan to Edmonton from the point crossed by our route. With this in view, I provided myself with a tracing of a portion of Palliser's map, showing the river between those two points. This proved of considerable service later on.

Early in September we commenced our return journey, having completed our explorations in the vicinity of Mount Brown, and being warned by the diminished appearance of our larder that it was time to seek civilization; and on the 9th we stopped for lunch a few miles beyond the Saskatchewan.

My proposal to paddle to Edmonton was strongly opposed by the other members of the party, but I was confirmed in my decision by the condition of our horses, whose backs were becoming very sore through our forced marches. The boat itself, from its awkward shape, was responsible for a good deal of this, and besides relieving the horses of a portion of their loads my departure would leave a saddle-horse at the disposal of the other members of the party. Being fond of boating, I looked forward to the trip with considerable pleasure, notwithstanding its loneliness.

About the middle of the afternoon we reached the Saskatchewan, which we were glad to find fordable, as on our outward journey the height of the water had necessitated a long detour to find a place where the river is confined to a single channel, which was crossed by boat, making the horses swim. After crossing, the horses were unpacked, and preparations soon made for my departure; the boat was put together and the oars converted into a double paddle; all my own belongings, and one-fourth of the provisions (there were four in the party), were put on board; and then, wishing Dr. Coleman and the others good-by, I pushed off, and in a few minutes a bend in the river hid them from view.

Owing to the lateness of the hour of starting I did not expect to travel far that day, but, nevertheless, made about twenty miles in two hours, such was the strength of the current. I was now outside of the mountains, among the so-called foothills, which would pass for mountains in any other part of the world where they were not overshadowed by their loftier neighbors. No difficulty from rapids was met with until just before camping for the night, when a spot was reached where the river narrowed to a width of about 100 feet, and rushed at a great rate against a cliff that appeared to bar its further progress, but which only caused it to make a sharp turn to the left, the water lashing itself into foam against its base. Not liking the appearance of things, I landed a short distance above and examined the rapid, but decided it could be run in safety. I made the mistake, however, of keeping too close to the shore on the left, and narrowly escaped coming to grief among some boulders, the boat striking one of these, but rebounding from its smooth surface, and soon the eddy below was reached in safety.

A couple of miles farther on, what looked like a similar rapid appeared in sight, and, as it was getting dusk, I decided to wait for daylight before attempting it, and so camped for the night.

My preparations for the night were soon made. The boat, if not affording very extensive accommodation as a tent, was a very effective shelter in case of rain, and having had supper there was nothing else to do but to retire for the night, which I did, my slumbers not being in the least disturbed by the fact that I was entirely alone.

The following morning I delayed my departure long enough to cook nearly all my provisions, so as to avoid any further delay on that account, and then, having packed up, I paddled on down the river. Shortly before noon I passed the mouth of the Ateko Sippi, a small river which enters the Saskatchewan from the southwest. At the time I mistook this river for the Clearwater, thinking a smaller stream seen farther back was the Ateko Sippi, and was disappointed the following day to find that I had only then reached the Clearwater. About three in the afternoon I passed through the gap in the outlying range of the Rockies, and for the rest of the afternoon had my attention fully occupied in guiding my boat through almost continuous rapids, and when about three hours later I was able to pause and look about me I found that the last vestige of the mountains had almost disappeared from view. The part of the river just passed through was the most dangerous met with. The danger was due not so much to the roughness of the water as the abrupt bends of the river, combined with the swiftness of the current, which made it necessary at times to strain every nerve to avoid being carried by the force of the current against the rocky cliffs, which were always met with at the sudden bends, and gain the eddy on the opposite side. I often found myself descending a rapid broadside-on, and paddling with all my strength for the side on which the eddy lay. This would be a very unsafe proceeding with the ordinary canoe, but the "Athabasca," as we called our boat, was almost non-capsizable, having a width of four feet and a length of twelve, a form but ill-adapted for speed, but admirably adapted to the work that was expected of it; speed is of very secondary importance in travelling down a river whose current averages from eight to ten miles an hour. On one occasion only was it necessary to land to empty the water out of the boat.

At 7.50 the following morning I was again under way, and at 4 p.m., as I rounded a bend of the river, the ruins of the Rocky Mountain house came in view. This was a few years ago an important trading post of the Hudson Bay Company, but having been deserted it was burnt by the prairie fires; for the country here is thinly wooded, the woodland being interspersed by patches of prairie. The chimneys are now all that remain to attest the existence at one time of this extensive and busy post; and, to judge from their number, each room of the buildings must have been provided with a fireplace, which was the practice in those days in this part of the world, where stoves were all but unknown.

About half a mile below the ruins the Clearwater River enters from the southwest. I landed here, and, having placed my property under the upturned boat, as it was raining, set out to look for a settler's house that, I had been told, was to be found about a mile up the river. I was obliged to guess on which side of the river it was situated, but I guessed aright, and in a few minutes came in sight of it. Even in the distance everything looked ominously quiet about the shanty, and I was quite prepared to find on reaching it that it was deserted. I then returned to my boat with my spirits as much damped by this discovery as my clothes were by the pelting rain, as I had hoped to replenish my stock of provisions, which was beginning to run low. I then reloaded my boat and paddled a couple of miles farther down the river.

Up to this time I had had very little time for reflection, but on this evening, as I sat beside my camp fire, with the oppressive stillness of the air broken occasionally by the distant howl of the coyote, I realized for the first time what it is to be entirely alone in a wilderness, with probably one hundred and fifty miles between myself and the next human being, and thought that if the poet who sighed "for a lodge in some vast wilderness" were only there he would be amply satisfied. Solitude certainly has its charms, which must be experienced to be appreciated, though probably a very few days would suffice for most people.

As soon as I began to stir in the morning, I was greeted by a chorus of howls from wolves, who had been tempted to come a little nearer than they otherwise would have come under cover of a mist that hung over everything; but none came near enough for a shot. Shortly after 7 o'clock I was again under way, as time was getting precious. At about 11 a huge cinnamon bear appeared walking quietly along the shore about eighty yards away. I at once picked up my rifle, but the noise made in doing so attracted his attention, and he sat down on his haunches to take a good look at the intruder. The lurching of the boat made it impossible to take a steady aim, so I exchanged the rifle for the paddle, and made for the shore, thinking he would wait, as he was taking matters so quietly, but as I was stepping ashore he beat a hasty retreat into the bushes, where I did not feel inclined to follow him. It took some days to recover from the disappointment caused by his sudden departure. In the afternoon, the current having become comparatively sluggish, and a head wind having sprung up, I decided that faster progress could be made with oars than by paddle, and landed and reconverted my paddle into a pair of oars. By 6 p.m. I reached the mouth of the Brazeau River, and camped at a spot that apparently had often served as a camp ground, judging from the number of stumps and inscriptions on blazed trees.

I hoped now to reach my destination easily in two days, but the current in the river was becoming more and more sluggish as I proceeded, and this fact, combined with the almost incessant head winds, made it impossible to do so.

The following day was spent as before, the crookedness and sluggishness of the river becoming exasperating.

The next day provisions began to look alarmingly scarce. After breakfast a piece of bread about as large as my hand, and less bacon, were all I had left, but, as I went on, the country began to show signs of the presence of man; stranded saw logs were occasionally to be seen, and here and there a deserted hut occupied some picturesque spot, and I expected soon to fall in with some lumbermen. At about 1 p.m. I heard the sound of chopping on the bank of the river, and was not long in landing and making my way to where the sound came from. I found a man working alone; his two companions, he told me, had gone down the river with a raft of timber. I was never more delighted at meeting any one; he was the only human being I had seen for nearly five days. He gave me enough provisions for a week, and I had some difficulty in preventing him giving me enough for a month. He kindly invited me to remain with him over night, probably not relishing loneliness even as much as I did, but I was in a hurry to reach Edmonton, knowing that there were only two trains a week from there, and fearing that I would be just in time to miss one, and so pushed on, having learned that there was a sawmill about twenty miles farther down the river. At 6 p.m. the mill was reached, and I was there informed that a train left Edmonton the following morning (Friday) at 7.30, and I resolved to catch that train, if possible, by rowing all night, though I had still over sixty miles to go. I rowed on until nine and then stopped and cooked some supper, and made preparations for appearing in civilization, as far as my limited wardrobe would permit, and at midnight set out again. The river at this part is comparatively placid, but occasional shoals and rapids made it necessary to be on the alert. The rapids were managed by dropping down stern foremost, thus being prepared to pull away from anything that looked dangerous. The night was beautifully clear, and a brilliant aurora afforded a certain amount of light. Shortly after seven in the morning I came across a party of miners washing for gold on a bar of the river, and on enquiring the distance to Edmonton was told that it was about fifteen miles, so I concluded that I had missed my train. As I was turning away, I heard one man make a remark to another that sounded very much like "That's a tough," which I considered very discouraging after my elaborate midnight toilet.

After a short stop for breakfast a mile or two farther I rowed on, every few miles meeting a party of miners washing for gold on the bars of the river, by which, I am told, they can earn from one to three or four dollars a day. One party I met finally told me I was only two or three miles from Edmonton, so I bestowed upon them the remainder of my provisions, and in a short time arrived at the ferry connecting Edmonton with Edmonton South, as it is called.

One of the first things I did on arriving was to telegraph to Dr. Coleman to announce my safe arrival. I had not been in town long before I met a real estate agent who pressed me to invest in town property, and showed me some advantageous sites. I did not invest, but I felt gratified to observe that everybody was not of the same opinion as my miner friends up the river. I was fortunate enough to meet several old acquaintances at Edmonton, who made my forced stay there so pleasant that it was almost with regret that I was able at last to bring it to a close, and join the rest of the party at Morley.