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OF THE
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APPENDIX I:

THE attention of members of the Institute is directed to the following recommendations of the British Association Committee on Zoological Bibliography and Publications :—

"That authors' separate copies should not be distributed privately before the paper has been published in the regular manner.

"That it is desirable to express the subject of one's paper in its title, while keeping the title as concise as possible.

"That new species should be properly diagnosed and figured when possible.

"That new names should not be proposed in irrelevant footnotes, or anonymous paragraphs.

"That references to previous publications should be made fully and correctly, if possible in accordance with one of the recognized sets of rules of quotations, such as that recently adopted by the French Zoological Society"

PROCEEDINGS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1906-1907

ANNUAL BUSINESS MEETING.

Assembly Room, Province Building, Halifax, 12th Nov., 1906.

THE PRESIDENT, F. W. W. DOANE, in the chair.

PRESIDENTIAL ADDRESS: (1) WORK OF THE INSTITUTE; (2) RESEARCH WORK; (3) SANITARY SCIENTIFIC WORK.—By F. W. W. DOANE, C. E., City Engineer, Halifax.

Gentlemen,—A year ago, at the beginning of my twentieth year as a member of the Institute, you elected me to the highest office in your gift, an honor which I appreciate more because I am fully conscious that a better selection might well have been made in order to maintain the standard established by my predecessors.

In opening the forty-fifth session of the Institute by a short review of the events of the past year, it is a pleasure to be able to report that we have met with no losses either through death or resignation.

Papers.—The following papers have been communicated to the Institute during the year:

1. Presidential Address.—By DR. H. S. POOLE.
2. The Flora of MacNab's Island, Halifax.—By CAPTAIN J. H. BARBOUR, M. D., Royal Army Medical Corps.
3. Catalogue of the Birds of Prince Edward Island.—By JOHN MACSWAIN.

4. Mining—Is it a Science?—By W. E. Lishman, M. A., M. Inst. M. E.
5. Additions to the List of Nova Scotia Fungi.—By Dr. A. H. MacKay.
6. Halifak Water Works.—By H. W. Johnston, C. E.
7. The Oil Fields of Eastern Canada.—By Dr. R. W. Ells.
8. The Frost and Drought of 1905.—By F. W. W. Doane.
9. Eels in Water Pipes and Their Migration.—By Watson L. Bishop.
10. Notes on Protective Coloring.—By Frank H. Reid.
11. The Grignard Synthesis: Action of Phenyl Magnesium Bromide on Camphor.—By H. Jermain Creighton.
12. Contribution to the Study of Hydroxylamine.—By G. M. Johnston **MacKay, B. A.**
13. Water Powers on the Mersey River, N. S.—By W. G. Yorston, C. E.
14. The Damage done to Timber by *Teredo navalis* and *Limnoria lignorum*.—By R. McColl, C. E.
15. Phenological Observations, Canada, 1905.—By Dr. A. H. MacKay.
16. Water-rolled Weed-balls.—By Dr. A. H. MacKay.

Of the thirteen authors who gave the Institute the benefit of their labors and observation, six presented papers for the first time, a fact which in itself is evidence of some progress. We cannot congratulate ourselves, however, that we are in the healthy condition that every member who has the best interest of the Institute at heart could wish. We have been depending too much on the work of the older members, and in consequence of the willingness with which they devote their time and energy to the arduous demands of each session, the enlistment of new workers has been somewhat neglected. While the interest of the older active members has not abated, their work could be lightened by the assistance of the younger members, who, by a little effort, might relieve the strain upon the knowledge and active intellect of those whose wonderful energy in the past has proved equal to the demand upon them, and who have done so much to place the Nova Scotian Institute of Science among the chief scientific associations of British America.

Membership.—No addition has been made to the list of corresponding members, but four have been proposed and approved as ordinary members or associate members. A number of new members have not yet qualified for membership by paying the annual fee in consequence of defects in our financial system. This matter is receiving the attention of the council, and it is probable that changes will be made which will lead to the adoption of a more satisfactory system and place the finance department on a better business basis.

It should be our aim first to "set our house in order," then to add to our membership as much as possible. We should have on our roll the name of every man in Nova Scotia who has the ability to add to our knowledge, and also all those who, though they may not have the opportunity or the requisite preparatory training to enable them to advance science themselves, are willing to encourage others in their efforts by their interest and their annual fees. There must be many of the latter class in the acquaintance circles of all our members, who might be induced to come in and help us if we make the effort. Indeed, there must be more persons in Nova Scotia devoting some portion of their time to scientific work than those whose names are inscribed on the membership roll of the Institute of Science. Let each member make a list of the names of those whom he considers eligible for membership and submit it to the new council. Let it be the duty of the council, assisted by individual members, to use every endeavor to obtain the allegiance of such persons, and I have no doubt that the result will be very beneficial to the Institute.

Meeting rooms.—The closing meeting of the last session was held in the room of the Mining Society, through the courtesy of its president. While one hesitates to record feelings of envy, it must be admitted that the cozy quarters placed at our service suggested speculations as to the benefits that would result to the Institute if we were able to maintain similar headquarters. If a campaign is inaugurated for increasing the membership and consequently the revenue of the Institute, the next step should be to consider the advisability and possibility of providing a home for our society. From the first the provincial government gave the use of the only spare room at its disposal, and we are still indebted to the generosity of the government for a place in which to hold our meetings, and also a place wherein to keep our valuable library.

Publication.—We are handicapped by our limited purse and other conditions, so that it would be impossible to expend a larger sum at present on the publication of papers. A great effort should be made, however, to bring this work up to date. We should then consider the advisability of printing before they are read, all papers of general interest or special importance. If an advance-proof of such papers could be sent out some time before the meeting at which they are to be read, it would doubtless result in freer and much more valuable discussion and larger attendance at such meetings. Even under our present system the discussion is often second in value only to the paper itself.

Research work.—The practical value of reseach work is being impressed upon the public, and the business portion of the public is becoming interested more and more in the results of such work.

An address on a strictly scientific subject is not often of particular interest except to those who are engaged in the department of science discussed. The superficial observer who sees the oak but forgets the acorn, is likely to ascribe the great material advances of recent times wholly to scientific knowledge and rare ingenuity, and to consider the great inventors and the great captains of industry as the most important agents in bringing about the modern era. No other agent, however, has been of greater influence in making the mechanical evolution of the latter part of the last century possible than the great scientific investigators whose forceful intellect opened the way to secrets previously hidden from men.

Nature turns a forbidding face to those who pay her court with the hope of gain, and is responsive only to those suitors whose love is for herself alone. It is impossible to know what application knowledge may have until after it is acquired, and the seeker after purely useful knowledge will fail to acquire any real knowledge whatever. In this fact lies the explanation of the extreme rarity with which the functions of an investigator of the laws of nature and those of the inventor who applies these laws to utilitarian purposes, are united in the same person.

This theme is one of special importance at the present time, because it is customary to ask about every new discovery in science, What is its value? It is only by going backward over the development of applied science that it is possible to realize the fundamental importance of research work. For instance, hardly any of the basic principles of engineering were discovered by men with any intent on practical work. The mathematical methods which are necessary for the engineer are the result of strictly scientific investigation, and the laws of physics and chemistry are being determined by the research work of men who care little whether their discoveries are to find immediate practical application or not. The development of industrial processes often suggests new subjects for investigation, and some of the best research work of to-day is being guided by business corporations, but the men who are so engaged are working in a purely scientific spirit, and leave the practical development of their results to the engineer.

The beginner in research work may be discouraged when he reviews the work of more advanced scientific investigators, in the belief that the greater part of the work has been done. He will soon learn, however, that in the words of the late Cecil Rhodes, "there is so much to be done." For instance, how little we really know of meteorology except a few statistics. How intangible is the air, yet it uproots strong trees firmly anchored in mother earth, tears heavy structures from their foundations and drops them in fragments far from their original location.

There is much to learn and plenty of room for every new worker who has the inclination, the energy and the persistency to wrest from nature her jealously guarded secrets.

Sanitary scientific work.—In that branch of science with which my daily work brings me in intimate connection, prominence has been given during the year to the extermination of the mosquito, the purification of water by copper sulphate, and the ventilation of sewers and plumbing, and the abolition of the main trap.

The extermination of the mosquito has been accomplished, where it has been undertaken by first a campaign of education, then the expenditure of considerable sums of money in destroying the breeding places by draining and filling up, etc.

The copper sulphate treatment of water has engaged the attention of the world, and it is apparently becoming more and more evident (1) that water infected with algæ can be purified by this means, and (2) that water which has been so purified is quite fit for human consumption, and that no one need fear harmful effects.

Abolition of the drain trap.—The ventilation of sewers and plumbing has been a burning question elsewhere, but the " abolition of the house trap " has become a live question in Halifax, and consequently may be worthy of more than passing notice.

The regulations of the city health board require the installation of a trap at or near the point where the drain leaves the house, and although there has been much diversity of opinion elsewhere regarding the necessity for its use, there had been no question here until the master plumbers asked that the sanitary regulations be amended so that the main trap could be omitted. This trap, known in England as the intercepting trap, is in that country intimately connected with the larger question of the ventilation of sewers and drains, which has been more or less the subject of controversy since the illness of King Edward, when Prince of Wales, in 1872. The intercepting trap was patented by W. P. Buchan, Glasgow, about 1875, and, without any special investigation, was adopted by the local government board and introduced into its model by-laws in 1877. Such official recognition caused its advantages to be taken for granted, and deterred many people from investigating the question for themselves. The controversy resulted in a general concensus of opinion that " sewer gas must be cut off from the house," and the intercepting trap was adopted with that object in view.

Recently many engineers engaged in municipal work have favored the abolition of the trap, and their argument has been greatly strengthened by experiments made in England and elsewhere to determine whether sewer air is actually dangerous or not. Medical officers of health are more conservative in their views, and are for the most part strongly in favor of the retention of the trap.

It is probably true that there is no local sanitary authority in this province, where sewers, drains and plumbing exist, which has not had to deal, at some period or other, with complaints as to the nuisance caused by the escape of sewer gas, and it may therefore be assumed that the subject is of importance to every section of the community.

It is not advisable or necessary in these remarks to introduce the technical pros and cons that are so often used. Such arguments may be reserved for a technical paper or for the benefit of municipal sanitary authorities. The question which is of special interest to us, and which, too, must be considered to a certain extent unsettled, since it is yet under investigation, is, does sewer air injuriously affect health?

About a year ago the borough council of Hampstead, England, employed two experts, F. W. Andrews, M. D., F. R. C. P., D. P. H., and W. H. Hurtley, D. Sc., to make analyses of sewer air and report on the bacteria suspended therein.

The particular points which the experts set themselves to investigate were: (1) Can it be determined whether the emanations from the sewers are likely to cause disease? (2) What is the substance which gives rise to the disagreeable odors? (3) What is the chemical composition of the sewer air at different levels?

As regards the first point, which is the most important, it is the general, but not altogether unanimous opinion, that sewage bacteria do not exist in sewer air. This opinion has been based upon the results of only a few investigations; and on the other hand it has been abundantly proved that sewer air, escaping direct into houses, has injuriously affected the health of the inmates. This fact has led to the assumption that there must be some subtle chemical action in such cases which has not yet been discovered, and which might possibly also exert its influence in the open air.

The bacteriological examination of sewer air has not received the attention which should have been given to it, and possibly we have in our own ranks members who, by research and investigation, can throw some light on this important question. Within the last few years improved methods for investigating air-borne bacteria, especially *Streptococci,* have been introduced, but they have not yet been applied to sewer air, and when it is borne in mind that *Streptococci* are the most abundant organisms in sewage, that they are amongst the most important of disease-producing bacteria, and that some at least of the diseases to which sewer air is credited with giving rise, are in all probability strepcococcal infections, it is plain that the examination of sewer air for *Streptococci* should prove an important field of investigation.

Improved methods have also been recently introduced whereby the common intestinal bacteria belonging to the *B. coli* group (including the typhoid bacillus) may be much more easily identified and isolated.

The first step taken by Dr. Andrews was to endeavor to find sewage organisms in the sewer air, and he succeeded in finding an organism which was not the true *B. coli communis,* but was identical with a characteristic sewage member of the group, present in the sewage to the number of at least 30,000 per c. c.

The most important experiments, however, were those relating to *Streptococci*; and Dr. Andrews established the fact that the *Streptococci* of the sewer air are very different from those of the fresh air outside the sewers, and in the very point in which they differ from those of the fresh air they tend to approach those of the sewage. The importance of this discovery cannot be overestimated, and it is fairly obvious that the whole future disposition of sewer ventilation or sewer air treatment may depend upon the facts which further examination in this direction will produce.

The question arises, what effect does this variation in the constitution of *Streptococci* have upon the human constitution? Both Dr. Andrews and Dr. Hurtley remained in the sewers for long periods and it is not recorded that they suffered at all; in fact, Dr. Hurtley specifically states that he did not experience the slightest inconvenience. In this connection the case of sewer men, who are notoriously healthy subjects, may be instanced.

Although these investigations seem to establish pretty clearly that sewer air, as such, is not necessarily dangerous, and that the probability of sewer air organisms being carried into the outer air so as to become a danger is exceedingly remote, yet it must be admitted that there is still an off-chance, and it is that off-chance which produces a doubt.

There is still a belief that, for some as yet unknown reason, sewer air escaping direct into dwelling houses is a danger, and that sewer smells are objectionable and a nuisance no one will deny. The public therefore will probably await the result of further investigation.

W. McKerron presented the treasurer's accounts, which were referred to the auditors.

The librarian's report was presented by H. Piers, showing that 1911 books and pamphlets had been received by the Institute through its exchange-list during the year 1905; and 1,457 had been received during ten months (January to October) of the present year, 1906. Particulars were also given of the total number of books and pamphlets received by the Provincial Science Library (with which the books of the Institute are incorporated) during the year 1905. This number was 2,590, of which 1,911 were the society's exchanges as above-mentioned. Increased use of the library was reported, as shown by the number of books borrowed, namely 536 in 1905. A card catalogue of the manuals and general works, arranged alphabetically by authors and subjects, has been completed during 1906, and these books have been arranged on the shelves according to the decimal system of classification. The report was received and adopted.

The Secretary reported that the Kings County Branch of the Institute had done no work during the session of 1905-6, nor during the previous session. It was resolved that the subject of branch societies be referred to the incoming council.

It was resolved that the thanks of the Institute be conveyed to HIS HONOR THE SPEAKER OF THE HOUSE OF ASSEMBLY, for his courtesy in permitting the use of the assembly room as a place of meeting.

Reference was made to the desirability of having some exchange system in Canada which would take the place of that of the Smithsonian Bureau of International Exchanges at Washington, which latter bureau can not now undertake the work of forwarding book packages to foreign countries owing to the magnitude to which such work had grown of late years. The subject was referred to the council.

The following were elected officers for the ensuing year (1906-1907):

President—F. W. W. DOANE, C. E., *ex officio* F. R. M. S.
Vice-Presidents—PROFESSOR EBENEZER MACKAY, PH. D.; PROFESSOR J. E. WOODMAN, D. SC.
Treasurer—J. B. MCCARTHY, B. A., M. SC.
Corresponding Secretary—A. H. MACKAY, LL. D., F. R. S. C.
Recording Secretary—HARRY PIERS.
Librarian—HARRY PIERS.
Councillors without Office—MAYNARD BOWMAN, B. A.; WATSON L. BISHOP; EDWIN GILPIN, JR., LL. D., F. R. S. C., I. S. O.; ALEXANDER MCKAY; PROFESSOR FREDERIC H. SEXTON, B. SC.; HENRY S. POOLE, D. SC., F. R. S. C.; WILLIAM MCKERRON.
Auditors—PROFESSOR D. A. MURRAY, PH. D.; R. MCCOLL, C. E

A vote of thanks was presented to the retiring treasurer, W. MCKERRON, for his services; to H. PIERS, for his work as secretary; and to the PRESIDENT, MR. DOANE.

FIRST ORDINARY MEETING.

Assembly Room, Province Building, Halifax, 14th Jan., 1907.

THE PRESIDENT, MR. DOANE, in the chair.

It was reported that PHILIP A. FREEMAN, engineer, Halifax Electric Tram Co., Halifax, had been elected an ordinary member.

A paper was read, entitled, "Notes on Mineral Fuels of Canada," by R. W. ELLS, LL. D., F. G. S. A., F. R. S. C., of the Geological Survey, Ottawa. (See Transactions, p. 61.)

SECOND ORDINARY MEETING.

City Council Chamber, Halifax, 11th March, 1907.

THE PRESIDENT, MR. DOANE, in the chair.

H. PIERS and J. B. MCCARTHY were appointed a committee to prepare a suitable design for a seal for the Institute, and to have the same engraved.

In the absence of the author, MR. PIERS read the following paper by GENERAL CAMPBELL HARDY:

REMINISCENCES OF A NOVA SCOTIAN NATURALIST: ANDREW DOWNS.—By MAJOR-GENERAL CAMPBELL HARDY, R. A., Dover, England.

In days gone by, when the writer of this paper was quartered at Halifax, N. S., then a great naval and military station of the imperial government, there were two interesting spots which a stranger generallv visited first, namely the Old Point Woods and Downs's Zoological Gardens at the head of the North West Arm. The former are now enclosed and preserved in the area termed Point Pleasant Park: the latter have vanished from the scene. It is then the object of this paper to recall a picture of the past, to speak of the remarkable man who lived at the head of the North West Arm, and to describe his charming location, Walton Cottage.*

A little stream runs in at the head of the North West Arm, and following it up by the road which branches from the main road from Halifax in the direction of the Dutch Village, a few hundred yards brought us to Downs's gates.

The cottage nestled in its prettily wooded grounds, with the shores of the Arm in the background receding towards the blue Atlantic. Here nature and cultivation were charmingly blended together, and the wild birds from the hills behind loved to come in and nest in perfect confidence in the owner's good will towards all living creatures. For I will say this of Downs by way of introduc-

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*The grounds on which Downs's zoological gardens were situated are now the property of the estate of the late John Doull, and Walton Cottage is at present the residence of Dr. Arthur Doull.

tion, that he was a man of sweet disposition, tender and merciful to all his feathered friends, and though perhaps he could not say yes to Emerson's pointed question, "Hast thous named all the birds without a gun?" he was incapable of any act of cruelty or neglect.

My acquaintance with Downs commenced very soon after arrival, for in him I found the very man who could tell me all about the wild creatures of this favoured little province, the ideal home of the naturalist and sportsman. To live and camp in the great backwoods of Canada had been mv ambition in early youth, and in his company I served an apprenticeship as it were, and commenced habits of observation which have stored my memory with the songs and scents of the woods and the ways of their denizens during a prolonged residence of some sixteen years.

In re-reading lately a very entertaining little book by Samuel Smiles, entitled "The Life of a Scotch Naturalist," I was struck by some points of resemblance between its subject, Thomas Edward, A. L. S., and Andrew Downs of Nova Scotia. Both were men of humble origin, and both became in their early lives devotees of nature study as it is now popularly termed, leaving their respective callings to work in that fascinating field. Both were strenuous workers, taxidermists and collectors, practical men and not over much given to library lore. Both were recognized by the scientific world as having acquired their knowledge of natural history at first-hand, and though cultivating their own powers of observation. It seems, too, that they had much similarity of character, the same honest grasping of facts and hatred of shams, the same Spartan-like simplicity of life, with much originality and a sturdy independence which under all circumstances compels respect. Edward was credited with many discoveries and additions to British zoology. Downs gave more impetus to forwarding the knowledge of local natural history than any Canadian before his day. Every visitor desirous of acquaintance with wild life in the woods or by the waters of Acadie, went to Downs for advice or reference; and few returned to Europe, after a sojourn more or less prolonged in the maritime provinces, without taking back either some trophy of the larger game or specimens of the beautiful avi-fauna of eastern Canada which had passed through our naturalist's skilful hands.

An extended biographical sketch of Downs's life on the model of Smiles's little work would doubtless be very interesting, but as he was a man who sought retirement and seldom troubled himself with correspondence, and as, moreover, time is fast effacing his memory in Nova Scotia, it would be difficult to get together sufficient and reliable materials for such a compilation. I have, however, recently received from the recording secretary of the Nova Scotian Institute of Science,[*] of which I am a corresponding member, a paper on this subject written by himself and embodying extracts from an article by the editor of the New York *Forest and Stream,* a personal friend and admirer of Downs, whom he had visited. On reading it, I was induced to refer to a number of old diaries and notebooks of Nova Scotian days, and was glad to find Downs's name frequently occurring therein, as well as an article which I contributed in 1864 to a Halifax newspaper[*] and have fortunately preserved, undoubtedly the first notice of Downs and his establistment which had then been published. I quote the article here, as a contemporary account of the naturalist and his interesting collection of animals:

> *Sketches in Our Neighbourhood: An Afternoon with Downs.*
>
> Half an hour's walk from the city, over the Common, and down the telegraph-road leading to the west, brings the visitor to the cross-roads at the head of the North West Arm. If a stranger, your question—"Is this the way to Downs's?" is probably answered by a piscatorial urchin, seated by a little brook which here trickles into the salt-water under a bridge, by "Yaas, that's it, where yer hear them burds screaming'," pointing to the road turning off towards the Dutch Village. In confirmation whereof the shrill scream of a peacock or discordant cry of a cockatoo reaches your ear, and we presently arrive at the gates of Walton Cottage Gardens.
>
> And here let me say ere proceeding, that these gardens were the first "Zoo" established on the American continent—a fact often recounted to me by the founder with some pride.
>
> Prettily surrounded and hid from the road by fir woods, Downs's house, approached by a circular drive, stands on a slight eminence overlooking the whole length of the North West Arm. It is a neat, rustic little residence with tall, sharp-pointed gables ornamented with trellis,

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[*] Harry Piers, Esq. See "Sketch of the Life of Andrew Downs, founder of the first zoological garden in America."—*Proc. N. S. Inst. Sci.*, vol. x, p. cii, with portrait.

[†] *The Acadian Recorder*, edited by Mr. Peter Hamilton and Hunter Duvar.

and a porch groaning under the weight of the honeysuckles and Virginia creepers which have seized upon it. Several pairs of antlers of moose and deer adorn the sides under the roof; and tall poles, bearing painted miniature cottages, are planted around for the express benefit of such birds as will take advantage of the gratuitous lodging thus afforded, and the offer of free board with the well-fed poultry in the yard—a spacious enclosure with a large, clear pond fed by a stream from the hill-side in the rear, and shaded by shrubberies, through which are cut prettily-winding walks in every direction.

Here we probably find the owner himself spreading Indian corn broadcast amongst a rude, greedy assembly of every kind of fowl—land-fowl and water-fowl, great thick-thighed cochins and diminutive bantams, hearty swans which come up to the banquet, with a hasty, waddling gait ill befitting their dignity, and fat, glossy ducks of every hue that at once suggest the idea of comestibles in the shape of green pease. In fact, I was about to pass them over as being, in the language of the advertisers, "too numerous to mention," but as Downs himself is engaged in feeding them, it is worth our while to stay and hear him expatiate on their beauties and peculiarities; for he is a quick, sharp-sighted, and enthusiastic naturalist, and will point out things which we should otherwise have never thought of noticing. "There are days," he says, "when the light seems to bring out the colours on birds' feathers which you would never see in dull weather, days when all nature seems brightened up by the peculiar state of the atmosphere; when the trees seem greener, when the sky has a greater softness and depth than commonly, and your own feelings are in tune with all around. Look at that wild turkey as he comes swelling along, and the sun's rays light up the wonderful metallic hues on the neck, back and sides, hues of bronze, and green, and orange-copper, which now and then flash with the brilliancy of the humming bird's plumage." A pair of pigeons alight at your feet, bowing and scraping around. Perhaps a delicate plum-bloom appears to colour their necks and breasts; but in a moment they burn with emerald green, and in another with the sparkling tints of hyacinth or topaz. These brilliant greens placed on a subdued ground-colour, and changing into the gleaming tints of precious minerals, are favourite touches of nature's pencil from amongst the wide range of colours with which she has so lavishly painted the plumage of birds. The beautiful pencil marking on the silver Hamburgs are pointed out to us, and the bright golden spangles on another variety of domestic fowls. The uncomfortable appearance of the little fowls from China with all their feathers curled back, and the curious blue ear-lobes of the Japanese, which have a blue skin underneath their white feathers and blue bones likewise; the beautiful green velvet jacket which sits so trim and close on the East Indian duck, are all brought under notice by the zealous exhibitor, and the uncouth—stay, I have used a wrong word, and shall be presently corrected by Downs himself, with whom

I heartily agree that there is nothing really ugly or frightful in nature, and though these terms are often employed conventionally, it is really very snobbish to do so, unless in the case of accident or design, by which nature has been made to fall short of her work. It appears to me the height of arrogance to criticize or disparage any of nature's handiwork. Wherein lies our ability to judge? "Ask a toad," says Voltaire, "what is beauty, the supremely beautiful, the *τό καλόν* ! He will tell you, it is my wife, with two large eyes projecting out of her little head, a broad and flat neck, yellow belly, and dark brown back." So, friend visitor, be warned not to revile even the toad in the presence of our naturalist, or perchance he may cause thee to be ashamed of thy speech.

Within a little paled enclosure adjacent to the yard are the wood-ducks, the gems of the collection. To see these beautiful birds looking their best, we must choose a bright day, such as has been described. No stuffed specimens can show the vivid colouring of the living and healthy bird in its prime. Many of the glossy hues fade in death, as well as the rich colouring on the upper mandible, of the iris and legs, and which cannot be artifically rendered with justice to the bright tints of life. The wood-duck, so called from its habit of roosting and building in trees, is a rather rare summer visitor in this province. It loves to make its nest in hollows in tall trees, by the banks of forest streams far from the haunts of man. Its Latin name (*Anas sponsa*) signifies the bride-duck, "a pretty name for a pretty creature," as Frank Forester says of it. As Downs chases them over the brook which trickles through this enclosure, and up the sunny bank, that we may the better observe the play of the light on their gorgeous plumage, we notice how strictly they keep in pairs, each drake accompanying his soft, modest-looking duck, and continually uttering a little, subdued cry—*peet, peet.* I have seen these birds in their wild state on the Shubenacadie; once on Gold River, and, more frequently, in the wild river solitudes of northern New Brunswick, when, as our invading canoe scared them from their haunts, they would fly down stream, their brightly-painted forms standing out against the dark background of fir-forest in the soft light of a summer's afternoon. A flock of almost equally beautiful little ducks, natives of South America, with less gorgeous, but exquisitely marked plumage and showy crimson spots on the bill, occupies the same cage as the wood-ducks, where also stalks a very conceited and rather obtrusive crane from the Mississippi, who marches around you, apparently earnestly regarding the ground, but really meditating as to the prudence of indulging in an old failing—that of casually driving his long, sharp beak through your boot.

We cannot fail to notice the tameness of the swallows (the white-bellied wood-swallow), which breed in the little boxes set up for them round the house, and sometimes but a few feet above the ground. Quite regardless of your presence, they continue their nest-building or feeding their young almost within reach of your hand. I like to see these swallow boxes set up round country houses; they seldom fail to attract a pair of tenants, and nothing is more pleasing than to hear their twittering song, as they busily flit past the window, when awakening on a bright summer's morning.

Many other wild birds also chose these grounds for their family residence. A pair of golden-winged woodpeckers have built in an old stump close to the house for several seasons; robins' nests are met with everywhere; last year a pair hatched two broods in a low fir bush by the side of the glass-house; and in the shrubberies, close to the paths, many varietiees of warblers may constantly be seen throughout the summer flitting to and from their closely-hidden nests. Nor is their confidence misplaced. Downs may apply the words of our gentle-minded Cowper in the "Winter Walk at Noon":

> "These shades are all my own. The timorous hare,
> Grown so familiar with her frequent guest,
> Scarce shuns me; and the stock-dove unalarm'd
> Sits cooing in the pine tree, nor suspends
> His long love-ditty for my near approach."

Sure of protection and ample fare, many migratory birds spend the long, cheerless winter in these grounds. One of these late, cold, dull days, by which the advance of the spring is this year so retarded, I heard the first song-bird here, the joyous note of the song-sparrow emanating from a thicket in the pheasant's enclosure. The little bird had been a guest all winter. Blue-birds (*Junco hiemalis*) and robins also remain. The latter are often seen during this season in many places in the neighbourhood.

It is very satisfactory to see robins and all other small birds now protected by law from being shot within the precincts of the city; whereas formerly they were continually stalked and fired at, particularly in the spring before mating, when the former birds hop over open grass-plots from which the snow has disappeared, in search of worms, in large flocks. Hard times do these appear for the early visitors, and many a buffeting snow-storm and hard-binding frost drives them to the verge of starvation before the new land flows for them with milk and honey, as the numbers of dead robins found on the snow-covered fields in the very cold weather of March, 1863, testified. Instead of cruel persecution, our small birds are deserving of encouragement and protection. In England the long-sustained suspicions of the farmer and the peasant as to the destructiveness of many species have been allayed, and every hedge-row is jubilant with songsters; whereas in France scarce a bird is to be seen in many districts, not only from their supposed noxious qualities, but from the comprehensive spirit of the term "*la chasse*" as pursued by French gunners.

"You call them thieves and pillagers; but know
They are the winged wardens of your farms.
* * * * * * *
And think of your woods and orchards without birds!
Of empty nests that cling to boughs and leaves,
As in an idiot's brain remembered words
Hang empty 'mid the cobwebs of his dreams!"

But to return from this digression to Downs's feathered captives who are apparently not a whit less happy than the wild birds who flit around them.

Leaving the motley assemblage of poultry and water-fowl in the yard, we enter the shrubberies by soft tanned walks along which are scattered the clean-looking, roomy cages allotted to a variety of feathered creatures. Here is an airy little tenement devoted to silver pheasants. The neatness of their plumage and the graceful sweep of their tails render them exceedingly ornamental; but they are, withal, so pugnacious that two separated males apparently devote their whole lives to pacing up and down the dividing wire netting, challenging each other to mortal combat. The silvery plumage of their necks and backs is beautifully pencilled with minute lines, and strongly relieved by their glossy black breasts and bodies. We so generally see birds with the lightest colours beneath, that, when this rule is excepted, a strange appearance is produced and the bird would almost seem inverted. Another instance is that of our common bob o'Lincoln in its summer dress. Further on, whole groves of young spruces are enclosed and netted over; and against their dark foliage the resplendent plumage of the golden pheasants shines in bright contrast as they run to and from the cover and their little house in the corner. Then there are aviaries with flocks of plump snow-buntings; another where the merle and throstle, so often mentioned in the poetry of the fields of merry England, nestle in the fir tree, happily forgetful of the hawthorn bush or oak coppice; the plumed and Californian quails from the far west pick lazily at ant-hills or squat in groups on the warm, sunny banks, under fern and low bushes tastefully introduced in their enclosures; whilst, in another, the spruce partridge of our own forests may be seen pruning the foliage of his favourite larch or silver-fir.

These grounds offer great natural advantages for the tasteful arrangement of a zoological garden: the sloping hillside topped by thick woods is continually broken by mossy hollows with numerous little brooks to which the woodcock and bittern often resort; and the dry, grassy knolls between are adorned by clumps of young firs and white birches, and the olive green tufts of the ground-juniper, amongst the roots of which the retiring mayflower trails towards the light.

By the side of one of these little valleys, dammed so as to form a miniature lake over which a picturesque rustic bridge is thrown, stands a building known as the "glass house," a light and ornamental structure of painted wood-work and glass used as a green-house and aviary for rare tropical birds, an aquarium room, and a museum; and from the summit of the tower can be obtained a beautiful view of the grounds and the surrounding scenery.*

The aquarium is very attractive; a constant stream of water, derived from a more elevated pond, flows through all its compartments. Here may be seen many inhabitants of our lakes and streams—the silver dace and the yellow perch, in all respects similar to the English species save in his bright golden hue; the cat-fish of hideous mien, whose wide, gaping jaws and voracity render him the tyrant of the lake; the little terrapin or mud turtle of our alluvial rivers basking on semi-submerged rock-work with gorgeously coloured species from other climes; and several other amphibious reptiles, including the yellow-throated and leopard frogs, and the large yellow-spotted salamander common to our little rocky pools by the road-side, though seldom seen, as it is strictly nocturnal in its habits.

But now let us glance at the birds of prey encaged close by. A splendid pair of bald-headed eagles at once arrest our attention, though they have not arrived at the mature age necessary to produce the condition of plumage from which their misnomer, "bald-headed," has been derived. In the adult bird the head, neck and tail become pure white; the pointed hackles of the neck laying in sharp regularity on the close bronze plumage of the bird's body. The iris, beak, nostrils and legs assume a bright golden orange hue. This is the chosen emblem of the United States—the bird of America. The description given of its habit of depriving the osprey of its finny prey, by the great ornithologist of this continent. Wilson, is a beautiful piece of composition; as likewise is that of Audubon, the subject of which is the eagle's attack upon the wild swan in mid-air. There is about this bird an unmistakable air of fierceness and intractability; and it continually indulges in a habit of throwing back its head and giving vent to screams of defiance which must strike terror into the breasts of the captives around.

In adjacent cages sit several specimens of our native birds of wisdom—the owls. These are the great horned owls whose deep-toned hooting emanating from the dark spruce swamps is so familiar to the sojourner in the woods. Heard on a calm, still night in the forest, this sound is most impressive, and, though so connected with melancholy associations, it brings with it nevertheless a strange feeling of pleasure, probably owing to the mournful notes harmonizing with the mystery with which our imagination delights to invest the woods at night, especially when fitfully illumined by the moon. There is a dapper little owl of this species—quite a beau, trim in plumage and wide-awake—confined in one of these cages, who will treat us to some of his music whenever we approach him; and we see, if we look closely, that in emitting the sound, the bill is not opened

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* The glass-house is now (1908) almost in ruins.

in the least; the sound is very gutteral and the throat swells to a large hemispherical bag and at the same time the tail is raised. The older birds of his species sit far back in the shade under the sloping roof, apparently absorbed in moody reflection; for we cannot look at their great eyes, over which the covering membrane, which acts as an eyelid, slowly falls and is withdrawn, and the apparent abstraction evinced by their form and attitude, without fancying them to be cogitating deeply.

> "Upon a beam aloft he sits,
> And nods, and seems to think, by fits."

A much brighter-looking bird, however, appears in the form of the snowy owl, confined close by, a stray wanderer from Arctic climes to our woodlands on an extended hunt for rabbits. His quick eyes, which he uses to seek his prey by daylight, unlike most of his family, follow our every movement. Dr. Gilpin states that this bird may be seen sitting in the full glare of the sun, watching the rabbit burrows on the sands of Sable Island, of which he has of late years become a visitor.

Finally our agreeable guide and entertainer conducts us to the top of the hill, where, standing on a huge, erratic boulder of granite which has been left by glacial action in its present site on a bare plateau of slate rock, we may enjoy the beautiful and comprehensive view which opens to us as we turn. Beneath us and at our right are the gardens, with their walks and shrubberies, and the white tops of the bird houses. Beyond, the North West Arm stretches away to the outer harbour; Thrumcap, projecting from the eastern shore, just coming into the picture; and the wooded top of McNab's Island appearing above the south end of the peninsula. The snugly ensconced little sheet of water called Chocolate Lake is partly seen. On the high lands of the peninsula which ridges in front of us, the citadel and its signal station, the common, the fields and farms dotted with white houses, and the wooded spur of Rockhead successively meet our view as we sweep the horizon. Then the blue expanse of Bedford Basin and its distant hills, with the little, white tower of the three-mile church nestling in a fir grove by its shores in the foot of the valley; the picture being bounded on our extreme left by the slopes of Geizer's hill, thickly wooded and skirted at its foot by the road which winds round the valley through the pretty settlement known as the Dutch Village.

And now we retrace our steps, and take leave of our worthy guide with many a good wish for his long enjoyment of the beauties of nature in the pleasant retreat which he has chosen. His conceptions of her teachings, and the mode in which he imparts them to the visitor, are alike original and sound; and few can leave the zoological gardens at the North West Arm without realizing that they have spent a happy afternoon with Downs.

> "Happy who walks with him! whom what he finds
> Of flavor or of scent in fruit or flower,
> Or what he views of beautiful or grand
> In nature, from the broad majestic oak
> To the green blade that twinkles in the sun,
> Prompts with remembrance of a present God."

It was a year or so (it may have been two) after the foregoing article was published that I find in my diary some notes on an incident in which I was much interested at the time, the packing and shipment of some live specimens of moose-deer at Walton Cottage gardens, consigned to Victor Emmanuel, then King of Italy, who was an enthusiastic acclimatizer of large game in his grounds at Pisa. The following is an extract from an account of this incident which I forwarded to the London *Field.* I may here mention that at this time much interest was taken in acclimatization, to forward which there were societies in London, Paris, and elsewhere. In Great Britain the leading men in this direction were Buckland, Grantley, Berkeley, Tegetmeir and others. I have not heard much of this subject of late, but curiously enough saw in a paragraph in my *Morning Post* quite recently a request from the government of New Zealand for as many as fifty moose deer, if procurable, to be forwarded from Canada to the antipodes. Of course the deer would go to the south island where both pine trees and snow are to be found, but what would their food consist of? That would prove, I think, the crux of the experiment.

It appears that Victor Emmanuel, imbued with the spirit of acclimatization, had been procuring a number of the deer of the New World through an agent who made known to our provincial naturalist his majesty's wants with respect to the monarch of the North American forest—the moose. The right man and the right place were selected; but although in no part of North America is the moose-deer more plentiful than in Nova Scotia, living in our small forest areas nearer the borders of civilization than anywhere else, so few of these noble animals are taken young, and successfully reared, that but three could be procured on that occasion throughout the province.

The trio consisted of two cow-moose of the ages of two and a half years and eighteen months, and a sprightly young bull-calf of seven months, the latter as nearly resembling an overgrown juvenile donkey as could well be imagined on the part of a member of the deer family. The youngest of the cows had been for the past year a much-admired resident in Downs's gardens, where, perfectly domesticated, and roaming in a railed-off patch of its native thickets, it had thriven and afforded much pleasure in contemplation of its strange action and configuration, so often described as uncouth, but so beautifully adapted to its natural state of existence. The larger animal was three-quarters grown, the finest tame specimen I had ever seen; she had been brought in from a distant settlement, the property of a farmer whose clearings verge on woods where moose are plentiful, and had been long a pet of the settlement, feeding with the domestic cattle and from the children's hands, and occasionally roaming at large in the woods. "I can't tell when I can bring her down," said the settler to Downs, when he offered to part with her; "I guess she's away off in the woods just now." But the next time her ladyship took a notion of returning to a state of civilization, the stable door was shut on her, and, driven into a roughly constructed cage of planks, she was shipped and brought down to Halifax in a schooner. A few days after her arrival I went to Downs's gardens to witness the packing of the moose for their voyage to Boston. A little previous fasting, and their excessive fondness for turnips, readily induced them to step boldly into the narrow crates prepared for them, so narrow that when we stuffed in the wadded bolsters to prevent their being injured by struggling or motion on board the packet, it was as tight a fit as could be imagined. "Pack them as tight as they can stand," were the express orders. I never saw animals take such sudden and close confinement so philosophically. Their long heads and prehensile mouffles were stretched out of the apertures in front, eagerly expecting the chopped turnips, without manifesting the least alarm at the novelty of their position; and they were most quietly and satisfactorily drawn into town on a long truck, and swung in their cages on to the deck of the packet. Mr. Downs himself accompanied them, taking plenty of their natural food, i. e. the tops of young birch and maple, and a few evergreen branches, such as the Canadian hemlock and silver fir, to which they are likewise partial, especially in winter. The cases were securely lashed across-ship, and the vessel started with favourable auspices. Alas, I have now to chronicle disaster; they made a capital run, almost within sight of Boston light, when one of our terrible mid-winter gales sprang up from the south-west, and drove them nearly the whole distance back. For nearly a week was the vessel most mercilessly buffeted, whilst the seas dashed over her; and under the influence of intense frost everything on board was coated with huge masses of ice. Suffice it to say, that the two smaller moose died from the roughness of the passage and their cramped position. The survivor would doubtless have perished likewise, had not two cages been knocked into one so as to allow her to lie down and stretch her limbs. This she always did when the weather was heaviest, invariably lying with her head towards the seas; and she was landed in Boston, and thence by train at New York in excellent health, and without a gall or scratch. This fine cow—whose value, I almost omitted to mention, was greatly enhanced by her being heavy with calf—was joyfully received by the agent for the King of Italy, and shared with a herd of thirty wapiti (also the property of his majesty, and alike awaiting a passage to Europe), the attentions of many visitors in the Empire City.

Although the passage which has proved so disastrous to the poor moose was unusually rough and protracted, even for a sailing vessel, we have a wrinkle here in connection with shipment of large animals of the deer tribe. Close packing, even with lots of padding, will not answer. Applied, perhaps, to short voyages, and where the animal is restive, it may do; but the exhaustion from a cramped and long-continued position, where it has to bear every shock as part and parcel of the ship, has proved fatal in the cases noted. On the opposite side, witness the largest moose quietly lying down in bad weather as soon as chance to do so was allowed her, and her always adapting her position to the motion of the vessel and the run of the sea. I, therefore, agree with Mr. Downs in the idea that a crate shaped like a hen-coop, well padded on the sides, and especially above, is the best form of cage for transporting large animals of the ruminant order on long sea-voyages.

As a suitable animal for acclimatization in England, I cannot recommend the moose. The great objection is the nature of his food; he is exclusively a wood-eater, living upon the tender branches of deciduous trees, with a proportion, more particularly in winter, of those of evergreens. No plantation or copse in England could thrive with a couple of moose in it; and, though fond of roots, such feeding would prove fatal, as I know from experience; whilst, with one exception, I have never seen a tame moose accept hay or grass. If it were not for this, we would have in the moose an animal most appropriate for acclimatization—with the speed of a trotting horse, the strength and endurance of an ox, a docile and useful beast of burden, and good for food. Its flesh, being very open in its fibre, is very digestible, possessing a good flavour between that of beef and that of venison. It always commands a good price in the market when in season.

Speaking of this animal, the moose was once exceedingly plentiful in the forests of Nova Scotia, and is still holding its own despite increasingly restricted areas, and the large annual tribute it is called on to pay to the sportsman—to say nothing of the poachers, back-wood settlers or greedy Indians. And so the constant employment of Downs as the one taxidermist in the province who could set up a head and horns, can be well imagined. All through the autumn and that part of the winter during which moose-hunting was legal, a stream of trophies from the woods came up to his work-sheds. The skins of the heads were there pickled in preservative liquor in vats, and the horns, with a portion of the frontal bone of the skull, cut out and labelled with the shooter's name. He employed a trusted workman to carve out the pine block (it was always of yellow pine) on which the skins were stretched and united round the horns, which were with the connecting piece of the skull firmly screwed down. It was quite a sight to see these magnificent sporting trophies ranged in his shed. Downs stuffed many hundreds of these moose heads as well as cariboo (I see Mr. Piers states eight hundred in his paper) and they are scattered all through Europe and America. Some I know of are still in good preservation after fifty years of resistance to time and the attacks of moth. One of his finest specimens is (or was) I believe in Buckingham Palace, having been presented to Her late Majesty Queen Victoria; whilst a whole family stuffed by him appeared in the Nova Scotia Court at the Paris exhibition of 1867. His charge was moderate; I think I used to pay him twenty or twenty-five dollars for setting up my own heads. The true-to-nature modelling of the curious nose of the moose was his forte. The eyes he put in, so he told me, were the upper part of the inturned glass at the bottom of a black bottle. I never heard anyone express aught but delight on receiving his trophy back from the hands of Downs.

To get the heads out of the woods to his establishment what work we sometimes had! To back the huge thing out of the woods, and such woods too, with swarms of blow-flies trying to lay their eggs on it (I am speaking of the warm days of the autumn hunting, in the winter the snow makes it much easier) was often a difficult undertaking even for an Indian, who carries it over his shoulders by the "carrying-strap," and he is liable to have one of the great moose-ticks fasten on his neck—"all same as pieces of fire, he bite." I remember once coming out of Beaverbank woods, twenty miles from Halifax, with a splendid head we had shot while "calling" the night before. My friend was my guest, who had come out from England to see the woods, and being most anxious to get the head into Downs's pickling tub the same day, I started off with about sixty pounds weight on my back, hoping to do it alone, the Indian being obliged to go back to the hunting ground to get the meat with the settlers' help. I did not get far. It was too much, and we had to obtain a cart or rather a waggon.

But to return from this digression to the occupant of Walton Cottage gardens. He called it Walton Cottage after visiting Charles Waterton, of Walton Hall, the author of *Wanderings in South America,* of which more anon. There were many additions to the zoo after my descriptive paper of 1864 was written, to wit bears, polar and black; moose, seal, beaver, etc. White bears are often procurable in Halifax, brought in by vessels trading with Labrador. The specimen I saw at Downs's was always consistently ferocious. Those of the black species, on the other hand, are pleasant to have as pets. The Indians often bring them in. I bought a young one for a dollar which did a deal of damage in my barrack room the first hour I possessed him, and, finally, by attacking my legs, compelled me to get on a chair. But he was an exception. I gave him to an officer going home—poor Welsford who fell at the Redan, and I believe the animal came to a bad end, having injured a child. I gave him porridge and milk, and I well remember his comical snarling face as he greedily plunged his head into it up to his eyes, growling the whole time. My wife and I, visiting Downs's establishment one afternoon, found two young bears encaged there making a great fuss, the owner having gone into town and left them without food—not a usual trait with Downs. I went up the hill to saunter awhile in the woods, and on returning, found her pacifying the youngsters by feeding them out of a child's bottle obtained from the house, one at a time, on her lap, to the astonishment of the boy who was left in charge. Perhaps I had better state here that a young bear, even at mid-summer, is not a very big animal. At birth, generally in February, it is surprisingly diminutive, not more than six inches in length, almost hairless, blind for the first month, and weighs less than a pound; four to six hundred pounds being the weight of the adult bears, *i. e.* the black species, the only one found in Nova Scotia.

Downs had some trouble with his seals. They were the ordinary harbour species (*Phoca vitulina*), frequently seen in Halifax harbour and in the North West Arm. Though wired in an enclosure with a pond and running water, the smell of the sea so near was too much for them, and several times have they been met on the road, bumping themselves along down the hill to the head of the Arm near which, the alarm having been given, they were recaptured.

To Downs the province owes the introduction of both the English pheasant and the Canadian red-deer (*Cervus virginianus*), and I find the following paragraphs in a paper entitled, "Provincial Acclimatization," which I contributed, in December, 1864, to the N. S. Institute of Natural Science, of which I was at that time a vice-president:

"With the fact of the introduction and breeding of the English and gold and silver pheasants at Mr. Downs's establishment we are well acquainted; and the most interesting fact is the well-ascertained capability of the English pheasant to live and find its own subsistence in our woods through a rigorous winter. Why should not this experiment be continued?"

I have known golden pheasants on the property of Mr. Faulkner, the brewery, Dartmouth, to roost out away from their weather-proof house in the branches of fir trees, uninjured in any way, on a cold night when 23 degrees of frost were registered.

And as to the Virginian deer, the following appears in the same paper:—"The red deer then of Maine and the Canadas, and more recently of New Brunswick, appears to be perfectly adapted for an existence in the Nova Scotian woods—a graceful species, but little inferior to the red deer of Europe, affording the excellent venison with which the New York and Boston markets are so well supplied. Indeed it is already with us, for a small herd of healthy animals may now be seen at Mr. Downs's gardens, to whom the country is already indebted for many an unassisted attempt at real, practical acclimatization."

Between the above and the present date, 1906, this beautiful deer has been turned out and so thriven that it is be found now in every county of the province. Its greatest enemy, the wolf, is not found in Nova Scotia, though frequent in the adjacent intervals a troop of these marauders comes in over the connecting isthmus and is heard of here and there from various counties which it visits, but the species has never been known to stay. There is something about this province which does not suit its fancy. In frequent wanderings I have only once seen the track of a wolf in Nova Scotian woods. It was chasing a young moose in deep snow.

Thanks to the ceaseless efforts of the Game Protection Society which was inaugurated at Halifax in 1852 when I was present, the province has definitely added *Cervus virginianus* to its larger game. It is everywnere increasing. One of the society's agents speaks of it in last year's report as "coming out in the fields among the cattle on several occasions."

Though spoken of in the yearly reports as being found wild here and there, the pheasant is not doing so well, as the fox, the wild-cat, the eagle, owl, and the rabit-snares are against it, with the great host of the weazel tribe—ermine, mink and marten. Raccoons, too, which are numerous in some parts of the province, are most destructive to game birds nesting on the ground.

In one of his papers on Nova Scotian birds, contributed by Downs to the N. S. Institute of Natural Science in 1865, Downs writes thus of the English sparrow:—"What a treat it would be to see these saucy fellows preening their feathers on our roofs and collecting in dozens round our doors to pick up the scraps, and I would even go so far as to say, gobbling up the cherries in our gardens; for who would not make a sacrifice of some kind to colonize his domain with such a family of merry friends?" Anent which Mr. Harry Piers, the secretarv of the Institute, writes me the following answer to a question about the sparrow, dated Halifax, 1904: "Yes, the European sparrow is met with everywhere in Nova Scotia, I am sorry to say. I once was his friend, but with all the evidence there is against him, I have had to turn over to his enemies."

Thoughtlessly brought over the Atlantic to eat up the cankerworm in the trees of American cities, the sparrows did well for a while, but with change of climate soon developed other tastes. They became almost wholly seed and vegetable eaters, devouring young buds on vines and trees, and injuring all cereal crops, so that they are now protested against as bad citizens and criminals and condemned by everyone. They increase very fast and spread everywhere, driving away tne native birds, taking their homes and making themselves generally nuisances. The same storv comes from Bermuda, where they are driving out the two wild birds of that colony—the beautiful blue and red birds. Another instance of the terrible mistakes which may be made by ill-advised acclimatization.

Although it has been stated that Downs was rather shy of letter-writing, there was one man whose correspondence he prized and whose praises he was never tired of recounting—the veteran naturalist, Charles Waterton, of Walton Hall, Yorks, the author of *Wanderings in South America,* and of many essays on natural history subjects—"My worthy master in ornithology," he calls him, as he quotes from the well-known book which I own took my own fancy immensely when, as a boy, I first read in its pages the wonders of the South American forest. In those untravelled times there was no library without it. On Downs's return from Europe, which he visited in 1864, being given a free passage in H. M. S. *Mersey,* and taking over many cases of birds as well as a stuffed moose, I went to see him, to hear him recount his adventures. At that time I lived with my family on the shores of the Arm and was a near neighbour. He had received many attentions from savants and had been a guest of Waterton. He spoke of Waterton's tenderness of feeling towards all created things, especially the feathered tribes; how he would allow no guns to be fired by sportsmen or others on his estate, how the wild birds all seemed to understand him, and what a motley gathering there was in the groves and shrubberies of the park at Walton Hall; how he would inveigh against the superficial and absurd natural history as often published in his days both in England and the United States, even Wilson and Audubon coming under the lash of his criticism. "You should hear him," said Downs, "talk of the Hanoverian rat, the only dumb creature I really believe which he really hated." Waterton being of an old English Roman Catholic family which had held Walton Hall for centuries, had no good word for the Hanoverian dynasty, and averred that he had evidence to prove that the grey rat was part of the freight of the vessel that brought over Dutch William. Anyhow, Walton Hall, besides having some of Cromwell's musket balls lodged in the old wood of the house porch, was more than ordinarily troubled by the grey rats, the deadly foes and exterminators of the old English black rat, both in Europe and America, which latter country it very soon reached. I remember a specimen of the black rat being shown at one of our Institute's meetings at Halifax, which had just been killed in Water Street. It was then stated that up to about a century ago it was the common vermin of both countries. In New Zealand, too, the European grey has destroyed the native black rat, once the sole animal food of the Maori, being the only indigenous quadruped of the islands.

Frank Buckland, an old friend of my own, was delighted to meet Downs. Every one of note visited his grounds, including our sovereign, King Edward, the late Duke of Edinburgh, Prince Jerome Bonaparte, and many others. Pleasure excursions to the head of the Arm by steamers often bore numbers of Halifaxians bent on an afternoon's ramble in his charming domain.

Offered the post of superintendent of the New York Central Park Menagerie in 1867, he declined the post through some misunderstanding, and, giving up his grounds at the North West Arm, died in Halifax on 26th August, 1892, aged eighty-one years all but one month.*

In concluding this paper, I think I cannot do better than close with the words of our friend in ending one of his contributions to the proceedings of our Institute, the subject of which was the land birds of Nova Scotia, read in 1865:

"Having now arrived, gentlemen, at the end of my present list, I must state that all the facts I have given may be safely relied on as they are the result of forty years' experience in bird life. And I would, here, as it is the very first time I have ever appeared as a reader in public, take the opportunity of counselling the young men of Halifax to take more interest than they do in the natural history of their country. Many an hour passed in walking up and down Granville Street in tight boots might be devoted far more profitably to studying the quiet scenes of nature. If I had listened to the advice given me by the young men of my time, I do not think I should have had the pleasure of appearing here this evening; and instead of being happy, as I now am, in the presence of my brother naturalists, and possessed of a cheerful home to which I can retire, surrounded by my feathered favourites, I should most probably either have descended to an early grave, or been the habitual frequenter of the tobacco and dram shops. No; the country for me, before all the pleasure and grandeur of the town. Old Waterton once said to me he would sooner be in the woods than in the finest palace in Europe."

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* Other particulars regarding his life, and a list of his published papers, will be found in Mr. Piers's article before referred to.

General Hardy's paper was discussed by the PRESIDENT, DR. A. P. REID, DR. A. H. MACKAY, W. L. BISHOP, H. PIERS, and T. C. JAMES.

The SECRETARY was directed to convey to GENERAL HARDY the thanks of the Institute for his interesting communication.

THIRD ORDINARY MEETING.

Assembly Room, Province Building, Halifax, 13th May, 1907.

THE PRESIDENT, MR. DOANE, in the chair.

It was reported that LOUIS L. MOWBRAY, of Hamilton, Bermuda, had been elected a corresponding member.

The SECRETARY read a letter from MR. STUPART, director of the meteorological service, Toronto, informing the society that the self-recording rain-gauge for Halifax, that had been asked for that station in accordance with a resolution of the Institute of 9th April, 1906, had been received by the department and would shortly be installed.

H. PIERS reported on behalf of the committee appointed on 11th March, that the committee had prepared a design for a seal for the Institute, and had had a die engraved, which had been approved by the council.

H. W. JOHNSTON, assistant city engineer, Halifax, read a paper entitled, "The Run-off from a Small Drainage Area near Halifax, N. S.," the drainage area in question being that of Bayer's Lake, a portion of the Chain Lakes water-shed. The subject was discussed by E. L. FENERTY, P. A. FREEMAN, H. PIERS, and the PRESIDENT.

W. L. BISHOP took the chair while the PRESIDENT, F. W. W. DOANE, city engineer, Halifax, read a paper on "Halifax County Water Powers: (1) Starr Manufacturing Company's Power." (See Transactions, p. 21). The subject was discussed by E. L. FENERTY, W. L. BISHOP, P. A. FREEMAN, and others.

HARRY PIERS,
Recording Secretary.

TRANSACTIONS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1906-1907.

The Influence of Radium on the Decomposition of Hydriodic Acid.*

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The first mention of the influence of radiant energy of any kind on chemical reactions was made by William Cruickshanks[1], who observed that hydrogen and chlorine combine under the influence of light. This particular reaction has been the source of many investigations, carried out by such men as Dalton[2], Draper[3], Bunsen and Roscoe, and, very recently, Mellor[4], Bevan[5], and Burgess and Chapman[6]. Of the numerous reactions affected by light, the following are some of the more important:—influence of light on silver salts, on the action of bromine and chlorine on metallic silver, on dyed colours, on enzymes in oxygen and hydrogen, on glass, on the oxidation of iodoform, action of oxygen on carbon bisulphide under the influence of light, the decomposition of hydrogen peroxide by light, effect of light on the combination of hydrogen and bromine, and the reaction between chlorine and benzene in the light.

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[1] Nicholson's Jour., 1801, (1), 5, 202.

[2] A New System of Chem. Phil., p. 300.

[3] Phil. Mag., 1844, (iii), 25, 9: 1845, (iii), 26, 473.

[4] Journ. Chem. Soc., 1904, 53.

[5] Proc. Camb. Phil. Soc., 1902, (ii), 264-266.

[6] Jour. Chem. Soc., 1906, 88, 1399.

Other forms of radiant energy whose effects on chemical action have been investigated are ultra violet light, Röntgen rays and radium radiations.

Only a comparatively small amount of work has been carried out on the effect of radium on chemical reactions. Hardy and Wilcocks[1] have investigated the oxidation of iodoform when acted on by Röntgen rays and by radium, and Hardy[2] has observed the coagulation of globulin under the influence of the latter. Becquerel[3] found that white phosphorus is changed into the inactive red phosphorus, and that mercuric chloride in the presence of oxalic acid is reduced to mercurous chloride by the radiations from radium. The Curies[4] have shown that the rays from radium change oxygen into ozone and discolour glass. Berthelot[5] cites the following cases: iodic acid is decomposed by radium rays and by light, with liberation of iodine, this change being much slower than that of iodoform; nitric acid gives off nitrous fumes when acted on by radium rays and by light. These, as far as I have been able to discover, are all the reactions that have been investigated up to the present time.

These investigations have been mainly of a qualitative nature, the quantitative side receiving very little attention. The following experiments were carried on with a view to finding out whether a quantitative examination of the change, if any, produced in hydriodic acid by the presence of radium would throw light on the part played by the rays in this decomposition. Hydriodic acid was chosen on account of its instability; and from its behaviour under the influence of light, it was believed that it would be affected by radium rays.

The effect of light on the decomposition of hydriodic acid has, in the last few years, been largely investigated. Pinnow[6],

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1. Proc. Roy. Soc., 72, 480, 200.
2. Proc. Phys. Soc., 1903, May 16.
3. C. R., 1901, 133, p. 709.
4. C. R., 1899, 129, p. 823.
5. C. R., 1901, 133, p. 659.
6 Ber. d. deut Chem. Ges., 1901, 34, 2528.

who has done a lot of this work, used acid solutions of potassium iodide for the production of hydriodic acid. He found that the best results are obtained when the solution of potassium iodide used has a concentration of 1 gram per litre. It was a solution of this strength that was used in all the following work. The hydriodic acid was set free from the iodide by a solution of sulphuric acid consisting of one part of acid (sp. g. 1.84) to five parts of water. The proportion of acid to iodide solution was one to eight.

The amount of oxidation was determined in the usual way, by titrating the liberated iodine with $\frac{N}{1250}$ sodium thiosulphate solution.

It was found that the end point could be determined very quickly and accurately by highly illuminating the solution by means of an electric light placed behind it, and reflecting back the rays through the solution by placing a piece of white paper around the beaker on the opposite side.

The potassium iodide used was the chemically pure guaranteed reagent supplied by C. F. Kahlbaum.

By carrying out the titration in the above manner, the error was found to be about ± 0.08 cc. sodium thiosulphate solution.

Five milligrammes of radium bromide of activity of about 1,000,000 were employed. The radium was enclosed in a small glass tube, so that only the β and γ rays were used.

The starting point in the investigation was to determine whether radium exerted any influence on the oxidation of hydriodic acid. For this purpose, the radium was placed over a vessel containing the acid solution of potassium iodide, of the concentration mentioned above, and allowed to bombard the solution for a certain time; at the end of that time the amount of decomposition was compared with that of a similar solution that had not been acted upon by radium. The vessels used to contain the solutions were ordinary wide-mouthed reagent bottles, with a capacity of about 125 cc. The small glass tube containing the radium was held in the end of a hollow brass rod, which was placed in a fixed position in a wooden block; this latter fitted into the mouth of one of the bottles Thus, by filling the bottle to a definite mark, the distance between the radium and the surface of the liquid was always kept the same. This distance was between two and three millimeters.

These experiments were all carried out in a photographic dark room, so that there was no chance of the reaction being influenced by light. The solution which was not to be acted on by radium was protected from the rays by a screen of lead, so placed that the solution would not be affected appreciably by the secondary rays set up in the lead.

Several experiments carried out in this way showed, at the end of twenty-four hours, that the decomposition in the solution acted upon by radium was greater than the decomposition in the other; but the excess varied in different trials from 15 per cent to 25 per cent. In order to obtain more concordant results for similar experiments, the temperature at which the reaction took place was kept constant for a series of measurements and it was found that this made a decided improvement in the agreement of the results. It was still found, however, that the differences in results under similar conditions were considerably greater than those due to experimental error. In order to see whether these differences were due to small errors in the mixing of the solutions, a large quantity of solution was prepared and divided into six equal parts of 225 cc. each. These were allowed to stand for twenty hours in the dark room, without radium, at a temperature of 16 ± $0^0.5$C. At the end of that time the amount of decomposition, as measured by the number of cc. of titrating solution required, was found to be for the several portions, 5.38, 5.23, 5.41, 5.34, 5.07, 5.33, respectively. The lack of equality of these numbers shows that the irregularity is not to be accounted for in this way.

The influence of the impurities in the ordinary distilled water used in making up the solution was next investigated, and it was found that when the water had a conductivity of 2.0 x 10^{-6} or less, at 18°C., expressed in Kohlrausch's unit (ohm^{-1}, cm^{-1})[1], the agreement between the amounts of decomposition of several similar solutions was within the limits of experimental error.

The water used in the following experiments was prepared according to the method of Jones and Mackay[2]. The ordinary distilled water was doubly distilled. The steam from the first flask, which contained the water mixed with an alkaline solution of potassium permanganate, was bubbled through an acid solution of potassium bichromate in a second flask. Into the neck of the latter flask was thrust a block-tin condenser, and held there by means of a cork made of a mixture of plaster of Paris and asbestos. The water thus obtained has a mean conductivity of 1.6 x 10^{-6} at 18°C. It was kept in bottles which had been used several years for that purpose.

It was found that the purity of the water, as determined by the conductivity, played an important part in the rate of decomposition of the solution. The table below shows the results obtained when using water of two different grades of purity in the preparation of the solutions.

In this table, and all those that follow, the numbers given denote the amount of $\frac{1}{1250}$ normal sodium thiosulphate solution required to titrate the free iodine content in the hydriodic acid solution at the specified times after the instant of mixing. The mixing was done in the dark room. In all cases the amount of hydriodic acid solution experimented upon was 50 cc.

The numbers in the following table are for the case where the mixture was left to stand in the dark room, and was not subjected to the action of radium or any other external action. The temperature was 15 $\pm$ 0°.5C.

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[1] Kohlrausch und Holborn: Leitvermögen der Elektrolyte, 1898, p. 1.

[2] Zeit. phys. Chem., 1897, 22, 237.

TABLE I.

Time in hours.	No. of cc. of $\frac{N}{1250}$ $Na_2S_2O_3$ solution required in titration when hydriodic acid solutions were made up with	
	Water of conductivity 4.98 x 10^{-6}.	Water of conductivity 2 16 x 10^{-6}.
7	0.73	0.90
11	0.97	1.04
15	1.38	1.40
20	1.68	1.63
25	2.05	....
30	2.45	1.79
35	2.80	...
40	2.86	1.95
50	3.20	....
70	4.05	...
95	4.37	3.08
120	4.25	3.35
170	3.75	3.24
200	3.24	3.24
300	3.45	3.22
380	1.58	3.23
450	....	3.21
550	....	3.25
650	0.89	3.20
1100	....	3.24

From an examination of this table it will be seen that there is a striking difference between the behaviour of solutions made up with ordinary distilled water, and with water which has been more carefully purified. For the less pure water the content of free iodine rises to a maximum in about four days, and then gradually falls off again; but with the purer water the iodine content increases with the time for the first five days and then remains constant for the next six weeks during which it was under observation. Similar hydriodic acid solutions made up with the less pure water were subjected to the influence of sunlight, and in that case also the iodine increases at first, reaches a maximum after some days, and finally disappears. Hence the effect of impure water is of the same nature whether the solution be left in the dark or acted on by the sunlight. It will be seen later that in certain circumstances radium has the same effect on solutions made up with pure water.

It would seem that the effect of the small amount of impurity in the water is to cause the iodine, by some sort of catalytic action to change into a third iodine product in addition to the hydriodic acid and free iodine, which alone we might at first expect. In the case of solutions made up with the purer water, where the iodine content tends towards a constant asymptotic value, as given in the third column of the above table the simplest explanation is that a third product is not being formed, and that we have there the ordinary equilibrium between the hydriodic acid, the hydrogen and the iodine. If the third product is still being formed, two suggestions present themselves to account for the continued constancy of the amount of free iodine present: (1) that the rate of formation of the third product is very small, but that in time the numbers in the last column of the table would begin to decrease also; (2) that the whole system reaches a state of equilibrium, and the iodine content will be constant however long the time. The former suggestion is the more probable one, since it is likely that by a more careful distillation of the water we have not got rid entirely of the cause of the trouble, but only reduced it in amount.

This, however, is not the only effect of the impurity in the water; it also accelerates the rate of accumulation of iodine. This is evident from the fact that the maximum value reached in the case of the less pure water is greater than the asymptotic value approached in the case of the more pure sample. As it was found that the rate of production of free iodine was much affected by temperature, it was felt that an answer to the question of whether radium radiations had a specific action of their own on hydriodic acid, or only changed in degree the action going on in their absence, was to be looked for from a study of the action at different temperatures both with and without the presence of radium. Further efforts at an explanation of what is the action of external agencies such as impurity, light, Becquerel rays, etc., will therefore be deferred until the experiments on the effect of temperature on solutions with and without radium have been detailed.

The following table contains the results obtained with water of a high degree of purity at a temperature of 24°C., both with and without radium. A new sample of 50 cc. of hydriodic acid solution was taken for each period of time shown.

TABLE II.

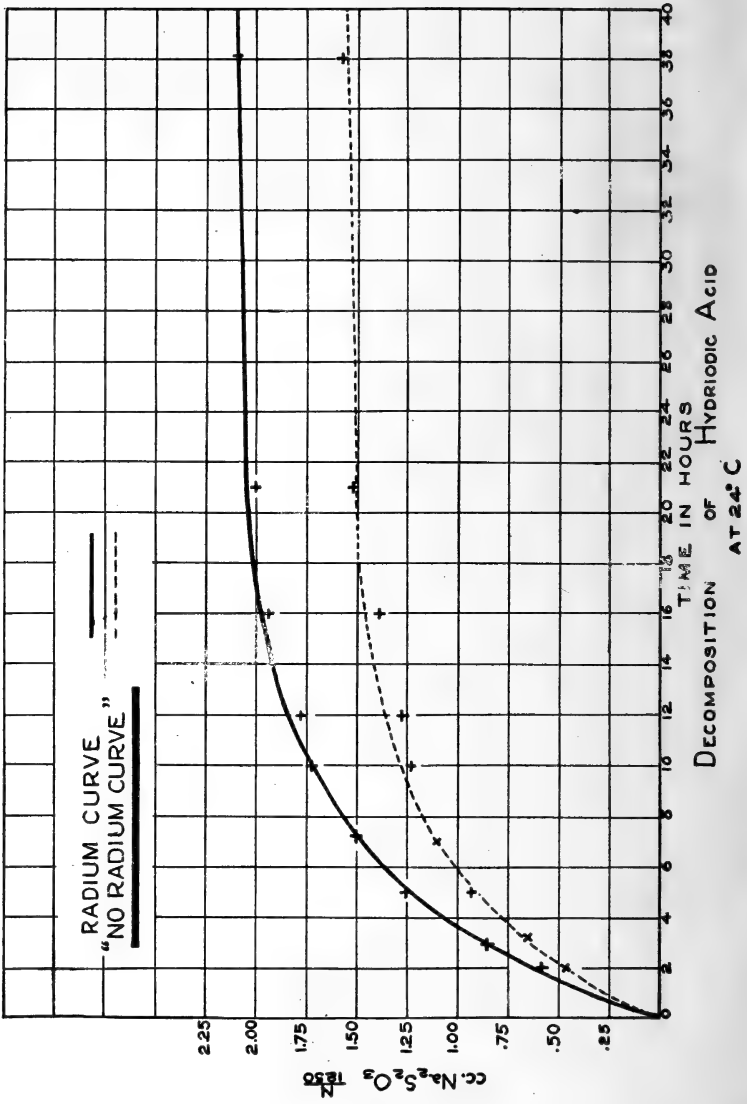
Time in hours.	No. of cc. of $\frac{N}{1250}$ $Na_2 S_2 O_3$ solution required in titration when decomposition of hydriodic acid solution takes place in the dark in the presence of			
	No radium.		Radium.	
	Observed y	Calculated from $y=a(1-e^{-bt})$ $a=1.54$, $b=0.175$	Observed y	Calculated from $y=a(1-e^{-bt})$ $a=2.10$, $b=0.175$
2	0.45	0.45	0.58	0.62
3	0.65	0.63	0.85	0.86
5	0.92	0.90	1.25	1.23
7	1.10	1.09	1.51	1.48
10	1.23	1.27	1.73	1.73
12	1.27	1.35	1.77	1.85
16	1.38	1.45	1.94	1.98
21	1.52	1.50	2.01	2.05
38	1.56	1.54	2.09	2.10

In the third and fifth columns of Table II. are added numbers calculated from the equation

$$y = a\ (1 - e^{-bt})$$

with the values of a and b there given, to show how well the observations are represented by curves of this type. These calculated curves are plotted in figure (1), the amounts of sodium thiosulphate solution being represented as abscissae. The observed values are marked and lie remarkably well on the curves. The similarity of these two curves seems to show that with pure water, at this temperature, the action of radium is of the same nature as that which goes on without it in the dark, but is greater.

FIG. I.



DECOMPOSITION OF HYDRIODIC ACID AT 24° C

If now, in the reaction under investigation, we assume that the hydriodic acid breaks down into iodine, and that this in turn breaks down into a third substance, then we have a case which is similar to the successive changes which take place in the break down of radium. Rutherford[1] has shown that if in such a change as this n is the amount of any substance A, in this case hydriodic acid, initially present, then the amount of B, in this case free iodine, at any time is given by the equation

$$y = \frac{n\lambda_1}{\lambda_1 - \lambda_2} \left(e^{-\lambda_2 t} - e^{-\lambda_1 t}\right) \ldots\ldots\ldots\ldots\ldots (1)$$

where λ_1 and λ_2 represent the rates of change of A into B and of B into C, respectively, where C is the third product.

Assuming that this third product is formed, there seem to be three probable ways in which the radium may act.

(1) The production of iodine is accelerated and also the production of the new product into which the iodine is changed.

(2) The production of iodine is unaffected, but that of the third product retarded.

(3) The production of the iodine is accelerated, while the production of the third product is retarded.

Of these three cases the two latter seem to be the least probable.

Let us apply equation (1) to the results of observation at 24°C. If the second change is very slow or zero, that is, if λ_2 is negligible, the amount of free iodine at the end of time t would be given by the equation

$$y = n\left(1 - e^{-\lambda_1 t}\right) \ldots\ldots\ldots\ldots\ldots (2)$$

Solving this equation for λ_1, we get

$$\lambda = \frac{\log n - \log (n - y)}{t \log_{10} e} \ldots\ldots\ldots\ldots (3)$$

Substituting in this equation values of t and y obtained from columns 1, 2, and 4 of Table II, we derive for λ values which show a very satisfactory agreement, as is seen in the following table:

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[1] "Radioactivity," p. 332.

TABLE III.

Time in hours.	No radium curve $.n=1\ 54$		Radium curve $.n=2.10$	
	Amt. $Na_2\ S_2\ O_3$ y	Rate of change. λ	Amt. $Na_2\ S_2\ O_3$ y	Rate of change. λ
2	0.45	0.173	0.58	0.162
3	0.65	0.183	0.85	0.173
5	0.92	0.182	1.25	0.181
7	1.10	0.719	1.51	0.181
10	1.23	0.160	1.73	0.174

This justifies us in supposing that at 24°C., both with and without radium, there is no third product being formed from the iodine; and the numbers given in columns three and five of Table II were calculated from equation (2). As was pointed out before, the action of radium serves merely to accelerate the action which goes on in its absence.

In order to see if more light would be thrown on the action of the radium the decomposition of hydriodic acid was observed at other temperatures.

The reaction was next observed at 12°C., and the results are given in the following table :

TABLE IV.

Time in hours.	No. of cc. of $\frac{N}{1250}$ $Na_2\ S_2\ O_3$ solution required in titration when the decomposition of hydriodic acid takes place in the dark in the presence of			
	No radium.		Radium	
	Observed y	Calculated from $y=a\ (1-e^{-bt})$ $a=1\ 92, b=0.07$	Observed y	Calculated from $y=a\ (1-e^{-bt})$ $a=2.90, b=0.07$
2.5	0.30	0.31	0.49	0.46
8.0	0.75	0.83	1.15	1.25
10.0	0.95	0.96	1.43	1.46
18.0	1.47	1.37	2.15	2.08
30.0	1.69	1.69	2.55	2.55

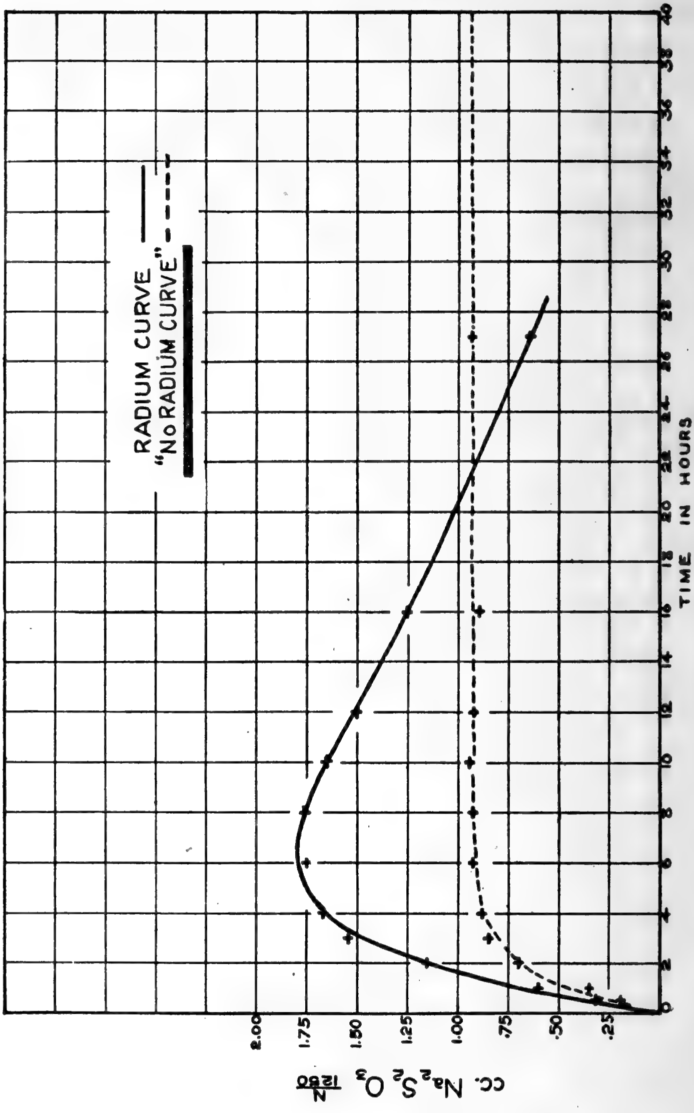
The curves for these numbers are similar in form to those for 24°C. The only difference between the behaviour at this temperature and that at 24°C. is that at the former the decomposition of the solution is much slower, and the equilibrium values consequently much longer in being reached. The effect of radium is again apparently only to increase the action in degree, but not to change it in type. Here, too, as at 24°C., there is probably no third product being formed from the iodine. The reaction was next observed at 36°C., and the following table shows the results obtained :

TABLE V.

Time in hours.	No. of cc. of $\frac{N}{1250}$ $Na_2S_2O_3$ solution required in titration when the decomposition of hydriodic acid solution takes place in the presence of			
	No radium		Radium	
	Observed y	Calculated from $y=a\ (1-e^{-bt})$ $a=0.92,\ b=0.70$	Observed y	Calculated from $y=a\ (e^{-bt}-e^{-ct})$ $a=3.3,\ b=0.06,$ $c=0.31$
0.5	0.18	0.27	0.30	0.38
1	0.35	0.46	0.60	0.69
2	0.70	0.69	1.15	1.15
3	0.85	0.81	1.50	1.46
4	0.88	0.87	1.65	1.64
6	0.93	0.91	1.75	1.79
8	0.92	0.92	1.75	1.75
10	0.93	0.92	1.65	1.64
12	0.91	0.92	1.50	1.52
16	0.90	0.92	1.25	1.24
27	0.93	0.92	0.65	0.65

The curves formed from these numbers are given in figure 2.

FIG. III.



DECOMPOSITION OF HYDRIODIC ACID AT 36°C.

At this temperature it is seen that the maximum is quickly reached in the case of the solution under the influence of the radium; and the effect due to the second reaction, the supposed changing of the iodine into a third substance, is soon noticeable. On the other hand, the curve for the solution not affected by radium resembles the curves for both radium and no radium at lower temperatures, but it would seem probable that in this case the time taken to reach the maximum is shorter. In this case also there is therefore no measurable formation of the third product. A comparison of the no radium curves for 12°, 24° and 36°C will show that with a rise in temperature the rate of decomposition of hydriodic acid increases, while the maximum amount of iodine in solution is less and the time taken to reach this maximum shorter. The same is true for the radium curves at 12° and 24°C.

If the theory previously stated of what is taking place be correct, the general equation (1) should be the equation of the radium curves for 36°C.

Rutherford[1] has shown that the smaller of the two quantities λ_1 and λ_2 is given by the latter part of the downward curve. The equation of this part of the curve is then of the form

$$y = n . e^{-\lambda t} \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Accordingly, from the observed values of y at 12, 16 and 27 hours, n was found to be 3.3 and λ_1 to be 0.06. By finding the differential of equation (1) with regard to time and equating it to zero, we find that the maximum occurs at a time T, given by the equation

$$\lambda_1 e^{-\lambda_1 t} = \lambda_2 e^{-\lambda_2 t} \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Putting for t the value 6.6 found from the curve, and for λ_1 its value 0.06, we find λ_2 to be 0.31. The numbers calculated from equation (1) with these values of the constants are given in the last column of Table V, and the agreement with the observed values falls well within the limit of experimental error.

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[1] Loc. cit., p. 343.

Since for no radium at 36°C., λ_1 was found to be 0.70, and λ_2 was zero (or very small), we see from the foregoing results that the influence of the radium at this temperature is to decrease the rate of decomposition of the hydriodic acid into iodine, and to increase the second action considerably, namely the transformation of the iodine into the third compound.

It is an easy matter to determine when the amount of hydriodic acid is half gone. If n is the amount of hydriodic acid initially present and P is the amount present at any time t, then

$$P = n\ e^{-\lambda_1 t}$$

Calling T the time taken for half of the hydriodic acid to be transformed, we have

$$\tfrac{1}{2} = e^{-\lambda_1 t}$$

$$\text{whence } T = -\frac{\log_e 0.5}{\lambda_1}$$

Substituting the values of λ obtained with no radium for 24°C. and 36°C. in this equation, we find that it takes about 384 hours at the former temperature and about 17 hours at the latter for half the amount of hydriodic acid to be decomposed into iodine.

Effect of Temperature.

In order to show the effect of temperature alone, both when the solution is under the influence of radium and without it, the reaction was allowed to proceed for ten hours at various temperatures. The results were as follows :

TABLE VI.

Temperature.	No. of cc. of $\frac{N}{1250}$ $Na_2S_2O_3$ solution required in titration when the decomposition of hydriodic acid takes place in the dark in presence of		Difference.
	No radium.	Radium.	
0	0.20	0.78	0.58
4	0.45	1.02	0.57
8	0.68	1.21	0.53
12	0.95	1.43	0.48
16	1.20	1.73	0.53
20	1.25	1.75	0.50
24	1.23	1.73	0.50
36	0.93	1.65	0.72
	Mean of all Differences except that for 36°C...		0.53

If these numbers are plotted it is seen that the curves are straight lines below 16°C. If the latter are produced backward they will cut the axis of temperature at about −12°C. and −3°C. for the radium and no radium curves respectively. At these temperatures there should be no decomposition unless the curves should become asymptotic, and, considering the steepness of the curves at 0°C., this would not seem probable for the "no radium" curve at least. Of course it was out of the question to keep the solution at −12°C. on account of its freezing, but a solution could easily be kept at −3°C. for a time.

This temperature (−3°C.) was easily obtained by placing the solution in a bath of very dilute alcohol, which was surrounded by a mixture of salt and snow. It required but little attention to keep this bath at a temperature of about −3° 6C. to −4°C.

It was found at the end of ten hours that the decomposition in a solution not under the influence of radium, and kept at a temperature of −3°C. during that time, was equivalent to 0.19 cc. sodium thiosulphate. Hence the curves at 0°C. must cease to be straight lines, and begin to run asymptotically toward the axis of temperature.

From this work on the effect of temperature we are again led to conclude that the radium intensifies the action that is already going on.

Effect of γ Rays Alone.

Hardy and Wilcocks[1] have shown that the γ rays from radium accelerate slightly the decomposition of iodoform, but that the acceleration is small as compared with that due to the β rays. In order to determine whether the γ rays behave in the same way upon the hydriodic acid reaction, the rays from the radium were made to pass through 6 millimetres of lead before entering the solution. This thickness of lead is sufficient to absorb all but the fastest β rays, and does not appreciably absorb the γ rays. The reaction was first allowed to go on for ten hours at 24°C, when the amount of free iodine was found to be equivalent to 2.10 cc. sodium thiosulphate solution.

For the sake of comparison the results for ten hours are here grouped:

No radium for 10 hrs. at 24°C	1.23	cc.	$\frac{N}{1250}$ $Na_2S_2O_3$	solution
β and γ rays	1.73	"	" "	"
γ rays	2.10	"	" "	"

At first this result seems to disagree with that obtained by Hardy and Wilcocks. Indeed it does not seem reasonable that the γ rays, whose energy is much less than that of the β rays, should accelerate the decomposition more than the latter. Closer consideration, however shows that the disagreement is only apparent and that the result is in accordance with the above theory of the break down of hydriodic acid.

For if, as we have supposed, there are two successive reactions taking place, both of which are accelerated by the influence of radium, then since it has been shown that the second one of these is the more influenced, it is quite probable that when the energetic β rays are absorbed and not allowed to enter the solution, the second reaction is relatively retarded, and so we have the amount of free iodine in the solution increased. If this is what is happening, then for a few hours after the

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[1] Loc. cit.

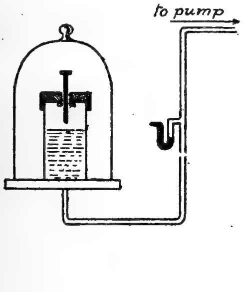
beginning of the reaction, before the second reaction begins to make itself felt, we should expect to find that the amount of iodine set free is less when the solution is acted upon by γ rays, than when it is acted upon by β and γ rays. At the end of three hours, when the solution had been kept at 24°C., the decomposition was found to be as follows :

No radium	for 3 hrs.	at 24°C	...0.65	cc.	$\frac{N}{1250}$	$Na_2S_2O_3$	solution
β and γ rays	"	"	....0.85	"	"	"	"
γ rays	"	"	...0.72	"	"	"	"

Influence of Sunlight and Radium in the Absence of Oxygen.

If a hydriodic acid solution such as was used in the preceding experiments be entirely freed from occluded air, and placed in a tube from which all the air has been removed, it was found that this tube could be placed in the sunlight for any length of time, without the solution showing any decomposition. In order to remove all occluded air before being sealed off, the solution was kept in a vacuum in the dark for twenty-four hours ; for otherwise it is found that extremely minute quantities of dissolved air will slightly decompose the hydriodic acid.

The same experiment was then tried with radium, instead of sunlight. In order to keep the solution under a vacuum for two or three days, without sealing up the radium in a tube with the solution, the vessel containing the solution with the radium was placed under a bell jar on a brass plate, connected by a glass tube to a "Geryk" vacuum pump. The joint between the bell jar and the brass plate was made perfectly tight by sealing it with a preparation made by heating together equal parts of pure india rubber, paraffin, and vaseline. When the vacuum was made this tube was sealed off from the pump. A delicate manometer connected with the jar, showed no change



in vacuum at the end of several days. It was found that the radium also produced no effect. The experiment was tried at room temperature only.

Summary.

1. When prepared with very pure water a hydriodic acid solution decomposes in the dark, reaching an equilibrium value. (Experiments made up to 36°C.)

2. Ordinary distilled water contains impurities producing some catalytic action which accelerates the decomposition of hydriodic acid solution in the dark, at the same time introducing another reaction, which causes the amount of free iodine to reach a maximum value and then fall off indefinitely. (Experiments made at 15°C. only.)

3. At any temperature up to 24°C, more iodine is liberated in a given time from a solution of hydriodic acid in the dark, under the influence of radium, than from one that is not so influenced.

4. When the experiment is tried at 36°C. this last statement is only true up to 24 hours; for whereas the amount of free iodine with no radium reaches an equilibrium value, with radium it reaches a maximum and then falls off indefinitely.

5. At 36°C. radium seems to cause the formation of the same third product which impurity in water produces at low temperature.

6. In general, increase of temperature tends to increase the amount of free iodine at any time, whether radium is used or not.

7. The γ rays alone cause more iodine to be free than do the β and γ rays together. (Experiments made at 24°C. only.)

8. Neither sunlight nor radium causes decomposition of hydriodic acid solution in absence of oxygen. (Experiment made at room temperature only.)

I wish, in conclusion, to thank Professors Mackay and Mackenzie, for their kind suggestions and criticisms during the progress of this work.

Dalhousie University, June 1st, 1907.

WATER POWER OF HALIFAX COUNTY, NOVA SCOTIA: PART I, DARTMOUTH LAKES POWER.—BY F. W. W. DOANE, C. E., City Engineer, Halifax.

(Read 13th May, 1907.)

It is not the purpose of this paper to present any novel or improved ideas in hydraulics or hydro-electric power, but first to call attention to the undeveloped possibilities in our well-known water courses, and second to describe somewhat in detail the water power available from a water shed in the county of Halifax, a portion of which is partially developed, the remainder almost as nature formed it.

To the average man a water power is necessarily something with a big dam across an imposing stream. Indeed, many engineers are accustomed to look for large watersheds and high heads, overlooking entirely the possibilities of the small streams. In the House of Assembly a short time ago, it was stated that there are no water powers in Nova Scotia worthy of the notice of the government. This assertion may or may not be correct, yet while all of the larger powers have been discovered, and many of them harnessed, there still remain many falls on our streams which have escaped notice or have been considered too unimportant to develop. Many hydraulic powers are in use, but are not furnishing anything like the quantity of power which they are capable of developing.

The board of trade last year, in a quarterly report, regretted the lack of cheap powers for industries in Halifax, but went no farther in a search for a remedy. Mr. Yorston, in his paper read before the Institute last year, stated fully the possibilities of the power on the Mersey River in Queens County. A portion of the dormant power in the Gaspereau Valley is being developed for transmission to the neighboring towns, Wolfville and Kentville, while the latent energy of the tides of the Bay of Fundy still await the master hand of the engineer, the promoter, and the capitalist.

With the rapid growth of the demand for power, and the necessity for obtaining that power as cheaply as possible, we can no longer afford to ignore the possibilities of the minor hydraulic powers, many of which are yet undeveloped, while others now in use are not developed to their full capacity.

We have no mountain streams with great heads in Halifax County, but there are many streams which contain possibilities which would justify investigation at least.

At twenty feet head it takes a wheel a couple of feet in diameter and a flow of about 3,500 cubic feet of water per minute to give 100 horse-power. At eighty feet head a 10-inch wheel will do the same work on one-quarter of the quantity of water, while with a very high head a mere brook may suffice to give a power that may be worth at least developing for local use.

Minor powers are not uncommon in any hilly district, but the small flow diverts attention from them. Yet this very class may have possibilities in the way of storage of water that would make them most attractive. In some cases where a number of square miles of watershed are available, it may be possible by the construction of dams to form storage lakes or increase the capacity of existing natural reservoirs, and by this means create a useful power where only a moderate stream flowed before.

There is, of course, a limit to the minimum quantity of continuous water power that is worth considering, whether for local use or in connection with electric transmission. The governing features of the problem are the general cost of development and equipment, the cost of transmission, and the cost of operation.

In hydraulic work the cost of conduits from the dam to the power house is generally the controlling item, and this is again determined by the distance necessary to be covered and the available flow.

If the cost can be kept in the neighborhood of $100 per horse-power, the outlook for an economical short transmission is good, since this means an annual charge of no more than $10 or $12 per horse-power for the motive power. The cost of wheels and generators with their equipment will run generally from $25 to $30 per kilowatt in cases where raising transformers are not needed, the usual case for small powers. All of this can be approximated very readily, as also can the cost of the necessary buildings.

The heaviest charges in small work come in the operating expenses and in the pole line. Pole lines for light wires need not cost more than $250 to $300 per mile, exclusive of wires and right-of-way. The latter, in working on a small scale, is commonly along the highway, so that the cost is small; but the cost of wire, unless the line is short, may add considerably. Still, at a given voltage, the cost of copper per kilowatt transmitted is a constant, and the only relatively fixed item is the cost of stringing, which varies only slightly with the size of wire until the larger sizes are involved. For mechanical reasons, however, it is not desirable to string wire smaller than No. 4 or No. 5; so that the minimum cost of conductor is somewhere about $500 per mile. Fortunately, the depreciation charge against bare wire is practically negligable, and wire of this minimum size will carry comfortably the output of the class of plant considered.

In hydro-electric plants the operating expense is largely one of fixed charge, while with steam plants it is made up of fixed charges coupled with variable items of coal, water, oil, waste and incidentals. With the hydro-electric plant, consequently the cost per horse-power per year is almost constant, regardless of whether supplied one hour a day or twenty-four hours a day. Repairs are about the only variable, and they may be considered as increasing in direct proportion to the load factor. Labor, oil, waste, etc., are nearly the same, irrespective of the proportion of light loads to full loads. With the steam plant, on the contrary, the items of coal, labor, etc., increase rapidly with the load factor, and hence the cost per horse-power per annum increases in almost the same proportion.

The cost of attendance is the most serious outlay in small stations. It means, generally, the pay of at least three men, and occasional extras—not less than $2,000 per annum, even for a very small plant. At 100 kilowatt capacity this would come to at least $20 per kilowatt per year, which added to the other charges, is pretty nearly prohibitive. At 200 kilowatt capacity, the operating charge gets down to reasonable figures. In a rough estimate, one will not go far wrong in saying that for electrical purposes a water power of 250 to 300 horse-power on steady flow is worth considering. Anything below this is of little account, except for local utilization, and the usefulness of the power increases rapidly above this point.

If the situation is favorable for storage, a good deal can be done with small streams; but unless the above amount can be made available without going to heavy expense, there is not much that can be done. If two or more such powers are available they can be often worked together to advantage. There are powers near the limiting size that have been passd over as too small, and these are the ones which ought to be carefully looked after in the interest of small places and small industries.

The fundamental fact that faces the engineer of a hydro-electric plant is that the total amount of hydraulic power available is, once for all, a fixed quantity. Of the rain that falls in the drainage area of the stream a certain proportion finds its way into the stream and that is all that is there available. Taking a series of years, too, the distribution of this available water through the year is approximately uniform, so that one can state broadly the total normal power per year, and that its distribution through the year follows a certain power curve. In some streams this curve is very regular, in others extremely irregular, showing torrents at certain seasons and rivulets at others. The task of the engineer is to take the power curve and do with it the best he can in earnings, attacking the problem with all the resource at his command.

No hydro-electric plant of limited capacity should be studied at the present time without considering the use of auxiliary power. Oftentimes such a study would result in the rejection of auxiliaries altogether. At other times, after all has been done that is possible in obtaining the best available storage, there may remain a feature of the problem which may be economically handled only by steam or gas auxiliaries. But a short time ago, the presence in any hydro-electric system of steam or gas auxiliaries, was considered a confession of weakness in the hydraulic system. Fortunately this false idea is fast losing ground, and it is recognized that the best of engineering is shewn by their use, and in consequence, hydro-electric opportunities are being utilized which were previously neglected.

Streams of comparatively constant flow, by the installation of steam or gas auxiliaries, are enabled to supply heavier loads than would be otherwise possible, though perhaps the most important use for auxiliaries is found in cases where the normal stream flow is very materially reduced during short periods of the year, by reason of special conditions in the watershed.

It is not reasonable to develop a hydro-electric station when a steam or gas station could be built which would supply the same territory at a lower cost, but it is also unwise to condemn a hydro-electric development because the cost per unit of capacity is high, when at the same time it can develop cheaper power than can be done in any other manner.

In the province of Ontario, the government has appointed a hydro-electric power commission, whose duty it is to develop and supply electric energy not only to municipalities requesting it, but also to any railway or to a private company distributing electricity.

In the annual report of the New York state water supply commission, that body strongly urges the state control of waters. This refers not only to such a regular examination f water supplies for potable purposes as shall insure the detection of any serious change in their quality, but also to the larger problem of the regulation of stream flow in order to prevent floods. The commission believes that it is unwise to allow the appropriation of potable waters for power purposes, except under such state supervision and regulation as is at present exercised in the case of water-works plants. The diminution of floods, the report states, could be brought about by the construction of reservoirs which need not flood public forests, an act prohibited by the constitution, and the waters stored in these reservoirs might be made a source of revenue. The portions of the report recently made public do not reveal any definite plans for legislation to carry out the suggestion, but the general proposition that the state should exercise an equitable supervision and control over the unappropriated waters of the state meets with public approval. The time is coming quickly when water powers and water supplies will be appraised much higher than now, and any failure to secure state control of them, so far as they are now unappropriated, may be unfortunate.

It is becoming daily more and more apparent that the coal mines, steamers and railroads cannot supply a permanent and continuous generation of power so readily as the rivers. The experience of the past has brought this home to all classes and sections of the Dominion, till in some parts of the country we are now appealing to our courts and legislative bodies to relieve us from the perils of fuel famine. These conditions are but the natural outgrowth of a national improvidence which in the past has consumed our store of domestic fuel for power purposes and has allowed to run to waste the easily available power resources of the water which constantly falls upon our hills, and will continue to fall while the earth is habitable.

Cheapness of power has long ago been demonstrated for the hydro-electric plant and transmission line; reliability is now being proved. The duplicate line has already become an established factor in the system, and attention has been turned to the duplicate plant as well. The advantages of the duplicate source will be the next study.

Not only is the unreliability in the supply of coal aiding in the development of hydro-electric projects, but the price also is exercising a great influence. We do not have to go far afield to hear tales of scarcity of fuel and closed plants in consequence of strikes, car famine, etc., and every consumer of coal knows that there has been a permanent increase of about 50 per cent. in the cost. This price will not be reduced, but in all probability will continue to advance, so that it may be claimed that the hydro-electric plant, which will begin by paying expenses, must necessarily become a source of profit in the near future.

Water Power of the Dartmouth Lakes.

The nearest water power to the city of Halifax is that owned by the Starr Manufacturing Company, in Dartmouth. Until very recently this power was not controlled entirely by one company. By the amalgamation of the Starr Company and the Dartmouth Rolling Mills Company, the whole water power becomes the property of the new company, and it is now possible to develop it to its full capacity.

The drainage area from which this power is obtained includes the watershed and water surface of five lakes. Beginning at a divide a short distance south of Cranberry Lake, which lies on the south side of the Preston Road, about three and one-half miles east of Dartmouth, the surface slopes northwardly and westwardly. Cranberry Lake empties by a stream about one-third of a mile in length, crossing the Preston Road into Lake Loon, which in turn drains into Lake Charles, about one mile and one-half westwardly as the crow flies. From Lake

Charles the surface slopes both northwardly and southwardly, Lake Charles being the highest of the chain of lakes utilized in the construction of the Shubenacadie Canal. While no longer needed for canal purposes, the masonry of the old locks is still in good condition, and is used by the Starr Company in connection with their storage dams.

When the lakes are overflowing, Lake Charles has an outlet at both ends, but except in time of freshet, the outlet is southwardly into Second Dartmouth Lake. The stream between Lake Charles and Second Dartmouth Lake is about seven-eighths of a mile in length, and passes through two of the old locks. From Second Dartmouth Lake the water flows directly into First Dartmouth Lake. From the latter, it is let down through Sullivan's Pond as it is required. Penhorn Lake, lying south of the Preston Road, about a mile and a half east of Dartmouth, drains into the Second Lake. Oathill Lake, situated about three-quarters of a mile eastwardly from the town, and south of the Preston Road, empties into First Lake.

From a map in the possession of the Deputy-Commissioner of Public Works and Mines, the areas have been obtained as follows:—

Lake Loon watershed	840	acres.	
Lake Charles watershed	3400	"	
First and Second Lakes watershed	3060	"	
Total area of lakes and watershed	7300	"	=11.4 sq. miles
Lakes only:			
Cranberry Lake	23	acres.	
Loon Lake	190	"	
Reservoir below Loon Lake	23	"	
Lake Charles	337	"	
First and Second Lakes	441	"	
Other lakes	36	"	
Area of lakes	1050	"	= 1.6 sq. miles
Area of watershed, not including lakes	6250	"	= 9.8 sq. miles

The country is rough and broken, a portion being wooded, and a large proportion waste land.

After passing through the Starr Manufacturing Company's works, the water, previous to the amalgamation of the two companies, was used again at the electric light station below Portland Street.

For this purpose the water was carried to a point opposite the light station by a flume 4 ft. 6 in. wide, and 15 in. deep. When examined by the writer the water was flowing about 14 in. deep with an inclination of .002 feet per foot. Under those conditions the sluice would discharge 1134 cubic feet per minute. From the flume the water was taken by a 4 ft. pipe to a 20 in. crocker turbine, working under a head of 18 ft. 4 in. At 75 per cent. efficiency the wheel would develop 29.25 horse-power.

The water running the Starr works is drawn from Sullivan's Pond through a 44 in. pipe, 417 feet long, with a discharging capacity of 12,900 cu. ft. per minute. The wheels work under 31 ft. head. The shop is run by a 30 in. wheel, "standard" make, purchased from T. H. Risdon & Co., Mount Holly, New Jersey. The grinding room machinery is kept in motion by a 10 in. "American" turbine manufactured by the Dayton Globe Iron Works Co., Dayton, Ohio. A 22 in. "special" new American turbine (Dayton make) has been used to operate electric generators for lighting the town.

The catalogue capacity of these wheels is:—

Size	Head in ft.	Revolutions.	Horse-power.	Cu. ft. of water used.
30 in.	31	262	83.4	1674
10 in.	31	681	21.8	465
22 in.	31	326	116.7	2492

A comparison with the theoretical horse-power of the water used shows that the wheels are rated at higher efficiency than they can reach in practical work. The large wheel is rated at 85 per cent. efficiency and the other two at 80 per cent.

At 75 per cent. efficiency 1674 cu. ft. at 31 ft. head = 73.5 horse-power.
75 " " 465 " 31 " = 20.25 "
75 " " 2492 " 31 " = 109.5 "

The Starr Company was under contract to supply power to the Electric Light Company up to 100 horse-power from sunset to midnight, and 30 horse-power from midnight to dawn. It is estimated, therefore, that the average quantity of water consumed per day in developing power was:—

1674
465

2139 cu. ft. per minute x 60 x 9 hours = 1 153,560 cu. ft. per day.
2492 " " x 60 x 6 " = 897,120 " "
1134 " " x 60 x 5 " = 2,390,880 " "

This quantity used at an equal hourly rate for twenty-four hours would produce 73 horse-power at 75 per cent. efficiency. Adding the 29.25 horse-power developed below, the total 24-hour power would be 99.25 horse-power. For nine hours it would produce 195+29.25=224.25 horse-power.

Assuming for the present that the quantity of water used daily is correct, it is not developing the total horse-power that it is capable of producing. If, instead of the present system, all of the water were carried in a pipe from Sullivan's Pond to a wheel at the electric light station, there would be a head of at least fifty feet. The above quantity of water would then develop at 75 per cent. efficiency, 116.75 horse-power for twenty-four hours, or 314.25 horse-power for nine hours. The nine-hour power would be an increase of 90 horse-power, or 40 per cent. In order to obtain this additional power it would be necessary to convert the hydraulic plant now running the Starr works into a hydro-electric plant.

The same water used for power at the Starr works is available for the development of power at the foot of First Lake, as Sullivan's Pond, through which water is drawn from First Lake for the Starr Company's plant, is comparatively very small, and has practically no watershed. When First Lake is full, there is a head of about twelve feet above Sullivan's Pond. Assuming that First Lake can be maintained at overflow level every day of the year, and that the quantity hereinbefore estimated is available, a wheel at the canal lock would develop at 75 per cent. efficiency, 28 horse-power for 24 hours, or 77.5 horse-power for 9 hours. If Sullivan's Pond could be raised 12 feet, this additional power would be available at the Starr works without electric transmission.

The quantity of power that could be taken from the estimated available water by carrying it in a pipe from First Lake to a wheel at high-water mark would not be greater than that developed by a wheel at the Canal lock at the foot of First Lake, and another at high-water mark, operated by water drawn from Sullivan's Pond. The total would be about 390 horse power for 9 hours, or 145 hore-power for 24 hours.

The fall in the stream from Lake Charles to Second Lake affords another opportunity to increase the total capacity of this power. This portion of the old canal is known as Port Wallis Locks. The upper lock gate is closed, and holds the water up to the level of Lake Charles. There is a fall in the lock of about 19 feet, and at the lower lock about 10 feet. Estimating the available portion of the rainfall over the watershed draining to this point at two feet, a wheel at Port Wallis Locks would develop 25 horse-power for 24 hours or 66 horse-power for 9 hours.

The quantity of water available, depending not only on the rainfall but on the possibility of storage, it is of the greatest importance to know what can be done to hold the water draining through the old canal. The writer is not familiar with Lake Loon, and has had no opportunity to ascertain the storage possibilities of this lake. It is stated, however, that a rise of three feet would cause the water to flow in another direction.

Lake Charles can be dammed at both ends. At the south end there is a good location for a dam. The lake could be raised six feet by a structure about 100 feet long. At the north end the dam would be from 100 to 200 yards in length. At one point on the Waverley Road the highway would have to be raised, as it is not much above the present overflow level of the lake. Raising Lake Charles six feet would increase the storage capacity about 90,000,000 feet, or about 40 days' supply for the Starr works. This additional storage would be nearly one-third of the estimated available rainfall, and there is no doubt in the mind of the writer that the storage in this power system can be increased so that the whole run-off in a dry or ordinary year can be held and used as required.

The contract with the Electric Light Company began January 1st, 1898. In 1894, which was a very dry year, the water failed, but all the wheels did not stop again for want of water until 1905, which was the dryest year on record.

In 1904 the shop ran by steam from August 5th to September 10th.

In 1904 the electric lights ran by water without stop.

In 1905 the electric lights ran by steam from September 14th to November 22nd.

In 1905 the shop ran half water, half steam, from August 29th to September 14th.

In 1905 the shop ran by steam from August 14th to Dec. 1st.

The Starr Manufacturing Company has an auxiliary steam plant, as may be inferred from the foregoing statement, which they use in case of emergency, or when once in ten years water fails. This plant affords a good illustration of the advantages of the auxiliary system, which permits a larger horse-power development on the available water than would be possible without it. In its absence the daily capacity of the plant would be reduced, and there would be danger of complete shut-down in case of accident or shortage of water.

The estimate of the quantity of water used daily at the Starr works is based on information given by the manager. If correct, the proportion of the rainfall is much larger than the usual estimate. 2,390,880 cubic feet of water every day, equals 872,671,200 cubic feet a year, which, spread over 7,300 acres, would be 33 inches, or 59 per cent. of 55,927, the average rainfall in Halifax. It is, therefore, probable that the estimated capacity is in excess of the actual capacity. The estimated capacity based on the manager's data is:—

At high-water mark (9-hour day) 365 days	314.25	h. p.	
At first lock	75 5	"	
At Port Wallis locks	66	"	
	457.75	"	
Possible nine-hour power under present development	224.25		
Possible increase	233.5	"	104 p. c.

It would be very interesting to know positively the exact quantity of water used by each wheel at the Starr works, and the exact total time run during one year, so that the run-off determined by Mr. Johnston and that at the Starr works could be compared.

A FEW CHEMICAL CHANGES INFLUENCED BY RADIUM: A NEW METHOD FOR THE DETECTION OF AMYGDALIN.*—By H. JERMAIN M. CREIGHTON, M. A., Dalhousie University, Halifax, N. S.

Read 13th April, 1908.

Up to the present time only a comparatively small amount of work has been carried out on the effect of radium on chemical reactions. Hardy and Wilcocks[1] have investigated the oxidation of iodoform, when acted on by Röntgen rays and by radium, and Hardy[2] has observed the coagulation of globulin under the influence of the latter. Becquerel[3] found that white phosphorus is changed into the inactive red phosphorus, and that mercuric chloride in the presence of oxalic acid is reduced to mercurous chloride by the radiations from radium. The Curies[4] have shown that the rays from radium change oxygen into ozone and discolour glass. Berthelot[5] cites the following cases: iodic acid is decomposed by radium rays and by light, with liberation of iodine, the change being much slower than that of iodoform; nitric acid gives off nitrous fumes when acted upon by radium rays and by light. The decomposition of hydriodic acid has been observed and studied by Creighton.[6] These, as far as I have been able to discover, are all the reactions that have been investigated up to the present time.

When it had been decided to investigate what influence radium had on different chemical changes, it seemed probable that the best results would be obtained if the radium were allowed to act on the substances that were to be transformed, under the conditions most favourable to the transformation. It was mainly for these conditions that the following substances were chosen.

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*Contributions from the Science Laboratories of Dalhousie University [Chemistry.]

[1] Proc. Roy. Soc., 72, 480, 200.

[2] Proc. Phys. Soc., 1903, May 16.

[3] C. R., 1901, 133, p. 709.

[4] C. R., 1899, 129, p. 823.

[5] C. R., 1901, 133, p. 659.

[6] Proc. & Trans. N. S. Inst. Science, XII, 1, 1.

Five milligrammes of radium bromide of activity of about 1,000,000 were employed. The radium was enclosed in a small glass tube, so that only the α- and β-rays were used.

Action of Radium on Lead and Tin.

After a particularly cold winter, 1867-68, it was found that some blocks of tin that had been stored in the customs house at St. Petersburg, had mysteriously crumbled to a grey powder. It has since been shown that tin exists in two allotropic forms, one of which is this grey powder, the other the ordinary white malleable metal. The transition temperature of these two varieties of tin is about 20° C., the former being stable below, and the latter above this temperature. The reason all ordinary tin, most of which is at a temperature below that of transition, does not change into the grey kind, is due to its being in a state of unstable equilibrium, and kept there by an unknown agent, to which the name passive resistance has been given. If in some way this passive resistance could be overcome, then the transition of white into grey tin would readily take place.

It was in order to see whether radium would do this that the following experiment was carried out.

Two pieces of white tin, about two and a half centimetres square and a millimetre thick were prepared from pure mossy tin, and their surfaces made smooth and clean. These were placed in a small leaden box, Fig. 1, and separated from each other by means of a leaden partition, which was sufficiently thick to keep all but the fastest β-rays from passing from one compartment to the other. The ends of the box were left open. The

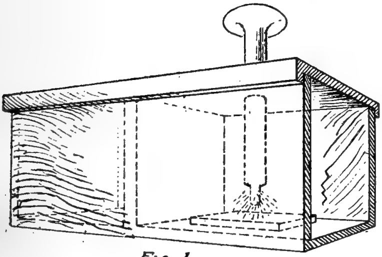

Fig 1

small glass tube, containing the radium, was held in the end of a hollow brass rod; this latter passed through a hole in one end of the leaden cover of the box, so that the radium was over, and about a millimetre distant from, the square of tin in one of the compartments of the box. This box was placed in a large tin box and kept at a temperature of about 0°C. for four months.

At the end of that time, the pieces of tin were taken out and examined under the microscope, and it was found that there was a formation of grey tin on the surface of each, but that the amount on the piece that had been bombarded by the rays from the radium, was greater than that on the piece which had not been so acted upon. This difference, however, was not very great, but the lead box which had contained the pieces of tin, had undergone a curious change, during the four months. The inside of the compartment into which the tube containing the radium had penetrated, was completely covered, with the exception of the bottom, with a thin white film, which was present in some places, particularly the top of the box, in relatively large quantities, while the other compartment did not contain the most minute trace of this substance. Around the hole in the top of the box, where the tube containing the radium entered, the lead was coated with the white substance, much more thickly than anywhere else. Some of this powder was scraped off and analysis showed that it was lead carbonate.

The only explanation the author can give of its formation is this. Some of the rays from the radium, after striking the surface of the tin, which was probably not perfectly even, were reflected upward, and bombarded the top of the lead box and ionized it, thus making it more active than it was. The portions of the lead which were thus made active, were able to combine with the moist carbon dioxide in the air, with the production of lead carbonate. This seemed to be borne out by the fact that it was the top of the box that was most coated with the carbonate.

The Action of Radium on Hydrogen Peroxide.

The action of radium on hydrogen peroxide was next investigated, as on account of its behaviour under the influence of light,[1] it was believed that it would be affected by radium rays.

The hydrogen peroxide solution used in these experiments had a strength of 4.832 grams per litre.

Since hydrogen peroxide, when it decomposes, breaks up into water and oxygen, its decomposition can be estimated by measuring the oxygen produced, or the amount of hydrogen peroxide left in the solution by titrating with potassium permanganate. As this latter method necessitated changing the amount of substance in the system, the former was chosen, and the oxygen was measured by the change of pressure it produced.

A large reagent bottle, with a side tubulature near the bottom, was half-filled with hydrogen peroxide. Into the side neck was fitted a long graduated tube with a bend at right angles, which was to act as a pressure gauge. The brass tube containing the radium was passed through a tightly-fitting rubber cork, which was fixed firmly into the neck of the reagent bottle and so adjusted, that the radium was about three or four millimetres away from the surface of the liquid. In this way, any increase in the volume of the gas over the peroxide would produce a change in its pressure, and this change could be read by means of the pressure gauge. Figure 2 shows the apparatus.

These experiments were carried out in a photographic darkroom, so that there was no chance of the reaction being influenced by light.

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[1] **D'Arcy, Phil. Mag., 1902 [VI], 3, 42.**

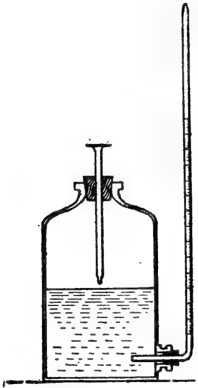

Fig 2.

360 cc. of hydrogen peroxide, of the strength mentioned above, were placed in the bottle just described, and put in the dark without being under the action of radium. The volume of gas enclosed over the liquid was 350 cc. The variations in pressure as observed by the pressure gauge were recorded for three hundred hours. After correcting this pressure for the variations due to changes of temperature and pressure, it was found that the pressure of the enclosed gas had not varied, showing that the peroxide had not suffered any decomposition during the time it was under observation.

Next an experiment was carried out, similar to that just described, except that the surface of the peroxide was bombarded by radium radiations. The increase in pressure was recorded from time to time, and the results obtained are tabulated in the following table:

TABLE I.

Time in hours.	Barometric pressure mm. Hg.	Temperature °C.	Height of liquid in manometer divisions.[1]	Increase in pressure of gas mm. Hg.	Corrected increase in pressure of gas mm. Hg.
0	761.0	19.1	145.0	....	....
7	762.01	18.8	149.9	0.5	1.7
15	762.11	18.0	157.3	1.1	4.4
30	764.10	18.8	160.2	1.4	4.1
40	763.90	19.2	165.0	2.0	2.7
50	764.01	18.0	156.0	1.0	5.8
75	761.39	17.1	151.3	0.6	6.4
100	767.11	16.6	155.5	1.0	10.9
118	764.31	16.8	163.0	1.9	10.0
142	766.01	17.9	167.0	2.2	8.4
165	764.02	18.0	162.1	1.9	6.7
200	765.13	18.0	160.1	1.4	6.8
219	764.99	18.1	158.4	1.3	6.3
238	764.41	18.1	155.0	1.0	5.6
265	760.99	19.5	163.0	1.9	0.8

20 scale divisions = 25 mm.

In the preceding table column five gives the changes in pressure of the gas in millimetres of mercury. These values have been calculated from the data in column four, the hydrogen peroxide having a density which is approximately one. Column six contains the values of column five after approximate corrections have been made for the changes due to variation in temperature and pressure; that is, these numbers represent the changes in pressure due to the increase of gas.

From these results, then, it is seen that the effect of radium on the solution of hydrogen peroxide is to decompose it. This decomposition, however, is small; for the increase in pressure corresponds only to a small increase in volume. In its behaviour towards hydrogen peroxide radium resembles light. It will be noticed that the pressure exerted by the gas, as given in the sixth column of the above table, after a time begins to decrease. The reason of this diminution in pressure will be considered later.

It is a well-known fact that the presence of finely divided solid matter or salts of the heavy metals slowly decomposes concentrated solutions of hydrogen peroxide, even at ordinary temperature. For this reason 10 cc. of $\frac{N}{10}$ solution of lead nitrate were added to 350 cc. of the dilute hydrogen peroxide used in these experiments. The addition of the lead nitrate to the peroxide caused the formation of a finely divided precipitate, the presence of which should also tend to decompose the solution. After making the necessary approximate corrections for changes in temperature and pressure, it was found that during the ten days the solution was under observation the pressure had not changed at all. Hence, it would seem that dilute solutions of hydrogen peroxide are not, or at most only exceedingly slowly, decomposed by the presence of finely divided solid matter or solution of lead nitrate.

An experiment similar to this was next carried out, with the exception that the surface of the liquid was bombarded with radium rays. The results are given below in Table II.

TABLE II.

Time in hours.	Barometric pressure mm. Hg.	Temperature °C.	Height of liquid in manometer divisions.[1]	Increase in pressure of gas mm. Hg.	Corrected increase in pressure of gas mm. Hg.
0	759.99	20.8	142.0	....	...
9	759.90	20.8	160.5	1.7	1.7
12	759.71	21.2	167.0	2.3	1.7
15	759.41	21.4	169.5	2.5	0.8
19	758.74	21.6	165.0	2.1	0.1
23	759.21	21.8	156.5	1.4	1.5
33	759.20	21.1	141.5	0.1	1.1
36	759.30	20.6	142.8	0.1	0.4
41	759.21	19.6	136.6	0.5	2.3
48	759.41	19.1	138.0	0.4	3.9
58	759.53	17.4	95.0	4.3	4.3
63	759.91	17.4	107.0	2.3	6.3
67	760.10	17.4	108.0	3.3	5.3
73	765.31	17.4	90.0	4.8	6.3
82	767.90	16.8	89.0	4.9	9.9
87	769.18	17.6	104.0	3.5	9.0
92	767.20	18.5	123.0	0.7	9.0
100	766.17	18.0	170.0	2.6	13.2
104	764.39	18.0	208.0	6.1	15.7
109	758.55	18.0	252.5	10.1	16.7
115	754.54	18.5	305.0	14.1	17.9
120	758.52	18.4	352.5	19.3	24.9
130	758.63	18.7	483.7	31.2	36.0
136	758.63	18.7	489.2	31.8	36.6
153	761.05	18.6	358.2	19.8	27.5
160	761.52	19.6	394.5	23.2	26.9
167	761.09	19.0	387.0	22.5	28.4
177	760.99	17.4	343.0	18.6	28.3
188	761.26	17.4	389.0	22.8	32.5
194	761.84	17.2	413.0	25.0	35.5
202	765.17	17.0	391.0	23.0	35.6
216	764.69	15.4	299.0	14.4	30.9
225	762.70	12.6	238.0	8.8	31.5
236	761.75	14.2	299.0	14.4	34.2
240	761.23	14.2	334.0	17.6	37.1
255	769.36	15.6	379.0	21.8	41.5
265	761.91	14.8	354.5	19.5	35.7
276	763.30	11.6	274.5	12.2	37.9
294	765.86	11.8	286.5	13.2	39.6
304	767.02	12.3	303.0	14.8	40.4
314	752.34	12.8	638.3	46.4	63.7
321	752.34	13.6	711.3	52.3	67.4
324	753.86	13.6	681.0	49.6	65.2

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[1] 20 scale divisions = 25 mm.

In column six of this table the increases in pressure due to the decomposition of the hydrogen peroxide are given, and on comparing these results with those given in Table I, it will be seen that the effect of the radium is to produce a much greater decomposition when lead nitrate is present than when it is not.

The Curies[1] have shown that the effect of radium radiations on oxygen is to transform it into ozone. It is to this cause that the decreases in pressure, corresponding to contractions in volume of the gas, observed in these experiments, have been attributed. Why there is this periodic change, the accumulative effect of which, as shown in Table II, is to enlarge the volume of gas, will have to be investigated more thoroughly before a suitable explanation can be given. On examining the gas which was over the liquid when the experiment was over, it was found that it contained 1.4 per cent. of ozone.

The foregoing experiments show that neither solutions of hydrogen peroxide (4.832 grams per litre), nor solutions of hydrogen peroxide in which lead nitrate is present undergo any decomposition in the dark; also that dilute solutions of hydrogen peroxide are slowly decomposed by radium, this decomposition being much more rapid when the solution contains lead nitrate and finely divided solid matter. Lastly, that ozone is produced by the action of radium on the oxygen present.

Action of Radium on Chloroform.

It is well known that the reason chloroform, $CHCl_3$, does not give a precipitate with silver nitrate, is due to the fact that it is unionized. As there seems to be no absolutely undissociated substance, there is in chloroform, probably some few chlorine ions; these are so few that when they unite with the silver ions present in the system, the amount of silver chloride is very much too small to be visible. However, as soon as these chlorine ions are removed from the system as undissociated silver chloride, more of the chloroform dissociates in

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[1] Loc. cit.

order to maintain the value of its solubility product, which must be exceedingly small. Thus the silver chloride accumulates very slowly and finally becomes visible. This explanation would seem to account for the appearance of silver chloride in a mixture of silver nitrate and chloroform a long time after mixing.

The following experiment was carried out to find whether chloroform could be ionized by radium to a sufficient extent, as to produce a visible amount of silver chloride when mixed with a solution of silver nitrate. About 50 cc. of chloroform which were found to produce no precipitate on mixing with a solution of silver nitrate, were placed in a wide-mouthed reagent bottle, with a capacity of about 125 cc. The brass tube containing the radium was passed through a tightly fitting rubber cork and fixed firmly into the mouth of the bottle. This solution was placed in the dark, and at the end of twenty-four hours it was shaken up with a few cc. of silver nitrate solution. After removing the water from the chloroform by allowing it to remain for a few hours over anhydrous copper sulphate, the liquid remaining possessed a milkiness which must have been due to the presence of silver chloride, thus proving that chlorine ions had been separated from the chloroform by the action of the radium.

Action of Radium on Amygdalin.

The laws of the action of light on glucosides, enzymes, toxins and antitoxins have been thoroughly investigated by Dreyer and Haussen,[1] who have shown that the effect of light on the glucosides is to cause them to break down with the formation of glucose. For the purpose of investigating the action of radium upon the glucosides, the most common one, amygdalin $C_{20}H_{27}NO_{11}$ was chosen. The amount of decomposition could readily be measured by estimating the amount of glucose formed.

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[1] C. R., 1907, 145, p. 564.

A saturated solution of amygdalin in water, was subjected to the action of radium rays for four days. At the end of that time part of the solution was tested with Fehling's solution for glucose. Not the least trace of glucose was found to be present. Another part of the solution was boiled with ammonium polysulphide, and after the excess of the latter had been removed by boiling, a few drops of dilute ferric chloride were added. As there was no change in colour hydrocyanic acid was inferred to be absent. Solutions of amygdalin were acted upon by radium for different lengths of time up to ten days, with the same result as above.

Although on boiling the solution of amygdalin, which had been under the influence of radium for a time, with a few drops of Fehling's solution, the copper was not reduced, thus showing the absence of glucose, the blue colour due to the copper, almost disappeared, a whitish or pale blue gelatinous precipitate was formed, and a fairly strong odour of ammonia was given off. If more than a few drops of Fehling's solution were added to the amygdalin, the blue colour did not disappear on boiling. When Fehling's solution was added to an ordinary solution of amygdalin, it was found that the same changes took place on boiling, except that the solution of amygdalin which had not been acted upon by radium, was not able to discolour as much Fehling's solution as was a solution that had been acted upon by radium. These changes must be due to some reaction taking place between the amygdalin and the Fehling's solution, or one or more of its constituents; these reactions are more complete when the amygdalin has been under the influence of radium for a time.

Amygdalin solutions were boiled with the constituents of Fehling's solution combined in all possible ways, but it was only when they were present so as to form Fehling's solution that the above results were obtained. When a solution of amygdalin was boiled with caustic potash alone, ammonia was given off but no precipitate was formed.

Liebig and Wöhler prepared amygdalic acid or glucomandelic acid, $C_{20}H_{28}O_{13}$ from amygdalin, by boiling it with baryta water, the change taking place in this way:—

$$C_{20}H_{27}NO_{11} + 2H_2O = C_{20}H_{28}O_{13} + NH_3$$

This acid is a white crystalline substance which readily forms amorphous salts.

It is probable that the change taking place with Fehling's solution is one similar to this. The action of the potassium hydroxide is to form amygdalic acid and ammonia, and at the same time an insoluble salt of the former is formed with the copper, which is held in solution by the sodium and potassium tartrate in the Fehling's solution.

The decomposition of amygdalin by Fehling's solution does not take place unless the solution is boiled. However, if the solution of amygdalin is boiled with potassium hydroxide, cooled, and then a few drops of Fehling's solution added to it the bluish precipitate is formed.

A quantity of this precipitate was formed and washed free from amygdalin and Fehling's solution. When some of it was heated on a piece of platinum foil it charred, showing that it contained organic matter, and a greyish residue containing a carbonate and copper, but no sodium nor potassium was left behind.

From the foregoing facts it would seem that, on adding Fehling's solution to a solution of amygdalin and boiling, we have a change taking place like that observed by Liebig and Wöhler, resulting in the break down of the amygdalin. As a result of this decomposition the nitrogen of the amygdalin is changed to ammonia, and a bluish white precipitate, which is probably a copper salt of amygdalic acid, is formed. It is believed that the evolution of ammonia and the formation of the precipitate noted above, might be used for the detection of amygdalin. When the amygdalin has been under the influence of radium for a time, it is found this change is more complete.

Since solutions of glucosides are readily changed into glucose by hydrochloric acid, even in the cold, it was believed that if a solution of amygdalin were bombarded with radium radiatons, this transformation might be accelerated.

The solutions of amygdalin used for this purpose had a concentration of ten grams per litre; the hydrochloric acid consisted of one volume of acid (sp. g. 1.2) to five volumes of water. The proportion of amygdalin to acid solution was ten to one.

The amount of decomposition was determined bv titrating the glucose that was produced, with Pavy's solution, 25 cc. of which =0.0151 gram of glucose $C_6H_{12}O_6$.

To determine whether the radium exerted any influence on the hydrolysis of amygdalin, the radium was placed over a vessel containing the acid solution of amygdalin, of the concentration mentioned above, and allowed to bombard the solution for a certain time; at the end of that time the amount of decomposition was compared with that of a similar solution that had not been acted on by radium. The vessels used to contain the solutions were ordinary wide-mouthed reagent bottles with a capacity of 125 cc. The tube containing the radium was securely fixed in a wooden block, which loosely fitted over the mouth of one of the bottles. Thus, by filling the bottle to a definite mark, the distance between the radium and the surface of the liquid was always kept the same. This distance was between two and three millimetres.

The following experiments were carried out in a photographic dark room, so that there was no chance of the reaction being influenced by light. The solution which was not to be acted on by radium was protected from the rays by a screen of lead, so placed that the solution would not be affected appreciably by the secondary rays set up in the lead.

Several experiments were carried out in this way, and the amount of glucose formed was estimated after different lengths of time. In the following table the numbers given in column two denote the amount of amygdalin solution required to decolourise 2 cc. of Pavy's solution (25 cc.=0.0151 g. $C_6H_{12}O_6$), at the specified times after the instant of mixing. The temperature at which the action took place was $18 \pm 0^{\circ}.5$ C.

TABLE III.

Time in hours.	No. of cc. of Amygdalin solution required to decolourise 2 cc. of Pavy's solution when acted on by		No. of grams of glucose per 1 cc. of Amygdalin solution acted on by	
	RADIUM.	NO RADIUM.	RADIUM.	NO RADIUM.
19	11.54	12.08	0.000104	0.000099
30	13.39	12.29	0.000089	0.000097
48	14.77	12.28	0.000081	0.000097
66	16.27	12.39	0.000073	0.000097

From an examination of this table it will be seen that there is a striking difference between the behaviour of solutions of amygdalin acted upon by radium and those which have not been so influenced. For the solutions that have been bombarded with the radiations from radium, the content of glucose reaches a maximum and then falls off again; but with the solutions not under the influence of radium the amount of glucose present increases with time and then remains constant. An effect similar to this has been observed by the author[1] when acid solutions of potassium iodide made up with ordinary distilled water are allowed to decompose in the sunlight or dark; and when acid solutions of potassium iodide made up with pure water (conductivity 2.16×10^{-16}), are allowed to decompose under the influence of radium. In each of these cases the content of free iodine reaches a maximum and then gradually falls off again.

It would seem that the effect of the radium is to cause the glucose, in some manner, to change into some new product. In the case of the solution of amygdalin which has not been under

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Loc. cit.

the influence of radium, where the content of glucose tends toward a constant asymptotic value, the simplest explanation is that the new product is not being formed, and we have an ordinary example of equilibrium between the amygdalin and its products of decomposition. If the new product is being formed two suggestions present themselves to account for the continued constancy of the glucose present: (1) that the rate of formation of the new substance is very small, but that in time the numbers in column five of the table would begin to drop also; (2) that the whole system reaches a state of equilibrium, and the amount of glucose will remain constant however long the time.

In order to ascertain whether the glucose was transformed into a simple substance or a complex one, by the action of radium, the effect of the latter on solutions of glucose in water and dilute hydrochloric acid, and on solutions of pure cane sugar in dilute hydrochloric acid was next studied.

Solutions of glucose and cane sugar of various strengths were experimented upon for different lengths of time, the change being measured by means of the polariscope. It was found that in no case was the change in the solution under the action of radium any different from that which was not influenced by radium, which seemed to show that the substance into which the glucose was changed in the amygdalin solution was not likely a simple one.

Action of Radium on Brass.

As has been mentioned before, the radium used in these experiments was enclosed in a narrow glass tube, which was held in the end of a hollow brass rod. The radium had been kept in this brass rod for about a year previous to these experiments. Some time after being placed there it was observed that the end of the brass rod, at which the radium was, began to be discoloured, and finally turned a deep grey. This discolouration was only at the surface next the air, for on scraping the surface of the rod with a knife, the inside was found to have the yellow colour of brass. While allowing the radium to act on hydrogen peroxide in the experiment previously described, where the brass rod was enclosed in an atmosphere of ozone, and air containing more oxygen than ordinary air, there was found on the part of the rod near the radium, a small quantity of this dark grey substance. Some of this was scraped off, care being taken not to remove any of the brass. On analyzing this substance it was found to contain only copper, there not being even so much as a trace of lead or zinc present. What has probably taken place is that the action of the radium on the brass in the presence of oxygen has slowly converted the copper of the alloy to copper oxide; the greater the amount of oxygen present the more rapidly the change takes place.

The results here given show that in many reactions the effect of radium is to accelerate that action already going on, and in the case of amygdalin and hydrochloric acid it may perhaps set up a new action of its own, besides accelerating the hydrolysis of the amygdalin into glucose, etc. Lastly the presence of amygdalin may be detected by boiling a solution supposed to contain it with a few drops of Fehling's solution and noting whether or not the odour of ammonia is given off.

The author's best thanks are due to Professor MacKay for the interest he has shown in these experiments.

Dalhousie University, Halifax, N. S.
March 30, 1908.

THE BEHAVIOUR OF SOLUTIONS OF HYDRIODIC ACID IN LIGHT IN THE PRESENCE OF OXYGEN.*—By H. Jermain M. Creighton, M. A., Dalhousie University, Halifax, N. S.

Read 13th April, 1908.

It is well known that solutions of hydriodic acid and acid solutions of potassium iodide readily change into free iodine and water. These reactions are accelerated by light, and also, as the author[1] has shown, by radium. While investigating "the influence of radium on the decomposition of hydriodic acid" the author[2] observed that the iodine set free by the oxygen increased with the time, reached a maximum and then gradually fell off again, under certain conditions. It was also observed that solutions of iodine placed in the sunlight slowly became colourless. It was to try to account for the disappearance of this iodine that this investigation was undertaken.

The hydriodic acid used in these experiments, was set free from solutions of potassium iodide by means of a sulphuric acid solution consisting of one volume of acid (sp. g. 1.84) to five volumes of water. The solutions of potassium iodide used had a concentration of 1 gram per litre. The proportion of acid to iodide solution was one to eight.

The amount of oxidation was determined in the usual way, by titrating the liberated iodine with $\frac{N}{1250}$ sodium thiosulphate solution.

It was found that the end point could be determined very quickly and accurately by highly illuminating the solution by means of an electric light placed behind it, and reflecting back the rays through the solution by placing a piece of white paper around the beaker on the opposite side.

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*Contributions from the Science Laboratories of Dalhousie University [Chemistry].

[1] Creighton, Proc. and Trans. N. S. Inst. Science, vol. xii, 1, 1.

[2] Loc. cit. Also Creighton and Mackenzie, Amer. Chem. Jour., 1908. 39, 4 (April).

The potassium iodide used was the chemically pure guaranteed reagent supplied by C. F. Kaulbaum.

By carrying out the titration in the above manner, the error was found to be about ± 0.08 cc. sodium thiosulphate solution.

As has already been stated, the iodine in solutions of hydriodic acid diminishes under certain conditions; in the case where the hydriodic acid is placed in the sunlight the iodine entirely disappears in time. If there was a new substance being formed, it was felt that its nature could best be ascertained from a study of the change under the action of sunlight, as this was the most easy to control and by far the most rapid.

As a starting point in this investigation, a large quantity of solution was made up in the manner previously described, and placed in a window where it would receive the most sunlight. Portions of 50 cc. of this solution were titrated with sodium thiosulphate from day to day and thus the variations in the content of free iodine were established.

On account of the reaction being a reversible one and its point of equilibrium being changed by light, the numbers in the following table are given for the days which were of about the same degree of brightness.

TABLE I.

Time in hours.	No of cc. of $\frac{N}{1250}$ $Na_2S_2O_3$ solution required in titration when the decomposition of hydriodic acid takes place in sunlight.	Time in hours.	No. of cc. of $\frac{N}{1250}$ $Na_2S_2O_3$ solution required in titration when the decomposition of hydriodic acid takes place in sunlight.
24	46.31	552	20.42
72	58.42	720	18.55
120	64.42	840	16.62
144	58.93	888	14.26
189	52.14	960	11.80
236	49.97	1056	10.74
288	45.14	1152	6.41
408	44.12	1272	3.12
456	28.55	1368	0.46
504	23.41	1392	0.00

From this table it is again seen that the iodine content reaches a maximum very rapidly and then slowly falls off again and finally disappears. During the last two hundred hours the disappearance of the iodine is relatively rapid. In this experiment it was found that the disappearance of the iodine was due, in part, at least, to evaporation; accordingly, to see whether evaporation was responsible for the whole change, and at the same time to determine how much light influenced this change of iodine, the following experiment was carried out.

300 cc. of an acid solution of potassium iodide, such as had been used already, were put in each of two reagent bottles, one amber colour, the other clear; these were closed, and about every twelve hours the air that was over the liquid was passed through U-tubes containing a solution of potassium hydroxide (sp. g. 1.27), by means of an aspirator.

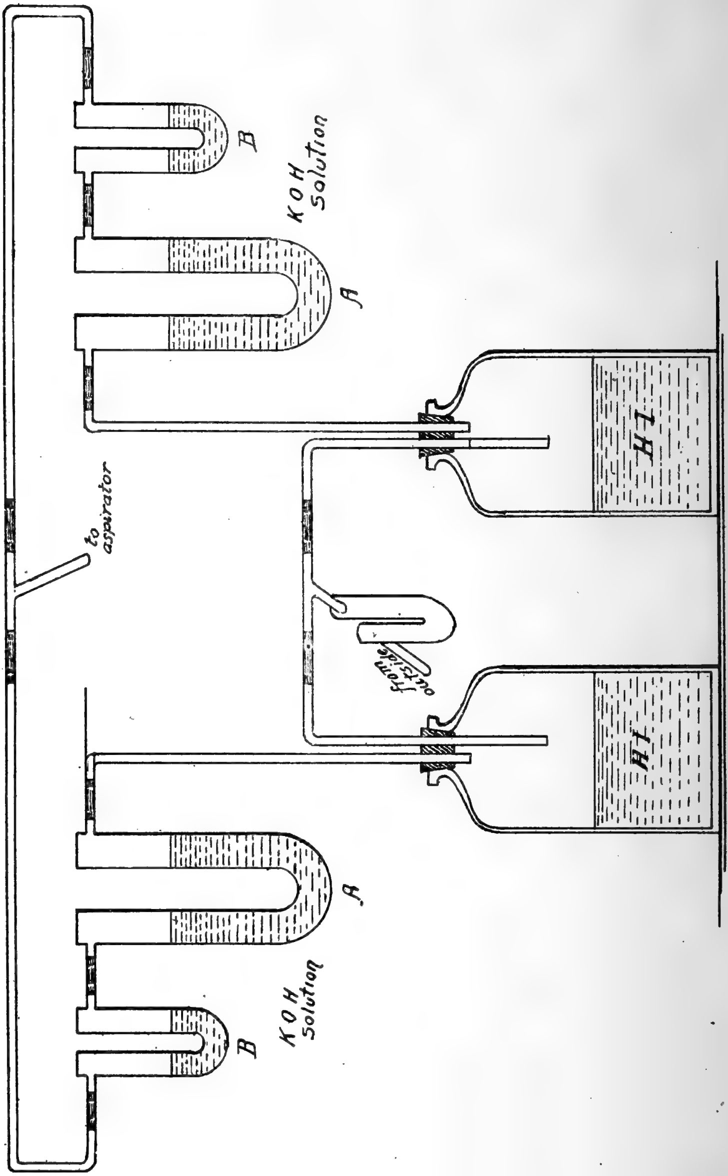
B
KOH Solution
A
to aspirator
from outside
HI
HI
A
KOH Solution
B

Fig I

The air thus removed was replaced by air from outdoors, which first passed through a U-tube containing potassium hydroxide. The air, after passing through this solution of potassium hydroxide divided, and half went to one solution and half to the other. After passing over these solutions it went, as stated, through the potassium hydroxide in the U-tubes, A and B, and then met in a common tube leading to the aspirator. By these means it was very easy to pass the same quantity of air over each solution. A diagram of the apparatus is given in Fig. 1. After the last trace of the iodine had disappeared the amount absorbed could easily be estimated. The use of the second smaller U-tubes marked B in the diagram was to make sure of the complete absorption of the iodine.

After the solution had been exposed to the action of sunlight for seven weeks, the solution in the bottle that was not coloured, became colourless. The solution in the amber coloured bottle still contained considerable quantity of iodine, and it was not for nearly another seven weeks that its colour entirely disappeared. This shows that the change of the iodine is accelerated by light, and that its loss cannot probably be totally accounted for by evaporation. On examining the U-tubes containing the caustic potash solution, it was found that the first one, A, contained iodine, while there had been none absorbed in the second smaller tube, B, showing that no escape of iodine had taken place.

The amount of iodine carried away by the air and absorbed by the solution of potassium hydroxide was next determined.

When iodine is absorbed in potassium hydroxide, there is formed five molecules of potassium iodide to one of iodate. The solution of hydroxide was acidified with sulphuric acid; and as some of the iodide might have oxidised to iodate, a little iodide was added to ensure complete decomposition of the iodate, then a few cc. of starch solution added, and the liberated iodine determined by means of sodium thiosulphate solution.

The potassium hydroxide solution from the U-tubes was diluted to 200 cc. 45 cc. of this solution were acidified and titrated with $\frac{N}{10}$ sodium thiosulphate solution, of which 1.53 cc. were required to remove the blue colour due to the iodine. From this data it may be shown that the 200 cc. of hydroxide, therefore, contain 0.0864 gram of iodine. Only one-sixth of this iodine was present as iodate in the potassium hydroxide solution, that is 0.0144 gram. The quantity of iodine as iodide was estimated by oxidising it to iodate by means of potassium permanganate solution; 1 cc. of this solution = 0.0056 gram of permanganate. 25 cc. of the solution of potassium hydroxide which had been diluted to 200 cc. was acidified slightly with sulphuric acid and then made alkaline with potassium carbonate. The permanganate solution was then added until the liquid became slightly pink. In this titration 4.40 cc. of the potassium permanganate solution, corresponding to 0.0246 gram of potassium permanganate, were required to oxidise the iodine. It will readily be seen that this amount of potassium permanganate has been used in oxidizing 0.0098 gram of iodine. Therefore, the amount of iodine in the potassium hydroxide solution as iodide was eight times this amount, or 0.0784 gram. Hence, the total amount of iodine lost by evaporation from the iodine solution and absorbed by the potassium hydroxide solution was,

0.0144 gram iodine as iodate
0.0784 " " " iodide
———
0.0928 " " absorbed.

In this experiment 300 cc. of iodide solution (conc. 1 gram per litre) which contained 0.2293 gram of iodine, were used, From these numbers it will be seen that the loss by evaporation was 40.47 per cent., which leaves still sixty per cent. to be accounted for.

Before leaving this experiment it would be well to mention here that after all the iodine had disappeared from the solution it still possessed a slight colour, not unlike the colour produced when Nessler's solution is added to a solution containing a minute quantity of ammonia. About a week after the last of the iodine had disappeared, this colour went also. In all solutions of hydriodic acid, where the iodine disappears, this colour was observed.

Although it seemed absolutely certain, from the fact that the second U-tube, B, in the above apparatus contained no iodine, none of it could have escaped out of the latter into the atmosphere, yet the objection arose that as the gas inside the bottles was taken out, carrying with it iodine, some of the iodine, although very unlikely, might have escaped. It was to overcome this objection that the experiment to be described was carried out.

500 cc. of acid potassium iodide solution were placed in a reagent bottle provided with a tightly fitting rubber cork, through which passed a glass tube provided with a stop-cock. This glass tube went almost to the bottom of the liquid as shown in Fig. 2. This tube was connected with a gas holder containing oxygen under pressure, the gas from which was first purified and dried, by passing through wash bottles containing sodium bicarbonate and concentrated sulphuric acid, before being allowed to enter the iodide solution.

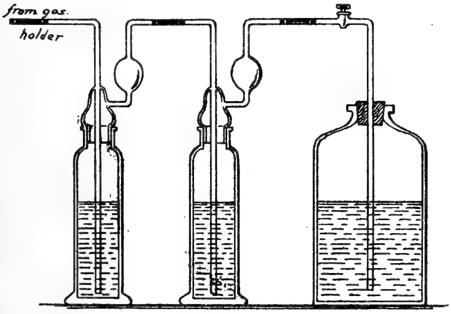

Fig 2

The stop-cock was opened, the rubber cork loosened, and the air in the bottle displaced by oxygen. The rubber stopper was then tightly fitted, the oxygen in the bottle allowed to attain the same pressure as that in the holder, and the stop-cock closed.

At the end of twenty-four hours on opening the stop-cock again, a large quantity of oxygen was found to bubble through the solution, showing that some of the oxygen there had been used up during the twenty-four hours. Every day as much oxygen as possible was forced into the bottles containing the solution, until at the end of about nine weeks, the solution had lost all its colour, with the exception of the slight peculiar colour mentioned previously. Some of the solution was drawn off and tested for iodine and iodides, but not the least trace of either was found to be present. The passage of oxygen into the solution was continued with the result, that at the end of another week, the slight colour possessed by the solution entirely disappeared. During this time it was roughly estimated that not less than twenty-five litres of oxygen, at the ordinary temperature of the laboratory and a pressure somewhat above the normal, were passed into the iodide solution.

On the foregoing grounds then, it is not unreasonable to suppose that the iodine is being transformed into some oxygen compound, and that this transformation is accelerated by light.

Creighton and Mackenzie[1] have shown in the case of solutions of hydriodic acid acted upon by radium, where the iodine content after a time begins to diminish, it is very probable it is the hydriodic acid that is transformed and not the iodine itself, thus lessening the content of free iodine by upsetting the equilibrium between the two substances. On account of the similarity between the two cases, it is possible that this is the manner in which the change takes place here.

The colourless solutions from which the iodine had disappeared were now examined. It was found that these solutions contained no iodide, but, however, a small quantity of iodate. If these solutions were allowed to stand for a few weeks after becoming colourless, before testing, there could not be obtained the slightest trace of iodate. These facts would seem

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[1] Loc. cit.

to show that the process of the change is one of oxidation, through the different oxygen compounds of iodine. The amount of iodine as iodate in the solution into which oxygen was passed, just after the last trace of iodine had disappeared, was found to be 0.0000372 gram per cc. or the 500 cc. started with would contain 0.0186 gram; that is, 4.87 per cent. of the original amount of iodine.

It is evident then that the amount of iodate present in the solution will be greatest just after the solution becomes colourless; that is, never very much greater than 4.87 per cent. This will readily be seen from the consideration that no appreciable amount of iodate could exist, while there was any potassium iodide or hydriodic acid present in a solution containing sulphuric acid. Also it has been shown that the amount of iodate decreases with time, after the solution loses its colour.

It seemed a not unlikely explanation that the iodine might be changed into periodates. It would appear a perfectly natural process for the hydriodic acid to be oxidised to iodic acid, possibly through the intermediate formation of hypoiodous acid, and this quickly transformed to some of the periodic acids. Of course, there could not, and need not, be any appreciable amount of these intermediate substances present at any time. In order to test this explanation the solution was examined for periodates.

On adding a solution of silver nitrate to the acidified solution a slight milkiness appeared. 0.0062 gram of this precipitate yielded on heating 0.0031 gram of metallic silver, which amount corresponds to the quantity of silver contained in silver dimesoperiodate, $Ag_4I_2O_9 + 3H_2O$. However, it could not be this substance, as the solution failed to yield iodine on reduction.

Since from the manner in which the iodine disappeared, it was believed that the iodine must have changed to some oxygen compound, the effect of strong reducing agents were tried on the solution. Zinc dust was added to the acid solution and allowed to act for a couple of hours; portions of the residue from the solution were heated with potassium cyanide and powdered charcoal, and with powdered magnesium; and lastly some of the residue was heated in a current of hydrogen to such a high temperature, that the sodium sulphate was reduced to sulphide. In neither of these instances was the slightest trace of iodine obtained.

As it was thought that an analysis of the solution might throw some light on the problem, the following determinations were undertaken.

80 cc. of the colourless solution that had been acted on by pure oxygen, and which, therefore, must have contained all the iodine originally in it, were exactly neutralized with potassium carbonate and evaporated to dryness. The residue after being dried at 110° for an hour weighed 8.0530 grams. This residue was used for the analysis, and the only substances that it could contain besides the iodine, were potassium, and sulphuric acid in the form of sulphate, (it was proved that there was no carbonate present).

The amount of sulphuric acid (SO_4'') was determined by precipitating with barium chloride. The following are the results obtained:

(1) 1.4914 grams residue yielded 1.9813 grams $BaSO_4$
(2) 1.4914 " " " 1.9842 " "

mean 1.9827

This weight of barium sulphate corresponds to 0.8168 gram of SO_4'', or to 54.76 per cent. of the residue used.

The potassium was estimated by precipitating as double potassium-platinum chloride. This precipitate after being thoroughly dried, was heated with oxalic acid and reduced to a mixture of metallic platinum and potassium chloride, Pt + 2KCl. From this the amount of potassium was determined. It was found that:

(1) 0.4890 gram of residue yielded 0.9674 gram Pt + 2KCl.
(2) 0.4890 “ “ “ 0.9610 “ “
mean 0.9642 “ “

This corresponds to 0.2193 gram of potassium, which is 44.83 per cent. of the residue used.

These results are arranged in the following wav so as to be more obvious:

	Theoretical composition of K_2SO_4	Composition of residue examined. (1) High results.	(2) Low results.
Potassium	44.87%	44.98%	44.68%
Sulphuric acid (SO''_4).	55.13%	54.81%	54.73%
	100.00%	99 79%	99.41%

When the weights of the substances corresponding to these percentages are calculated for 1.4914 grams there is obtained:

	Theoretical for K_2SO_4	Residue examined. (1) High results.	(2) Low results.
Potassium	0.6694 g.	0.6699 g.	0.6664 g.
Sulphuric acid (SO''_4)	0.8220 g.	0.8175 g.	0.8162 g.
	1.4914 g.	1.4874 g.	1.4826 g.

It will be seen that 1.4914 grams of the residue used, correspond to 14.81 cc. of solution, and should therefore contain 0.0100 gram iodine. The above analysis shows the difference between this amount of residue and the amounts of potassium and sulphuric acid (SO''_4) that it contains. The discrepancy between this difference and the amount of iodine that should be in the residue cannot be accounted for at present.

Although the results of this investigation have been negative in the main, nevertheless some information as to the behaviour of hydriodic acid in the presence of oxygen and light has been ascertained. It has been shown that hydriodic acid in the presence of oxygen is slowly changed to something else, the colour of the solution due to the liberated iodine ultimately disappearing. This change is greatly accelerated by light. There is good reason to believe that the process of the change is one of oxidation, but all attempts to reduce this oxidation compound have failed, and the condition in which the iodine exists still remains unsolved.

In conclusion, my most hearty thanks are due to Professor Mackay for his valuable criticisms, and the kind interest he has taken in this investigation.

Dalhousie University, Halifax, N. S.
April 2nd, 1908.

NOTES ON MINERAL FUELS OF CANADA: BY R. W. ELLS, LL. D., F. R. S. C., Geological Survey, Ottawa.

(Read 14th. January, 1907.)

The rapidly growing importance of the Dominion of Canada, with its ever-increasing development of manufacturing industries, and its general commercial progress, calls for continued research for materials suitable for the generation of light, heat and power. To some extent the latter feature is now being supplied by the production of electricity through the utilization of the numerous waterfalls found in every province, and the power thus furnished will doubtless in a few years be sufficient not only to supply our numerous manufacturing centres, but to do away to a large extent with the use of steam on our great lines of railway. But since the varied climate of our country makes artificial heat a necessity for nearly half the year, and many industries exist for which electrical power is not readily available, a constant supply of mineral fuel will always be required. From this standpoint, therefore, a brief glance at our present known available resources in this line may not be devoid of public interest.

Not so many years ago it was the generally accepted opinion that Canada, as a whole, was largely lacking in this element of a nation's progress. The coal fields of the Maritime Provinces were known to some extent, and had been worked on a small scale for many years, but Ontario and Quebec were regarded as entirely lacking in a natural fuel supply. As regards coal proper, this is practically true for both provinces, yet other materials exist which, as will be pointed out, will furnish a fairly good substitute for bituminous coal. Of the boundless stores of mineral fuel which have been discovered on the great plains and in the valleys scattered through the sea of mountains in British Columbia, as well as along the Pacific coast, our knowledge even forty years ago was exceedingly limited.

The object of the present paper is to direct attention to the large supplies of this fuel which are found in all parts of the Dominion, and which are suitable for the generation of light, heat and power. The substances available for this purpose include, in addition to the several varieties of coal which range from anthracite to the newest lignite, such minerals as anthraxolite, albertite, oil-shale, petroleum, natural gas and peat.

Coal, etc.

The coals of the Atlantic provinces have been mined for nearly or quite a century. They belong to the Carboniferous period, and in point of age contrast strongly with the immense deposits found on the great western plains, along the eastern slopes of the Rocky Mountains, and further west on the Pacific coast, which belong in part to Cretaceous and in part to Tertiary rocks.

The eastern deposits have been described in numerous reports and papers, both in governmental and scientific publications. The principal areas, considered from the economic standpoint, are in Nova Scotia, where at least four well-defined coal-basins occur. Of these the most easterly, known as the Sydney area, is divided into several portions, in which a number of seams are found, aggregating probably not far from fifty feet of coal. This basin probably represents the western margin of a great Carboniferous area which extends beneath the intervening broad strait which separates Cape Breton from Newfoundland, since in the south-western part of the latter province a well-defined coal basin also occurs. The seams of the Sydney basin extend seaward, and have been worked for many years beneath the water, the extension in this direction forming a coal area of great economic importance.

Other important coal deposits in this island are in the western part, and are found in the Richmond and Inverness basins. In recent years, owing to railway construction, these areas have been rendered accessible, and large quantities are now regularly shipped both by land and water.

On the mainland of Nova Scotia, the most important coal field at present is in Pictou County, and though this field is much faulted in places, it has been worked for a century, and is noted for the immense thickness of the coal beds contained, which in one case reaches nearly or quite forty feet. In the western part of the province, in Cumberland County, the Springhill basin inland, and the Joggins basin on an arm of the Bay of Fundy, are large and important factors as regards a coal supply, and though the seams worked at these two places have as yet never been directly connected, the extension of the beds of the Joggins along the northern limit of the Carboniferous basin has been traced for many miles, and a number of collieries have been located along their outcrop. These have been producers of coal in considerable amounts for a number of years.

The Carboniferous basin of New Brunswick is extensive, comprising more than 10,000 square miles. The formation, however, is comparatively thin, and the coal-bearing rocks are regarded as of Millstone-grit age, and as beneath the Productive measures of Nova Scotia, the thick beds of that province not appearing in this direction. The workable seams in New Brunswick rarely exceed twenty inches in thickness, so that the output can never equal that of the adjacent province, but some thousands of tons are mined yearly and find a ready market. In the Upper Carboniferous formation, also, several small seams are found, but these are not sufficiently large to be mined.

In Quebec seams of coal are almost entirely absent, the only deposit of the kind occurring in Devonian slates, in a small layer two to four inches thick, on the shore of Gaspé Basin, and of no economic value. The oil-fields of this district, though exploited for a number of years by numerous borings, have as yet failed to produce petroleum in paying quantity; but there are large areas of peat throughout the province, which, by the new process of manufacturing into blocks by drying and pressure, promise to become an important factor in the mineral resources of the province before many years. Borings for natural gas and oil in the valley of the St. Lawrence, between Montreal and Quebec, have shewn that the former occurs at several points in this district, and has been locally utilized to some extent already, though up to the present there has been no large development of these substances such as found in Ontario.

In the latter province true coals are entirely absent; but in the area south of James Bay large deposits of low-grade lignite have recently been found, which, though of poor quality, may become of value as this part of the province becomes opened up for settlement. Anthraxolite is also found in deposits of considerable extent in the old rocks of the area west of Sudbury, which are probably of Huronian age. This, at first, was regarded as possibly furnishing a new source of supply for fuel. The large percentage of impurity in the material, with its low colorific value, has hitherto prevented its utilization for commercial purposes. The large deposits of natural gas and petroleum in the Niagara and Petrolea districts have been largely utilized, the former being piped to several cities in the United States, notably to Buffalo and Detroit, as well as supplying a constantly increasing local demand. The peat deposits of this province are also being utilized for the manufacture of a very excellent fuel suitable for domestic purposes and for the generation of heat in factories and on railways.

The area north of Lake Superior is occupied by crystalline rocks which extend westward to the shores of Lake Winnipeg, where they are again overlaid by sedimentaries of Silurian and Devonian age. The Carboniferous rocks are not found in this direction, but a broad area of Cretaceous sediments commences a short distance west of the Red river, near Winnipeg, and extends, apparently without interruption, to the Rocky mountains. This formation contains numerous beds of coal, principally of the lignite variety.

These deposits of the west were first brought into prominence from twenty-five to forty years ago. Many of them are high grade and true coking coals, which occasionally pass into anthracite in the eastern slopes of the mountain range, while the great seams of the plains east of the Rockies still remain in the form of lignite to a large extent. Among the most important of the true coals which have been extensively worked since the building of the Canadian Pacific railway, are the large seams found in the Crows Nest pass, and along the valley of the Bow River, near Banff.

The anthracite character of these coals has evidently been developed through the agency of heat induced by pressure during the time of mountain uplift. All these western coals are therefore of much more recent date than are those of the eastern provinces. It is so far as yet known, the true Carboniferous rocks of the Rocky Mountains do not contain coal.

Between the eastern outcrop of the Cretacous rocks of the plains and the coal outcrops of the eastern slope of the Rocky Mountains, immense deposits of lignite and of lignitic coal occur. They are mined at several points, the most easterly being at Souris, near the western boundary of Manitoba. In some places this lignite has a high fuel value, but can be distinguished from true coals, among other things, by the fact that, unlike the bituminous variety, lignite and even the higher grade known as lignitic coal will not coke. Lignite also contains a much higher percentage of moisture than the true coals, this feature in some cases reaching as much as 15 to nearly 20 per cent. Immense beds of this lignite are found along the upper portion of the North and South Saskatchewan Rivers, and further north extend into the Peace River district. It is extensively mined for local use at Edmonton on the North Saskatchewan, and at several places nearer the United States boundary.

Passing westward across the broad chain of the Rocky Mountains there follows a great belt of rocks, presenting a number of formations ranging from the Carboniferous down into the pre-Cambrian, in which no coals may be expected. But about 200 miles east of Vancouver in a direct line, or near Sicamous on the Canadian Pacific railway, coal-bearing rocks again make their appearance. These are of a still more recent date than those of the plains, being for the most part of Tertiary age. Owing, however, to greater alteration, the lignite character of the contained coals has been changed, so that the fuels from these deposits, which occur for the most part as basins resting on igneous rocks, are now in the form of true coals, and in many cases form a fuel of great value. The contained coals are sometimes of large extent, ranging in thickness from thin seams up to great beds of twenty feet, or even in some cases of more than sixty feet in thickness.

Among these important deposits may be mentioned those of the Nicola and Similkameen valleys, lying to the south of the Canadian Pacific railway; of the North Thompson, 40 miles north of Kamloops, and of the Marble Canon a few miles northwest of Ashcroft. Further north, numerous deposits of coal are found, among the most important of these being the recently discovered areas in the Bulkley valley, south of the Skeena river, and not far from the projected line of the Grand Trunk Pacific railway, where large seams of high grade bituminous coals and semi-anthracites are exposed. These promise to be of great value on the advent of the railway. Along the upper waters of the Peace river, also, several large seams of fine coal have recently been located; but at present these are not available owing to distance from transportation.

On the Pacific coast the coal-bearing rocks again change their character and belong to the Cretaceous series. Here, as at Vancouver island, are the large mines of Wellington, Nanaimo, Comox, and Ladysmith, in which area large seams occur, some of which, as in the Wellington district, have been worked extensively for nearly forty years. These not only supply the fuels for the Pacific division of British Columbia, but are shipped very largely to the cities on the American coast, as far south as San Francisco. These coals are of the bituminous variety, generally of excellent quality, and well adapted for coking. Further north, on Graham island, of the Queen Charlotte group, both the anthracite, bituminous and lignite varieties are found. The former, although exploited at intervals for nearly forty years, has never been found sufficiently firm to be mined at a profit. The alteration at this place from the lignite or bituminous coal has evidently been due to heat induced by pressure of the beds against the igneous rocks which form high mountains to the west, whereby the rocks and contained coals have been crushed, while dikes of newer rocks have also penetrated the series. Smaller deposits of anthracite have been found in the coal basin of the interior, occurring under like conditions.

In this interior basin of Graham island, however, large deposits of high grade bituminous coal occur which outcrop at several places in beds of great thickness. This part of the island gives promise when opened up, of becoming one of the most important coal fields of the Pacific slope. The containing rocks of both the bituminous and anthracite varieties are of Cretaceous age, while the eastern part of the island is occupied by Tertiary rocks, in which are found seams of lignite of good thickness.

Still further north, in the Yukon district, large deposits of lignite have been found along the Klondike and several other streams. These have been mined to a small extent locally, and will, doubtless, become important as the country is opened up.

Some of the seams contain coal of very good quality, and in the White Horse district coals of fine quality have been reported.

The northern portion of the Dominion, as along the valley of the Mackenzie river, and even on several islands off the mouth of that great stream, are known to contain coal beds, mostly of the lignite variety, which, however, have not yet been utilized.

Petroleum and Natural Gas.

In addition to the coals so briefly sketched, other sources of supply for heating and lighting are found in the presence of petroleum, natural gas, bituminous shales, anthraxolite, albertite and peat. These, with the possible exception of the last named, have a different origin from the ordinary coals. They, however, constitute a very important factor in the development of the various interests of the Dominion.

Among these, petroleum and natural gas may be regarded as the most important. In Ontario, where these occur in the greatest abundance, the petroleum has hitherto been regarded as derived from rocks of Devonian age, though that these are the original source of the gas and oil has never been conclusively established. In the oil fields of the United States, more especially in the Appalachian area, the source of the oil is as low as the Trenton limestone, while in the western or Pacific states it is found in great abundance in formations as high in the geological scale as the Cretaceous and Tertiary, so that petroleum has even a wider range than coal itself. As for that peculiar form of carbon known as anthraxolite, its range is still lower since it is found in rocks generally styled Laurentian, as well as in the Huronian and Lower Cambrian.

In the Atlantic provinces and in Gaspe, borings for oil have been carried on for more than half a century in rocks chiefly of Devonian age. Owing largely to the fact that these rocks are much broken and tilted, and often inclined at high angles, no important economic results have as yet been obtained from any of the areas thus tested. Among the principal petroliferous rocks in the eastern provinces are deposits of bituminous shale which are found in New Brunswick, Nova Scotia and in Gaspé. Oil springs are seen at a number of points in the areas occupied by these rocks, and in part these shales are so highly charged with bituminous matter as to yield by distillation from 30 to over 100 gallons of oil per ton. Some of these form a good fuel, burning readily in the grate or furnace, the great drawback to a perfect combustible being the very large amount of residue or ash.

In the present stage of oil distillation as conducted in Scotland, Germany, France, Australia, New Zealand, and elsewhere, there would appear to be a good opportunity for successfully exploiting these bituminous shales for the manufacture of petroleum by distillation, since in the several countries just mentioned, this industry is carried on extensively and profitably on material much less rich in bituminous matter than the shales of our own country.

In natural gas, which is an industry of comparatively recent development in Canada, the advance in production has been very rapid. Large quantities have been found in western Ontario, much of which is piped to the cities of Detroit and Buffalo adjacent to Lake Erie. Natural gas has also been found in somewhat limited quantity as yet in Quebec, in the St. Lawrence Valley, and at several of the borings for oil in the eastern provinces. But little attention has, however, been paid to this industry in this part of the Dominion.

In the great north-west, however, the indications for large developments of gas are favourable. Thus at Medicine Hat, and at other points along the Canadaian Pacific railway, at Edmonton, and further north along the upper Athabaska river, it has been found, and in some places has already been applied, to the purposes of lighting and heating. At the last named locality it was struck in immense volume in connection with the borings made some years ago by the Dominion government for petroleum, the rush of the gas being so great that the borings were suspended. At this place it has been constantly escaping for the last ten years, no attempt having been made till recently to check the enormous waste that has been going on for all this time. As the area, however, is entirely uninhabited, and at a long distance from settlement, this waste has hitherto been of less importance than if the area were near commercial centres. It is probable that in the near future, natural gas will play a very important part in the economy of the new provinces of the west, and will be the great source of light and heat, as well as of power, for many of the cities of the plains.

It is also to be expected that in certain portions of the plains country, east of the Rocky Mountains, properly located borings will disclose the presence of oil-fields in that area. The oil fields of Colorado, as at Florence and Boulder, are situated on rocks practically of the same horizon, the oil there being found in the Pierre shales, which underlie the lignite-bearing Laramie sandstone. The Florence oil field has been a producer continuously for more than twenty years, several of the wells having yielded enormously. Up to the present time, in the western part of Canada but slight attempts have been made to find oil, with the exception of the borings made under government management some ten to twelve years ago, in the area along the upper North Saskatchewan and Athabaska rivers. At neither of these places, however, did the borings reach the supposed oil-bearing strata, owing largely to the great flow of gas encountered.

Peat.

Peat is found in large quantities in nearly all parts of the Dominion, and about forty years ago attempts were made to utilize certain deposits in Quebec in the manufacture of a peat fuel. As the product was simply pulped and air-dried, without being consolidated, the results, while giving good results as a fuel both for domestic and railway consumption, were unfitted, owing to its great bulk, for the purposes required. Within the last few years, however, a series of experiments have shewn that peat, properly dried and then compressed, furnishes an excellent fuel for many purposes, and can be made and sold on the market at a good profit, the demand far exceeding the available supply, so that it is anticipated that in a few years, with still further improvements in modes of drying and pressure, this source of mineral fuel will form an important part of Canada's mineral resources.

HALIFAX WATER WORKS.—H. W. JOHNSTON, Assistant City Engineer, Halifax, N. S.

Read 12th February. 1906.

The city of Halifax is situated on a peninsula. at the head of Chebucto Bay, formed by the harbour and Bedford Basin on the east and north, and the North West Arm on the west, and joined to the mainland by a strip of land about 1½ miles wide at the Dutch Village, separating the Arm and Basin. The slopes to the water on all sides are steep, and there is a practically level plateau at the summit extending north and south about two miles and east and west one mile, with a high hill called Shaffroth's or "Hungry Hill" at the north end. The general elevation of this plateau is from 150 to 170 feet above mean low tide, and the elevation of Shaffroth's or "Hungry Hill", the highest point in the city, is 247.50 feet. There is also an elevation at Willow Park, the highest point at present supplied with water, of 225. The business district lies on the eastern slope between Jacob Street and Salter Street, surmounted by the citadel, which is 214 feet above mean low tide. The chief wharves are from Richmond to South Street, a distance of about 2¼ miles. The rest of the city, with the exception of a few streets, is residential, with few houses on the western and northwestern slopes.

The city was founded in 1749 and incorporated in 1841. Previous to 1844 the city was dependent entirely upon wells for its domestic supply, and on them and the salt water of the harbour for fire protection. It was the custom at that time on an alarm of fire being sounded for the citizens to turn out and assisted by the troops line the streets and pass buckets of water from the harbour to supplement the scanty supply from the wells, which was drawn by a hand fire pump owned by the military authorities. In the year 1844 a company composed of local men was formed, with a capital of £15,000, under the name of the Halifax Water Company, which on the 17th of April obtained a charter from the legislature of Nova Scotia, for the purpose of supplying the inhabitants of the city with water. An amendment to the act of incorporation was passed during the same year, providing that the city council might make such ordinances as might be deemed necessary for raising such monies as might be required to furnish the city with public fountains, hydrants and fire plugs, abundantly supplied with water, by causing a fair and proportionate rate, not less than £400 in each and every year, to be made upon the whole property of the city; and that the said company should in consideration of the said annual payment of £400, erect and build in the city eighteen fountains and hydrants and twenty-five fire plugs. The first meeting of the company was held at the Exchange Coffee House on the 22nd July, 1845, when a board of directors, consisting of James B. Uniacke, Thomas Hosterman, W. A. Black, William Lawson, Jr., William B. Fairbanks, James N. Shannon, and William Stairs, were elected. Mr. Stairs refusing to act, the Hon. Michael Tobin was elected in his stead. Mr. Uniacke was elected president, and continued to act as such until 1855. Mr. Charles W. Fairbanks was employed by the directors to make surveys of the lakes adjoining the town, and on their completion Mr. John B. Jarvis, a well known engineer of New York, was engaged to report on a scheme to supply the city with water.

On the 28th August, 1845, he submitted his report to the Company recommending that the water be brought from Chain Lakes—two lakes about $2\frac{1}{2}$ miles long, situated about $1\frac{1}{4}$ miles from the head of the North West Arm—by a line of pipes to a reservoir on Wind Mill Hill (now called Camp Hill), the elevation of this reservoir to be 170 feet above mean low tide. That the Chain Lakes be connected by an open channel or canal with Long Lake (formerly called Beaver Lake) about 1200 feet long, and that the surface of Long Lake be raised from its elevation of 175 feet to 200 feet above tide by a dam at its outlet at McIntosh's run. Mr. Jarvis estimated the population of the town at from 20,000 to 25,000, and that there would be 1500 water takers within five years from the introduction of the supply, and that this number would ultimately reach 2000. This would require, at 200 gals. for each tenant, 400,000 gals per day. The natural flow from the valley of the Chain Lakes was estimated to be capable of supplying the mill owners who had rights in the stream and dams already built, and to furnish the town with 300,000 gals per day for five months in the year, leaving seven months supply to be stored in the reservoirs. This supply he estimated could be obtained from the Chain Lakes storage reservoir. In his report he makes no mention of any data regarding precipitation, and the presumption is that as there were no records for Nova Scotia in existence previous to this record, the New York or Massachusetts records were taken. He recommended that a 12-inch pipe, which was estimated to be capable of discharging 800,000 gallons per day when new, but only 700,000 when incrusted, be laid from the Chain Lakes to the reservoir in the city. The estimated cost of the works, including Long Lake, the reservoir on Wind Mill Hill and the distribution, was about $120,000. The reservoir was proposed to be 1.58 acres in area and about 15 feet deep, which would hold a supply when drawn down of about 5,000,000 gallons.

Before leaving this report, there is a clause dealing with the principle of municipal ownership of water-works which should be quoted, especially as the question of municipalities owning or controlling all public utilities is to-day a very live issue. After reciting several benefits following the introduction of water-works, he says: "A good supply of pure water has a further public benefit in promoting the cleanliness, health and general comfort of the citizens. These are considerations that should induce a city to supply water under their own authority. If the rates should not be sufficient the general benefits would be ample remuneration for an deficiency that might, under favorable circumstances for the introduction of water, be necessary."

A further report was submitted by Mr. Jarvis on the 10th September, 1845, on the advisability of bringing water direct from Long Lake without connecting with Chain Lakes. He reported that the cost of bringing the water by open cut to within 1500 feet of the lower end of Chain Lakes and then laying pipes, would be practically the same as the original estimate, and he could see no objection to the scheme. However, the directors adhered to the original scheme and constructed a dam at Long Lake, the canal from Long Lake to Chain Lake, and a 12-inch pipe line from Chain Lake to St. Andrew's Cross (the local name for the junction of Robie Street and Quinpool Road), but did not build the reservoir on Wind Mill Hill. Considerable trouble was had in securing the rights to Chain Lakes from the mill owners, but eventually these were secured, although on terms which have been the cause of dispute ever since.

The water was turned on to the city in 1848, the first service pipe being laid to Mr. Liswell's house and bakery on Gottingen Street on the 29th September, 1848. (The 6-inch main originally laid on this street was taken up in 1905.)

A contract with the city was made on October 3rd, 1849, agreeing to supply eighteen fountains or hydrants and twenty-five fire plugs at an annual rental of £400. In July, 1849, the directors of the company authorized a free supply of water to be given the poor from certain hydrants between the hours of six and seven morning and evening.

At this time the engineer reported that there were 2700 houses inhabited and 400 uninhabited between North Street and the gas works.

In 1849 the shareholders instructed the directors not to build the reservoir, and in 1851 the portion of the act requiring this to be done was repealed. In December, 1849, the directors issued a notice to water takers that they should during the ensuing winter keep the water constantly running in a small stream during the night to keep the pipes free from frost —an order that has ever since been only too faithfully carried out, much to the detriment of the works and the financial showing of the system.

In fact, as early as 1854, the directors, in replying to the city's complaint of poor pressure, said that the difficulty in keeping up the supply has been caused by the great waste of water, by the water takers running it off during the severe weather. In this year, finding the supply insufficient, the directors employed Mr. J. Forman to make an examination of the lakes and report on the advisability and expediency of raising Lower Chain Lake, and to what extent, and also the propriety of laying another 12-inch pipe from the head works at Chain Lakes and the advantages to be derived from it. Mr. Forman reported to the directors on the 5th August, 1854, and at a special meeting of the shareholders on the 24th February, 1855, a resolution was passed authorizing the directors to proceed with the laying of a new line of pipes, providing the opinion of a competent engineer who had not been connected with the company be first obtained. An amendment that the directors turn their attention to the immediate waste of water was defeated by a large majority. Acting under this resolution, Mr. Forman was again engaged to report on an increased supply, and in answer to a series of questions put to him, advised that the effect of a 12-inch pipe would double the supply and would cost £6,026. To give full effect to the increased supply the 9-inch, 6-inch and 3-inch distribution pipes should be changed to 12-inch, 9-inch and 6-inch. Also that a 15-inch main would give fully one-half more than the existing supply at a cost of

£8,500, and that there was more water in the lakes than a much larger pipe than one of this capacity could run, and that there would be no danger to existing distribution pipes from increased pressure. He also reported that the cost of bringing the water to the pipe-house direct from Long Lake in a conduit would cost £7,200; but he could see no advantage to be gained. By repairing and raising Long Lake dam 290 million gallons, extra storage would be gained at an outlay of £550. He did not think that a reservoir on Camp Hill would obviate the necessity of a new pipe to the lakes; but it would add to the present supply by storing water at St. Andrew's Cross when the consumption of the town was less than the flow through the mains. This would be the case at some periods and tend to preserve the effective head. In reply to the request whether he could suggest anything to remedy the present evil resulting from frost, he recommended that frequent inspections of water-cocks be made and consumers warned against allowing a more copious flow to run than was necessary.

At the annual meeting on the 2nd July, 1855, Forman's report was adopted, and the directors authorized to lay another line of 12-inch pipe if necessary arrangements could be made with the city council as to increased cost. A resolution also passed that a strict supervision be had over water takers to prevent excessive waste. The city having agreed to pay £200 per annum for an additional ten hydrants, providing some changes were made in the distribution, at a meeting 15th January, 1856, the shareholders decided to lay a 15-inch pipe, which was done in the fall of this year. The company also raised its rates to all private takers fifty per cent. The city first approached the company in this year with a view to buying the works, but the latter's reply was that they were not then in a position to sell. In 1859 a committee of the city council was appointed, after the great fire of the 9th September in that year, to report on the improvement of the fire department and on the best means of obtaining an additional supply of water for the city. After considering several propositions this committee reported to the council recommending the purchase of the company's works by the city, and also that the Birch Cove Lakes be acquired and connected to a reservoir on Shaffroth's Hill, from whence the water be distributed by three lines of pipes, one supplying the north, one the south and the other the middle district of the city. This scheme was proposed and advocated by Mr. E. J. Longard. Acting upon this report, the council again approached the company, and at a special meeting of the latter it was resolved to sell the works to the city for £52,000, which offer the city accepted, delivery to be made on the first of May, 1860; but as the city neglected to secure the necessary legislation, the agreement fell through. In the following year, however, the sale was made to the city for £56,000. The transfer of the works was made on the 30th June, the formal transfer of the deeds, etc., being made on the 5th August, 1861.

The water company's capital when the works were taken over by the city was £44,000. There were 960 water takers at an average rate of £13 per annum, with special rates to the military, breweries, bakeries and distilleries; and £700 was being paid by the city for rental of fire and street hydrants. There was about 21 miles of pipes laid for the supply of the city. After the transfer, the works were managed on behalf of the city by a board of three paid water commissioners under authority of an act passed 15th April, 1861. The commission was composed of J. A. Bell, chairman, and Messrs. J. L. Barry and E. J. Longard, the latter taking the place of Mr. J. R. Morse, who was elected by the city council but declined to serve. These gentlemen continued to act until the control of the works was vested in a committee of the council (the board of works) on the 30th September, 1872.

Before the purchase of the works a commission on water-supply, with Mr. Henrv E. Pugsley as chairman, was appointed by the city council, and they engaged Mr. James E. Laurie, C. E., of New York, to report on the works and increased sources of supply. Mr. Laurie submitted his report, which is an exceedingly interesting and valuable document, on the 10th May, 1860. The population of the town at that date was 30,000, and there were 892 water tenants on the books of the company. Allowing eight persons to a family, this would give 7,136 people using the water; but as the barracks, navy yard and city counted as single tenants and a large number were using water from free hydrants, he estimated that there were about 20,000 consumers. While the mains were capable of discharging 2,000,000 gallons per day, on account of there being only about two 12-inch distributing mains only about 1,500,000 gallons were being used by these 20,000 consumers, or at the rate of 75 gallons per capita per day. In calculating for an increased supply he based his estimate on a population of 60,000 using at the rate of 83⅓ gallons per capita per day or for a total of 5,000,000 gallons per day.

He discussed two plans for increasing the supply, and two for the proposed high service, and also improvements in the distribution system:—

1st. Long Lake.—By raising this lake three feet and replacing the 12-inch main with a 24-inch main a daily supply of 5,000,000 gallons with a storage capacity for 160 days would be obtained at an estimated cost of $70,070.00.

2nd. Birch Cove Lakes.—These lakes consist of several bodies of water connected by narrow passages, having a surface elevation of 239 feet above mean low tide, and an area of 241 acres, with several other lakes emptying into them. The natural flow was small, a 9-inch x 12-inch penstock carrying the greater part of the water in the dry season to a mill on the stream. Assuming the lakes to be capable of being raised ten feet, which was problematical, as the eastern banks were low and unsuitable for dams, and eight feet of water being drawn off, the capacity of the reservoir would be 586,000,000 gallons or 117 days full supply for the city. But as the mills on the stream would require the whole natural flow through the summer and autumn, it would be necessary to purchase their rights, or there would be available for the city's use but forty-six days supply. The cost of bringing water from these lakes, including $40,000 for land and compensation and $30,000 for reservoir on Shaffroth's Hill, would be $353,980.

3rd. High service, Ragged Lake.—This lake lies about 2¼ miles westerly from the gate-house at Chain Lake, and contains about 100 acres of water area at an elevation of 325 feet above tide. Lying at the summit level of the country, it has a limited water-shed (less than 300 acres by a later survey) and would not be a suitable source to furnish the quantity required. The estimated cost of obtaining a supply from this source, exclusive of the distribution, was $55,030.

4th. Pumping by steam power to Shaffroth's Hill.—The most convenient station for pumps would be near St. Andrew's Cross, and the costt, including the annual working expenses capitalized at 6 per cent. would be $99,000. Another scheme was suggested—to use the stream running from the Chain Lakes to Hosterman's mill to pump into a stand pipe, and thence by gravity to a reservoir on Shaffroth's Hill. The first cost would not be very different from pumping by steam, but the operating expenses would be less. The practicability of the plan depended on the amount of water running from Chain Lakes in a dry time, the amount required to operate the pump being about 4½ million gallons per day. In summing up, Mr. Laurie recommended that Long Lake dam be raised and a 24-inch main be substituted for the 12-inch from the lakes to St. Andrew's Cross, as the whole of the city, with the exception of the district lying to the north and west of Gerrish and Creighton Streets, could be supplied by gravitation. This district would have to be supplied either by bringing water from a higher source or by pumping to a reservoir. He also recommended extensive changes in the distribution system.

In 1863 the original 12-inch main was taken up and a 24-inch main laid in its stead. Long Lake dam was not raised until some years later, but the distribution system was remodelled and enlarged on the lines of the report. The commissioners in their annual report for this year discussed the necessity for a high service supply and warmly advocated something being done, as without artificial means being employed sufficient head could not be obtained from Long Lake to supply the higher levels of the city with water by gravity. In reviewing Laurie's report they mentioned a high hill near the foot of Chain Lakes suitable for a reservoir site, which would do away with the necessity of a stand pipe and reservoir on Shaffroth's Hill in case it was decided to adopt the method of pumping from the Chain Lakes. William Gossip, Jr., C. E., was engaged to report on the question of obtaining a high level supply from this source. On the 29th of June of this same year he submitted a lengthy report dealing with this matter and also with the general state of the works, in substance as follows:—That to pump by water-power from the Chain Lakes to a reservoir on the adjacent hill would require the following quantities of water: To work the water-wheel and keep the reservoir full (supposing 600,000 gallons per day to suffice for the high service for some years to come) 5,000,000 gallons per day, to which must be added 2,000,000 gallons for the low service, 600,000 for the high and 100,000 for leakage and waste, or a total amount of 8,600,000 gallons per day from the Long and Chain Lakes reservoirs. The lakes in their then state were estimated to be capable of sustaining a daily draught of 5,000,000 gallons without reducing the level of Long Lake to more than two feet below the waste weir in the driest part of the year, leaving a deficiency of 400,000,000 gallons. By raising Long Lake dam three feet (at a cost of $1,450) 260,000,000 gallons additional storage could be had, leaving 140,-

000,000 gallons more required, which could only be obtained by tapping some new source. The waters of Spruce Hill Lake could be diverted into Long Lake and supply this amount by a cut about a quarter of a mile long at a cost of $16,000. The cost of the new works, using water-power for pumping, would be $61,411 and using steam-power $44,537, the annual operating charges in the former case being $800 and in the latter $3,286.50.

The commissioners, however, were imbued with the idea that the Spruce Hill Lakes, lying about three miles to the westward of Long Lake, were the best available source of supply, and in 1865 obtained the services of Mr. W. B. Smellie to make surveys and report on their capabilities. On the 5th April, 1865, he reported that he had made a survey of the lakes and found the second lake had an area of 92½ acres, and was 153 feet above Long Lake, and the third lake an area of 70 acres, and about 2½ feet higher than the second. He recommended a dam across the outlet of the second lake, raising the water 7½ feet, which would allow, say, 6 feet of water to be drawn from the second lake and 3½ feet from the third, and would yield 217 millions of gallons, or 180 days' supply of 2,000,000 gallons per day. By raising the lake one foot higher twenty-two days' further supply could be had, and by lowering the pipe three feet below the existing surface an extra quantity equal to twenty days' consumption would be obtained.

In a further report on the 8th July, 1865, the cost of building a canal to let the water of Spruce Hill Lakes down to Long Lake was estimated to be $33,500, and to conduct the water by a line of pipes to a reservoir near Chain Lakes would be $87,000. But neither of these schemes commended itself to him, and he recommended conducting the water from the lakes to St. Andrew's Cross by a 15-inch pipe, which would be capable of delivering two and one-half million gallons every twenty-four hours.

The commissioners, after considering the various reports upon the proposed increase in supply, had no hesitation in recommending that Spruce Hill Lake be raised 10 feet, and the water conducted into the city by a line of pipes.

In 1866 the whole scheme was submitted to Mr. Thomas C. Keefer, and on September 25th of that year he submitted his report. He recommended taking the supply from Spruce Hill Lake by gravity, and estimated that these lakes would ordinarily furnish a supply of 2,000,000 gallons, and in a dry year not less than 1,000,000 gallons per diem, or sufficient for a liberal supply for 20,000 persons, or about double the number assigned to the high level district. A 15-inch pipe to within a mile and a quarter of the lake and a 20-inch pipe connected through the intervening distance to the lake would deliver 2,000,000 gallons per day at the higher levels and 3,000,000 per day at a level of 100 feet above tide. He also suggested that in future an intermediate system might be obtained by catching a portion of the Long Lake water at an elevation of 50 feet above the lake and forming a reservoir and running a line of pipes to town. In January, 1867, the city council adopted this report. Work was commenced on the 17th April, 1868, on the dam and pipe line, and the work was finished in the following year.

By an act of legislature, passed 18th April, 1872, the powers and functions hitherto exercised by the commissioners of water supply were to cease on the 30th September of the same year, and a committee of the city council called the board of works was vested with all the said powers and functions. The following quotation is taken from the first report of Mr. E. H. Keating, the first city engineer of Halifax, in 1873. Adverting to the formation of the commission in 1861, he said: "The new commission seemed to work well, and great praise is due to the gentlemen who comprised the board for the energetic manner in which they grappled with the difficulties with which they had to contend, and for the manner in which the work of the department was planned and executed. To them is due the credit of establishing the works as we have them to-day, and if unsatisfactory it is through no fault that can be attached to the plans that were adopted, but rather through the neglect of enforcing stringent ordinances, the necessity for which I am informed was repeatedly urged upon the council by the board." Since 1872 the works have been under the control of the board of works and managed by the city engineer of the city of Halifax.

As may be gathered from the foregoing history of the works, the district supplied by the Long and Chain Lakes lies at an elevation below 150 feet above mean low tide, and that supplied by the Spruce Hill Lake system above this elevation. The former is called the low service district and the latter the high. Both are supplied by gravitation. One of the great difficulties in connection with the high service shortly after its introduction, was the constant and urgent demand of the consumers near the higher levels of the low service district, as the pressure became lower through the increased consumption for the letting down of this service to the lower levels. While this was combatted strongly by the commissioners and subsequently by the city engineer, it was frequently done, and greatly impaired the efficiency of the high service system. However, since the introduction of the 27-inch low service main the supply has been kept back nearer its proper level. At present the lowest points supplied by the high service are the Victoria General Hospital and poor house, where the ground is at an elevation of 100 feet, and on Uniacke Street, at an elevation of 120 feet.

Low Service Gathering Grounds and Storage Reservoirs.

The water shed of the low service system comprises an area of 4,455 acres, including the lakes—904 acres in the Chain Lakes and 3,551 acres in the Long Lake gathering grounds, the water area in the former being 97 acres and in the latter 459 acres. Included in the Chain Lakes water shed is Bayer's Lake with an area of 16 acres. The run-off from this water-shed has never been measured, although some measurements of the flow from the Bayer's Lake portion have been made, and the calculation of its yield has to be made from the rainfall. In estimating the capacity of the gathering grounds there must be considered the extent and character of the drainage area, the average and minimum yearly rainfall, the distribution of the rains through the various months of the year, the average and least percentages that are carried by the streams, the storage capacity that can be secured and the evaporation from the surface of the area.

The slopes of the drainage area of Long Lake and Chain Lake are steep, and consist chiefly of rock formation with scanty soil and not very much vegetation. The rainfall is measured by the Dominion meteorological agent in the city of Halifax, and at the lakes by the city water department. The gauges at the lakes are set in such a position that they should measure accurately the precipitation. The average yearly rainfall in the city of Halifax, from 1869 to 1905, is 56 inches and the minimum 45.808 inches in 1894. In Mr. Keefer's report of 1876 the rainfall for the years 1859 to 1865 is given, and during this time a minimum of 39 inches is recorded for 1860 and an average of 51.62 inches for the seven years. It is not known by whom these records were made.

The writer is unaware of any studies to determine the evaporation having been undertaken in Nova Scotia, but the generally accepted rule here is to allow that one-half the rainfall will be lost from this cause and all that falls on the water surface of the drainage area. In his opinion this would cover the loss on the low service water-shed as there are few swamps or shallow places where the water lies, and as before mentioned, the slopes are fairly steep. In fact, taking the area of the water-shed, the amount flowing over the waste weirs, the amount estimated to be delivered in town, the loss from leakage at the dams and the amount delivered to the mill owners, the writer is of the opinion that an average of 50 per cent. throughout the whole year is available as the run-off from the Long Lake drainage area. Since 1889 the quantity running to waste yearly over Long Lake waste weir has varied from 250,000,000 gallons to 2,173,000,000 gallons. The reservoir has always been full during those years in either March, April or May.

To increase the available flow, it is necessary to store the water in time of flood and thus equalize the distribution of the rainfall. There are three low service reservoirs,—Long Lake, with waste-weir level at 206.00 feet, having a surface area of 423 acres, an available depth of 8.20 feet and a capacity of 871,522,000 gallons; Upper Chain Lake, with waste-weir at same level and sluice at 194.70, an area of 37 acres and a capacity of 107,674,000 gallons; Lower Chain Lake, with waste-weir at same level of 206.00 feet, main pipe at level of 192.24 feet, and an area of 42 acres and a capacity of 157,374,000 gallons; giving a total available storage in the low service reservoirs of 1,136,570,000 gallons—sufficient to supply the legitimate wants of a population of 50,000 for a period of 225 days, allowing 100 gallons per capita. But to show the enormous draught on this system, in November of 1905 all but 60,000,000 gallons of this storage had been exhausted in supplying 18,000 consumers between the 15th of June, when the reservoirs were full, and the 15th of November, the rainfall during this period amounting to 12.683 inches. The lowest level to which Long Lake has been drawn down being 8 feet below waste-weir on the 14th November, 1905. At the end of December, 1905, the level of Long Lake waste-weir was raised one foot, which will increase the available storage by 115,000,000 gallons.

High Service Gathering Grounds and Storage Reservoir.

The water-shed of Spruce Hill Lakes amounts to 1,009 acres, including a water area of 218 acres in the lake and 6 acres in Fish Pond. The geological formation is similar to that of the Long Lake water-shed, but the slopes are somewhat flatter. Mr. Keefer estimated the yield from this gathering ground in the driest year at an average of one and one-quarter million gallons per day, and that in wet years this amount would be doubled. The storage capacity of the lake is estimated to be 700,000,000 gallons, or sufficient for a population of 31,000 for 225 days, allowing 100 gallons per day per capita.

Cleaning Lakes.

In raising the Spruce Hill Lakes, the area flooded was thickly covered with trees, brushwood and moss, which apparently had never been cleaned out, and which after a short time died and greatly contaminated the water.

The effect was so bad that for a few years previous to 1876 the water became unfit for domestic use. In that year the lake was drawn down to a level of 7 feet 9 inches below the waste-weir, and the bed of the lake was cleared of fallen trees, brushwood and decomposed vegetable matter, and the stumps were grubbed out. The trees and stumps taken out were covered with a green slime. When Long Lake was raised, the shores were thoroughly cleared, but in common with all the lakes certain forms of vegetation thrive between high and and low-water level, and it has to be periodically cleaned out.

Growths.

The growth of algæ was first noticed in 1878. In that year samples of water, algæ and mud from Chain Lakes and water from Long and Spruce Hill Lakes were collected in September when the water was low and sent to Professor Lawson to analyze. His analysis of water from Long Lake yielded a dry, solid residue, as follows:—

Inorganic matter..................	1.71	grains to the gallon.
Organic "	2.13	" " "
Total	3.84	" " "

Another sample, taken from Chain Lakes near the pipe-house, gave:—

Inorganic matter	2.48	grains to the gallon.
Organic "	2.68	" " "
Total	5.12	" " "

The inorganic matter consisted chiefly of alumina and iron, with silica (soluble), common salt and a mere trace of lime. The water belonged to the class of soft waters such as are collected in districts where there are no rocks capable of yielding soluble substances. The sources of the impurity taken up by the water in its passage through Chain Lakes was discovered in the form of a very peculiar deposit found in Upper Chain Lake extending over the greater portion of the lake bottom, of a thickness of over five feet in level places. It varied in consistency from that of soft cheese to that of baker's bread, and in color from whitish to dark ferruginous brown, in some places nearly black. It consists to a very large extent of the remains of microscopic organisms belonging to the class of infusoria. The chemical analyses of four samples is as follows:—

No. of sample.	Color.	Insoluble in H. Cl.	Soluble in H. Cl.	Total Inorganic matter.	Organic matter.	Water.
1	Pale brown.	38.40	11.36	49.76	11.32	38.92
2	Pale whitish.	38.96	9.44	48.40	9.60	42.00
3	Between 1 and 2.	38.16	11.04	49.20	8.72	42.08
4	Dark fur. brown.	.....	.....	24.70	11.85	63.45

This deposit has no doubt originally consisted of swamp muck formed by the remains of plants, infusoria, etc., but by the long subjection to the action of water passing over it has lost much of its organic matter.

A few specimens of fresh-water sponge (Spongilla), whose decay gives a very offensive odor to water, were found in Upper Chain Lakes in 1878, and in 1883 the growth was increasing to such an extent that men were sent to collect all the specimens that could be found, since which date no more have been observed. In 1877 a microscopic alga called *trichormus flos aqua* was found in Spruce Hill Lake, which had the effect of giving the surface of the water, especially near the shore, a brilliant green color. This is not known to be injurious, but is regarded as an indication of water being stagnant or containing organic matter. It has not reappeared, and was probably removed by clearing the lakes of vegetable matter. In 1885 new forms of algæ appeared in Chain Lakes, consisting of a galatinous substance forming in detached masses, from the size of a marble to a large apple, and adhering but slightlv to the soil and stone under water, a light breeze being sufficient to detach quantities of this substance and carry it to the screens in the pipe-house where, if allowed to collect, it would soon cut off the supply to the city. Lime scattered along the shores of the lakes seems to kill this growth, and a certain amount is deposited yearly to prevent its starting.

An analysis of the water from the various lakes was made in 1890 by Mr. Maynard Bowman, with the following results:

SOURCE OF SAMPLE.	SOLIDS.			NITROGEN AS			Chlorine.	Phosphoric Acid.	OXYGEN ABSORBED.		Valuation.	Class A.	Class B.
	Blackened.	Loss on Ignition.	Dry at 100° C.	Albuminoid Ammonia.	Free Ammonia.	Nitrates.			In 15 minutes.	In 4 hours.			
Ragged Lake		25	42	.1470	.0471	Trace	4.7	None	2.347	6.057	137.5	III	IV
Lower Chain Lake		35	47	.1814	.0400	"	5.3	"	2.460	6.117	146.1	III	IV
No. 55 South Street		28	43	.1743	.0413	"	5.2	"	2.360	6.039	141.3	III	IV
No. 66 Bedford Row		28	50	.1671	.0314	"	5.8	"	2.460	6.160	144.9	III	IV
Spruce Hill Lake		21	36	.1671	.0400	"	6.3	"	2.620	6.314	50.3	III	IV
Wellington Barracks		28	46	.1814	.0400	"	6.3	"	2.614	6.243	151.7	III	IV
Quinpool Road		28	46	.1814	.0314	"	6.3	"	2.558	6.173	148.7	III	IV

There are two points in the above that require special consideration, viz., the high figures for albuminoid ammonia and the oxygen absorbed. An opinion based on those leads to but one result, that the water is impure.

According to Wanklyn, Chapman, and Smith, the limit for albuminoid ammonia is 0.066 parts per million for a good water, while here we have from 0.1470 to 0.1814, which is a very large excess.

This impurity is chiefly attributable to contamination with animal matter, but situated as the lakes are and considering their surroundings its origin is not apparent. Nevertheless, there is no question but that Lower Chain Lake must in the spring receive a large amount of impurity from the accumulations of the winter washed into it from the road along its banks. Ragged Lake under this head is the least of all, though its figures are much higher than they should be. As to the oxygen absorbed, 3 parts per million is considered to be the limit of a water of medium purity, while we have here more than 6.

This does not necessarily condemn the water, peaty water not being considered injurious. Still the figures are high, and the water carries a large amount of organic matter and should be filtered before use in all cases.

The following is extracted from a report of Prof. George Lawson on the foregoing analysis:—

"The result of analysis showing Ragged Lake water to contain 0.1470 parts per million of albuminoid nitrogen and the other samples from 0.1671 to 0.1814, the average of the whole being 0.1714, affords sufficient evidence of organic impurity in all the waters. The high rate of oxygen absorbed tells the same tale. In such cases it is usual to regard the albuminoid nitrogen as having its origin in sewage or animal matter, hence the great stress laid by water analysts upon the albuminoid nitrogen. Without further knowledge of them, these three waters, with the exception perhaps of Ragged Lake, would be regarded by most water authorities as impure, unfit for use, or at least, doubtful. It may be, and I incline strongly to this view, that the acidity of our waters enables it to give results by the ordinary ammonia process which tends to exaggerate the apparent amount of albuminoid nitrogen. It is still more likely that a large proportion of the albuminoid nitrogen is due to vegetable sources. The avidity for oxygen is probably owing to peaty and other vegetable substances, as well as ferrous salts, all of which we know exist in the water and are not injurious in the way in which decaying animal matter and sewerage are. For these reasons, I see no immediate cause for alarm, but there is certainly good reason for thorough investigation as to the sources of the apparent pollution. Dr. Fox, in his book on sanitary examinations of water, etc., gives an analysis of a water closely resembling the Halifax samples (albuminoid ammonia=0.18, free ammonia=0.08, nitrates and nitrates=0.1, chlorine=4.5) and remarks, 'Such a water when the nitrates and nitrites and chlorides are insignificant cannot be condemned, but would simply be described as somewhat dirty.' It may be that our Halifax water is not essentially impure, but only somewhat dirty. Those who use it are impressed with this latter feature of the water by observing its color and sediment. As a natural water accumulated in a silicious and granitic, rocky, comparatively uninhabited district it ought to be pure and no doubt will be when measures are taken to preserve its purity. The first thing to be done is to make a thorough survey of the shores of the several lakes and their tributary streams, and of the deposits and accumulations in the lake bottoms. In this way the sources of pollution can be reached. It may then be possible to avoid or remove them and to supply Halifax with as pure water as is within reach of any city on the continent."

In October, 1905, samples were collected and analyzed by Prof. E. MacKay, Dalhousie College, with the following results:—

Source of Sample.	Ammonia.		Chloride.	Nitrogen.		Required oxygen.		Total solids.
	Free.	Albuminoid.		Nitrate.	Nitrate.			
Long Lake	.01	.222	10.5	.425	.....	9.870	12.8	118.0
Tap, Young Avenue...	.014	.224	10.9	.400	.....	9.80	13.4	122.8
Spruce Hill Lake	.026	.120	8.0	.500	.....	9.68	14.1	103.2
Tap, Dalhousie College.	.020	.124	7.8	.300	..	9.60	14.1	107.9

The above are given in parts per million.

In his report Prof. MacKay says: "All samples had a somewhat yellowish tint due to dissolved vegetable matter. Of the total dissolved solids more than 70 per cent. was found to be of vegetable origin. The amount of vegetable matter is relatively large, and to this is due the high values found in ammonia. The analyses showed all samples to be wholly free from indication of essentially injurious constituents or contamination."

In a paper read before this Institute, Dr. Campbell said he found the Halifax water remarkably free from bacteriæ.

Dams and Waste-Weirs.

The dam at the foot of Long Lake was built by the Halifax Water Company in 1848. It was 950 feet long and 29 feet high. The original design called for a structure 20 feet wide on top, 29 feet high above the surface, the inner slope to be 3 to 1 and the outer $1\frac{1}{2}$ to 1; a puddle-wall to be built 6 feet thick, its front in line with the inner edge of the top, to be backed with 6 feet of coarse gravel, the whole surrounded with fine gravel and loam; the outer slope to be covered with stones, the toe of the inner slope to be composed of coarse gravel and small stones; the level of the waste-weir (which was a wooden structure) to be 200.00 feet above mean low tide.

In 1877 the dam was raised and strengthened by putting rafts of brushwood and straw covered with fine material in front where leaks had developed, and raising the dam five feet, widening the top to twenty-four feet and flattening the outer slope to 2½ to 1. The water side was protected by a heavy sloping wall surmounted by a granite coping 18 inches high and forming a low wall along the front. The dam was lengthened to 1,018 feet to the west of the waste-weir. In 1892 the dam was raised two feet and strengthened by depositing 5,000 cubic yards of good material on the face. The present waste-weir at an elevation of 205.99 feet above low tide was constructed in 1878 of massive granite masonry and strengthened in 1888 by the addition of a concrete wall at the front. It is 62 feet 6 inches long and the crest is 3 wide and level, the fall from the crest to the apron being 3½ feet. The latter is constructed of granite slabs about six feet long with granite paving outside. There is a sluice-way closed with an iron gate at the eastern end, 62 inches wide and 50 inches high and at a level of 198.90.

In December, 1905, iron staunchions were secured to the top of the weir and the sill raised one foot, or to an elevation of 207.00 by placing two 6-inch timbers in position.

The highest level to which the water has risen over the weir is 25 inches on the 19th October, 1896.

In 1873 leaks were reported in the Long Lake dam by the city engineer, and in June, 1877, thermometrical observations were taken in the lake and at each of the runs of water along the foot of the dam, when it was found that the two largest runs were from leaks and the rest from springs under the embankment. Weirs were placed on these, and the actual amount of leakage was found to be 14.7 gallons per minute from the eastern one and 6.6 gallons per minute from the western one. As the results of the improvements made in 1892 these leaks have been very materially reduced, in one case a flow of 2 inches over the measuring weir dwindling to ¼ inch and the other stopping altogether.

When Lower Chain Lake was raised in 1894, a new dam was constructed outside the existing one. It is practically two dams joined by a natural hill, the north one also having a hill projecting into and buttressing it. The north part of the dam has a concrete core-wall 4 feet wide on top and 6 feet at bottom carried down to the solid ledge-rock and continued into the banks on each side and running through the waste-weir. The embankment is formed of gravel and loam laid in thin layers and well compacted. The old 12-inch pipe used to let down water to the mill owners runs through the dam, also the 24-inch main to the pipe-house, which is at the foot of the outer slope. A leak developed where the 24-inch came through the core-wall, but it was repaired with concrete and has shown no signs since. The length of this dam is 550 feet, the top width 12 feet. The outer slopes are 2 to 1, and the inner 3 to 1, paved with heavy stones. The waste-weir is at the northern end of the dam at an elevation of 206 feet, and is of similar design to the Long Lake weir, the dimensions being 16 feet long, width of crest 3 feet, and a fall of 9½ feet broken by a ledge 5½ feet from the crest. The apron is paved with heavy granite slabs and concrete. A 20-inch exit pipe runs through the weir to be used as a waste pipe. The south part of the dam is constructed to the same design as the northern part, with a gate-house in the centre of it. The top and outer slopes of both this dam and Long Lake dam were covered with street sweepings hauled from town and sown with grass seed and in a year were covered with a strong, thick sod. There are two small dams between the two Chain Lakes, the south one built in 1883, with a sluice 24x36 at a level of 194.70; the north with the old waste-weir built in 1886.

The main dam at Spruce Hill Lake is an earthen structure 1,200 feet long, 12 feet wide on top the slopes, both inner and outer, being built of granite about 16 inches thick. There is no puddle or core-wall through it, but it was built by simply compacting layers of the best available material. There are two smaller dams about 300 feet and 250 feet long respectively, of the same section as the main dam. The dams were constructed in 1868 and the granite face wall in front of the dam was built in 1891-3 and the dams raised at that time. The present waste-weir was built in 1883 at an elevation of 362.79. It is constructed of granite with four openings of 9 feet 3 inches each in the clear, separated by cast-iron standards to receive stop logs to retain the surplus water. There are three such timbers in place, each 6 inches square, thus raising the level to 364.29.

Gate-Houses.

There are two gate-houses at Chain Lakes. The north one, originally built in 1857, is located at the north part of the dam at the toe of the outer slope, and consists of an iron tank built in sections, bolted together and caulked. The water is drawn from the lake to this chamber by a 24-inch pipe. It was raised in 1894 by bolting a section to the existing chamber. The 24-inch supply main is connected with this house.

The south gate-house was built in 1894, over the channel which led to the old south pipe house, which was the original one built in 1848 and destroyed when the new one was completed. The new one is built of concrete and is 16 feet deep by 12½ feet wide by 16½ feet long with walls 4 feet thick. It is drained by a 12-inch pipe. Both the 24-inch and the 27-inch mains connect in this house, but may be separated should occasion arise. There is a straining wall about 100 feet long in front of this gate-house built of loose stones, 4 feet 6 inches thick on top with slopes of 1 to 4. The new house is ample in size and avoids the difficulty always had with the north house which is too small to vent the water freely, and was always in danger of choking up owing to the small size of the screen chambers. There is a weir near the north gate-house to measure the water let down by the 12-inch pipe to the mill owners.

The original Spruce Hill Lake gate-house was of similar design to the old ones at Chain Lake, consisting of an iron tank with three divisions, an inlet, screen and outlet chamber, and was built about 150 feet north of this dam, a 20-foot pipe running through the dam and connecting with the lake. In 1889 a permanent structure of brick, concrete and granite was built in the dam of the following dimensions: 16 feet deep by 10 feet 4 inches wide and 8 feet 5 inches long, with walls 4 feet thick.

The screens are made of No. 19 brass wire, and have sixty-four meshes to the square inch.

Employees of the water department live both at Spruce Hill Lake and at Chain Lake dams, whose duty it is to look after the dams and gate-houses. The screens, in summer when the water is low, require changing frequently as they become choked with leaves or other impurities suspended in the water. During the fall of 1905, when the water was at its lowest, two men were on duty day and night continually changing the screens, otherwise the supply could not have been kept up to the city through them.

Canal.

As has already been stated, the water was conducted from Long Lake to Chain Lakes by a canal, which was originally constructed in 1848 by an open cut, and was intended to be low enough to draw the water of Long Lake down seven feet below the waste-weir level, but during construction, owing to difficulties met with by the contractor, the grade line was raised 1 foot 3 inches, thus, only allowing 5 feet 9 inches of Long Lake water to be drawn off. The conduit was 2 feet by 2½ feet, and was entirely too small to pass the water in sufficient volume to give full effect to the storage of Long Lake. The present conduit, rebuilt in 1886, is 1,300 feet long, 3½ feet wide and 4½ feet high, built of 4-inch by 4-inch hemlock deal, with four manholes throughout its length. Its upper end is at an elevation of 196.20, with a fall to Chain Lake of six inches.

Ice.

The experience with the formation of anchor ice has been similar to that of other places. With a sheet of open water at a temperature of 32 degrees F., and the temperature of the air varying from 5 degrees to 20 degrees above zero, and a high wind blowing, the ice forms in small detached needles or crystals. Thin portions of it accumulate in spongy masses and float along at or below the surface, their specific gravity differing but little from that of water. They adhere readily to all solid bodies with which they come in contact, and grow rapidly when once they have secured a centre of crystallization. It will not form in bright sunshine—on the contrary, it rises to the surface in spongy masses, and when the surface freezes over it lets go its grip. The lee side of a reservoir gets most of its anchor ice, and whenever we have been troubled with it the wind has always been from a north-westerly direction. Between 1883 and 1893 no trouble was had from ice, and it is thought that this was due to the fact that a screen of stout pickets driven into the bottom, capped on top with a boom rising and falling with the level of the water, was placed in front of the gate houses. In 1892 this was removed, and on the 11th December of that year ice closed the sluice gate at the south gate-house cutting off the supply to the 24-inch main, and continued until four o'clock in the morning, when the wind subsided, and the ice stopped running. In 1898 the filter wall already referred to was built in front of the south gate-house, but ice formed inside the wall, and there was danger that the gate-house would freeze up solid, so the screens were removed until the danger had passed. This is the last time there has been any trouble from it.

Riparian Rights.

When the Halifax Water Company decided to bring the water from Chain Lakes there were several mills situated on the stream flowing from the lakes and enjoying the privilege of the water from them. Some difficulty having arisen in securing the rights to the water, it was seriously contemplated by the company to bring the water direct from Long Lake. However, an agreement was eventually made in 1849 with the owner of the privileges, that for a consideration of £500 the water company could build dams and take the water from Chain Lakes, provided that they would not interfere with the natural flow through the lakes as heretofore enjoyed by the mill owners. The first difference arose in 1863, when the commissioners of water-supply received a letter from the attorneys of the mill owners, stating that the mills had closed down for want of water, and that in previous years the water company had let down a supply in dry weather. The commissioners on this occasion gave orders to their superintendent to let down enough water to fill Chocolate Lake, on the understanding that this was not to be taken as a precedent or to act as any acknowledgment of the rights of the mill owners to the supply, and on April 13th, 1863, they presented a lengthy report dealing with these claims. From that time to this there has been constant friction with the mill owners as to the amount of water which should be let down to them under the agreement. This has culminated in an action being brought by them for a declaration of their rights and an injunction restraining the city from interfering with their supply. As this is now before the courts the question may not be discussed fully, and is mentioned only to serve as an example of the necessity for looking to the demand for a largely increased supply always following the introduction of water to a town in a short time, and of the advisability of either securing all the rights to a watershed, or at least, having a definite agreement as to the actual quantity to be allowed the owners, and the method by which said quantity should be measured.

Mains.

The water was originally brought from the Chain Lakes to the city by a 12-inch main to St. Andrew's Cross, laid in 1848, and was assumed by Mr. Jarvis to be capable of delivering at this point 800,000 gallons daily. It was of cast iron, and was ordered in Scotland through Messrs. Kidston & Son, of Glasgow, and cost £7 5s. per ton delivered, the freight being 15/ per ton. 2,550 feet of these pipes were to be $\frac{5}{8}$ inch thick, to be tested to withstand a pressure of 160 pounds to the square inch, and 13,650 feet to be $\frac{1}{2}$ inch thick tested to 145 pounds. All pipes were to be 9 feet long. 550 of these pipes were ordered with spigots cast on them to fit a $\frac{3}{4}$-inch iron service pipe, so that the water would not have to be turned off in making connections. The pipes were uncoated and were laid with lead joints.

In January, 1856, the water company ordered from Kidston & Sons 284 lengths of 15-inch pipe, 9 feet long, $\frac{3}{4}$ inch thick, to be laid in the valley of the North West Arm, and 1,341 lengths $\frac{5}{8}$ inch thick; the pipes to be tested to 165 and 135 pounds respectively. These pipes were laid during that year alongside the 12-inch. The estimated delivery of this pipe was over 1,000,000 gallons per day at St. Andrew's Cross. Messrs. Kidston wrote to the directors recommending the use of a coating (Smith's patent varnish) which was then just coming into use, and the directors wrote saying that if this coating had the approval of authorities in Great Britain to put it on the pipes; but subsequently, fearing it would reduce the capacity of the pipes, passed the following resolution, a copy of which they sent their agents:—

Resolved,—That the directors having ordered a 15-inch pipe, which was larger than was contemplated for the very purpose of preventing the pipes filling up, do not consider that the glazing mentioned will be necessary; but if the glazing is considered an advantage that all the small pipes ordered be glazed.

Fortunately, before this letter was received, the order had been placed and the pipes came out coated. These pipes were laid with wood joints. The cost was £5 14s. 10d. per ton, exclusive of freight.

In 1862 the commissioners of water-supply took up the original 12-inch main and substituted therefor a 24-inch main. These pipes were ordered from Glasgow. The quantity required for the North West Arm valley to be 1 inch thick, tested to 200 pounds; and the remainder to be ¾ inches, tested to 150 pounds. All pipes to be 9 feet long and coated with Smith's patent coating. They were laid with wooden joints and cost £4 4s. 3d. per ton, exclusive of freight or duty, or £6 18s., exclusive of truckage. The total cost of laying this main was $54,994.39, or an average cost of $4.00 per lineal foot. The estimated capacity was 5¼ million gallons when new. There is a 12-inch exit pipe at the Dutch Village Road. On the introduction of the "high service" in 1868, the 15-inch main laid in 1856 was used as a part of the supply main and was extended to within 1¼ miles of Spruce Hill Lakes, this latter distance being laid with 20-inch pipe. These are ⅝ inch thick and the 15-inch are ¾ inch. They are 9 feet long and coated with Smith's patent varnish and are laid with wooden joints. That portion of the old 15-inch lying in the valley of the Arm was uncovered and lead joints substituted for the wood. On the 14th January, 1869, the commission had a report from their superintendent, complaining that the 15-inch pipes laid the previous year were giving considerable trouble from the fact of the unequal casting, a number of pipes breaking under a pressure of 68 pounds. On examination these pipes were found to be only ⅜ inch thick on one side and full ⅞ inch on the other, and during the winter the pressure was regulated so as not to exceed 45 pounds at Chain Lakes pipe house. The pipes split along the thin side. The estimated capacity of this main when discharging at an elevation of 250 feet was 2,485,000 gallons. There are exits in this main at the end of the 20-inch, at Beaver Dam Brook, at head of Chain Lakes, and at the Dutch Village Road.

In 1893 a new low service main, 27 inches in diameter, was laid from the Chain Lakes. This main follows the route of and is laid alongside the other two supply mains, to the brow of the hill on the western side of the Dutch Village Road, thence striking across the valley in a straight line to Bayer's Road near North Kline Street, thence along Bayer's Road and in prolongation thereof to Kempt Road, and then to Young Street at the corner of Gottingen Street, connecting there with a 24-inch main running to Cogswell Street, where the latter joins the 12-inch and 15-inch running from the 24-inch at St. Andrew's Cross. The specification for this pipe calls for three thicknesses—$\frac{3}{4}$, $\frac{7}{8}$, $1\frac{1}{32}$,—the first to test to 250 pounds, and the latter to 300 pounds per square inch, and while this test is being applied the pipes to be struck a series of sharp blows at various points throughout their length with a 3-pound hammer attached to a handle 16 inches long. The pipes are 12 feet long with turned and bored joints, and coated inside and out with coal-pitch varnish. The contract price delivered in Halifax, free of all charges, was $32.05 per 2,000 pounds for plain pipe and $56.10 for special castings. The contract for excavating the trench was let for $1.85 per cubic yard for rock and 28 cents for earth excavation; measurement limited to a trench 4 feet wide. The cost of the 27-inch main laid was $5.71 per lineal foot, inclusive of all charges. The cost of the 24-inch laid in Gottingen Street was $5.52, inclusive of all charges. This main slopes from the lake and from Gottingen Street to the Dutch Village Road, where a 12-inch exit pipe is placed.

Coating.

The coating on the high service main and on the 24-inch was ordered as "Smith's patent varnish." This is probably the coating process of Dr. Angus Smith, which was first introduced in the United States in 1858. The weight of experience seems to show that in uncoated pipes the first ten or twelve years of their life results in more or less rapid corrosion. After they have become thoroughly tuberculated very slight changes take place. If this is removed by scraping or cleaning it begins to form again, and the life of the uncoated pipe becomes much reduced.

The interior of coated pipes become tuberculated in the same way, due to a large extent to defects in the coating, but very much less quickly, and when removed by scraping the iron is uninjured. The writer was present recently when a piece of pipe was cut out of the 15-inch main, and when the deposit was rubbed off the coating was as sound and good as when first put on. The outside of the pipe was also in good condition. The pipe had been cleaned a year previous, and the tubercules had not begun to form, but there was a slight deposit over the face of the pipe. The following points should be observed in coating cast-iron water pipes:—

That the ovens in which the pipes are heated before being dipped in the coal tar bath shall be so arranged that all portions of the pipes shall be heated to an even temperature.

The pipes should be heated to a temperature of 300° F. before being dipped.

The varnish to be heated to a temperature of not more than 300° F., and kept at this while the castings are in the bath.

The pipes should not be submerged for less than five minutes, and when taken from the bath should be evenly coated.

Joints.

There are three kinds of joints in use in the water system, —lead, wood, and turned and bored. These latter joints have been in use since 1890, but they do not seem to find favor with engineers in America and are very little used in Canada or the United States; although in the Metropolitan Water Works of

Mass., for the crossing of the Charles River, one of the three kinds of joints used was described as follows: Three turned grooves were made in the bell instead of the single one so as to hold the lead more securely, and the spigot was smoothly turned with a straight taper to a standard pattern so as to be interchangeable. After inserting one of these tapering spigots in the bell of the pipe and running the joint with lead the spigot could be withdrawn, and when again inserted would make a tight joint. This is practically one pattern of a turned and bored joint. In the pattern used in Halifax a lip or rim is cast on the spigot end of the pipe, varying in length from $2\frac{1}{4}$ inches in a 27-inch, to $1\frac{3}{4}$ inches long on a 6-inch pipe, tapering about 1-24 of an inch in its length. A finished lip or rim is cast in the hub, the pipes are then centered in a lathe and the rim on the spigot end is turned and the rim on the hub end is bored by the same movement of the lathe. Care is taken that the pattern is made to give a full size casting so that when planed down the ends fit accurately. The total depth of the hub varies in the different sizes from 4 to 5 inches.

In laying, the pipe is lowered into the trench with the joint smeared with oxide paint, and placed in position on the blocking, entering the faucet of the last laid pipe. The next pipe is then lowered and held in its slings while the men in the trench swing it backwards and forwards and thus ram the last laid pipe tightly home in its place. A block of hard-wood between the pipes are lowered with a derrick. Should there be any slight diameter are held in slings by four men on the bank; larger pipes are lowered with a derrick. Should there be any slight weepage the joint soon rusts tight. In the fifteen years' experience with this form of joint there have only been two discovered leaks through them, one in the 27-inch main near Young Street, and one in the 6-inch main in Young Avenue. In the latter case the pipe was laid in the sewer trench. As the back filling of the latter settled, the blocking of the pipe was disturbed and the pipe settled and drew one joint. In the case of the 27-inch, a leak developed during the winter following the laying of the pipe, and on digging down to the main a joint was discovered to have drawn out about $\frac{3}{4}$ of an inch. This was caulked with cold lead and gave no trouble until the following winter, when it again showed signs of leaking, and on investigation the joint was found to have drawn another $\frac{1}{2}$ inch. The blocking of the pipes on each side had apparently not settled out of place, being laid on the top of the ledge rock. It was thought that this drawing apart of the joint might have been due to the contraction of the pipes. Assuming the difference of temperature to have been 30 degrees, which is a fair estimate between the temperature of the pipes when laid and when the leak developed, the contraction to open the joint $\frac{3}{4}$ inch would have to take place through 324 feet of pipe. If this took place on each side of the defective joint there would be a strain on the joint of over 16 tons, the pipes weighing a ton and a quarter to the 12-foot length, if the leakage was from this cause, it should close up again in the summer when the temperature of the pipe rose. Unfortunately, the $\frac{1}{2}$ inch which is said the pipes separated in the second winter was not measured accurately, but was estimated by the foreman and may have been overstated; but assuming it to be correct, the writer cannot advance any theory for the increase in the opening from this cause, as there would not be any more difference in the temperature than the amount given above. It is possible that the joint may not have been driven home, and as at this point there was only about four pounds pressure when testing, the oxide paint used may have prevented the leak showing when the pipe was tested on being laid, and a settlement may have occurred in one or two lengths of pipe distant from the leak dragging the pipe apart at the weakest point.

It will be seen from the description of the method of laying, that the process of lowering and blocking is exactly the same as for plain pipe, except the ramming home, which takes but very little more time than the extra care required in centering the pipe for a lead joint and then the joint is complete; whereas, with the plain pipe the process of joining has not yet been begun and necessitates considerable labor and material being employed to finish the work. To get the best results with lead or wood joints also requires a higher class of labor. The pipes can be sprung around curves, but in this case should be caulked with lead.

Previous to the introduction of the turned and bored pipes, wooden joints were used extensively for pipes of 6 inches and over. They have the merit of cheapness as compared with the lead joint and are durable, but possess the defect of being liable to be blown out with a sudden increase of pressure, and most of our trouble with discovered leaks has been from this cause. The faucets of the 24-inch and 15-inch for this kind of joint were made tapering $\frac{1}{8}$ inch inwards. The joint is made as follows:—After the pipe is inserted in the socket it is raised up by means of a tool called a raising iron and soft pine wedges or staves, thoroughly seasoned and cut to the radius of the pipe, are inserted on the lower side for about $\frac{1}{3}$ of the circumference of the pipe. The pipe is then lowered, and raising irons are driven in the top and on each side of the joint, at intervals of about 3 to 5 inches. The wedges are then driven in with a sledge-hammer beginning from those already laid and working up both sides, the raising irons being withdrawn as the work proceeds. When all the wedges are in, keys are driven where necessary between them to tighten the joint.

The wood joints in the 15-inch main, where under the water of the Chain Lakes, were strengthened by adding an angle strap of wrought-iron bolted closely to the pipe in front of the wedges. The difference in cost of turned and bored, and plain pipes, has varied from 55 cents to $1.00 per ton, the former being the difference in the tenders for the 27-inch and 24-inch pipes laid in 1893. The net saving over lead joints in laying the 27-inch man amounted to $3,147. Taking the cost of turned and bored pipes at 75 cents per ton more than plain pipes, the following table gives the detailed cost of laying mains with turned and bored, lead, and wood joints.

Cost of Laying and Jointing, 9 feet lengths of C. I. Pipe with Wood, Lead, and Turned and Bored Joints.

		WOOD.					LEAD.							TURNED AND BORED.			
Size in inches.	Weight of 9′ length.	No. of pipes six men will lay and test in 10 hours, costing $10.20.	Cost of labor per length.	No. of staves @ 1¾. No. of wedges @ ¼.	Cost of staves and wedges.	Cost of one length laid, jointed and tested.	No. that 6 men will lay and test in 10 hours, cost $10.20.	Cost of labor per length.	Llbs. lead @ 3½c.	Cost of lead.	Lbs. gasket @ 6¼c.	Cost of gasket.	Cost of one length laid, jointed and tested.	No. that 6 men will lay and test in 10 hours, cost $10.20.	Cost of labor for each length.	Extra cost of pipe per length @ 75c. per ton	Cost of one length laid, jointed and tested
24	2077	10	$1 02	22	$0 44	$1 46	10	$1 02	50	$1 75	½	$0 04	$2 81	15	$0 68	$0 75	$1 43
20	1263	12	85	19	38	1 23	12	85	40	1 40	½	04	2 29	18	56	47	1 03
15	1128	15	68	16	32	1 10	15	68	30	1 05	⅓	02	1 75	23	44	42	86
12	680	20	51	13	26	77	20	51	24	84	⅓	02	1 37	32	32	25	57
9	500	25	41	12	24	65	25	41		60	¼	02	1 03	40	25	19	44
6	280	30	31	9	18	52	30	34	17	42	⅛	01	77	50	20	11	31
4	156	....	...	....	.....	....	40	26	12	28	1-10	01	55	60	17	05	22
3	130	....	...	...	......	.....	50	21	8	21	1-10	01	43	......	.....	....	....

Incrustation of Pipes, and Cleaning.

In 1875 the old 3-inch water pipes laid by the Halifax Water Company having become almost choked up with rust and sediment, they were cleaned out during the succeeding year by a scraper attached to iron rods and propelled by hand. The scraper had four arms or knives, attached to a center and sprung outwards by a thick rubber disc. This method was not practically applicable to pipes of a larger diameter than 12 inches. The cost of cleaning was 14 2-10 cents per lineal foot. In 1880 about a mile of 12-inch pipe was cleaned by a self-acting mechanical scraper, imported from Scotland, and known as the Kennedy scraper. 1887 Mr. Keating, the city engineer, at that time, constructed new scraping machines which differed from the others in having additional springs for the cutters and pistons. These scrapers consist of an iron rod to which are attached two pistons and two sets of cutting tools, one in front of the other. The cutters are each made up of four strips of steel 2½ inches broad, sloping backwards from the rod, and at their outward termination sharpened like the barbs of an arrow, thus they can yield when necessary and the cutting diameter can be altered by moving the steel strips. The pistons are of iron, lead and leather to which are added rubber springs. All the main supply pipes were cleaned in that year at an average cost of 2 8-10 cents per lineal foot. The immediate results were that the average pressure on twenty-five hydrants on the wharves increased from 34.2 pounds in February, 1881, to 52.4 pounds in February, 1882. These were on the low service. On the high service there was a pressure of 19 pounds on hydrants where in the previous year there had been no water at all. The pipes have been cleaned periodically since that date and usually twice a year.

In cleaning the mains the water is turned off at the gate-house and the exit opened and pipes emptied. A section of pipe, jointed with collars and bolted together, is removed and the scraper inserted by hand into the main. The piece taken out is then replaced and secured. The water is turned on, and by its power forces the scraper along. As it passes the exits they are turned off by men stationed there, and the scraper continues its course to the end of the main where a length of pipe has been removed. A sufficient quantity of water escapes through the valves ahead of the scraper to wash the incrustation removed and keep it from sticking. The water is allowed to run for some time until the sediment disappears, when it is shut off and the length of pipe inserted again and the water turned on to the distribution pipes. The average cost of cleaning the 24-inch low service main for the past twenty years has been 15.07 for each cleaning of 13,400 feet, and of cleaning the high service main $18.80 for each cleaning of 36,340 feet. Between 1882 and 1904, both inclusive, there has been cleaned 223 miles of mains at a total cost $732.07, or at an average rate of $3.28 per mile.

Distribution Mains.

The pipes in the distribution system are of cast iron, all those laid since 1855 being coated, and those 6-inch and over laid before 1890 having mostly wooden joints. They range in size from 3 inches to 24 inches in dameter, the mains to the hydrants being, with few exceptions, taken from a 6-inch pipe or larger. Some of the old 3-inch mains lately removed and replaced with larger pipes, when cut, were found to be so choked that there was barely room to insert a lead pencil through the opening. These were old, uncoated pipes and the metal had deteriorated badly. The mains are generally laid on the north and east sides of the streets, with valves set in line with the street lines. Iron pipes with sleeves were first used for stopcock boxes about 1862, before that wood had been used. The valves used for letting the high service into the low for purposes of fire protection are kept clear from ice and snow during the winter.

In 1905 there were 69.68 miles of mains and distribution pipes, and 804 valves.

Hydrants.

There were 424 hydrants in use at the end of 1904. A large number of these are of an old style set in a brick-well or chamber below the sidewalk inside the curb. The chamber is covered with a cast-iron plate, provided with a hatch, by which access is gained to the bottom of the hydrant where it joins the branch from the mains. This arrangement, while admitting of the easy removal of the hydrant, is objectionable on account of the difficulty and expense in keeping the valves free from ice, and the large iron plate becoming smooth and dangerous to pedestrians. These hydrants are gradually being replaced by a hydrant of a special pattern. The main valves and guide-rod, which also forms the waste valve, are similar to the Matthews' hydrant. A brass and leather attachment to the valve rod forms the waste valve. There is a waste hole bored in the center of the flange in the stand pipe against which this valve works. The hole was formerly at the bottom of the hydrant, but owing to the difficulty of reaching it, it has in the later patterns been placed in the side. The main screw of the valve rod is protected from the action of frost and water by a partition and stuffing box. The frost jacket is securely bolted to the iron seat, and when once set need never be removed. It forms an air chamber which prevents the frost from reaching the valve. A third nozzle is added to take the suction hose of the fire engines. The hydrants are examined and opened twice a day by the employees of the water department all through the winter.

Service Pipes.

When the city took over the works in 1861, only about one quarter of the number of families on the line of pipes were supplied with water directly by service pipes to their houses, the remainder obtaining their supply from the free domestic hydrants paid for by the city. These service pipes were in all cases $\frac{3}{4}$ inch cast iron pipes connected to the distribution mains by spigots cast on the latter. When on the assumption of control of the works by the city, a general assessment was levied to provide the funds necessary to maintain them, all citizens on the line of pipes applied for service pipes to their properties. There had been considerable doubt in the minds of the directors of the water company as to the material to be used for service pipes, and in 1846 they asked Mr. Jarvis for a report as to the merits of tin-lined lead pipes for this purpose. He replied that three-quarters of the service pipes used in New York at that time were common lead pipes, and adds that there was considerable discussion then going on as to the injurious effects of lead pipe on water. He had no doubt they injured a pure water, but that the length is so short that no material influence is produced. However, the water company, as before stated, laid all service pipes of cast-iron. The commissioners of water-supply decided to use lead pipes, and during their first year in office they laid over 6½ miles of lead service pipes to supply water to 1,058 takers. A large number of these were renewals as the old ¾ inch iron pipes were found to be badly choked and corroded. Since that time all services have been lead pipes. While Halifax water is a very soft water, and as such, from general observation elsewhere, should be injuriously affected by lead pipes, such has not been the case, the experience being that after a short time a film or layer of sedimentary deposit forms over the surface of the pipe which prevents the water coming in direct contact with it. No cases of lead poisoning from using the water have been reported since the introduction of lead pipes for services in 1861. Under the regulations of the water department, each building is entitled to one ½ inch service pipe laid at the department's expense from the main to the street line. In the event of a larger pipe being required the difference in cost is paid for by the person desiring the same. In the winter of 1882-3 a very large number of underground leaks were discovered and were found to result from the service pipes being severed at the connection with the main. The gas company had the same trouble during this winter, and the city engineer at the time suggested that the only cause of this could be from shock of earthquake felt on the peninsula on the 31st December, 1882. Subsequent to the explosion of the Acadia Powder Company's works at Waverley (about 12 miles from Halifax) on the 1st January, 1905, the gas company had the same trouble with a number of their service pipes, especially on Coburg Road and in that vicinity, but the water pipes escaped injury.

At one time in the history of the works eels were a constant annoyance in choking service pipes, but latterly it is quite rare to have any bother from this cause. An exception to this was in 1896, when owing to the danger of ice blocking the screens at the pipe house they were removed, and the following spring there were several complaints of service pipes being choked by eels.

The total number of service pipes laid up to the first of January, 1904, was 6,939.

Consumption and Waste.

In January, 1906, three Venturi meters were received from the makers, to measure the quantity of water flowing into the city. One of them the 15-inch, was installed, and it was hoped that results would have been obtained before the reading of this paper, but owing to delay in sending the registering apparatus no records have as yet been obtained.[*]

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[*] The Venturi meters having been set and put in operation during the period between the reading of this paper and its publication, the exact consumption has been obtained, and this note is added giving the revision of the figures in accordance with the information thus gained. For the 24 hours ending at 1 p. m. on the 6th December, 1906, the following quantity of water passed through the meters:—

Through the 14″ meter 2,291,500 gallons.
" 24″ " 4,492,500 "
" 26″ " 4,586,000 "

Making a total of 11,370,000 imperial gallons flowing into the city. This would give a consumption of 140 gallons per day per consumer on the high and 477 gallons per consumer per day on the low service, or an average of 321 gallons per day per consumer, or taking the whole population of the city, an average consumption of 277 gallons per capita per day. The figures given in the body of the paper were conservatively estimated, and while startling enough, were considerably below the actual results, which are unequalled by any other city of which the writer has any knowledge.

The Venturi meter is different in principle, design and operation from the water meters generally used for measuring water, it consists of two truncated cones of cast-iron, joined at the smallest diameter by a short throat lined with brass having a diameter varying in different meters from one-quarter to one-half of the diameter of the large ends of the cones, the three parts making what is known as the meter tube. At the up-stream end and at the throat small holes are drilled into the tube, from which pipes are carried to the register. The operation of the meter is due to the fact that when water is flowing through the tube the pressure at the throat is less than at the up-stream end, and that the difference in pressure is dependent upon the quantity of water flowing through the tube. The differing pressures at the up-stream end and throat of the meter tube are transmitted through small pipes to the register, which can be located at any convenient point within 300 to 400 feet of the tube. In the register the differences of pressure affect a column of mercury which carries a float. The position of the float is thus made dependent upon the quantity of water passing through the meter; and by suitable mechanism the quantity is recorded by a counter, and the rate of flow at intervals of ten minutes is recorded upon a chart, so that the fluctuations in the flow throughout each day can be observed. Although the pressure at the throat of the meter is often several pounds less than at the inlet or up-stream end, the lost pressure is almost all regained by the time the water reaches the outlet end of the tube, so that the net loss of pressure caused by the meter is seldom more than one pound under ordinary conditions of use. The meters in Halifax are set on a by-pass so as not to interfere with the operation of the scraper in cleaning the mains.

As there has been no direct means of measuring the water used it has had to be estimated by finding out the loss of pressure by friction in the pipes by gauges placed on hydrants at different points, and to estimate the co-efficient to use in the Chezy formula. In a report on the water system of St. John, N. B., it was found, by experiment, that the co-efficient to use there was 65. For new pipe this should be about 120, so that the discharge from their 24-inch main laid in 1873 would be a little more than one-half that of a new pipe. The 24-inch and 15-inch in Halifax have been cleaned regularly twice a year for some time, although the usual fall cleaning was omitted last year on account of the lowness of the water in the lakes; but from an inspection of the condition of the pipes where cut this year, the above co-efficient of 65 is considered much too low for the mains of the Halifax waterworks system, and 80 would be nearer the mark, although this is considered a minimum. However, assuming 80 to be applicable, the amount of water flowing into the city on the 8th of January, 1906, was 3,288,600 gallons through the 24-inch main, 4,294,000 gallons through the 27-inch main, and 1,600,000 gallons through the 15-inch main, or a total of 7,582,600 gallons for the low service and 1,600,000 for the high, or 9,182,600 for the whole city. The day was mild and there had been but little frost for some days previously. There are 19,000 consumers on the low service and 16,400 on the high. This would mean an average consumption for all the water takers of 260 gallons per capita per day, or 399 gallons per capita on the low service and 98 gallons per capita on the high.

Our population as given by the last four census returns is as follows:—

1871	29,582	1881	36,100
1891	38,437	1901	40,332

The figures for per capita consumption were given for the actual number of consumers. The better and usual practice is to give the per capita consumption for the total population as there may be some industries using large quantities of water, the employees of which may not be using water for domestic purposes. The figures given above would show a consumption for the entire population (assuming it to be 41,000) of 224 gallons per capita per day. From exhaustive investigations undertaken by the Metropolitan Water Board of Massachusetts, the conclusion arrived at was that a liberal supply for domestic purposes is 25 gallons per day, for manufacturing, mechanical and trade use 23.5 gallons, and for public use 7 gallons, making a total of 55.5 gallons per capita per day. Taking these figures as being applicable to Halifax, the consumption should be 2,275,000 gallons per day, which means that 6,907,680 gallons per day are being wasted. The average daily consumption through 144 meters on dwelling houses of various values in the city amounts to 105 gallons for each service pipe. Allowing five persons to a family, this would give 21 gallons per capita per day, which agrees practically with the amount stated above as being a fair and liberal allowance for domestic use. Another proof that the figures of the daily consumption are under estimated, is the fact that during the past year on the low service supply over 1,000 million gallons of storage was used up during 155 days which would equal 6,500,000 gallons per day.

If 60 gallons per capita per day be assumed as a fair allowance, it follows that at least 170 gallons per capita per day brought into the city is wasted either through leaks in the mains or water pipes and fittings in private premises. There is no doubt considerable leakage from the mains, particularly on the low service where so many of them are laid with wood joints; and a number of them are laid through or near old drains and sewers, so that the leaks do not show at the surface but the water runs off through drains. In Milton, a small town in Massachusetts, where all the services are metered and where the total quantity of water supplied is measured, and there are 35 miles of pipe laid, the leakage from the mains amounts to about 3,600 gallons per day per mile of pipe. In Fall River it amounts to 10,000 gallons per day per mile of pipe, although in their case they have only 96 per cent. of their services metered, and the consumption for the other 4 per cent. is estimated; and in seven cities having over 86 per cent. of the services metered the amount of water unaccounted for varies from 3,500 to 23,000 gallons per mile per day (these amounts are in United States gallons). Waste from pipes and fittings on the premises of water takers is due to defective plumbing or to negligent or wilful waste in allowing the water to run from the taps. In a house with modern plumbing the chief cause of waste is from a leaky ball-cock in the tank supplying fixtures. In one instance a meter was put on a pipe supplying a closet where the valve in the flushing cistern was worn and did not fit its seat properly. The waste was but a trickling stream, but the consumption was 1,073 gallons a day, while after the valve was repaired it was reduced to 43 gallons. In other houses closets supplied with hopper-cocks are the chief cause of waste. There are at present about 450 of these in use in the city. In 1891 a test was made on nine of these closets, and applying the results then obtained there would be a waste from this source alone of three-quarters of a million gallons per day. During the cold weather an enormous amount of water in the aggregate is allowed to run to prevent pipes freezing. As up to the present there has been no means of accurately measuring the water supplied to the city, this amount cannot be stated in gallons; but the pressure at night at the various permanent gauges throughout the city drops from five to ten pounds below that of the day time. The modern method of controlling waste is to supply each taker through a meter, so that each consumer pays only for the water used. There were on May 1st, 1905, 6,939 service pipes, of which 5 per cent. were metered. In October, 1905, when owing to the small rainfall there was danger of the supply becoming exhausted a house to house inspection by the police was ordered, and wherever any leaky fixtures were found the water was turned off and only turned on again when repairs had been made and on payment of a fine. The immediate result of this was a gain of eleven pounds pressure all over the city, notwithstanding there was a loss of 3¼ pounds owing to the lowness of the lakes. This in conjunction with the fact of the pressure lowering at night would seem to prove conclusively that the waste from the mains bears a very small proportion to that from negligent and wilful waste.

The following table of the data of the consumption of water of eleven cities about the size of Halifax gathered from late reports is here inserted to enable a comparison to be made, and also to show the effect meters have on the consumption of water. It will be noticed that the average consumption of those cities having over 50 per cent. of their services metered is 41 United States gallons, and those under 50 per cent. 91 gallons, or 50 and 197 imperial gallons per capita respectively:

TOWN.	Population supplied.	Number of services.	Percentage of services metered.	Miles of pipe.	CONSUMPTION.	
					Daily.	Night rate.
Brocton	37,800	....	90.	....	36	....
Woonsocket	34,474	......	86.7	....	28	......
Newton	35,400	..	86.	......	54	......
Malden	36,900	6,700	63.4	82.	47	25
Haverhill	37,200	....	10.	....	95	.....
Waltham	24,550	....	6.	......	99	......
Quincey	26,800	4,850	3.1	83.7	89	57
Salem	36,250	......	3.	......	79	.....
Everett	28,000	4,670	1.	42.	81	55
Chelsea	35,000	6,251	2.	38.7	94	65
Halifax	35,400	6,939	5.	69.6	260	......

Financial.

The rates are levied from four sources,—meter, fire protection, domestic and special.

The meter rates vary from 15 cents to 7 cents per 1,000 gallons by a sliding scale, depending on the quantity of water used per day. A meter rental is charged on all meters except those on domestic supply. The consumer pays only for the actual quantity used, and there is no minimum rate for this class of consumer. The fire protection rates are levied on the assessed value of all lands and premises and are paid by all classes of consumers.

The domestic rates are levied on the assessed value of properties and also on the number of fixtures, the minimum rate for fire and domestic purposes being $4.00 where no meter is on the premises.

Water is supplied to the military and naval properties and the Intercolonial railway under special agreements, in the former cases at so much per fixture and in the latter by actual measurement of water consumed, with a lump sum added for fire protection. No mains are extended in the distribution system unless a bond is executed guaranteeing the interest at 5 per cent. on the actual outlay required. This business-like method of making extensions has been the means of assuring the revenue keeping pace with the expenditure. The following statement shows the amount of the funded debt and annual cost of maintenance in five year periods since the city took over the works.

1860	Funded Debt,	£ 71,900	—The cost of the works, £56,000 paid for this year	
1865	"	$ 640,000	– Nova Scotian currency.	
1870	"	669,653.33	—Dominion currency.	
1875	"	740,973.33		
1880	"	740.973.33	– Maintenance	$55,496.46
1885	"	740,973.33	"	58,605.76
1890	"	633,906.48	"	66 534.96
1895	"	990,266.67	"	65,894.91
1900	"	1,056,600.00	"	69,252.38
1905	"	1.056 600.00	"	83,511.77*

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* Includes cost of renewing old 3-inch mains with 4-inch mains.

FUNGI OF NOVA SCOTIA: FIRST SUPPLEMENTARY LIST.—BY A. H. MACKAY, LL. D., F. R. S. C., HALIFAX.

Read 11th December 1905; revised to November 1907.

This list is the first supplement to the "provisional list" presented to the Institute on the 8th December, 1902—three years ago—and published in the *Transactions*, vol. xi, page 122. My colleagues contributing to this list are (1), Mr. R. R. Gates, M. A., of Middleton, Annapolis county [in 1907, doing post-graduate work at Chicago University]; (2), Mr. Clarence L. Moore, M. A., of Pictou Academy [at present, 1907, principal of county academy and public schools, Sydney] and formerly a post-graduate student in Johns Hopkins University; (3), Miss Minnie C. Hewitt, science teacher in the Lunenburg Academy; and (4), Mr. W. P. Fraser, B. A., science master in the Pictou Academy (last collection in 1906). The list is not large, and some of the determinations may be inexact, but it is hoped that the annual publication of new species found will stimulate these and our other students of the fungi to more energetic and systematic exploration and study of the species indigenous to the province.

It is also expected that the corps of workers now taking an interest in our fungi will, before long, enable us to correct any wrong determinations, if there are any, in this and in the provisional list of 1902. The nomenclature will then be revised so as to keep in touch with the most modern classification, and a new and more complete list be published. In the meantime, the general order and nomenclature of M. C. Cooke, which were followed by our earliest fungologists and by the provisional list, will generally govern the order and nomenclature of this supplementary list as far as convenient. The authorities are noted in the usual manner by their condensed initials; RRG, CLM, MCH, WPF, and AHMK.

Species Not Reported in the "Provisional List."

Amanita frostiana Pk. Point Pleasant Park, Halifax, AHMK. Middleton, RRG. Poisonous. It approaches in appearance *A. muscaria,* but is much smaller. Lunenburg, MCH. New Glasgow, WPF.

A. rubescens Pers. Point Pleasant Park, Halifax, AHMK. Common in woods, Middleton. Said to be edible; but even the expert should use caution if experimenting with it. It is distinguished from the other Amanitas by the reddish color which suffuses the stem and other parts when bruised, RRG. New Glasgow and West River, Pictou county, WPF.

A. flaviconia Atkinson. New Glasgow, WPF.

Lepiota cristata A. & S. Lunenburg, MCH.

L. granulosa Batsch. Lunenburg, MCH.

L. illinita Fr. Lunenburg, MCH.

Armillaria robusta A. & S. Middleton, edible, RRG. Lunenburg, MCH.

A. viscipedes Pk. Lunenburg, MCH.

A. ponderosa Pk. (?). Lunenburg, MCH.

Tricholoma schumacheri Fr. Middleton, RRG.

T. imbricatum Fr. Lunenburg, MCH.

T. virgatum Fr., var. *acutum*. Middleton, RRG.

T. brevipes Bull. Lunenburg, MCH.

T. albobrunneum Pers. Middleton, RRG.

Clitocybe ectypoides Pk. Middleton, RRG.

C. ochropurpurea Berk. Middleton, edible, RRG.

C. fumosa Pers. Lunenburg, MCH.

Collybia butyracea Bull. Middleton, edible, RRG.

C. acervatus Fr. Lunenburg, MCH.

Pleurotus petaloides Bull. Lunenburg, MCH.

Mycena latifolia Pk. Middleton, edible, RRG.

M. leaiana Berk. Middleton, RRG.

Omphalia campanella Batsch. New Glasgow, WPF.

Pluteus cervinus Shæff. New Glasgow, WPF.

Clitopilus micropus Pk. Middleton, rare, RRG.

Pholiota caperata Pers. Middleton, edible, RRG.

P. squarosoides Pk. Lunenburg, MCH.

Hebeloma glutinosum Lind. Lunenburg, MCH.

H. crustuliniforme Bull. Lunenburg, MCH.

Galera tenera Schæff. Lunenburg, MCH.

Stropharia æruginosa Curt. A group of this species was found in October of 1904 near the door steps of the house of Mr. Watson Bishop, in Dartmouth. It was remarkable on account of its more or less azure-blue green color, due to the colored slime mainly, for the ground color was more or less yellowish. Its spores were purple tinged. This fall only very small caps developed in the same spot, presumably on account of the unusually dry autumn season, AHMK.

S. stercoraria Fr. Dartmouth Park, Halifax Co., AHMK.

Hypholoma perplexum Pk. Halifax and Dartmouth, AHMK. Middleton; "From *H. sublateritium* it is distinguished by its usually smaller size, more slender hollow stem, the yellow-greenish and purplish tints of the gills, and the absence of a bitter flavor;" C. H. Peck, Memoir, N. Y. State. Museum, No. 4, vol. 3, Nov. 1900, RRG. Lunenburg, MCH.

Cortinarius cinnamomeus Fr., var. *semi-sanguineus* Fr. Middleton, edible, RRG.

Paxillus involutus (Batsch) Fr. Middleton, edible, RRG.

P. atro-tomentosus (Batsch) Fr. New Glasgow, WPF.

Hygrophorus pudorinus Fr. Middleton, RRG.

H. fuligineus Frost. Middleton, edible although exceedingly glutinous. Common in woods, especially under pines after the autumn frosts, occurring with the following Middleton species, RRG.

H. limacinus Fr. Lunenburg, MCH.

H. flavodiscus Frost. Middleton, edible, RRG. Lunenburg, MCH.

H. distans Berk. Lunenburg, MCH.

H. puniceus Fr. Halifax, AHMK. Lunenburg, MCH.

H. coccineus Schæff. Lunenburg, MCH.

Lactarius scrobiculatus Scop. Middleton, RRG.

L. aurantiacus Fr. Middleton, RRG.

L. deceptivus Pk. Middleton, edible, RRG.

L. theiogalus (Bull) Fr. Middleton, edible, RRG.

L. volemus Fr. New Glasgow, WPF.

L. hysginus Fr. Middleton, edible, RRG.

L. chelidonium Pk. New Glasgow, WPF.

L. pallidus Fr. Dartmouth, AHMK.

Russula foetens Fr. Middleton. Has a heavy empyreumatic odor, RRG. Pictou county, WPF.

R. brevipes Pk. Lunenburg, MCH.

R. flavida Pk. Lunenburg, MCH.

R. variata Bann. Purple capped Russula, Dartmouth, AHMK.

Craterellus cantharellus (Schw.) Fr. Dartmouth, AHMK.

Marasmius cohærens (Fr.) Bres. Pt. Pl. Park, Halifax, AHMK.

Boletinus porosus Pk. On new made lawn, New Glasgow, WPF.

Boletus piperatus Bull. Common in open fields, Middleton, RRG. New Glasgow, WPF.

B. scaber Fr., var. *fuligineus.* Middleton, edible, RRG. var. *fuscus,* Lunenburg, MCH.

B. ornatipes Pk. Middleton, edible, RRG.

B. subglabripes Pk. Middleton, RRG.

B. versipellis Fr. Common, New Glasgow, WPF.

B. salmonicolor Frost. Dartmouth, spores, 8-9 microns x 3. AHMK.

B. rubinellus Pk. Under conifers, New Glasgow, WPF.

B. unicolor Frost. Lakes, Dartmouth, AHMK.

B. peckii Frost, var. *lævipes.* Pt. Pl. Park, Halifax, AHMK.

B. eximius Pk. Point Pleasant Park, Halifax, AHMK.

B. conicus Rav. Spores 12 x 4 microns, Dartmouth, AHMK.

B. affinis Pk. Waverley, Halifax county, AHMK.

B. purpureus Fr. Dartmouth, AHMK.

B. bovinus L. Lunenburg, MCH. Dartmouth, AHMK.

Polyporus (fomes) ribis Fr. On the bases of old red currant bushes, Dartmouth, AHMK.

P. hispidoides Pk. On dead trunks of *Picea.* New Glasgow, WPF.

P. schweinitsii Fr. Dartmouth, AMHK. Lunenburg, MCH. (*Phæolus sistotremoides* Murrill.)

Hydnum cyathiforme Schæff. Common near Pictou town, in thickets of spruce and fir, CLM.

H. scabrosum Fr. Lunenburg, MCH.

H. graveolens subzonatum Pk. Middleton, RRG.

Phæodon fennicus (Karst.) Hennings. On the ground under conifers. Merigomish, WPF.

Tremellodon gelatinosum Pers. A few specimens were found on decaying firs or spruce lying on mossy ground in the woods above Hartley's Waterfall, Pirate's Cove near Mulgrave, Strait of Canso, Nova Scotia, on the 29th Sept., 1904. Dr. G. U. Hay and AHMK.

The following descriptive note was made on the largest specimen about 36 hours after collection, when it must have shrunken considerable. Pileus white, opal-like, spatulate, spines white, 500 by 600 microns long, 250 to 300 microns broad at the base, from which they taper to the points which are distinctly recurved towards the stipe. Length of specimen 15mm, breadth of the fan-shaped frond 7 mm, and of the stipe 4 mm. Spores 6 to 7 microns in diameter. The whole was shrinking very rapidly while drying and becoming smoky brown and opaque.

Clavaria pistillaris Linn. Middleton, edible, RRG.

C. fusiformis Sow. Middleton, common, edible, RRG.

C. vermicularis Scop. Lunenburg, MCH.

C. ligula Schœff. Growing under conifers. French River and New Glasgow, WPF.

C. mucida Pers. Growing on decaying log. New Glasgow, WPF.

Exidia glandulosa Fr. Middleton, RRG.

Dacromyces stillatus Nees. On railroad ties, Middleton, RRG. New Glasgow, WPF.

Phallus dæmonum Rumph. Lunenburg, MCH.

Bovista pila B. & C. Common, Pictou, WPF.

Lycoperdon wrightii B. & C. Lunenburg, MCH.

Septoria acerina Peck. On leaves of *Acer pensylvanicum,* New Glasgow, WPF.

S. œnotheræ West. On leaves of *Oenothera biennis,* New Glasgow, WPF.

Colletotrichum lindemuthianum (Sacc. and Magnus) Briosi and Cavara. On cultivated beans. New Glasgow, WPF.

Phragmidium subcorticium (Schrank) Wint. Common on *Rosa,* New Glasgow, WPF. On *Rosa blanda,* Pictou, CLM.

Triphragmium clavellosum Berk. On leaves of *Aralia nudicaulis*, New Glasgow and West River, WPF. Pictou, CLM.

Gymnoconia interstitialis (Schlecht) Lagerh. *Cæoma nitens* (Schw.). Sori form orange colored confluent patches on the under side of the leaves of *Rubus strigosus.* Pictou, CLM.

Coleosporium solidaginis (Schw.) Thum. On *Aster patens*. Pictou, CLM.

Melampsora medusæ Thum. On leaves of *Populus grandidentata*. The areas surrounding the sori become almost coal black in color early in autumn. Pictou, CLM.

Peridermium balsameum Peck. The aecidia are white, arranged in two irregular rows on the under side of the leaves. The whole leaf takes on a bleached appearance. I have only found this species occurring at considerable altitudes. Pictou, CLM.

Peridermium decolorans. Peck. On *Picea rubra.* Pictou, CLM.

Peridermium elatinum (A. & S.) K. & S. On *Abies balsamea*, causing the formation of "witches' brooms." Pictou, CLM.

Puccinia suaveolens (Pers.) Rostr. Pictou, appearing throughout spring and summer on the leaves and stems of the Canada thistle. Affected plants appears very rarely to mature seed if at all, CLM. On leaves of *Carduus lanceolatus.* New Glasgow, WPF.

P. taraxaci Plow. On *Taraxacum officinale.* Pictou, CLM.

P. coronata Corda. Common on leaves of *Avena sativa.* Pictou and New Glasgow, CLM, WPF.

P. rubigo-vera (DC.) Wint. On leaves of *Agropyron vulgare.* New Glasgow, WPF.

P. orbicula Peck and Clinton. On *Nabalus.* New Glasgow, WPF.

P. menthæ Pers. On *Mentha.* Piedmont Valley, WPF. Pictou, CLM.

P. circææ Pers. On *Circæa.* French River and New Glasgow, WPF. Saltsprings, Pictou, CLM.

P. cicutæ Larch. On leaves of *Cicuta maculata.* Piedmont Valley, WPF. Pictou, CLM.

P. asteris Duby. Common on *Aster macrophyllum.* Westville, WPF.

P. violæ (Schum.) DC. Common on *Viola.* Pictou, CLM and WPF.

P. claytoniata (Schw.) Syd. On *Claytonia virginica.* Loch Broom, WPF.

Puccinia acuminata Peck. The sori form cushion-like, dark purple spots on the under sides of the leaves of *Cornus canadensis.* On the upper side a corresponding depression marks the position of the sorus. Pictou, CLM.

Puccinia sessilis Perse (?). On *Maianthemum canadense.* Pictou, CLM.

Ustilago levis (Kellerman and Swingle) Magnus. On *Avena sativa,* WPF.

U. nuda (Jensen) Kellerman and Swingle. Common on *Hordeum vulgare,* WPF.

Sphacelotheca hydropiperis (Schum.) DeBary. On *Polygonum sagittatum.* Pictou and Piedmont Valley, WPF.

Entyloma lineatum (Cke.) Davis. On leaves of *Zizania aquatica.* New Glasgow, WPF.

Uromyces trifolii. (Hedw). Lev. On *Trifolium pratense* and *T. repens.* Pictou, CLM.

Uromyces caladii (Schw.) Farlow. On *Arisæma trifolia.* New Glasgow, WPF. Saltsprings, Pictou, CLM.

Chrysomyxa pirolæ (DC.) Rost. Middleton, forming a bright yellow coating on the under surface of the leaf of *Pyrola elliptica,* RRG.

Cystopus candidus (Pers.) Lev. Pictou, common on *Capsella Bursapastoris,* CLM.

Uredo agrimoniæ (DC.) Schrœt. Common on leaves of *Agrimonia eupatoria,* WPF. Saltsprings, Pictou, CLM.

Cercospora callæ Peck and Clinton. On leaves of *Calla palustris.* New Glasgow, WPF.

C. leptosperma Peck and Clinton. On the leaves of *Aralia nudicaulis.* New Glasgow, WPF.

Cladosporium herbarum (Pers.) Link. On decaying fungi. New Glasgow, WPF.

Sepedonium chrysospermum (Bull.) Fr. Common on Boleti, (Conidial stage of *Hypomyces chrysospermus*), WPF.

Empusa muscæ Cohn. Pictou, common everywhere on the house fly, more particularly during the autumn months, CLM.

Sporodina grandis Link. Pictou and New Glasgow on decaying *Boleti,* WPF.

Onygena equina (Wild) Pers. Growing on the hoofs of horses. New Glasgow, WPF.

Sphærotheca castagnei Lev. Collected at Pictou 28th Aug., 1905, on *Bidens frondosa*; and 21st Sept., 1905, on *Taraxacum officinale*, CLM.

Phyllactinia suffulta (Reb.) Sacc. Pictou, 2nd Oct., 1905, on leaves of *Alnus incana,* CLM.

Uncinula salicis DC. Collected at Pictou, 15th Sept., 1905, on species of *Salix*, probably *discolor,* CLM.

U. circinata C & P. Pictou, 10th Oc., 1905, on leaves of *Acer rubrum,* CLM

Podosphæra oxyacantha. Pictou, on *Spiræa salicifolia.* Noted on *S. tomentosa,* CLM.

Microsphæra alni D. C. Pictou, very common on Lilac, the mycelium appearing in July and spores maturing in August and until late in the fall. Also common on *Alnus incana,* 2nd Oct., 1905; and on *Viburnum cassinoides,* CLM. On leaves of *Syringa vulgaris*, New Glasgow and Pictou, WPF.

M. erineophila Peck. Collected near Saltsprings, Pictou county, 10th August, 1905, on leaves of *Fagus ferruginea* affected with leaf mites, CLM.

M. vaccinii (Schw.) Pictou, 3rd Oct., 1905, on *Gaylussacia resinosa;* 1st Oct., 1905, on *Epigæa repens*, CLM.

Erysiphe communis Wall. Collected at Pictou, 29th Aug., 1905, on *Oenothera biennis, Ranunculus acris, and R. repens,* CLM.

E. cichoracearum DC. Collected at Pictou, 23rd Sept., 1905, on various species of *Solidago,* CLM.

E. galeopsides DC. Pictou, 10th Aug., 1905, near Saltsprings on *Chelone glabra.* Common on this host in shaded situations and on the lower shaded leaves of plants growing closely together, CLM.

E. aggregata Peck. Collected at Pictou, 25th Aug., 1905, Very common on the fertile aments of *Alnus incana*—as many as two-thirds of them being affected over considerable districts. Spores were forming at date of collection but were not mature. Spores mature about May of the spring following. *Alnus viridis* does not seem to be so susceptible to its attacks, CLM.

Helvella crispa Fr. Middleton, RRG.

Geopyxis carbonaria (A. & S.) Sacc. Middleton, RRG.

Peziza vesiculosa Bull. Middleton, RRG.

Chlorosplenium æruginosum Tul. Pictou county. Ascocarps on rotting trunks of *Fagus ferruginea,* 3rd Sept., 1905. Also on decaying *Alnus incana.* The fructification of this species is said to be rather uncommon, CLM. Middleton, commonly occurring on rotten wood giving it a green color and making it phosphorescent, RRG.

Exoascus robinsonianus Giesenhagen. Deforming the bracts in the pistillate aments of *Alnus incana.* Very common, WPF.

Elaphomyces cervinus (Pers.) Schroter. Pictou, under beech trees; parasitized by *Cordyceps ophioglossoides,* CLM. Subterranean at the base of pine stump, Pictou WPF.

Claviceps purpurea Fr. Pictou, on barley, 2 Oct., 1905, CLM. On *Agroyprum repens,* New Glasgow, WPF.

Cordyceps ophioglossoides Ehr. Collected at Pictou, 23rd Sept., 1905, growing in leaf mould under beech trees in a subterranean fungus probably a species of *Elaphomyces,* CLM. Parasitic on *E. cervinus,* Pictou, WPF.

Hypomyces viridis (Albertini and Schweinitz). Middleton, rare. The same as *H. luteo-virens.* Identified by Prof. W. G. Farlow, Cambridge, Mass., U. S. A. The host in this case was not determined with certainty, but it appeared to be *Hygrophorus pudorinus* Fr. The gill surface only was attacked, becoming a dark green.

Xylaria polymorpha Grev. Pictou, collected in August and September, and at Saltsprings. Appears here to grow exclusively on rotting *Fagus ferruginea* on which it occasionally becomes very abundant, CLM. Middleton, RRG.

Daldinia concentrica (Bolton) Ces. and DeNot. On dead *Ulmus americanus*, New Glasgow, WPF.

Phyllachora graminis (Pers.) Fckl. On *Agropyrum repens* New Glasgow, WPF.

Dothidea pteridis Fr. On *Pteris aquilina*, near Yarmouth, by Miss E. Chesley Allen, AHMK.

Dimerosporium collinsii (Schw.) Collected at Pictou 10th Sept., 1905, on leaves of *Amelanchier canadensis*. The affected leaves frequently persist on the branches through the winter and spores mature in May of the following spring.

Podospora amphicornis Ell. Collected 10th Aug., 1905, on rabbits' dung at Saltsprings, Pictou county, CLM.

The Myxomycetes.

Mr. C. L. Moore, M. A., published in *The Bulletin of the Pictou Academy Scientific Association,* Vol. I., No. 1, June, 1906, a list and general sketch of *thirty-three* species of *Myxomycetes,* under the title, "The Myxomycetes of Pictou County," Nova Scotia. A monograph of the Myxomycetes of Pictou County by Mr. Moore, may appear soon in the Transactions of the Institute; so that there will be no advantage in the enlargement of the present list to contain a reprint of the list of 1906.

Species Previously Reported but Found in New Localities, with Notes.

Amanita vaginata Bull. *Amanitopsis vaginata* (Bull) Roz. Middleton, generally mouse colored, but often variable; a yellowish brown form occurring in this vicinity; also the deadly poisonous *A. phalloides,* common in woods, RRG.

Lunenburg, MCH, and also *verna, cæsarea,* and *muscaria.* New Glasgow, *vaginata, verna,* and *muscaria,* WPF.

Armillaria mellea Vahl. Common on decaying stumps, especially of *coniferæ,* in the neighbourhood of Halifax, Pictou, Middleton, AHMK and RRG. Lunenburg, MCH.

Tricholma equestre, sejunctum and *columbetta.* Lunenburg. MCH.

Clitocybe laecata Scop. Common near Halifax. (Var. *striatula*), Pictou and Middleton. Variable, not poisonous, RRG and AHMK.

Clitocybe nebularis, candicans and *multiceps.* Lunenburg, MCH.

C. clavipes Pers. Shelburne, CSB. Middleton, RRG.

C. infundibuliformis Schæff. Pictou, September, CLM.

Pleurotus serotinus Schrad. Edible. Middleton, RRG. Truro, JMS. Pictou, AHMK. Lunenburg, MCH.

P. lignatilis Pers. Lunenburg, MCH.

Collybia platyphylla and *dryophila.* Lunenburg, MCH. *C. radicata,* New Glasgow, WPF.

Mycena galericulata Scop. Lunenburg, MCH.

Omphalia umbellifera L. Lunenburg, MCH.

Pluteus cervinus Schdæff. Edible, Middleton, RRG, Halifax, JS.

Naucoria pediades Fr. Lunenburg, MCH.

Psalliota campestris, Stropharia semi-globata, and *Hypholoma sublateritium.* Lunenburg, MCH.

Psylocybe fœnisecii P. Willow Park, Halifax, JS. Glace Bay, Cape Breton, N.S., R. A. H. MacKeen, M. D. This latter species was identified by C. H. Peck, State botanist, of New York, to whom I referred it after receiving it with a communication containing the following information from Dr. MacKeen:—

"Early this week I was called to attend three children ranging in age from 3.5 to 4.5 years. The history I obtained was practically the same in each case.

"The parents noticed a staggering gait, inability to talk, and a tendency to laugh in a hysterical way. When I saw the patients some time had elapsed from the appearance of the first symptoms. There was a marked dilation of the pupils, flushed face, inability to stand, restlessness, occasionally an idiotic laugh. The appearance was one of intoxication. The children lived some distance apart but had been playing in the backyard when taken sick. There was practically nothing alarming as pulse, temperature and respiration were normal. The whole impression seems to have been made on the nervous system.

"The appearance was suggestive of belladonna poisoning, but as there was no way of their obtaining that plant, we had to look elsewhere. The mother of one patient handed me a mushroom or toadstool which he had brought her, saying it was 'good to eat berries." This looked like evidence of the infant's having eaten of this fungus. The other children, I learned subsequently, had been playing among the same fungi. What puzzles me is that I have always understood this class of poisons produced gastro-intestinal irritation, vomiting and purging. Not only were these symptoms absent, but it was extremely difficult to provoke vomiting. Happily, after a few hours the symptoms passed away, leaving no after effects."

This description was written on the 21st of September, 1905, and a week or two later, Mr. Peck wrote as follows:

"The specimens of mushroom sent are in my opinion a small form of *Psilocybe fœnisecii* (Pers.) Fr., called the Mowers' mushroom or Haymakers' mushroom. It is usually found growing among grass in meadows, pastures or lawns. I have eaten it when cooked and regard it as an edible species, having never experienced any ill effects from it. It is not pleasant in flavor when raw, and I would not think children would eat enough of it in the raw state to produce any ill effects."

This genus of fungi has purple-brown spores, but when old is not easily distinguished from others of similar habit such as

Panæolus which is black spored, and *Stropharia* which is reddish spored. The spores of the Glace Bay specimens were rather larger than the measurements given of *Psilocybe* by M. C. Cooke; so that it may not be identical with the species reported from elsewhere. Cook's measurements give the size about 10 x 6.25 microns, while those of our species varied from 13 x 8 to 14 x 9 microns. Again, although the cooked fungus might be safe, the uncooked might be deleterious. In order to stimulate the observation and recording of experiments on these fungi I report some of the observations already made on the genera referred to above. Of *Panæolus campanulatus* MacIlvane says:

"Mr. R. K. Macadam, Boston, Mass., informs me that he has information of a case of poisoning by this fungus. 'The victim experiences dizziness, dimness of vision, trembling and loss of power and memory. He recovered after simple treatment, and was well inside 24 hours.' A full account of this case is to be found in 'The London Medical and Surgical Journal,' vol. 36, Nov., 1816. The poison acts as a sedative. I have several times eaten of this fungus in small quantities, because larger could not be obtained, and with no other than pleasant effect. There does not appear to be any case of poisoning reported of it since 1816, which, considering the inquisitiveness of man, is singular. Caution is advised."

With respect to the nearly related species, *Panæolus papilionaceus,* MacIlvane says:

"The effects of eating this fungus are very uncertain. I have seen it produce hilarity in a few instances, and other mild symptoms of intoxication, which were soon over and with little reaction. Many personal testings have been made without effect. Testing upon others vary with the individuals. It is not dangerous, but should be eaten with caution. Being of small size, and not a prolific species, quantities of it are difficult to obtain. Moderate quantities of it have no effect whatever."

Of the reddish spored *Stropharia,* he says:

"The entire genus has been under a cloud. Writers upon it assert some of its members to be dangerously poisonous. So far as carefully tested by the writer (MacIlvane) no doubtful species has been encountered, and one *(S. semiglobata)* has been eaten by himself and friends since 1881, notwithstanding its dangerous reputation."

It was Sowerby who drew attention to the above discussed species as dangerous, and intimated that in one case it had been fatal. A near relative of the Glace Bay species, *Psylocybe semilanceata,* a dark-purple spored agaric of the same general appearance, has its spores nearly of the same size. And, according to M. C. Cooke, a careful English authority, it has a dangerous reputation, having been said to have proved fatal to children when eaten raw. MacIlvane says it is not deleterious when cooked.

As there is much to learn yet about the effects of eating the different species of our fungi, it is hoped that all well attested experiences may be reported for publication and record. A fatal case of poisoning was reported from the neighborhood of Kentville the previous year; but the species were not known. The victim was an old man who had collected them for his supper, which it is presumed he had often done before. The symptons were those of *Amanita* poisoning, and the accidental inclusion of one specimen in the collection would have been sufficient to account for the results.

This case was thus described in a communication from W. B. Moore, M. D., on the 11th August, 1904:

"Mr. M., a farmer age 62 years, came home from his work late in the evening, apparently in good health, and very hungry. On his way home he hastily gathered a lot of mushrooms, and as hastily prepared them, with the assistance of his old wife (no one else living in the house) for supper with meat, etc. He ate them all, the old lady not partaking, and soon afterwards developed marked symptoms of poisoning from an irritant and depressing agent. There was severe pain and distress in stomach and bowels, with vomiting and rapid exhaustion accompanied by abdominal distension, drawn features and haggard countenance with clammy and cold skin, subnormal temperature and cardiac failure, suppression of urine and paralysis of bowels. Although eliminative and supportive measures were used thoroughly it was impossible to prevent death, which occurred in about 33 hours from the time he ate the supper—apparently from paralysis of the heart from the effects of some toxic agent.

"Ptomaines might produce a similar train of symptoms, but there was no evidence to show that the food he ate had undergone any decomposition likely to produce poisonous alkaloids. I think the most reasonable assumption is that some poisonous fungus was included in the lot he gathered, although this cannot be proven as the fungi were eaten. The old lady could not give a clear idea of the different kinds which might have been present.

"I saw a somewhat similar case a few years ago, in which the man recovered; and in this case it was also impossible to demonstrate the kind or kinds of mushrooms eaten. As I have seen only these two cases during a period of more than twenty years in general practice, in a community in which large quantities of mushrooms are consumed, I assume that the poisonous fungi are few and far between in this region of the province; for I think there is doubtless much carelessness among people in the matter of selection."

Panæolus retirugis Fr. Edible, Middleton, RRG. Antigonish, JMS.

Panæolus campanulatus L. Lunenburg, MCH.

Coprinus comatus Fr. Middleton, RRG. Common throughout the province, and one of the most valuable edible species, AHMK. Lunenburg, MCH.

C. micaceus (Bull.) Fr. Middleton, RRG. New Glasgow, WPF.

C. plicatilis Fr. Lunenburg, MCH.

Cortinarius violaceus (L) Fr. Middleton, edible with an earthy flavor, RRG. Reported in "provisional list" from other parts of the province, AHMK.

C. albo-violaceus and *cinnamomeus*. Lunenburg, MCH.

Lactarius resimus Fr. Middleton, rather common in pine woods, RRG. Antigonish, JMS.

L. lignyotus Fr. Middleton, RRG. Pennant, Halifax, JS. The "bright crimson surface resembling fine silk plush" reported by Dr. John Somers and quoted in the "provisional list" of 1902, has not been observed by any other collector, and is supposed to be an accidental error.

L. vellereus Fr. Lunenburg, MCH.

L. piperatus Fr. Middleton, RRG.

L. subdulcis Fr. Middleton, extremely variable. RRG.

Russula heterophylla Fr. Dartmouth, AHMK. Shelburne, CSB. Lunenburg, MCH. MacIlvane has eaten specimens cooked repeatedly without harm. RRG.

R. adusta, depallens and alutacea. Lunenburg, MCH.

Cantharellus cibarius, aurantiacus and *floccosus*. Lunenburg, MCH; *cibarius*, New Glasgow, WPF.

Panus stypticus Fr. Middleton, common on stumps, tastes unpleasant in the throat, RRG. New Glasgow, WPF.

Schizophyllum commune Fr. Lunenburg, MCH. Middleton, RRG. New Glasgow, WPF.

Lenzites sepiaria Fr. Middleton, RRG. Lunenburg, MCH. *L. abietina* Fr. New Glasgow, WPF.

L. betulina Fr. Lunenburg, MCH.

Boletus cavipes Kalchb.—(*Boletinus pictus*). Pt. Pl. Park, Halifax, AHMK; also at New Glasgow, WPF.

B. clintonianus, luteus, subluteus, edulis (*claviceps*). Lunenburg, MCH; also at New Glasgow, *americanus, granulatis, chrysanteron, chromapes* and *felleus*, WPF.

B. felleus Bull. Pt. Pl. Park, Halifax, spores 14-15 x 4 microns, AHMK.

Polyporus lucidus Fr. (*Ganoderma tsugæ* Murrill). Middleton, RRG. Lunenburg, MCH. New Glasgow, WPF; also *picipes*.

P. sulphureus Fr. Cow Bay, on decaying coniferous stump Halifax county, AHMK.

P. albellus Pk. Middleton, RRG.

P. fomentarius Fr. Middleton, common, RRG. Lunenburg, MCH. (*Coltricia*, Murrill). New Glasgow, WPF.

P. epileucus Fr. Lunenburg, MCH.

P. chioneus Fr. Middleton, RRG. Lunenburg, MCH.

P. applanatus Fr. Middleton, RRG. Lunenburg, MCH. New Glasgow and Pictou, WPF.

P. circinatus Fr. Middleton, RRG. Lunenburg, MCH.

P. betulinus Fr. Middleton, common on birch, RRG. New Glasgow, WPF.

P. elegans Fr. Lunenburg, MCH.

P. brumalis Fr. Middleton,RRG. Lunenburg, RRG. New Glasgow, WPF.

P. perennis Fr. and *cinnamomeus* (Jacq.) Sac. Lunenburg, MCH. (*Coltricia*, Murrill). New Glasgow, WPF.

P. versicolor Fr. *Polystictus versicolor*, Middleton, very common, RRG. Lunenburg, MCH.

P. abietinus Fr. Lunenburg, MCH.

P. hirsutus Fr. Middleton. RRG. Lunenburg, MCH. New Glasgow, WPF; also *pinicola* (Swartz) Fr., *pergamenus Fr., cinnabarinus, ignarius* and *Favolus europæus*.

Dædalia confragosa P. Lunenburg, MCH. New Glasgow, WPF; also *quercina* and *unicolor.*

Hydnum imbricatum L. Middleton, RRG. New Glasgow, WPF.

H. zonatum. Lunenburg, MCH.

H. repandum L. Middleton, RRG. Lunenburg, MCH.

Hydnum coralloides Scop. Mt. Thom, Pictou Co., on *Fagus ferruginea,* CLM. Lunenburg, MCH.

Stereum hirsutum Fr. Middleton, RRG.

Clavaria cinerea Bull. Middleton, RRG. Lunenburg, MCH.

C. botrytis, cristata, rugosa and stricta. Lunenburg, MCH.

C. aurea Schæff. Dartmouth, AHMK.

Clavaria coralloides L. Pictou, September, on ground, CLM.

Tremella lutescens Fr. Lunenburg, MCH.

Hirneola auricula-judæ Pk. New Glasgow, WPF.

Cyanophallus caninus Fr. Lunenburg, MCH.

Lycoperdon gemmatum Fr. Middleton, RRG. Pictou, LCH. Lunenburg, MCH. New Glasgow, WPF.

L. pyriforme Schæff. Lunenburg, MCH.

Scleroderma vulgare Fr. Lunenburg, MCH. New Glasgow, WPF.

Crucibulum vulgare Tul. On decaying trunks of deciduous trees, Pictou, CLM. New Glasgow, WPF.

Puccinia graminis Pers., *Ustilago tritici* Jen., *U. avenæ Jen.* New Glasgow, WPF. Pictou, on wheat and oats, CLM.

Ascophora mucedo Tode = *Mucor mucedo* L. = *Rhizopus nigricans* Ehrenb. (The common black mould of bread, &c.). Common, Halifax, Pictou, &c., AHMK, CHM, and WPF.

Morchella conica Pers. Middleton, RRG.

Gyromitra esculenta Fr. Middleton, common, May in sandy soil under pines, and reputed poisonous, RRG. Dartmouth, AHMK.

Mitrula vitellina Sac., var. *irregulare* Pk. Near Dartmouth, AHMK. Pictou, CLM. Lunenburg, MCH.

Spathularia velutipes Cook & Farlow. Middleton, RRG.

Leotia lubrica Pers. Lunenburg, MCH.

Peziza badia P. Middleton, RRG.

Hypomyces lactifluorum (Schw.) Tul. Middleton, common, RRG. Pictou, common, CLM.

Scorias spongiosa (Schw.) Fr. Specimen growing on alder found near Halifax by Mr. Harry Piers, within a few weeks ago, reported previously from Bedford Range and Yarmouth.

APPENDIX I.

LIST OF MEMBERS, 1906-07.

ORDINARY MEMBERS.

	Date of Admission.
Bayer, Rufus, Halifax	March 4, 1890
Bishop, Watson L., Supt. of Water Works, Dartmouth, N. S.	Jan. 6, 1890
Bowman, Maynard, B. A., Public Analyst, Halifax	March 13, 1884
Brown, Richard H., Halifax	Feb. 2, 1903
Budge, Daniel, General Supt. Halifax & Bermuda Cable Co., Halifax	Oct. 30, 1903
*Campbell, Donald A., M. D., Halifax	Jan. 31, 1890
Campbell, George Murray, M. D., Halifax	Nov. 10, 1884
Colpitt, Parker R., City Electrician, Halifax	Feb. 2, 1903
*Davis, Charles Henry, C. E., New York City, U. S. A	Dec. 5, 1900
Dixon, Prof. Stephen Mitchell, B. A., B. A. I., University of Birmingham, Birmingham, England	April 8, 1902
Doane, Francis William Whitney, City Engineer, Halifax	Nov. 3, 1886
Donkin, Hiram, C. E., Deputy Com. of Mines, Halifax	Nov. 30. 1892
Egan, Thomas J., Halifax	Jan. 6. 1890
Fearon, James, Principal, Deaf and Dumb Institution, Halifax	May 8, 1894
*Forbes, John, Moncton, N. B	March 14 1883
*Fraser, C. Frederick, LL. D., Principal, School for the Blind, Halifax	March 31 1890
Freeman, Philip A., engineer, Hx. Elec. Tramway Co., Hx.	Nov. 6, 1906
Gates, Herbert E., Architect, Halifax	April 17, 1899
Hattie, William Harrop, M. D., Supt. N. S. Hospital, Dartmouth	Nov. 12, 1892
Hayward, A. A., Halifax	Nov. 7, 1905
Irving, G. W. T., Education Dept., Halifax	Jan. 4, 1892
Jack, Prof. Ernest Brydone, M. A., C. E. Dalhousie College, Halifax	Nov. 7, 1905
Johnston, Harry W., C. E., Asst. City Engineer, Halifax	Dec 31, 1894
*Laing, Rev. Robert, Halifax	Jan. 11, 1885
McCarthy, Prof. J. B., B. A., M. SC., King's College, Windsor, N. S	Dec. 4, 1901
McColl, Roderick, C. E., Provl. Engineer, Halifax	Jan. 4, 1892
Macdonald, Simon D., F. G. S., Halifax	March 14, 1881
*MacGregor Prof. James Gordon, M. A., D. SC., F. R. S., F. R. S. C., Edinburgh University, Edinburgh, Scotland	Jan. 11, 1877
McInnes, Hector, LL. B., Halifax	Nov. 27, 1889
*McKay, Alexander, Supervisor of Schools, Halifax	Feb. 5, 1872
*MacKay, Alexander Hector, B. A., B. SC., LL. D., F R. S. C., Superintendent of Education, Halifax	Oct.. 11, 1885
MacKay, Prof. Ebenezer, PH. D., Dalhousie College, Halifax	Nov. 27, 1889
*MacKay, George M. Johnstone, Dartmouth, N. S	Dec. 18, 1903
MacKenzie, Prof. Arthur Stanley, PH. D., Dalhousie College, Halifax	Nov. 7, 1905
McKerron William, Halifax	Nov. 30, 1891

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*Life Members.

	Date of Admission.
Marshall, Gilford R., Principal, Compton Avenue School, Halifax	April 4, 1894
Morton, S. A., M. A., County Academy, Halifax	Jan. 27, 1893
Murphy, Martin, C. E., D. SC., I. S. O., Saskatoon, Sask	Jan. 15, 1870
Murray, Prof. Daniel Alexander, Ph. D., Dalhousie College, Halifax	Dec. 18, 1903
Piers, Harry, Curator Provincial Museum and Librarian Provincial Science Library, Halifax	Nov. 2, 1888
*Poole, Henry Skeffington, A. M., ASSOC. R. S. M., F. G. S., F. R. S. C., M. CAN. SOC. C. E., HON. MEM. INST. M. E., Halifax	Nov. 11, 1872
Read, Herbert H., M. D., L. R. C. S., Halifax	Nov. 27, 1889
*Robb, D. W., Amherst, N. S	March 4, 1890
Rutherford, John, M. E., Halifax	Jan. 8, 1865
Sexton, Prof. Frederic H., Director of Technical Education, Halifax	Dec. 18, 1903
*Smith, Prof. H. W., B. SC., Agricultural School, Truro, N. S.; Assoc. Memb., Jan. 6, 1890	Dec. 1900
*Stewart, John, M. B. C. M., Halifax	Jan. 12, 1885
Wheaton, L. H., Chief Engineer, Coast Railway Co., Yarmouth, N. S	Nov. 29, 1894
Wilson, Robert J., Secretary, School Board, Halifax	May 3, 1889
Winfield, James H., Manager, N. S. Telephone Co., Halifax	Dec. 18, 1903
Woodman, Prof. J. Edmund, M. A., D. SC., School of Mining and Metallurgy, Dalhousie College, Halifax	Dec. 3, 1902
*Yorston, W. G., C.E., City Engineer, Sydney, C. B	Nov. 12, 1892

ASSOCIATE MEMBERS.

Archibald, Monro, B. A., B. SC., Truro, N. S.	Nov. 7, 1905
*Caie, Robert, Yarmouth, N. S	Jan. 31, 1890
*Dickenson, S. S., Commercial Cable Co., New York, U. S. A	March 4, 1895
Edwards, Arthur M., M. D., F. L. S., Newark, N. J	Dec. 12, 1898
Gates, Reginald R., University of Chicago, Chicago, Ill., U. S. A.	Feb. 2, 1903
Haley, Prof. Frank R., Acadia College, Wolfville, N. S	Nov. 5, 1901
Harlow, L. C., B. SC., Prov. Normal School, Truro, N. S	March 23, 1905
Haycock, Prof. Ernest, Acadia College, Wolfville, N. S	May 17, 1899
Hunton, Prof. S. W., M. A. Mount Allison College, Sackville, N. B	Jan. 6, 1890
Jaggar, Miss A Louise, Cambridge, Mass	Dec. 5, 1900
James, C. C., M. A., Depy. Min. of Agriculture, Toronto, Ontario	Dec. 3, 1896
Jennison, W. F., Sydney, C. B	May 5, 1903
*Johns, Thomas W., Yarmouth, N. S	Nov. 27, 1889
*Keating, E. H., C. E., Toronto Ry. Co., Toronto Ont.; Ord. Memb. April 12, 1882	April 11, 1900
Lawrence, H., D. D. S., Wolfville, N. S	March 9, 1903
McIntosh, Kenneth, St. Peters, C. B.; Ord. Memb., Jan. 4, 1892	June 1900
*MacKay, Hector H., M. D., New Glasgow, N. S	Feb. 4, 1902
McKenzie, W. B., C. E., Moncton, N. B	March 31, 1882
McLeod, R. R., Brookfield, N. S	Dec. 3, 1897
Magee, W. H., PH. D., Annapolis, N. S	Nov. 29, 1894
Matheson, W. G., New Glasgow, N. S	Jan. 31, 1890
Payzant, E. N., M. D., Wolfville, N. S	April 8, 1902
Pineo, Avard V., LL. B., Kentville, N. S	Nov. 5, 1901
*Reid, A. P., M. D., L. R. C. S., Middleton, Annapolis Co., N. S	Jan. 31, 1890
*Robinson, C. B., B.A., New York Botanical Garden, New York, U. S. A.	Dec. 3, 1902
*Rosborough, Rev. James, Musquodoboit Harbour, N. S	Nov. 29, 1894
Russell, Prof. Lee, B. S., Worcester, Mass	Dec. 3, 1896
Sawyer, Prof. Everett W., Acadia College, Wolfville, N. S	Feb. 6, 1901

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*Life Members.

CORRESPONDING MEMBERS.

Ami, Henry M., D. Sc., F. G. S., F R. S. C., Geological Survey, Ottawa, Ontario	Jan. 2, 1892
Bailey, Prof. L. W., Ph. D., LL. D., F. R. S. C., Fredericton, N. B	Jan. 6, 1890
Ball, Rev. E. H., Tangier, N. S.	Nov. 29, 1871
Bethune, Rev. Charles J. S., M. A., D. C. L, F. R. S. C, Ontario Agricultural College, Guelph, Ont	Dec. 29, 1868
Cox, Philip, B. Sc., Ph. D., Chatham, N. B	Dec. 3, 1902
Dobie, W. Henry, M. D., Chester, England	Dec. 3, 1897
Ells, R. W., LL. D., F. G. S. A., F. R. S. C., Geological Survey, Ottawa, Ont	Jan. 2, 1894
Faribault, E. Rodolphe, B. A., B. Sc., Geological Survey of Canada, Ottawa; Assoc. Memb., March 6, 1888	Dec. 3, 1902
Fletcher, Hugh, B. A., Geological Survey, Ottawa, Ontario	March 3, 1891
Fletcher, James, LL. D., F. L. S, F. R. S. C., Entomologist and Botanist, Central Exp. Farm, Ottawa, Ontario	March 2, 1897
Ganong, Prof. W. F., B. A., Ph. D., Smith College, Northampton, Mass., U. S. A	Jan. 6, 1890
Hardy, Maj.-General Campbell, R. A., Dover, England. (Originally admitted Jan. 26, 1863)	Oct. 30, 1903
Harrington, W. Hague, F. R. S. C., Post Office Department, Ottawa	May 5, 1896
Hay, George U., D. Sc, F. R. S C., St. John, N. B	Dec. 3, 1902
Litton, Robert T., F. G. S., Melbourne, Australia	May 5, 1892
McSwain, John, Charlottetown, P. E. I	Dec. 3, 1902
Matthew, G. F., M. A., D. Sc., F. R. S. C., St. John, N. B	Jan. 6, 1890
Maury, Rev. Mytton, D. D., Ithaca, N. Y., U. S. A	Nov. 30, 1891
Mowbray, Louis L., Hamilton, Bermuda	May 3, 1907
Peter, Rev. Brother Junian, Fall River, Mass., U. S. A	Dec. 12, 1898
Pickford, Charles, Halifax	March 2, 1900
Prest, Walter Henry, M. E, Webbwood, Ont; Assoc. Memb., Nov. 29 1894,	Nov. 2, 1900
Prichard, Arthur H. Cooper	Dec. 4, 1901
Prince, Prof. E. E., Commissioner and General Inspector of Fisheries, Ottawa, Ontario	Jan. 5, 1897

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* Life Members.

LIST OF PRESIDENTS

OF THE NOVA SCOTIAN INSTITUTE OF NATURAL SCIENCE, AFTERWARDS THE NOVA SCOTIAN INSTITUTE OF SCIENCE, SINCE ITS FOUNDATION IN 1862.

	Term	*of*	*Office.*
Hon. Philip Carteret Hill, D. C. L.	31 Dec. 1862	to	26 Oct. 1863
John Matthew Jones, F. L. S., F. R. S. C.	26 Oct. 1863	"	8 Oct. 1873
John Bernard Gilpin, M. A., M. D., M. R. C. S.	8 Oct. 1873	"	9 Oct. 1878
William Gossip	9 Oct. 1878	"	13 Oct. 1880
John Somers, M. D.	13 Oct. 1880	"	26 Oct. 1883
Robert Morrow	26 Oct. 1883	"	21 Oct. 1885
John Somers, M. D.	21 Oct. 1885	"	10 Oct. 1888
Prof. James Gordon MacGregor, M. A., D. SC., F.R.S., F.R.S.C.	10 Oct. 1888	"	9 Nov. 1891
Martin Murphy, C. E., D. SC., I. S. O.	9 Nov. 1891	"	8 Nov. 1893
Prof. George Lawson, PH. D., LL. D., F. I. C., F. R. S. C.	8 Nov. 1893	"	10 Nov. 1895
Edwin Gilpin, Jr., M. A., LL. D., D. SC., F. G. S., F. R. S. C., I.S.O.	18 Nov. 1895	"	8 Nov. 1897
Alexander McKay	8 Nov. 1897	"	20 Nov. 1899
Alexander Howard MacKay, B. A., B. SC., LL. D., F. R. S. C.	20 Nov. 1899	"	24 Nov. 1902
Henry Skeffington Poole, M. A., D. SC., A. R. S. M., F. G. S., F. R. S. C.	24 Nov. 1902	"	18 Oct. 1905
Francis William Whitney Doane, C. E.	18 Oct. 1905	"	11 Nov. 1907
Prof. Ebenezer MacKay, PH. D.	11 Nov. 1907	"	——

NOTE—Since 1879 the presidents of the Institute have been *ex-officio* Fellows of the Royal Microscopical Society.

The first general meeting of the Nova Scotian Institute of Natural Science was held at Halifax, on 31st December, 1862. On 24th March, 1890, the name of the society was changed to the Nova Scotian Institute of Science, and it was incorporated by an act of the legislature in the same year.

Stewart Wallace
75¢