
THE · ROYAL · SOCIETY · OF · CANADA · 1882
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DU

CANADA

TROISIÈME SÉRIE—TOME XV

SÉANCE DE MAI 1921

EN VENTE CHEZ
J. HOPE ET FILS, OTTAWA; LA CO. COPP-CLARK (Limitée), TORONTO
BERNARD QUARITCH, LONDRES, ANGLETERRE
1921

PROCEEDINGS

AND

TRANSACTIONS

OF

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OF

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1921

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1903-1904	Col. G. T. Denison, B.C.L.
1904-1905	Benjamin Sulte, LL.D.
1905-1906	Dr. Alex. Johnson,
1906-1907	Dr. William Saunders C.M.G.
1907-1908	Dr. S. E. Dawson, C.M.G.
1908-1909	Dr. J.-Edmond Roy
1909-1910	Rev. Geo. Bryce, LL.D.
1910-1911	R. Ramsay Wright, M.A., B.Sc.
1911-1912	W. F. King, LL.D., C.M.G.
1912-1913	W. Dawson LeSueur, B.A., LL.D.
1913-1914	Frank D. Adams, Ph.D., F.R.S., F.G.S.
1914-1915	Sir Adolphe-B. Routhier
1915-1916	Alfred Baker, M.A., LL.D.
1916-1917	A. B. Macallum, Ph.D., F.R.S.
1917-1918	W. D. Lighthall, M.A., B.C.L., F.R.S.L.
1918-1919	Hon. Rodolphe Lemieux, LL.D.
1919-1920	R. F. Ruttan, M.D., C.M., D.Sc.
1920-1921	A. P. Coleman, M.A., Ph.D., F.R.S.
1921-1922	Duncan Campbell Scott, Litt.D.

LIST OF ASSOCIATED SOCIETIES

Ontario

Hamilton Association for the Promotion of Science, Literature and Art.
The Hamilton Scientific Society.
L'Institut canadien-français d'Ottawa.
The Women's Wentworth Historical Society.
The Entomological Society of Ontario.
Women's Canadian Historical Society of Ottawa.
Elgin Historical and Scientific Institute.
Women's Auxiliary of the Elgin Historical and Scientific Institute.
Ontario Historical Society.
The Huron Institute.
Niagara Historical Society.
The Ottawa Field Naturalists' Club.
Royal Astronomical Society of Canada.
Canadian Institute, Toronto.
Historical Society, Kingston.
Toronto Astronomical Society.
Lundy's Lane Historical Society.
Women's Canadian Historical Society of Toronto.
United Empire Loyalists' Association of Canada.
Peterborough Historical Society.
Canadian Forestry Association.
Hamilton Ladies' College Alumnæ.
Club littéraire canadien-français d'Ottawa.
The Historic Landmarks Association of Canada.
Waterloo Historical Society.

Quebec

Société du Parler français au Canada, Québec.
Société de Géographie de Québec.
Société d'Economie sociale et politique de Québec.
The Quebec Society for the Protection of Plants from Insects and Fungus Diseases.
The Antiquarian and Numismatic Society of Montreal.
L'Institut canadien de Québec.
Natural History Society of Montreal.
Microscopical Society, Montreal.
Société historique de Montréal.
Cercle littéraire et musical de Montréal.
Literary and Historical Society, Quebec.

British Columbia

The Natural History Society of British Columbia.

Nova Scotia

The Nova Scotia Historical Society.
The Nova Scotian Institute of Science.

Manitoba

Manitoba Historical and Scientific Society.

New Brunswick

New Brunswick Historical Society.
New Brunswick Loyalists' Society.
Miramichi Natural History Association.
Natural History Society of New Brunswick.

THE ROYAL SOCIETY OF CANADA

PROCEEDINGS FOR 1921

FORTIETH GENERAL MEETING

SESSION I.—(*Wednesday, May 18.*)

The Royal Society of Canada held its fortieth annual meeting in the Victoria Memorial Museum, Ottawa, on May 18, 19 and 20.

The President, Dr. A. P. Coleman, took the chair at 10 a.m. and, having called the meeting to order, requested the Honorary Secretary to call the roll.

The following Fellows answered to their names or arrived later during the session.

OFFICERS OF THE SOCIETY

President..................Dr. A. P. Coleman.
Vice-President and Hon. Sec...Dr. Duncan C. Scott
Honorary Treasurer..........Mr. C. M. Barbeau.
Honorary Librarian..........Dr. D. B. Dowling.

SECTION I.—Auclair, E. J.; Barbeau, C. M.; Caron, I.; Chapais, Thos.; Chartier, Emile; Chouinard, H. J. J. B.; David, L. O.; DeCelles, A. D.; Delâge, C. F.; Gérin, L.; Lemieux, Rodolphe; Mignault, P.B.; Morin, Victor; Myrand, Ernest; Rinfret, Fernand; Roy, Pierre-Georges; Roy, Camille; Rivard, A.; Sulte, Benjamin.

SECTION II.—Brett, G. S.; Bryce, George; Burpee, L. J.; Cappon, James; Coyne, J. H.; Cruikshank, E. A.; Doughty, A. G.; Herrington, W. S.; Hill-Tout, Chas.; Howay, F. W.; Lighthall, W. D.; Longley, J. W.; Martin, Chester; Macphail, Sir Andrew; McLachlan, R. M.; Oliver, E. H.; Riddell, W. R.; Scott, D. C.; Shortt, Adam; Skelton, O. D.; Stewart, H. L.; Wood, W.

SECTION III.—Allen, Frank; Archibald, E. H.; Baker, Alfred; Bain, J. W.; Boyle, R. W.; Burton, E. F.; Clark, A. L.; Dawson, W. B.; Deville, E.; Eve, A. S.; Fields, J. C.; Glashan, J. C.; Huard, V. A.; Johnson, F. M. G.; King, L. V.; Klotz, Otto; McGill, A.; McLennan, J. C.; Patterson, J.; Plasket, J. H.; Ruttan, R. F.; Shutt, F. T.; Stupart, Sir Frederic; Sullivan, C. T.

Section IV.—Adams, F. D.; Brock, R. W.; Camsell, Charles; Coleman, A. P.; Collins, W. H.; Dowling, D. B.; Dresser, J. A.; Faribault, E. R.; Graham, R. P. D.; Johnston, R. A. A.; Kindle, E. M.; Knight, C. W.; Miller, W. G.; McConnell, R. G.; McInnes, William; Parks, W. A.; Walker, T. L.

Section V.—Bensley, B. A.; Buller, A. H. R.; Cameron, John; Fraser, C. McLean; Harrison, F. C.; Huntsman, A. G.; Knight, A. P.; Lewis, F. J.; Lloyd, F. E.; McKibben, P. S.; Mackay, A. H.; McMurrich, J. P.; Nicholls, A. G.; Prince, E. E.; Thomson, R. B.; Thompson, W. P.; Saunders, C. E.; Willey, Arthur.

Letters of regret for absence were received from the following: Bailey, L. W.; Burgess, T. J. W.; Harris, D. Fraser; Tyrrell, J. D.; Ami, H. M.; Grant, W. L.; Wrong, Geo. M.; Murray, Walter; Paquet, Mgr. L. A.; Gosselin, Mgr. Amédée; Scott, H. A.; and Després, A. C.

It was moved by Dr. Brock, seconded by Dr. Adams, that the minutes of the annual meeting of last year as contained in the printed proceedings of last year in the hands of the Fellows be confirmed.—Carried.

The Annual Report of Council, printed copies of which had been delivered to the Fellows, was then presented by the Honorary Secretary. The Report was as follows:

REPORT OF COUNCIL

FOR THE YEAR 1920–1921.

To the Fellows of The Royal Society of Canada,

The Council have the honour to present the following report on the work of the Society during the past year:—

The last Annual Meeting was held in Ottawa on May 19, 20 and 21. The meeting was a very successful one, the registered attendance of Fellows being the largest in the history of the Society. The accommodation for the general and sectional meetings in the Victoria Memorial Museum proved very satisfactory and it has been decided to utilize space in the Museum again this year, not only for the general meetings, but also for the Presidential Address and Popular Lecture.

I.—Proceedings and Transactions of the Society.

Volume XIV, Third Series of the Transactions, consists of 577 pages, with illustrations, and a bound copy will be laid upon the table for inspection. Distribution will take place immediately after the meeting.

The agenda this year shows a large increase in the number of papers to be presented, indicating a continued interest by the Fellows in the work of the Society.

II.—Election of New Fellows.

This year there were vacancies in all the Sections. The Council have much pleasure in reporting that the following candidates received a majority of the votes cast, and their election is submitted for confirmation.

Section I.

M. L'abbé Ivanhoe Caron.

Section II.

R. M. MacIver, M.A., D.Phil.
J. L. Morison, M.A., D.Litt.
E. H. Oliver, M.A., Ph.D.

Section III.

Maitland C. Boswell, M.A., Ph.D.
R. W. Boyle, M.A., Ph.D.
Daniel Buchanan, M.A., Ph.D.

Section V.

Paul S. McKibben, B.S., Ph.D.
Chas. E. Saunders, B.A., Ph.D.
W. P. Thompson, M.A., Ph.D.

In Section IV none of the candidates received a majority vote.

III.—Deceased Members.

Again this year we have to record two vacancies caused by death in the ranks of the Fellows: Sir Adolphe B. Routhier and Dr. W. H. Ellis. Sir Adolphe Routhier was a Charter Member and Dr. Ellis was elected in 1891. The biographical sketch of Sir Adolphe Routhier has been prepared by Hon. Thomas Chapais, and that of Dr. Ellis by Dr. Maurice Hutton.

SIR ADOLPHE ROUTHIER.

Sir Adolphe Routhier, ancien président de la Société royale, est mort le 27 juin 1920, à l'âge de 81 ans. Il était un des citoyens éminents de notre pays.

Né à Saint-Placide, dans le comté des Deux-Montagnes, il avait fait des études classiques très brillantes au séminaire de Sainte-Thérèse. Ayant décidé d'embrasser la profession légale, il fit son cours de droit à l'Université Laval, à Québec, où il reçut le degré de bachelier en droit. Il fut ad mis au barreau de la province de Québec en 1861, et pratiqua comme avocat pendant douze ans dans le district de Kamouraska. En 1868 et 1872, il brigua sans succès le mandat de député à la Chambre des Communes. En 1873, le gouvernement de Sir John MacDonald le nomma juge de la Cour supérieure pour le district de Charlevoix. Subséquemment il fut transféré à Québec. Il devint juge en chef en 1904. Auparavant, il avait été appelé à présider la Cour de vice-amirauté. Sur le banc, il se fit toujours remarquer par la clarté et la précision de ses jugements.

Sir Adolphe Routhier était doué d'un beau talent littéraire. On lui doit un grand nombre d'ouvrages, *Causeries du dimanche*, *A travers l'Europe*, *En canot*, *les Echos* (poésies), *A travers l'Espagne*, *Les grands drames*, *Conférences et discours* (2 volumes), *De Québec à Victoria*, *La reine Victoria et son jubilé*, *Le Centurion*, *De l'homme à Dieu*, *Paulina*, *Montcalm et Lévis*, etc. Il avait cultivé les genres les plus variés, poésie, roman, impressions de voyage, apologétique, études sociales, critique littéraire. Comme orateur sa réputation était grande et méritée. Il avait un timbre sympathique, une diction nette, un geste aisé. Sa belle imagination donnait à sa parole la couleur et l'éclat. Ses discours se faisaient remarquer par le mouvement, la chaleur et l'élévation. Le juge Routhier fut incontestablement l'un des maîtres de l'éloquence française au Canada; et si, parmi ses compatriotes, il eut des émules, il rencontra peu d'égaux. Pendant plus de trente ans il fut l'orateur obligé de toutes nos grandes manifestations, de nos inaugurations, de nos conventions, de nos congrès religieux et nationaux. Sa parole entraînante captivait les auditoires les plus choisis. Il possédait vraiment le magnétisme oratoire. Et ceux qui l'ont entendu dans ses grands jours d'éloquence en conservent un vivant et persistant souvenir.

Resté maître de ses facultés intellectuelles en dépit des années, Sir Adolphe Routhier donna l'exemple du labeur, jusqu'aux extrêmes limites de l'âge. Octogénaire, il travaillait encore; et la mort seule

Sir Adolph Routhier

put interrompre sa merveilleuse activité d'esprit. A la première page d'un de ses derniers ouvrages on pouvait lire ces mots: "En préparation, *Blanche des Aulnes*, roman canadien; *Conférences et Discours*, 3e série." L'écrivain qui traçait ce programme de production future avait plus de quatre-vingts ans!

Sir Adolphe Routhier était l'un des membres fondateurs de la Societé royale, créée par le Marquis de Lorne en 1882. Il avait été président de notre académie canadienne de 1914 à 1915. Par son décès celle-ci perd l'un de ses membres les plus illustres.

WILLIAM HODGSON ELLIS.

William Hodgson Ellis was borne in Holme Hall, Bakewell, Derbyshire, near Chatsworth and Haddon Hall, on November 23rd, 1845. He was the son of the resident physician, John Eimeo Ellis, and his wife, who was the only daughter of Mr. Joseph Hodgson of Holme Hall. John Eimeo Ellis graduated from the University of London in 1839 with gold medal in Anatomy and Physiology. He became a member of the Royal College of Surgeons in 1840. He emigrated with his family to the State of Illinois in 1857 and removed to Toronto two years later.

The subject of this sketch entered the University of Toronto in 1863, received his B.A. in 1867 with Gold Medal in Natural Science; his M.A. in 1868, and his M.B. in 1870. He immediately went to London, England, and obtained a position on the house staff of St. Thomas' Hospital, securing his L.R.C.P. in the autumn of 1871, when he returned to Canada.

He settled down to practice his profession, but was immediately offered the position of lecturer in chemistry in Trinity College, and shortly afterwards he undertook similar duties in the newly-founded School of Technology. This latter institution became in 1877 The Ontario School of Practical Science in which he was Assistant Professor of Chemistry. In 1887 he became Professor of Applied Chemistry, a position which he held till his retirement.

In 1907, when the School of Practical Science became the Faculty of Applied Science and Engineering of the University of Toronto, he was made head of instruction in chemistry for the whole University. After the death of Dean Galbraith in 1914, he was made Dean of the Faculty of Applied Science, from which position he retired in 1919.

In the Medical Faculty, he held the position of Professor of Toxicology and Medical Jurisprudence from 1897 to 1913, when he was obliged to resign owing to the pressure of other work. For more than 30 years he was retained by the Attorney-General of Ontario as analyst and expert toxicologist in connection with criminal cases. During the same period he was Public Analyst for the Inland Revenue Department.

The variety and pressing nature of his daily work prevented him from writing any extensive scientific treatises; but numerous papers from his pen are to be found in the Transactions of the Canadian Institute, the Report of the Bureau of Mines and in the Transactions of the Royal Society.

In 1915 he was honoured by the University of Toronto with the degree LL.D., and in 1917 a similar honour was conferred upon him by McGill University.

In 1917 he was made Honorary Member of the Engineering Institute of Canada. He was a fellow of the Institute of Chemistry, and a Fellow of the Royal Society of Canada.

He was an ex-president of the Royal Canadian Institute, and ex-chairman of the Canadian Section of the Society of Chemical Industry.

This is the merest outline of an academical and professional life crowded with interesting detail. While his activities and his value to the University were acknowledged by his colleagues, he had endeared himself to them through his character. He was appreciated as the wit, the humourist, the poet and the artist, who redeemed the academical life from the reproach of being dull and pedantic. His wit and humour, his poetry and his pictures cannot be treated separately; they were blended by chemical fusion in one product. They live for his colleagues in many and consoling memories, and especially in the little volume called "Way-side Weeds"; a humble title testifying alike to the author's modesty and to his love of flowers.

It is difficult to find happier versions of academic humour and vivacious persiflage than for example the verses called the Duffer's Elegy, celebrating the game of golf as played in Hades, especially the stanzas:—

"Cocytus Styx and Phlegethon
  As hazards serve extremely well
In this particular alone
  The Lambton links are just like Hell.

WILLIAM HODGSON ELLIS

"The asphodel wants cutting sadly,
The lies are wretched, more's the pity,
But everything is managed badly
By that Infernal Green Committee.

"Come, lay aside your shroud and pall,
And play a friendly round with me,
A Dead Sea apple was the ball,
A pinch of churchyard dust the tee."

Almost equally delightful is the ode to the unnameable river of New Brunswick and to Jaeger's flannel; the epigram on the Bal Poudré; the more serious philosophy of The Iceberg; and the very Horatian parody of the First Ode of Horace. But many of his humorous sallies and much of his appreciation of humour never reached print in prose or poetry and yet recur when his name is heard.

The artist also underlay the poet. When the writer wanted once upon a time to relieve the tedium of the Archæological Institute of America by reminiscences of Socrates in his self-chosen roles of a spiritual mid-wife, of a cross-questioning mosquito, of an intellectual torpedo-fish, it was Dr. Ellis's humorous and artistic hand which drew for me the philosopher in these fancy-dresses; as the Attic Sairey Gamp, as the Marathonian Mosquito, as the Salaminian torpedo-fish. Without the lifelike caricatures of the deft draughtsman, the Socratic humour would have stung too deeply, would have shocked too severely the learned audience, would have paralyzed them even as the fish its victims; or, worse still, might just have left them cold.

He belonged, I suppose, spiritually as well as literally, to the older generation of men of science; even science and art together, even wit, humour and poesy did not begin to exhaust his interests.

When he reached the span of life he became, owing to the Great War, Dean of the Faculty of Applied Science when he would have preferred to retire into private life. He saw the war through to a successful close; he sent both his sons to the front, one as a brilliant medical investigator, the other as a lieutenant of infantry; he received both back alive, though not unwounded, and gladly retired from work and enjoyed a short year's rest.

While enjoying a holiday with his friend Dr. Rudolf on Lake Joseph, Muskoka district, he was fatally stricken and passed away after a few hours on the 23rd of August, 1920.

IV.—Visit of the Society of Chemical Industry.

Council would direct attention to the Annual Meeting of the Society of Chemical Industry, which is to be held during the last week in August, 1921. The principal meeting of the Society will be held in Montreal. A visit will be paid to Grand'Mere and Shawinigan Falls, and the Society will spend a day in Ottawa; afterwards Toronto and Niagara Falls will be visited.

It may be remarked that five of the eighteen sections of the Society are in Canada and that a number of its members are also Fellows of The Royal Society. Under these circumstances it behooves the Society to welcome to Canada such a distinguished body of scientists and business men.

While the itinerary will not make it possible for The Royal Society to entertain the visitors, it is suggested that the Honorary Secretary be directed to extend a welcome and to offer co-operation so far as it is possible to do so.

V.—Nova Scotia Historical Celebration.

Mr. L. M. Fortier, President of the Historical Society of Annapolis Royal, has advised the Society that a triple celebration of historic events of interest and importance will take place in Annapolis Royal on Wednesday, August 31st next. On that day tablets will be unveiled commemorating (1) the tercentenary of the charter of New Scotland, 1621; (2) the bicentenary of the establishment of British Civil Courts in Canada, 1721, and (3) Judge Haliburton's arrival in Annapolis Royal in 1821. The tablets are to be presented to the Nation and erected in Fort Anne, now a Canadian National Park, for safekeeping. The presentations will be made by representative speakers of the Government of Nova Scotia, prominent members of the Bench and Bar of Canada, and of the Historical Association of Annapolis Royal. The tablets will be formally received for the Nation by the Minister of the Interior and placed in the custody of the Superintendent of Fort Anne.

Mr. Fortier expresses the hope that The Royal Society of Canada will appoint a delegate to be present on this occasion.

VI.—Finances of the Society.

It seems to the Council advisable to make some special comment on the financial statement of the Honorary Treasurer. It was necessary this year to be restrictive in the expenditure for printing and the Sections loyally supported this policy by reducing their demands for space to the minimum.

We began the year with a credit balance of $1,094.00, to which was added the Parliamentary appropriation of $8,000.00 and the grant from the Advisory Council for Scientific and Industrial Research of $3,000.00, for the purpose of assisting the publication of scientific papers. Payment in full for the cost of printing the Transactions for 1919-20 had not been made at the close of that year; $3,844.83 being the balance in full of the cost of the volume for 1919-20, was paid from this year's funds.

The total cost of the volume for 1920-21 and the miscellaneous printing to date has been $6,627.37, to which should be added the printing and contingencies expended for this Annual Meeting, estimated at $400.00. Payments aggregating $5,500.00 have already been made and the unexpended balance of the funds for the year just closed will be approximately $250.00.

It will be apparent from this statement that we enter the year with our grant of $8,000.00 unimpaired, plus an available balance of $250.00—$8,250.00 in all.

VII.—Report of the Honorary Librarian.

For the current year there has been an increase in the receipts of exchange publications, other than evident accumulations during the War period. This is noticeable in the case of exchanges from Finland. This increase is an evidence of the general resumption of former peaceful pursuits and studies. As a measure of economy the Society have been without the services of a librarian, and as a consequence, there is an accumulation of uncatalogued material to be dealt with, but an examination of the shelving accommodation reveals the fact that the room provided has been fully occupied by the volumes already received. More space is required, and as the yearly receipts are large this may necessitate a further appeal for separate quarters for the Society.

In order to estimate the growth of the library the receipts of separate publications for the year is appended. These are arranged in order of numbers, and also of volume.

United States		485
British Empire		243
Great Britain	100	
Canada	100	
Australia	20	
New Zealand	5	
Malay States	1	
South Africa	5	
India	11	
Ceylon	1	
Finland		72
France		53
Belgium		43
Switzerland		35
Netherlands		32
Sweden		30
Japan		20
Italy		22
Portugal		18
Germany		14
Uruquay		8
Peru		7
Spain		6
Brazil		4
Austria		4
Norway		3
Argentine		3
Equador		2
Denmark		2
Total receipts		1,106

Bound volumes received estimated at less than twenty.

D. B. Dowling,
Hon. Librarian.

VIII.—Report of the Honorary Treasurer.

The following statement, coveiing the financial year ending on April 30th, 1921, includes the Government Grant Account and the General Account. It has been audited by Dr. J. C. Glashan and Dr. Adam Shortt, who were appointed for the purpose.

FINANCIAL STATEMENT OF THE ROYAL SOCIETY OF CANADA FOR THE YEAR ENDING APRIL 30, 1921.

GOVERNMENT GRANT ACCOUNT.

RECEIPTS.

By Balance in The Bank of Montreal, April 30, 1920	$1,094.41
" Grant from The Dominion Government	8,000.00
" Grant from The Hon. Advisory Council for Scientific and Industrial Research	3,000.00
" Bank interest on account	101.84
	$12,196.25

EXPENDITURE.

To Printing and publication of *Transactions*	$9,432.58
" Clerical assistance	770.00
" Insurance	43.80
" Miscellaneous expenditure	153.39
" Balance in The Bank of Montreal, May 4, 1921	1,796.48
	$12,196.25

GENERAL ACCOUNT.

RECEIPTS.

By Balance in the Merchants' Bank of Canada, April 30, 1920	$4,060.82
" Annual subscription and initiation fees	1,571.95
" Sale of *Transactions*	38.25
" Reimbursement of loan	2,300.00
" Interest on investments	420.30
" Bank interest on account	142.34
	$8,533.66

EXPENDITURE.

To Railway fares of Fellows	$ 875.25
" Expenses of Annual Meeting	205.60
" Investment in Ontario Government bonds (inclus. of interest and cost)	5,122.96
" Miscellaneous expenditure	21.04
" Balance in The Merchants' Bank of Canada, April 30, 1921	2,308.81
	$8,533.66

Audited and found correct:

J. C. GLASHAN
ADAM SHORT } *Auditors.*

C. MARIUS BARBEAU,
Honorary Treasurer.

Ottawa, May 11, 1920.

When the Honorary Secretary had finished reading the Report it was moved by Dr. McInnes, seconded by Dr. Fields that the Report of Council be received and that the question of adoption be voted on to-morrow.—Carried.

It was moved by Hon. Thos. Chapais, seconded by Dr. Roy that the election of M. L'Abbe Ivanhoe Caron as a Fellow of Section I. be confirmed.—Carried.

It was moved by Mr. Burpee, seconded by Dr. Coyne that the election of Dr. John Lyle Morison, Dr. R. Morison MacIver, and Dr. Edmund H. Oliver as Fellows of Section II be confirmed.—Carried.

It was moved by Dr. Shutt, seconded by Dr. Fields that the election of Dr. Maitland C. Boswell, Dr. Daniel Buchanan, and Dr. Robert William Boyle as Fellows of Section III be confirmed.—Carried.

It was moved by Prof. Thomson, seconded by Prof. Lloyd, that the election of Dr. Paul Stilwell McKibben, Dr. Charles E. Saunders, and Dr. Walter P. Thompson as Fellows of Section V. be confirmed.—Carried.

The following new Fellows were introduced:—Dr. MacIver, Dr. Morison, Dr. Oliver, Dr. Saunders, Dr. Thompson and Dr. McKibben, as well as Professor Knight and Professor Martin elected in 1920.

The Honorary Secretary announced the following proposed amendments to the by-laws:—

(1) By Dr. Duncan C. Scott: That paragraph 2 of Section 6 of the By-laws be amended to read:—"The number of Fellows in each Section shall be limited as follows:—Section I, 40; Section II, 50; Section III, 40; Section IV, 25; Section V, 40.

(2) By Dr. R. F. Ruttan: That paragraph 2 of Section 6 of the By-laws be amended to read:—"The number of Fellows in each Section shall be limited as follows:—Section I, 40; Section II, 40; Section III, 50; Section IV, 25; Section V, 40.

(3) By Dr. D. B. Dowling: That paragraph 2 of Section 6 of the By-laws be amended to read:—"The number of Fellows in each Section shall be limited as follows:—Section I, 40; Section II, 40; Section III, 40; Section IV, 30; Section V, 40.

The effect of these amendments would be to increase the membership in Section II from 40 to 50, in Section III from 40 to 50 and in Section IV from 25 to 30.

It was moved by Dr. Brett, seconded by Mr. Burpee, that these proposed amendments be referred to the Sections to report to the general meeting.—Carried.

Professor C. McLean Fraser, who represented Canada at the Pan-Pacific Scientific Congress held at Honolulu, Hawaiian Islands, 1920, presented a report of the proceedings of that body, of which the following is an abstract:—

"Over one hundred scientists from Japan, China, Phillipines, Australia, New Zealand, Hawaii, United States, Great Britain and

Canada, attended the Pan-Pacific Scientific Congress held in Honolulu, August 2-20, 1920, with H. E. Gregory, Honolulu, as Chairman. The Canadian Fisheries Association sent the only delegate from Canada.

"In the general meetings the following subjects were discussed:—Ocean currents and their significance; The origin of the Hawaiian Fauna and Flora; Race relations in the Pacific; Relation of ocean currents to marine organisms; Seismology of the Pacific; Volcanology of the Pacific; The framework of the Pacific; Mapping of the Pacific; Presentation by sections of programmes of research; Training of scientists for Pacific work; Means and methods of co-operation.

"For discussion of subjects more particularly affecting single branches of science the Congress divided into the following sections:—Anthropology; Botany; Entomology; Geography, with sub-sections Geodesy and Topography, Terrestrial Magnetism, Meteorology and Physical Oceanography; Geology and Seismology; Volcanology; Zoology.

"The general resolutions dealt with the desirability of organizing an International Research Council to direct co-operation in Pacific research work, the necessity of sufficient financial returns for scientific work to permit of young men entering upon such work with an assurance of a comfortable living and the benefit to be obtained by a more extensive interchange of men, either men experienced in research or graduate students beginning such work, among Universities and Research Institutions in the various Pacific countries.

"The resolutions from each of the sections were numerous but of course more specific.

"A Holdover Committee was selected to carry on until an International organization can be formed or until the next Congress. The Committee consists of H. E. Gregory, Hawaii, Chairman; E. C. Andrews, Australia; C. M. Fraser, Canada; F. Omori, Japan; C. Chilton, New Zealand; T. W. Vaughan, United States.

"The Bishop Museum, Honolulu, has consented to preserve the records of the Congress, to publish and distribute the reports, papers and proceedings, and to act as representative of the members of the Congress after its adjournment.

"Part I of the transactions, containing a short account of the organization, proceedings and resolutions, has been published. Part II, not yet published, will give papers, reports, etc., in full."

The Presidential Address—(*Wednesday Evening, May 18*)

The Presidential Address was delivered on Wednesday evening in the Victoria Memorial Museum. The chair was occupied by the Vice-President, Dr. Duncan C. Scott. The President's subject was "The Gaspé Peninsula; A Study of the Geology of the Region and its Influence on the Inhabitants" (Illustrated). The Address will be found printed in full as Appendix "A."

SESSION II.—(*Thursday Afternoon, May 19*)

The President took the chair.

It was moved by Dr. Fields, seconded by Prof. Lloyd, that the Report of Council be adopted.—Carried.

The reports of the following associated societies were then presented:—

The Historical Landmarks Association of Canada, Lundy's Lane Historical Society, Ontario Historical Society, Huron Institute, Niagara Historical Society, Women's Canadian Historical Society of Toronto, Ottawa Women's Canadian Historical Society, Hamilton Scientific Association, L'Institut canadien-francais de la cité d'Ottawa, Literary and Historical Society of Quebec, La Société historique de Montreal, The Natural History Society of Montreal, Nova Scotia Historical Society and Nova Scotian Institute of Science.

Report of Committee on Scientific Conditions in Canada

A fundamental purpose of the Royal Society of Canada is to foster research; and in particular the main purpose of Sections III, IV and V is to encourage scientific research, to recognize scientific ability, and to encourage those who possess it.

Your Committee therefore recommends that the following suggestions be adopted by the Royal Society of Canada:—

1. That a Fellow elected to one of the three sections more particularly referred to above required to qualify within three years by the presentation to his Section of an original paper embodying the results of research carried out by himself.

2. That the Fellowship of the Sections be enlarged sufficiently to permit increase in the number of active research workers of recognized ability.

3. That the suggestion be brought to the attention of the older members of the Section in question, whose condition or responsibilities prevent active participation in the work of the Section, that it is possible for such to retire from active Fellowship full of honour, their services to Science and to the Royal Society of Canada being recognized in placing them on the retired list of Fellows with retention of Title. Their counsel and influence may thus be retained, and at the same time room afforded for the reception of desirable new Fellows.

The following resolution from Section IV, was then brought before the meeting:—

"Whereas none of the candidates presented for election to Section IV this year received the requisite proportion of votes cast and Whereas it is expedient that the two vacancies now existing in Section IV be filled without further delay, be it

"Resolved that the By-laws of the Society be suspended and that Robert C. Wallace and George Albert Young be admitted to full membership in the Society."

It was moved by Dr. McInnes, seconded by Mr. Johnston that this resolution be approved.—Carried.

Mr. R. P. D. Graham, of Section IV, who was elected in 1920, and Dr. Young, the newly elected member, were then introduced.

It was moved by Mr. Justice Riddell, seconded by Dr. Coyne, that this report be referred to all the Sections for consideration.—Carried.

THE POPULAR LECTURE—(*Thursday, Evening May 19*)

The annual Popular Lecture was given in the Victoria Memorial Museum before the Fellows and guests of the Society by Dr. J. C. McLennan. The subject of Dr. McLennan's address was "Recent Advances in Physics". This address is published in full as appendix B.

SESSION III.—(*Friday Afternoon, May 20*)

The President took the chair at 3 p.m. and called for the Reports of the Sections.

REPORT OF THE SECTIONS

Section I

PROCÈS-VERBAL DE LA SECTION I

Membres présents ou inscrits: MM. Thomas Chapais, Cyrille Delâge, L.-O. David, Ernest Myrand, Pierre-Georges Roy, Adjutor Rivard, A.-D. DeCelles, Rodolphe Lemieux, P.-B. Mignault, Léon Gérin, MM. les abbés Elie-J. Auclair, Ivanhoë Caron, Camille Roy, Emile Chartier, MM. H.-J.-J.-B. Chouinard, Victor Morin, Benjamin Sulte et Marius Barbeau.

Se sont excusés de leur absence: Mgrs. L.-A. Paquet et Amédée Gosselin, MM. les abbés H.-A. Scott et A. Couillard-Després.

Travaux lus ou présentés:

1. Un récensement inédit de Montréal, en 1741, par M. E.-Z. Massicotte, M.S.R.C.

2. Les Canadiens au lendemain de la capitulation de Montréal (8 sept. 1760), par M. l'abbé Ivanhoë Caron, M.S.R.C.

3. Madeleine de Verchères, plaideuse, par M. Pierre-Georges Roy, M.S.R.C.

4. Guerres des Iroquois, 1670-1673, par M. Benjamin Sulte, M.S.R.C.

5. Sir Adolphe Routhier; son œuvre d'homme de lettres, par M. l'abbé Elie-J. Auclair, M.S.R.C.

6. La race canadienne-française, par M. le chanoine Emile Chartier, M.S.R.C.

7. Le Régiment de Carignan, par M. l'abbé A. Couillard-Després, M.S.R.C.

8. L'abbé Joseph-Sévère Nicolas Dumoulin, missionnaire à la Rivière-Rouge, 1818-1823, par M. le juge L.-A. Prud'homme, M.S.R.C.

9. Un homme d'état canadien; regards vers le passé, par l'Hon. Rodolphe Lemieux, M.S.R.C.

10. Les Acadiens du diocèse d'Antigonish, par M. l'abbé Joseph Raiche.

11. L'enseignement social et économique de saint Thomas d'Aquin, par Mgr. L.-A. Paquet, M.S.R.C.

12. A propos d'annexion, par M. Fernand Rinfret, M.S.R.C.

13. Les contes de fées au Canada, par M. Régis Roy.

Le 20 mai au matin, la Section I et la Section II de la Société royale et la Section d'Ontario de la Société de folklore d'Amérique tinrent leur dernière séance conjointement.

Il fut résolu d'un commun accord:—De ne pas accepter le projet soumis aux Sections de rendre obligatoire à leurs membres la présentation d'un travail, une fois dans trois années, aux séances de la société;

—D'abolir les procédures spéciales établies il y a deux ans pour l'élection des nouveaux membres, dans la Section I;

—De tenter l'organization d'une séance annuelle sous les auspices de la Section I, à Québec, à Montréal ou à Ottawa, dont le but serait de présenter et de faire connaître au public certains travaux des membres de la Société royale—la première séance devant avoir lieu à Montréal, sous la direction du Vice-président, M. le chanoine Emile Chartier;

—D'exprimer les regrets de la Section à l'occasion de la démission d'un de ses membres les plus distingués, S. G. Mgr. Paul Bruchési;

—De proposer que deux vacances en tout soient établies pour l'élection de nouveaux candidats au cours du prochain exercice.

Election des dignitaires pour l'année qui commence:

Président, M. le juge L.-A. Prud'homme;

Vice-président, M. le chanoine Emile Chartier.

Sécrétaire, M. Marius Barbeau.

Comité de lecture et de publication: Hon. juge Adjutor Rivard, MM. Ægidius Fauteux et A.-D. DeCelles.

Marius Barbeau,
Sécrétaire de la Section I.

On the motion of Mr. C. M. Barbeau, seconded by Mr. Benjamin Sulte, the report of Section I was adopted.

REPORT OF SECTION II

The Section held four sessions, on the 18th, 19th and 20th May, in the Library of the Victoria Museum, the last meeting on the morning of the 20th being in conjunction with Section I and the Ontario Branch of the Folk-Lore Society. The following Fellows were in attendance: Messrs. Brett, Bryce, Burpee, Coyne, Cruikshank, Doughty, Herrington, Hill-Tout, Howay, Lighthall, Longley, MacIver, Macphail, Martin, McLachlan, Morrison, Oliver, Riddell, D. C. Scott, Shortt, Skelton, Stewart and Wood, as well as a number of visitors.

The Secretary read a statement showing that during the last ten years 30 of the existing Fellows of Section II had contributed one or more papers and 7 had contributed none; and that during the last three years 21 Fellows had contributed papers, and 16 had failed to do so. He submitted that the preparation of papers for the Society should be regarded as one of the definite obligations of membership.

The Section discussed the Notice of Motion to amend paragraph 2 of Section 6 of the By-laws, and decided to recommend to the Society that the number of Fellows in Section II be limited to 50, or, in other words, increased from 40 to 50, but that not more than 3 new members be elected in the event of the amendment being adopted.

Lt.-Col. Denison and Sir Edmund Walker not having attended a meeting or presented a paper since 1917, the operation of By-law 8 was suspended in order to retain their names on the list of Active Members.

Dr. Coyne was appointed as the representative of the Section on the nominating committee of the Society.

Mr. Justice Riddell read a communication from Prof. Currelly in regard to the possibility of restoring some of the great homes of England as national monuments. The communication was ordered to be filed.

A communication was read from Mr. Moses B. Cotsworth of New Westminster, in regard to a proposed international Fixed Calendar. Ordered to be filed.

In regard to the triple celebration at Annapolis Royal in August, the Section recommends that General Cruikshank, Mr. Justice Longley, Prof. MacMechan and Prof. Stewart be appointed delegates to represent the Society, together with such other Fellows as may find it possible to attend the celebration.

The advisory committee on nominations for the section was elected as follows:—Dr. Short, Prof. Edgar, Dr. Coyne, Mr. Lighthall, Dr. MacMechan, Prof. Martin and Judge Howay.

In regard to the Report of the Committee on Scientific Conditions in Canada, the Section is substantially in agreement with the Committee's recommendations designed to strengthen the membership of the Society and stimulate a more active interest in its activities by the Fellows; and recommends that the Council be requested to so amend Section 6 of the By-laws as to insure that in future no Fellow shall be permitted to remain on the active list who is unable or unwilling to fulfil the obligations of membership as to attendance and the presentation of original papers.

The printing committee of the Section consists of the following members: Mr. Burpee, Dr. Morrison and General Cruikshank.

The following officers were elected: President, Mr. Justice Riddell; Vice-President, Prof. Hill-Tout; Secretary, Mr. Burpee.

The following papers were read, in extenso, in the form of a summary, or by title:

1.—Presidential Address. On the Study of History and the Interpretation of Documents. By Brig.-Gen. E. A. Cruikshank, LL.D., F.R.S.C.

2.—Governor Musgrave's work in British Columbia. By Judge Frederick William Howay, LL.B., F.R.S.C.

3.—The "transfer" of Rupert's Land and the "North-Western Territory" in 1870. By Chester Martin, M.A., B.Litt., F.R.S.C.

4.—Sault Ste. Marie (June 14, 1671). By James H. Coyne, LL.D., F.R.S.C.

5.—John White: first attorney general of Upper Canada (1792-1800). By Hon. William Renwick Riddell, LL.D., F.R.S.C.

6.—William Firth: third attorney general of Upper Canada (1807-1811). By Hon. William Renwick Riddell, LL.D., F.R.S.C.

7.—The Archives of Quebec. By Lieut.-Col. William Wood, D.C.L., F.R.S.C.

8.—William Osgoode: first chief justice of Upper Canada (1792-1794). By Hon. William Renwick Riddell, LL.D., F.R.S.C.

9.—Robert Isaac Day Grey: first solicitor general of Upper Canada (1797-1804). By Hon. William Renwick Riddell, LL.D., F.R.S.C.

10.—Earliest route of travel between Canada and Acadia. Old-time celebrities who used it. By Ven. Archdeacon W. O. Raymond, LL.D., F.R.S.C.

11.—An African captive: a Canadian soldier. By Hon. William Renwick Riddell, LL.D., F.R.S.C.

12.—When human beings were real estate. By Hon. William Renwick Riddell, LL.D., F.R.S.C.

13.—Was Molly Brant married? By Hon. William Renwick Riddell, LL.D., F.R.S.C.

14.—An old provincial newspaper. By Hon. William Renwick Riddell, LL.D., F.R.S.C.

15.—The loss of the *Atalante*. By Archibald MacMechan, B.A., Ph.D., LL.D., F.R.S.C.

16.—A second President Lincoln. By Rendell Williams, Presented by Hon. William Renwick Riddell, LL.D., F.R.S.C.

17.—The St. Lawrence Waterway: A Problem in Economics. By Lawrence J. Burpee, F.R.G.S., F.R.S.C.

18.—The political philosophy of John Stuart Mill. By George S. Brett, B.A., F.R.S.C.

19.—America's Export Wheat problem. By Lawrence J. Burpee. F.R.G.S., F.R.S.C.

20.—The literary use of astronomical schemes. By George S. Brett, B.A., F.R.S.C.

21.—The Nature of Chinese Verse. By Edward Sapir, Ph.D. Presented by Duncan Campbell Scott, Litt.D., F.R.S.C.

22.—The Ancestry of Archibald Lampman. By Rev. Ernest Voorhis, Ph.D. Presented by Duncan Campbell Scott, Litt.D., F.R.S.C.

23.—Maturin and Diderot. By Dr. H. Ashton. Presented by Judge Frederick William Howay, LL.D., F.R.S.C.

24.—The Stone Medallion of Lake Utopia. By W. F. Ganong, Ph.D., Corr. Member, R.S.C.

25.—The phylogeny of man from a new angle. By Charles Hill-Tout, F.R.A.I., F.R.S.C.

26.—A Bird's-eye view of Indian Languages North of Mexico, *with map*. By Edward Sapir, Ph.D. Presented by J. H. Coyne, M.A., LL.D., F.R.S.C.

27.—The Clash of Civilization. By Diamond Jenness, M.A. (Oxon.), F.R.A.I. Presented by Adam Shortt, C.M.G., M.A., LL.D., F.R.S.C.

28.—Some Political Ballads of Old France in Canada. By C. M. Barbeau, F.R.S.C., and Edward Sapir, Ph.D.

29.—Captain John Deserontyou. By Miss M. Eleanor Herrington, M.A. Presented by W. S. Herrington, K.C., F.R.S.C.

LAWRENCE J. BURPEE,
Secretary.

On motion of Mr. Burpee, seconded by Gen. Cruikshank, the report of Section II was adopted.

REPORT OF SECTION III

The meeting of 1921 was one of unusual interest and success by reason of the large and varied programme, which contained papers recording important progress in practically every field of the Section's activities. Probably at no previous meeting has there been presented so much advanced scientific and research work—a gratifying feature and indicative of the many achievements by Canadian men of science during the past year in physics, mathematics and chemistry.

Five sessions were held and all were well attended. As for several years past the greater number of the papers were given in abstract, allowing time for discussion of the subjects by the Fellows present. Experience has shown that these discussions add greatly to the interest and value of the programme.

The attendance of the Fellows was somewhat below the average, but was considerably augmented by the presence of a number of interested visitors, chiefly from Montreal and Ottawa. The list of Fellows in attendance at the several Sessions of the Section is as follows: Professor J. C. Fields, President; Sir Frederic Stupart, Dr. W. Bell Dawson, Professor J. Watson Bain, Dr. J. S. Plaskett, Dr. E. Deville, Dr. Frank T. Shutt, Professor E. H. Archibald, Professor E. H. Burton, Dr. J. C. Glashan, Professor Louis V. King, Professor A. S. Eve, Mr. John Patterson, Professor A. L. Clark, Dr. Frank Allen, Dr. F. M. G. Johnson, Professor J. C. McLennan, Professor Alfred Baker, Dr. C. T. Sullivan, Professor R. F. Ruttan, Dr. Boyle.

Three new Fellows were elected during the past year: Professor M. C. Boswell, Professor D. Buchanan and Dr. R. W. Boyle.

The Secretary reported the loss through death of Professor W. Hodgson Ellis, the retirement of Professor W. R. Lang and the resignation of Dr. D. McIntosh who was now a resident of the United States.

The more important resolutions carried by the Section are as follows:

That this Section recommends that the term "attendance," as officially used in connection with the requirements of continued membership, be interpreted to mean attendance at the meetings of the Section to which the member belongs.

That this Section urges, funds permitting, the publication of papers presented before Section III and IV immediately after the Annual Meeting.

That the Section recommends that authors be furnished 100 copies or reprints of their papers, with covers.

That a committee consisting of Messrs. Klotz, Plaskett and King be appointed to consider and report on the communication of Mr. B. Cotsworth with respect to the Fixed Calendar League.

That the following members comprise the Editorial Committee for the ensuing year: Professor A. S. Eve, Professor Louis V. King, Dr. Otto J. Klotz, Professor J. C. McLennan and Dr. F. B. Allen.

That the representatives of the Section on the General Printing Committee for the ensuing year be Dr. Otto J. Klotz and Mr. John Patterson.

That Professors J. C. Fields and J. C. McLennan be appointed a committee to confer with a joint committee from the other Sections of the Society to consider and recommend conditions of "continued membership" and retirement.

That the following Fellows be appointed the Membership Committee of the Section for the ensuing year: Professor Fields, Professor McLennan, Professor Ruttan, Dr. Klotz and Mr. John Patterson.

That all vacancies in the Section occurring throughout the year be filled in the usual manner at the Annual Elections.

That, provided the General Society confirms the recommendation to increase the membership of the Section to 50, not more than three of the vacancies be filled at the next annual election.

That Professor Eve and Dr. Deville be representatives of the Section on the General Nominating Committee of the Society.

That the membership of this Section be increased to 50 and that the General Society be requested to confirm this recommendation.

Report of Committee on Scientific Conditions in Canada

A fundamental purpose of the Royal Society is to foster research; and in particular the main purpose of Sections III, IV and V is to encourage scientific research, to recognize scientific ability, and to encourage those who possess it.

Your Committee therefore recommends that the following suggestions be adopted by the Royal Society of Canada:

1. That a Fellow elected to one of the three sections more particularly referred to above be required to submit, within three years, to his Section an original paper embodying the results of research carried out by himself.

2. That the Fellowship of the sections be enlarged sufficiently to permit increase in the number of active research workers of recognized ability.

3. That the suggestion be brought to the attention of the older members of the Sections in question, whose condition or responsibilities prevent active participation in the work of the Section, that it is possible for such to retire from active Fellowship full of honour, their services to Science and to the Royal Society of Canada being

recognized in placing them on the retired list of Fellows with retention of title. Their counsel and influence may thus be retained, and at the same time room afforded for the reception of desirable new Fellows.

The election of officers for the ensuing year resulted as follows: President, Dr. Otto J. Klotz; Vice-President, Professor J. Watson Bain; Secretary, Mr. John Patterson, M.A.

The following papers were read in full or by abstract at the Sessions of the Section:

1.—Presidential Address. Professor J. C. Fields, F.R.S.C. Division in Relation to the Algebraic Numbers.

2.—Ionization Potential and the Size of the Atom. By A. S. Eve, F.R.S.C.

3.—Detection of Variation in Electric Earth Currents by Coil and Galvanometer. By A. S. Eve, F.R.S.C., and E. S. Bieler.

4.—The Effective Range of Beta-rays. By Miss V. Douglas, B.A., and J. A. Gray, D.Sc. Presented by A. S. Eve, F.R.S.C.

5.—The velocity of Sound in Air and Soil. By J. A. Gray, D.Sc. Presented by A. S. Eve, F.R.S.C.

6.—Properties of X-rays Excited by Beta-rays. By J. A. Gray, D.Sc. Presented by A. S. Eve, F.R.S.C.

7.—The Absorption of Gamma-rays. By J. A. Gray, D.Sc. Presented by A. S. Eve, F.R.S.C.

8.—A Note on the Examination of Materials by X-rays. By J. A. Gray, D.Sc. Presented by A. S. Eve, F.R.S.C.

9.—The Transmission of Heat through the Thin Boundary Films of Air or of Water at the Surface of Glass. By A. Norman Shaw, D.Sc., and L. A. Smith, B.A. Presented by A. S. Eve, F.R.S.C.

10.—The Viscosity of Ether at Low Temperatures and of Solutions of Acetic Acid in Liquid Hydrogen Bromide. By E. H. Archibald, Ph.D., F.R.S.C., C. E. Stone and E. M. White.

11.—Preliminary Report on the Lubricating Properties of the Different Series of Hydrocarbons. By W. F. Seyer, Ph.D. Presented by E. H. Archibald, F.R.S.C.

12.—An Automatic Mercury Pump. By D. F. Steadman. Presented by E. H. Archibald, F.R.S.C.

13.—Some Results of the Destructive Distillation of British Columbia Alder and Douglas Fir. By W. A. Hardy, B.Sc. Presented by E. H. Archibald, F.R.S.C.

14.—On the Variation of the "emanating power" of Certain Uranium Minerals with Temperature and a New Secondary Radium

Emanation Standard. By J. H. L. Johnstone, M.B.E., Ph.D. Presented by H. L. Bronson, Ph.D., F.R.S.C.

15.—The Effect of Thermo-Luminescence on Electrical Conductivity. By C. A. Mackay, B.A. Presented by H. L. Bronson, Ph.D., F.R.S.C.

16.—The Anemometer Factor. By J. Patterson, M.A., F.R.S.C.

17.—Pilot Balloon Methods in Canada. By J. Patterson, M.A., F.R.S.C.

18.—On Some New Formulæ for the Direct Numerical Calculation of the Coefficient of Mutual Induction of Coaxial Circles. By Louis V. King, D.Sc., F.R.S.C.

19.—On a New High Frequency Vibration Galvanometer. By Louis V. King, D.Sc., F.R.S.C.

20.—On the Photographic Recording and Measurement of Radio-telegraph Signals. By Louis V. King, D.Sc., F.R.S.C.

21.—On a New Lecture Room Illustration of Atomic Models. By Louis V. King, D.Sc., F.R.S.C.

22.—On the Refractive Indices of Metallic Vapours. By Professor J. C. McLennan, F.R.S.C.

23.—On the Absorption Spectrum of Liquid and Gaseous Oxygen. By W. W. Shaver, M.A. Presented by Professor J. C. McLennan, F.R.S.C.

24.—On the Structure of the Balmer Series Lines of Hydrogen. By Professor J. C. McLennan and Mr. P. Lowe.

25.—On the Spectrum of Helium, Hydrogen and Carbon in the Extreme Ultraviolet. By Professor J. C. McLennan and Mr. P. A. Petrie.

26.—On the Liquefaction of Hydrogen. By Professor J. C. McLennan, F.R.S.C.

27.—Nitrophthalic anhydrides and acetylamino-phthalic anhydrides with toluene and aluminium chlorides. By W. A. Lawrence, M.A. Presented by Professor F. B. Allan, F.R.S.C.

28.—Bromphthalic anhydrides with benzene and aluminium chloride. By H. N. Stephens, B.A. Presented by Professor F. B. Allan, F.R.S.C.

29.—The Effect of Certain Chemicals on the rate of Reproduction of Yeast. By N. A. Clark, B.S.A., M.A. Presented by Prof. W. Lash Miller, F.R.S.C.

30.—The passage of Hydrogen and of Helium through Silica Tubes. By Prof. J. B. Ferguson and G. A. Williams, B.Sc. Presented by W. Lash Miller, F.R.S.C.

31.—The Action of Methyl-green on Yeast. By W. B. Leaf, B.Sc. Presented by W. Lash Miller, F.R.S.C.

32.—Pressure-volume relations of superheated liquids. By K. L. Wismer. Presented by Professor F. B. Kenrick, F.R.S.C.

33.—Scattering of light by dust-free Liquids. By W. H. Martin, M.A. Presented by Prof. F. B. Kenrick, F.R.S.C.

34.—Note of Wolski's paper on optically empty liquids. By Professor F. B. Kenrick, F.R.S.C.

35.—Re-determination of the Melting Point of Sodium Chloride. By Professor J. B. Ferguson. Presented by Prof. W. Lash Miller, F.R.S.C.

36.—Researches in physical and Organic Chemistry carried out in the chemical laboratory of the University of Toronto during the past year:—

(*a*) The intermediate compounds in the reaction between phthalic anhydride, benzene and aluminium chloride, and their use in the sylthesis of mixed phthalides. By T. C. McMullen, B.A. Presented by Prof. W. Lash Miller, F.R.S.C.

(*b*) The reaction of Naphthalic anhydride with benzine and aluminium chloride. By F. Lorrimans. Presented by Prof. W. Lash Miller, F.R.S.C.

(*c*) Carbothoxy-benzoyl chlorides with aluminium chloride and various aromatic hydrocarbons. A number of new compounds have been prepared. By M. E. Smith, B.A. Presented by Prof. W. Lash Miller.

(*d*) The action of ammonium fluoride on yeast in the presence of agar. By Miss I. L. Roberts, B.A. Presented by Prof. W. Lash Miller, F.R.S.C.

(*e*) The effect of various chemicals on the bunching of yeast. By F. I. Eldon. Presented by Prof. W. Lash Miller, F.R.S.C.

Groups of as many as one hundred cells have been grown.

(*f*) The effect on the growth of yeast of an unknown constituent of malt, and the isolation of the same. By G. H. W. Lucas. Presented by Prof. W. Lash Miller, F.R.S.C.

(*g*) A study of the extent to which various liquids can be superheated and of the conditions under which superheating is possible. By C. S. Gilbert. Presented by Prof. W. Lash Miller, F.R.S.C.

(*h*) Solubility of crystal faces; an investigation of the equilibrium between various crystal faces and solutions, with special reference to cubic and octahedral sodium chloride. By G. Hasa, B.S., and J. W. Russell. Presented by Prof. W. Lash Miller, F.R.S.C.

(*i*) The dissociation pressures of Spencerits, a basic phosphate of zinc. By J. W. Rebbeck, B.A.Sc. Presented by Prof. W. Lash Miller, F.R.S.C.

(*j*) The equilibrium between hydrogen, steam, and the oxides of iron. Chandron's value of the equilibrium constant for ferrous oxide has been confirmed, and the existence of solid solutions between ferrous oxide and the magnetic oxide has been established. By D. M. Findlay, R. M. Robertson and H. G. Noble. Presented by Prof. W. Lash Miller, F.R.S.C.

(*k*) Quantitative study of the electrolysis of neutral sodium sulphide and of sodium hydrogen sulphide. By W. R. Fetzer, M.A. Presented by Prof. W. Lash Miller, F.R.S.C.

(*l*) Study of automatic current regulation in electric furnaces. By J. Kelleher, B.A.Sc., and A. E. R. Westman. Presented by Prof. W. Lash Miller, F.R.S.C.

(*m*) The recovery of precious metals from the anode slimes in nickel refining. By H. W. Powell. Presented by Prof. W. Lash Miller, F.R.S.C.

(*n*) The effect of the chemical treatment of storage battery separators on their mechanical strength, porosity and electrical conductivity. By J. H. Ratcliff. Presented by Prof. W. Lash Miller, F.R.S.C.

(*o*) The performance of laboratory electrical furnaces. By T. M. Barry. Presented by Prof. W. Lash Miller, F.R.S.C.

(*p*) The effect of the composition of battery paste on the time required to form the paste and on its mechanical strength. By W. D. Stalker. Presented by Prof. W. Lash Miller, F.R.S.C.

(*q*) The preparation of boron carbide from boric acid and carbon in the electric furnace. By J. M. Logan. Presented by Prof. W. Lash Miller, F.R.S.C.

(*r*) A method for the rapid and accurate estimation of copper in alloys. By E. W. McHenry. Presented by Prof. W. Lash Miller, F.R.S.C.

(*s*) The rapid determination of nitrate in Chili saltpetre. By Miss J. I. Lane. Presented by Prof. W. Lash Miller, F.R.S.C.

(*t*) Methods for the rapid determination of arsenic and of zinc in ores. By Prof. L. J. Rogers and J. E. Clarke, B.A.Sc. Presented by Prof. W. Lash Miller, F.R.S.C.

37.—On the Reduction of the Circulants to Polynomial Form with Applications to the Circulants of the 7th and 11th Degrees. By Dr. J. C. Glashan, F.R.S.C.

38.—The Gravitation Potential of an Anchor Ring. By Prof. A. H. S. Gillson. Presented by Prof. James Harkness, F.R.S.C.

39.—Some Tidal Problems. By Prof. A. H. S. Gillson. Presented by Prof. James Harkness, F.R.S.C.

40.—Law of Distribution of Particles in Colloidal Solutions. By Prof. E. F. Burton, F.R.S.C., and Miss E. L. Bishop.

41.—Production of Heat during Charcoal Absorption. By Stuart McLean, M.A. Presented by Prof. E. F. Burton, F.R.S.C.

42.—The Relation between Coagulative Power of Electrolytes and Concentration of Colloidal Solutions. By Prof. E. F. Burton, F.R.S.C., and Mr. E. D. MacInnes.

43—The Radial Velocities of 570 Stars. By J. S. Plaskett, F.R.S.C.

44.—The Orbit and Dimensions of TV Cassiopeiæ. By J. S. Plaskett, F.R.S.C.

45.—The Temperature Control of the Stellar Spectrograph. By J. S. Plaskett, F.R.S.C.

46.—The Orbital Elements of the Brighter Components of Boss 497. By W. E. Harper, M.A. Presented by J. S. Plaskett, F.R.S.C.

47.—The Orbits of Spectroscopic Components of Boss 4622. By W. E. Harper, M.A. Presented by J. S. Plaskett, F.R.S.C.

48.—The Intensity Distribution in Tupical Stellar Spectra. By H. H. Plaskett, B.A. Presented by J. S. Plaskett, F.R.S.C.

49.—The solution of Plane Triangles by Nomographic Charts. By S. D. Killam, Ph.D. Presented by Dr. Tory, F.R.S.C.

50.—Note on the Geometrical Equivalence of certain Invariants. By Charles T. Sullivan, Ph.D., F.R.S.C.

51.—The Interpolation of breaks in Tide Curves for recording Gauges. By W. Bell Dawson, M.A., D.Sc., F.R.S.C. (M.Inst.C.E.).

52.—The Vertical Movement of Alkali under Irrigation in heavy clay soils. By Frank T. Shutt, D.Sc., F.R.S.C., and Alice H. Burwash, B.A.

53.—Notes on the Nature of Burn-outs. By Frank T. Shutt, D.Sc., and Alice H. Burwash, B.A.

54.—Reversible Pendulum. By H. F. Dawes. Presented by J. Patterson, M.A., F.R.S.C.

55.—Characteristic X Rays from Boron. By Professor A. L. Hughes, B.A., D.Sc. Presented by Professor A. L. Clark, B.Sc., Ph.D., F.R.S.C.

56.—A New Experiment in Vibration. By Professor John Satterly, F.R.S.C.

57.—Note on the Spectra of Potassium. By Professor J. C. McLennan, F.R.S.C.

58.—Note on Infrared Spectroscopy. By Professor J. C. McLennan, F.R.S.C.

59.—Selected Radiations emitted by Specially Excited Mercury Atoms. By Mr. H. J. C. Ireton, M.A. Presented by Prof. J. C. McLennan, F.R.S.C.

Frank T. Shutt,
Secretary.

On motion of Dr. Shutt, seconded by Dr. Deville, the report of Session III was adopted.

REPORT OF SECTION IV

During the three days of the Annual Meeting, May 18, 19 and 20, five sessions of Section IV were held, which were attended by the following Fellows, 18 in number:—

Dr. W. McInnes, President; Dr. F. D. Adams, Mr. R. W. Brock, Mr. Charles Camsell, Dr. A. P. Coleman, Dr. W. H. Collins, Mr. D. B. Dowling, Mr. J. A. Dresser, Mr. E. R. Faribault, Mr. R. P. D. Graham, Mr. R. A. A. Johnston, Secretary; Dr. E. M. Kindle, Mr. C. W. Knight, Mr. R. G. McConnell, Dr. W. G. Miller, Dr. T. L. Walker, Dr. G. A. Young, Dr. W. A. Parks.

On the unanimous recommendation of the Section, Dr. Robert C. Wallace and Dr. George Albert Young were elected members by resolution of the General Meeting to fill vacancies in the Section.

A resolution was passed endorsing the motion to increase the membership of the Section from 25 to 30 and it was further agreed that should this motion carry at the General Meeting three new members be elected in 1922.

The Report of the Committee on Scientific Conditions in Canada was very thoroughly discussed and with regard to the suggestions set forth it was agreed: (1) that the provisions of Clause 1 are unnecessary inasmuch as the scientific attainments of candidates for Fellowship in the Royal Society of Canada are thoroughly scrutinized under the present method of procedure; (2) that the adoption of the provisions of Clause 2 would tend to encourage research and would be in the interests of the Society; (3) that the provisions of Clause 3 touch upon a matter which would be better left entirely to the discretion of individual members concerned.

A proposal emanating from the Geological Society of London and suggesting the formation of an International Union of Geologists was discussed at some length and it was agreed that this was a matter which might well be left in abeyance until such time as the question of the future of international gatherings shall have been discussed and determined at the International Geological Congress, which it is proposed shall be held in Brussels, Belgium, in 1922.

The following were elected officers of the Section for 1921-22: President, Dr. W. A. Parks; Vice-President, Mr. E. R. Faribault; Secretary, Mr. R. A. A. Johnston.

The following are Committees appointed by the Section:

Committee on Nominations: Dr. William McInnes (1 year); Mr. R. A. A. Johnston (2 years).

Committee on Printing: Mr. E. R. Faribault; Mr. James White; Dr. Wm. McInnes.

Mr. James White and Dr. William McInnes were appointed to act with the General Printing Committee.

The following sixteen papers were read either in full, by summary, or by title:

Programme

1.—Presidential Address. William McInnes, LL.D., F.R.S.C.

2.—Political Geology. By Willet G. Miller, B.A., LL.D., F.R.S.C.

3.—Cobalt: Its Underground Geology. By Cyril W. Knight, B.Sc., F.R.S.C.

4.—Pleistocene Oscillations of Sea-Level in the Vancouver Region, British Columbia. By W. A. Johnston, M.A., B.Sc., F.G.S.A. Presented by R. A. A. Johnston, F.R.S.C.

5.—The Distribution of the Stringocephalus burtoni Fauna in Canada. By Edward M. Kindle, A.B.M.Sc., Ph.D., F.R.S.C.

6.—Notes on the Lithification of Recent Limestones in the Florida-Bahama region. By Edward M. Kindle, A.B., M.Sc., Ph.D., F.R.S.C.

7.—Meozoic Sands and Clays in Northern Ontario. By Joseph Keele, B.Sc. Presented by R. A. A. Johnston, F.R.S.C.

8.—On Triarthrus glaber, Triarthrus canadensis, and Triarthrus spinosus. By W. A. Parks, B.A., Ph.D., F.R.S.C.

9.—The Head and Fore Limb of a Species of Monoclonius from the Belly River Formation of Alberta. By W. A. Parks, B.A., Ph.D., F.R.S.C.

10.—A Species of Conularia from the Lockport Limestone at Hamilton, Ont. By W. S. Dyer, B.A. Presented by W. A. Parks, B.A., Ph.D., F.R.S.C.

11.—The Annaheim Meteorite. By R. A. A. Johnston, F.R.S.C., and H. V. Ellsworth, M.A., Ph.D.

12.—A Supplementary Study of Panoplosaurus Mirus. By Charles M. Sternberg. Presented by William McInnes, B.A., LL.D., F.R.S.C.

13.—Camsellite—A New Mineral Species. By H. V. Ellsworth, M.A., Ph.D., and Eugene Poitevin, B.A.Sc. Presented by R. A. A. Johnston, F.R.S.C.

14.—The Blithfield Meteorite. By R. A. A. Johnston, F.R.S.C., and M. F. Connor, B.A.Sc.

15.—Some Chemical Studies of Conglomerates. By T. L. Walker, M.A., Ph.D., F.R.S.C.

16.—On the Mispec Group (Devonian). By G. F. Matthew, LL.D., F.R.S.C.

R. A. A. Johnston,
Secretary, Section IV.

On motion of Mr. Johnston, seconded by Dr. Dowling, the report of Section IV was adopted.

REPORT OF SECTION V

The Section held four regular sessions, with the Chairman, Professor A. P. Knight, present on each occasion.

There was a good attendance of Fellows and visitors and much interest was taken in the papers presented and their discussion.

The following Fellows were present: Bensley, Buller, Cameron (John), Fraser, Harrison, Huard, Huntsman, Knight, Lewis, Lloyd, McKay, McKibben, McMurrich, Nicholls, Prince, Saunders, Thompson, Thomson, Willey—nineteen in all.

The Secretary was added to the Nominating Committee of the Society, to act with Professor Knight as representatives of Section V.

The members of the Printing Committee of last year were requested to remain in office for another year, those of the Sectional Printing Committee being Professor Macallum and Doctors Prince and Huntsman, with the two latter on the General Printing Committee.

Professor A. B. Macallum and the Secretary were nominated to act with the Council in the selection of new members. The new members elected to the Section this year are: Dr. McKibben (London), Dr. Saunders (Ottawa), Dr. Thompson (Winnipeg).

The Officers for next year, 1921-22, are: President, Professor Lloyd; Vice-President, Professor Willey; Secretary, Professor Thomson.

The following resolutions were passed on to the General meeting:

(1) That the Honorary Secretary be asked to transmit for publication in *Nature* and *Science* an account of the proceedings of Section V, to be prepared by the Secretary.

(2) In regard to the appointment of a Committee to prepare a list of Canadian Scientists in Biology; such list to be a guide in the nomination of new Fellows, at the suggestion of Doctor Field that Sections III and IV were preparing similar lists.

(3) Approval of the Committee on Scientific conditions in Canada.

(4) That whereas the membership of Section V is so much below its quota that the by-law in Section 6, p. 5, restricting the number of members elected in any one year to 4, be suspended for 1921-22 to allow the Section to elect 6 new Fellows.

(5) In regard to participation in the management of Botanical Abstracts, suggesting the names of Professors Faull and Lloyd as Royal Society representatives.

The Section recorded its regret at the loss of one of the Charter Members of the Royal Society, the distinguished botanist, Professor John Macoun, and instructed the Secretary to request one of the older members to prepare an account of his life and work, to be presented to the Section at the next annual meeting. It was also thought desirable to draw the attention of the General Meeting to the fact that there is a liability to overlook the death of Fellows of the Royal Society, whose names appear on the retired list as at present arranged and placed, and to suggest that these names be printed at the beginning of the list of Fellows of the various Sections.

Approval was also expressed of the steps that the Field Naturalists' Club are taking to secure a suitable memorial of Professor Macoun.

After considerable discussion of the importance of the work of Professor Macoun and of the lack of availability of his publications on both plants and animals, it was moved by Professor Willey and seconded by Professor Lloyd, that the Government be urged to employ a competent person or persons to have Professor Macoun's work revised, brought up to date and republished. The motion was carried unanimously.

The list of papers presented was as follows:

1.—Presidential Address. The Lobster Problem. By A. P. Knight, M.A., M.D., F.R.S.C.

2.—The cell wall of the Mucilage Cells in the Cacti. By Francis E. Lloyd, M.A., F.R.S.C.

3.—The Application of Dakin's Method of Extraction by Butyl Alcohol to the study of Trypti, Digestion of Protein. By Andrew Hunter, M.A., B.Sc., M.B., Ch.B. (Edin.), F.R.S.C.

4.—Significant alterations in the Neuroblast-nuclei of the Embryonic Retina: A Study in Bio-Dynamics. By John Cameron, M.D., D.Sc., F.R.S.E., F.R.S.C. (Lantern).

5.—(i) Further Experiments on Conditions influencing the Life History of the Frog. By A. T. Cameron, M.A., B.Sc., F.I.C., F.R.S.C.

6.—(ii) Notes on Thyroid Problems:

(*a*) The effect of thyroid feeding on the hypertrophy of body-organs in the white rat. By F. A. Sedziak. Presented by A. T. Cameron, M.A., B.Sc., F.I.C., F.R.S.C.

(*b*) The Comparative effects of thyroid and parathyroid feeding on growth and organ hypertrophy in the white rat. By J. Carmichael. Presented by A. T. Cameron, M.A., B.Sc., F.I.C., F.R.S.C.

(*c*) The experimental production of tetany in the white rat by thyroid feeding. By J. Carmichael. Presented by A. T. Cameron, M.A., B.Sc., F.I.C., F.R.S.C.

7.—(iii) The effect of Thyroid Feeding on Rats and Pigeons on Vitamine Deficient Diets. By A. T. Cameron, M.A., B.Sc., F.I.C., and A. Moore.

8.—(iv) The Relative Toxicity of Certain Anions. By A. T. Cameron, M.A., B.Sc., F.I.C., F.R.S.C., and M. E. Hollenberg.

9.—A Study of the Abdominal Musculature of Orthopteroid Insects. By Miss Norma Ford, M.A. Presented by E. M. Walker, B.A., M.B., F.R.S.C.

10.—(i) The Vascularity of the Cerebral Cortex of the Albino Rat. By E. Horne Craigie, B.A., Ph.D. Presented by B. A. Bensley, B.A., Ph.D., F.R.S.C.

11.—(ii) A Study of the Ciscos (Herring) of Lake Erie. By W. A. Clemens, M.A., Ph.D. Presented by B. A. Bensley, B.A., Ph.D., F.R.S.C.

12.—(i) The Production of Fruit-bodies by Mycelia of Monosporous Origin in the genus Corpinus. By Miss Irene Mounce, M.A. Presented by A. H. R. Buller, D.Sc., Ph.D., F.R.S.C. (Lantern).

13.—(ii) Upon the Chemotactic attraction of Fungi for Slugs. By A. H. R. Buller, D.Sc., Ph.D., F.R.S.C. (Lantern).

14.—The sound made by Fungus Guns and a simple method for rendering audible the Puffing of Discomycetes. By A. H. R. Buller, D.Sc., Ph.D., F.R.S.C. (Lantern).

15.—Coloured Thinking and Allied Conditions. By D. Fraser Harris, M.D., D.Sc., F.R.S.E., F.R.S.C.

16.—(i) The Red Discolouration of Cod Fish. By F. C. Harrison, B.S.A., D.Sc., F.R.S.C., and Margaret Kennedy, B.A.

17.—(ii). A Note of the Persistence of *Spirochaeta duttoni* through several Generations of Artificially reared Ticks (*Ornithodorus moubata*). By E. Melville DuPorte. Presented by F. C. Harrison, B.S.A., D.Sc., F.R.S.C.

18.—(iii) Studies of the Pathological Histology of Mosaic-diseased Plants. By B. T. Dickson, B.A. Presented by F. C. Harrison, B.S.A., D.Sc., F.R.S.C.

19.—(i) The Bay of Fundy and Pelagic Eggs. By A. G. Huntsman, B.A., M.B., and M. E. Reid.

20.—(ii) The effect of Light on Growth in the Mussel. By A. G. Huntsman, B.A., M.B., F.R.S.C.

21.—Terminal Branchings in the Human Lung. By Herbert G. Wilson, M.B. Presented by J. P. McMurrich, M.A., Ph.D., F.R.S.C.

22.—Notes on Canadian Entomostraca. By A. Willey, D.Sc., F.R.S., F.R.S.C.

23.—Les filicinées de la Province de Québec, par le Frère Marie-Victorin, présenté par A. P. Knight, M.D., F.R.S.C.

24.—(i) The Pelagic Origin of Marine Animal Forms. By E. E. Prince, B.A., LL.D., F.L.S., F.R.S.C.

25.—(ii) Some new Points in the Life of the Post-larval Lobster. By E. E. Prince, B.A., LL D., F.L.S., F.R.S.C.

26.—(iii) Description of a new species of Canadian Pike (Lucius). By E. E. Prince, B.A., LL.D., F.L.S., F.R.S.C.

27.—Seasonal Changes in the Cells of Evergreen Leaves. By Francis J. Lewis, D.Sc., F.R.S.E., F.L.S., F.R.S.C., and G. M. Tuttle, M.Sc.

28.—Agglutination Reactions of Strains of Bacillus of Pfeiffer. By Dr. H. B. Maitland and Dr. G. C. Cameron. Presented by Professor J. J. MacKenzie, F.R.S.C.

29.—A Peculiar Bacteriolytic Substance in Rabbit Serum for Bacillus of Pfeiffer. By Dr. H. B. Maitland. Presented by Professor J. J. MacKenzie, F.R.S.C.

30.—Spontaneous Hemorrhages in the Lungs of Rodents. By Dr. H. B. Maitland. Presented by Professor J. J. MacKenzie, F.R.S.C.

31.—A Degenerative Change in Human Adrenal Medulla. Associated with Acute Pyogenic Infections. By Professor J. J. MacKenzie, F.R.S.C., and Dr. W. P. Warner.

32.—Glycogen Content of the Heart of Starved and Well-fed Rabbits. By J. J. R. Macleod, M.B., Ch.B., and D. J. Prendergast.

33.—Oxygen Unsaturation of the Blood during Anoxæmia. By J. J. R. Macleod, M.B., Ch.B., and S. U. Page.

R. B. Thomson,
Secretary, Section V.

On motion of Professor Thomson, seconded by Dr. Knight, the report of Section V. was adopted.

It was moved by Mr. Burpee, seconded by Prof. Hill-Tout, that the appointment of Fellows named by Section II to represent the Society at the celebrations in Annapolis Royal in August (Brig.-Gen. Cruikshank, Mr. Justice Longley, Prof. MacMechan and Prof. Stewart) be approved.—Carried.

It was moved by Prof. Thomson, seconded by Dr. Knight, that the by-laws be suspended and that Section V be permitted to elect six fellows at the next election.—Carried.

It was moved by Mr. Burpee, seconded by Mr. Justice Riddell, that the report of the Committee on Scientific Conditions in Canada be referred to Council.—Carried.

Dr. J. P. McMurrich presented the report of the Committee on Museum Accommodation.

1. The Committee recommends that the Society request the Government to approve the appointment by the Society of a committee to draw up a plan of organization for an adequate Canadian National Museum.

2. That, contingent upon the approval of the Government as above, the President-elect be asked to appoint such a committee.

It was moved by Dr. McMurrich, seconded by Dr. Huntsman, that the report be adopted.—Carried.

The notice of motions to amend the by-laws so as to provide for increased membership in Sections II, III, and IV was then considered.

It was moved by Mr. Burpee, seconded by Dr. Coyne, that the membership of Section II be increased from 40 to 50.—Carried.

It was moved by Dr. Shutt, seconded by Dr Deville, that the membership of Section III be increased from 40 to 50.—Carried.

It was moved by Dr. Dowling, seconded by Dr. McInnes, that the membership of Section IV be increased from 25 to 30.—Carried.

The report of the Nominating Committee was presented by Dr. A. P. Knight and the following nominations were made: President, Dr. Duncan C. Scott; Vice-President, Dr. J. Playfair McMurrich; Honorary Secretary, Mr. Charles Camsell; Honorary Treasurer, Mr. C. M. Barbeau; Honorary Librarian, Dr. D. B. Dowling.

It was moved by Mr. Brock, seconded by Dr. Faribault, that the report of the Nominating Committee be received and adopted.—Carried.

The Newly elected President, Dr. D. C. Scott, then took the chair.

It was moved by Dr. Bryce, seconded by Dr. Saunders, that the following Fellows constitute the General Printing Committee for the year: Mr. Barbeau, Mr. Gerin, Dr. Klotz, Dr. Prince, Dr. McInnes, Mr. Patterson, Dr. Scott, Dr. Shortt, Dr. Dowling, Dr. Fields, Dr. Lloyd, Dr. Huntsman.—Carried.

It was moved by Mr. Johnston, seconded by Dr. Walker, that the following Fellows be appointed Auditors for the year 1921-22: Dr. Glashan and Dr. Shortt.—Carried.

It was moved by Dr. Parks, seconded by Dr. Fields, that the thanks of the Society be presented to the Deputy Minister of Mines and to Dr. McInnes, the Director of the Victoria Memorial Museum, for their kindness in arranging for the accommodation for the Annual Meeting.—Carried.

It was moved by Dr. Huntsman, seconded by Dr. McLean Fraser, that the thanks of this meeting be presented to the officers of the Society, the Members of Council and the Auditors, for their very efficient services during the past year.—Carried.

The meeting was then declared adjourned by the President, Dr. Duncan C. Scott.

APPENDIX A

PRESIDENTIAL ADDRESS

THE GASPÉ PENINSULA

A Study of the Geology of the Region, and its Influence on the Inhabitants

BY

A. P. COLEMAN, M.A., Ph.D., F.R.S.

THE GASPÉ PENINSULA

A Study of the Geology of the Region, and its Influence on the Inhabitants.

Introduction

The Gaspé peninsula, projecting like a huge lobster's claw between the St. Lawrence and the Bay of Chaleurs, was naturally the first part of the province of Quebec to be visited by white men. In 1534, Jacques Cartier landed on its eastern end and raised a cross in token of its possession by France. Even before this Basque and Breton fishermen sought the cod in its waters and must have been familiar with its bold cliffs and promontories. Later, some of the earliest settlements in Canada were established on its shores and several of them have persisted to the present day.

Books have been written in eulogy of Gaspé and its people, such as Le Clercq's *Nouvelle Relation de la Gaspesie*, in 1691; Langelier's *Esquisse sur la Gaspesie*, in 1884; Clarke's charmingly written *The Heart of Gaspé*, in 1913; and Pelland's *Guidebook to la Gaspesie*, published by the Quebec Government in 1914. These and numerous other writings suggest a country long and favorably known.

At present, a great railway transports every year hundreds of thousands of travellers past its western end; other thousands of passengers sail down the St. Lawrence on Atlantic liners close to the northern shore of Gaspé and enjoy its grand scenery; while hundreds of tourists visit the watering places of its southern shore.

One naturally expects to find Gaspé one of the best known parts of Canada, thoroughly explored and mapped and easily visited. In reality the interior of Gaspé is the least known part of southern Canada and remains a trackless wilderness, inhabited only by wild animals. Whoever would cross the peninsula from north to south must shoulder a pack and toil through dense woods and wild mountains before reaching civilization again. Actually no one ever undertakes the journey except, at intervals of years, some party of land surveyors or of scientific men.

If you ask for a map of Gaspé at Ottawa or Quebec you will receive two broad sheets which, when put together, show its lobster claw outline and a rim of roads and settlements, and on the south even railroads, all clinging close to the sea coast. A few lumber roads run a little way towards the interior, and one from the south reaches half way across; but in the heart of the region one sees nothing but a few boundary lines and some lakes and wandering rivers. The explorer who reaches their shores often finds that these lakes and rivers are incorrectly placed and wrongly shaped.

The maps available give, at first sight, no indication of mountains in Gaspé. The blank interior might be nothing but a plain. A closer look shows a few names of peaks and figures indicating elevations, but no one would suspect that the highest mountains in eastern Canada rise as an impassable range a few miles from the northern coast. North of the St. Lawrence the Laurentides are famed in song and story, but one scarcely hears of the Shickshocks to the south, though they rise more than a thousand feet higher than the loftiest known peaks on the other side of the river.

The maps now obtainable are almost worthless for the explorer of the interior of Gaspé, but careful enquiry at Ottawa will disclose the fact that a real topographical map of the peninsula was made many years ago by the Geological Survey and was published in 1884. It was rough and by no means complete, but it shows at least the northward curve of the mountain range which makes the stiff backbone of the country, and it is of far more use in exploration than the modern maps. Unfortunately the draughtsman who prepared the map has misplaced one or two of the peaks, as one can see from Logan's description.

The Geological map gives names to six peaks on the main range of the Shickshocks; but only one of them, Mt. Albert, is known to the present inhabitants of the region, and this name has been transformed into M'albert. On the other hand, a striking peak on the upper waters of Chat River is called Mt. Nicolabert by the river men, though this name does not appear on any map. A lower peak on the opposite side of the river is called economically Le Frere de Nicolabert. These three names and one other, "Couvert de Chaudron," are the only ones heard during two summers field work; and usually enquiry as to the names of mountains is answered merely by a scornful "Des Shickshocks," since the habitant has no use for these barren ridges.

My own interest in the range arose from a study of the Labrador ice sheet, whose boundaries and thickness have never been carefully determined. The Shickshock range, including the highest peaks in eastern Canada, might afford an opportunity to gauge the thickness of the great ice sheet, and so was briefly examined during two summers' geological work in Gaspé (1918-1919). All the highest points were climbed and their elevation determined, and a map was made of Tabletop, from which the most important summits rise. The mountains proved to be higher than had been supposed.

The field work included a study of the glacial deposits and of the marine terraces of the lower parts of the peninsula and gave opportunities for observing the effects of the physical features of the region on the lives of the inhabitants. This address is mainly founded on the observations made during the months spent in geological work.

Physical Features of Gaspé

The south shore of the lower St. Lawrence presents a surprisingly smooth and unbroken curve, ending toward the southeast in the sharp spine of the Forillon. There is nothing like it elsewhere on the coasts of Canada; and it is peculiar in another way, this northward bending back of Gaspé has not a single harbor. No ship larger than a schooner or a tug boat can find shelter on the 200 miles of storm-beaten and pitiless shore; and even they can only squeeze into some river mouth at high tide. This is a very serious lack on so wild a coast, and the want of commodious harbors on the north side of the peninsula has greatly influenced the lives of the inhabitants.

The south side of Gaspé is as ragged in outline as the north is smooth and has no lack of harbours, including the famous Gaspé basin where a fleet of large ships can find perfect shelter.

There are, of course, geological reasons for this strong contrast between the two sides of the peninsula. The graceful bow on the north corresponds to the sweep of the Shickshock mountains, which form the last swing of the sigmoid curve of the great Appalachian chain. The south shore of the St. Lawrence below Quebec conforms to the intimate structure of the mountain system, and in Gaspé the range of highest mountains keeps close to the shore, sometimes reaching the sea as grand cliffs. All the rock structures, even of the lowlands, on the north coast of Gaspé are bent into the same tense bow, and hence there are no broad bays or inlets to form harbours.

On the north side of the steep mountain range plains are few and narrow and often have a niggardly soil of sand or gravel; while on the south they are broad, and frequently the soft rocks have weathered into a rich and deep soil, giving fine farmlands. This lack of symmetry of the peninsula has profoundly influenced the lives and habits of the people on its opposite sides.

To these physiographic features must be added the factor of climate. The north side of the mountains is chilled and depressed with fog or rain whenever the wind blows across the St. Lawrence or the gulf; while the broad southern lands are sheltered from these inclement winds by the lofty wall of mountains and face the well-named bay of Chaleur. Thus the two sides have different climates, the north with chill summers and a very long and snowy winter, while the south has a comparatively long and warm summer, with a winter no worse than that of Montreal.

The Building of the Shickshocks

The building of a mountain range requires long and laborious preparation. In the case of the Shickshocks the preparation went on during the earlier half of the Palæozoic and included the laying down of thousands of feet of sediments, mainly on a shallow sea bottom, but partly on land. In Cambrian and Ordovician times the sediments were of mud, gray, or reddish, or black with organic matter, but including some beds of sand. Toward the end of the Ordovician there were dry land conditions and an extraordinary boulder conglomerate with great and small blocks of limestone and of eruptive rocks was spread out along what is now the northern rim of Gaspé. The source of these stones is unknown, since no rocks like them occur in the region; but one may suppose that they came from land now beneath the sea. The size of the boulders in the conglomerate suggests the work of ice, but final proof of glacial action has not yet been reached.

Then come shallow seas again in which Silurian shales and limestones were deposited, often charged with fossils. In the early Devonian Gaspé was once more dry land, however, clothed with a primitive vegetation instead of a possible ice sheet. Psilophyton, distantly related to the modern club mosses, was wide spread, the earliest known land plant.

During the Devonian important mountain building operations took place; the earlier rocks being squeezed into closed folds or broken into slices by thrust faults and driven by an overwhelming push of the sea bottom against the solid resistance of the Archæan continent to the north. It is likely that similar thrusts had occurred before, but the relations of the rocks are too tangled and obscure to be quite sure of this.

As a consequence of the folding and faulting of the beds more ancient underlying rocks, pre-Cambrian schists, were thrust up in the axis of the rising mountain range far above their original level; and at the eastern end of the hard schists fissures were opened through which great quantities of molten matter welled up, now found as peridotite or serpentine in Mt. Albert and as granite in Tabletop. At about the same time several smaller molten masses rose at various points to the south of the main range, but it is probable that none of the eruptive materials reached the surface as volcanoes, the movements of molten magma going on beneath a cover of sedimentary rocks.

While the mountains were being built destructive forces were at work also and even before the end of the Devonian, parts of the original structures had been planed down, so that upon their upturned edges sandstones and coarse conglomerates of Devono-carboniferous age could be piled up to a thickness of thousands of feet, as shown by Clarke. These were chiefly land formations, but there are fresh water beds also, containing splendidly preserved fish at Scaumenac bay on the southern side of Gaspé. There is evidence, too, of the work of mountain glaciers in a bed of ancient boulder clay, including striated stones.

All of this is very ancient history, the record ending with the early Carboniferous, after which, until the very latest geological periods, one can only infer what took place from present conditions. For details of the early geology one should consult the Geological Survey Reports (1857, 1863, 1880-82, and 1882-84) and Dr. Clarke's excellent accounts of the geology and palæontology of southeastern Gaspé.

The Carving Down of the Shickshocks

The present mountains are merely remnants of a once mightier range which in its prime, toward the close of the Palæozoic, probably reached a height of 10,000 feet or more and rivalled the present frontal range of the Rockies. These earlier Shickshocks differed greatly from the present mountains. Their highest parts probably consisted of sedimentary rocks, and the culminating ridge was ten miles farther south than now. It is probable, too, that they had gentler slopes, at least on the north side, than the abrupt precipices one encounters at present.

The eruptive rocks, especially the granite, must have cooled very slowly beneath thousands of feet of shale and limestone and sandstone; but during the hundred or more millions of years that have passed since the close of the Palaeozoic the Shickshocks have been undergoing destruction through the work of wind and weather and running water and only the ruins of the once lofty range remain.

The softer overlying sedimentary rocks have been carved away and the ancient core of resistant schists and the hard eruptive masses have been disentombed and now form the highest peaks and ridges. By this process of differential erosion the crest of the mountain range has not only been greatly lowered, but has been shifted northwards for several miles, as shown by transverse river valleys, so that the once deeply buried harder rocks now rise as an almost impassable wall near the north shore, while the softer materials slope more gently toward the south.

The physical contrasts between the two sides of the peninsula have their origin, then, in geological phenomena that took place more than one hundred millions of years ago; and the lives of the people inhabiting the north and the south shores have been shaped by these far-off events.

Later Geological History of Gaspé

While the main geographical features of Gaspé were fashioned in the ways described the finishing touches were given to the landscape as we now see it in the latest geological periods, during the Ice Age and the time of marine invasion. When the province of Quebec was overwhelmed with an ice sheet thousands of feet thick, the Shickshocks alone rose island like above the vast expanse of white as ridges and hills of barren rock. From them local glaciers, like those of the Rocky mountains, radiated out through the valleys and joined the sea of ice that enclosed the range on all sides. The hollow resting places of these local glaciers now form U-shaped valleys or cirques, in which there is usually a lake or pond dammed by a moraine.

While the great lobe of ice that filled the valley of the St. Lawrence never rose high enough to cross Gaspé, it has left its mark on the north coast in the form of innumerable blocks of granite, gneiss and other rocks transported from the Laurentide hills east of Quebec. The finest churches of Gaspé are built of these erratics and form collections of Archaean rocks that are well worthy of study by the geologist.

The land sank under its great burden of ice, and when the load was slowly removed by thawing toward the end of the Glacial period, the sea returned at higher levels than now, carving or building the terraces which are so marked a feature of the shores of the lower St. Lawrence. As the land rose, terrace after terrace was formed, until at last an equilibrium was reached at the present sea level.

The life of the habitant is closely bound up with these marine levels, especially on the precipitous north side of the peninsula, where the mud of the old sea bottom often supplies a few fertile fields, and the beach ridges of gravel provide the best of roads. The roads and the villages strung out along them usually follow one of the lower terraces, occasionally dropping to the Micmac terrace, the lowest of all, rising only twenty feet above high tide.

The marine terraces are highest at the west end of Gaspé, where they reach more than 400 feet above the sea, and decline steadily toward the east to about 150 feet. This corresponds, no doubt, to the thinning of the ice sheet as it approached its eastern edge, the rise of the land being greatest where the ice was thickest.

The Rivers of Gaspé

Most of the rivers of Canada have a very youthful character and display many lakes and waterfalls and their channel is often poorly defined. This is due to the work of the great ice sheets which blocked all the old valleys with glacial debris and forced the rivers to follow new routes. Gaspé, not having been covered by the main ice sheet, has rivers of a much older habit, with few waterfalls, no lakes on their lower stretches, and usually well graded channels, occupying in many places deeply cut V-shaped valleys.

On the north side of Gaspé, Ste. Anne and Chat rivers may be navigated for thirty-five miles by canoes or small boats that are poled up stream, and navigation ends on these small rivers right in the heart of the mountains. On the Cascapedia river, following the gentler southern slope of the peninsula, a team of horses can tow a heavily loaded scow to the lumber camps 45 miles from the sea, showing the well graded character of the river. The St. Anne and Chat rivers have another extraordinary, and at first unaccountable, feature. Both begin placidly in a lake on the south side of the mountain range and then, more tumultuously, plunge through canyons cut 2,000 or 3,000 feet below the summits on each side before the lower navigable parts begin.

Why should these small rivers flow north through the highest part of the mountains instead of following the natural slope of the land southwards, like the Cascapedia? How did they carve their way through the barrier of mountains?

One cannot imagine them as flowing up hill to attack the mountains, but one may suppose that when they began their work the range was higher on the southern side than on the northern, and that, while the softer rocks on the south were being rapidly eroded, the two rivers were active enough to keep pace with the destruction, eating their way down through the hard back-bone of eruptive rocks and ancient schists to the north.

The Higher Mountains

Mt. Albert (3,660 feet), at the head of navigation on Ste. Anne river, is the only high mountain easily reached and occasionally climbed, the attraction being the caribou that make their home there. One ascends 3,000 feet through forest, the latter part of the trail being very steep, and suddenly one comes upon a snow bank at the foot of a bare cliff. Scaling the very summit one is surprised to find, not a peak, but a flat plain stretching for miles to the west. Most of the few square miles of tableland are a dreary waste of brownish serpentine blocks; but toward the north there is a belt of swampy meadow enclosing a pond and at the northern rim a higher ridge of hornblende schist up whose sheltering slopes spreads a thicket of spruce bushes. On the highest point of schist one may often see a big caribou with branching horns silhouetted against the sky like a figure in bronze, motionless, enjoying the breeze and the prospect. On all sides except to the west the tableland drops off suddenly in steep cliffs to valleys 1,000 feet or more below, all clothed in forest. Across the deep valley of St. Anne river and eight miles away rises the blue bulk of Tabletop; to the north the wooded hills sink toward the gleaming sea twelve miles away, and to the south a hilly country with here and there a lake fades into the distance.

Tabletop

The clumsy and inappropriate name of Tabletop was given by the Geological Survey to the highest group of mountains in Canada east of the Rockies. The name would have been suitable for Mr. Albert, which is flat topped, but is quite amiss when applied to the rounded summits and flaring valleys of this mass of granite, including differences of level amounting to nearly a thousand feet.

Tabletop is hard to reach and is very seldom visited, so that even the people of the region know nothing of it except as a part of the Shickshocks. A terrible trail through fallen timber brings one to Lac aux Americains at 2,300 feet. This beautiful lake between tremendous cliffs is on no map except my own. Its name comes from a party of American botanists who studied the plants of Mt. Albert and Tabletop a number of years ago.

From the lake one ascends a steep mountain ridge, the lower part covered with stunted trees, the middle part clothed largely with exasperatingly stiff spruce bushes, and the upper part bare scree and rock, from which one looks down a thousand feet upon the blue lake, apparently vertically beneath.

Crossing the rounded stony summit of the first mountain, 3,900 feet above the sea, bushes and then stunted trees appear once more on the side sheltered from the west winds, and at 3,500 feet beside a streamlet trees are tall enough to make camp. There are ancient spruces and balsams, a foot in diameter and less than thirty feet high, but hundreds of years old and rotten at heart. Here the French-Canadian misses his beloved white birch, whose tough bark serves such a multitude of purposes in camps at lower levels.

The Tabletop forms an extraordinary little world to itself, more like northern Labrador or the Rockies at timberline than the province of Quebec 3,000 feet below. On almost all sides impassable cliffs prevent intrusion from the lowlands and man scales the walls very seldom. Its bare mountain domes of decaying granite provide secure pastures for the caribou, while the shallow valleys with groves of stunted evergreens, meadows of swampy grasses and innumerable ponds and lakes are the home of the moose, both unusually tame.

Half a dozen of the mountains reach above 4,000 feet; and aneroid readings make the elevation of one of them 4,350 feet. On the rocky slopes of these mountains wherever a little soil has lodged one finds red and white flowering heathers and Arctic berries, such as the low cranberry, the dwarf blue berry, the black crowberry and the insipid bear berry. Still higher up are the cushions of moss campion covered with pink flowers, just as in the Rockies at 7,000 or 8,000 feet, while scanty grasses, pale gray reindeer lichen and certain mosses reach the wind-swept tops of the mountains.

On the south side of some of the highest points a few great snowbanks were slowly melting at the end of July, 1919. Probably some of them last till the snows begin to fall again in September. Tabletop has a climate of its own, like that of northern Labrador, with nine months winter and a summer darkened with mist and fog and driving rain whenever the wind blows from the sea. The fine days are superfine, however, with brilliant sun and a cool springlike air that is most inspiring.

An area of about thirty square miles of Tabletop rises above 3,000 feet and once the rim is scaled there are no difficulties in exploring the hills and valleys except those caused by thickets of spruce in sheltered spots and swamps and lakes in more open places. A dozen or more lakes and ponds may be seen from any of the mountain tops, and doubtless there are far more of them in this little area than in all the rest of Gaspé. Those toward the northwest drain into Ste. Anne river and are without fish; those toward the southeast are tributary to Madeleine river and are inhabited by speckled trout, giving a ready way of determining the watershed.

The geological map shows the name of Richardson peak, 3,700 feet, near the southwest corner of Tabletop. My determination of the height is 4,090 feet. No other mountain of the group has received a name. The highest point, reaching 4,350 feet, is near the eastern side, and may be called the Botanists' Dome, since it is near the main camp of the American botanists. A cairn, probably erected by them, marks the summit, from which one looks down upon Gaspé. Just to the east of the dome there is a drop of more than 2,000 feet to wooded valleys leading off to the sea. In clear weather one should see Anticosti and the Laurentides across the St. Lawrence; but haze robbed us of that vision. Toward the west rises Mt. Albert and then point after point of the Logan range, each bluer and fainter than the last one.

The Logan Range

The first high mountains known to have been climbed in the Shickshocks are thirty miles west of Tabletop, near the head waters of Chat river. The highest was determined by Logan himself, as reaching 3,768 feet. On the Geological Survey map it is called Mt. Logan, but it may be better to reserve that honoured name for the highest point in Canada, the Mt. Logan of the Yukon territory, 19,850 feet high.

The next mountain to the west, probably Logan's Mt. Mattawees, is a little lower, and is sometimes called by hunters "Le Couvert de Chaudron," from its flat, dome-shaped summit. The third mountain is Bayfield (3,471 feet), separated from the others by the deepest canyon in the Shickshocks, where Chat river has carved its valley down to 400 feet above the sea, so that there is a chasm of 3,000 feet between the mountains toward the east and those to the west. All of these mountains consist of Archæan schists, so that their surface differs greatly from the granite domes of Tabletop. The peaks just mentioned rise just above timberline and in some cases there are deeply cut cirque basins containing lakes on their flanks.

The fifty miles of mountains rising above timberline and forming the most elevated part of the Shickshocks, include the wildest and most alpine summits of eastern America except the Torngats of Northeastern Labrador; and one would expect to find them a centre of attraction for the tourist with motor roads and hotels and crowds of summer visitors as in the White mountains. Instead, they are one of the wildest and most inaccessible parts of the province of Quebec and form an impassable barrier to communication between the narrow north and the broad south of the peninsula. It is this bleak mountain range which has preserved uncontaminated the primitive human communities of Gaspé. Their whole life and their outlook upon the world are shaped and limited by the Shickshocks.

The People of Gaspé

With an area as great as that of some European Kingdoms, Gaspé has a population of perhaps 100,000, spread out thinly around the edges of the peninsula. In origin the population is very mixed. To the aboriginal inhabitants, the Micmac Indians, have been added colonies of fishermen on the eastern coast, groups of Acadians and French-Canadians, and of U.E. Loyalists, as well as bands of Irish and Scotch immigrants, farther west. On the broader southern side of Gaspé, these groups of French or English speaking settlers have remained more or less separate, but on the northern side the habitant has almost completely absorbed the English speaking elements.

At the extreme east of Gaspé the Forillon extends thornlike into the Gulf, the final tip of the range of mountains. It presents limestone cliffs to the northeast, rising vertically from 500 to 800 feet above the open sea; while toward the southwest the beds are tipped steeply toward more sheltered waters, with here and there a minute cove and gravelly beach where boats can land. It is not surprising that the Channel Islanders who settled at Grandgrève are fishermen with houses perched like nests of seabirds on the steep slopes, ready to plunge into the water when shoals of fish approach the shore. They farm a few fields so steeply tilted seawards that they can only be ploughed one way, turning the furrows down hill.

The people of Percé and of Bonaventure island, also, though on more level ground, are almost as much dependent on the sea as the gulls and cormorants and the puffins and gannets that nest on the nearby cliffs, though summer visitors, attracted by the beach and the marvellous Pierced Rock, which gives the name to the village, have influenced the character of the settlement. The rocks and the cliffs have driven them all to gather their main harvest from the sea. At this end of the peninsula the cod is king and the men of Jersey long ago founded wealthy and powerful companies to catch and cure and market codfish.

Away from the actual coast well graded rivers come down into sheltered harbours, exactly suited to float logs from the wooded mountains inland; and at every river mouth there is a sawmill with its rows of square lumber piles gleaming yellow against the dark hills, while not far off a column of smoke ascends for ever where the refuse is burning. Approaching the mill you are greeted with the resinous odour of the fresh spruce and hear the scream of the circular saws tearing their way through the logs as they are transformed into boards.

The lumberman in winter is often a farmer in summer, and as one goes westwards on the south side of Gaspé broad fields begin to spread out between the hills and farming becomes of greatest importance. There are green pastures where sleek cattle graze and expanses of clover and of oats or barley or wheat; and in the autumn two-horse wagons, loaded with fragrant hay or with sheaves, move towards the open doors of barns. In some of these prosperous farming communities English is the only language, often spoken with a Scotch or Irish accent, and the whole atmosphere is that of the Maritime provinces rather than of Quebec; but in a majority of places French is the language used. Several settlements which began with U.E. Loyalists or other English-speaking inhabitants are now largely French, as, for instance, New Richmond and Maria; but so far as observed, the French-speaking people of southern Gaspé are usually bilingual.

At the southwest corner of the peninsula, where the Matapedia river enters the delta of the Restigouche, there is a little colony of the descendants of Scotch farmers perched on a projecting corner of the tableland, 800 or 1,000 feet above the sea level, still preserving their accent and customs; while a mile to the north a newer settlement of French-Canadians has cleared its farms. The two groups are completely segregated, each having its own steep, winding road down the escarpment to the station on the Intercolonial Railway.

It is probable that a new geological factor may presently arise to modify human relationships in Gaspé. Large deposits of zinc and lead ores have been found in the southern foothills of the Shickshocks, almost in the geographical centre of the peninsula, and if these develop into important mines the "Heart of Gaspé," now practically virgin forest and uninhabited, may become a bustling mining camp, bringing in railroads and hordes of labourers from the south of Europe and transforming a lovely wilderness into a fire-scarred and sordid human anthill. The mixture of races and languages will then become much more complicated than at present, and the charm of seclusion and aloofness from the turmoil of modern civilization will presently depart from southern Gaspé.

People of the North of Gaspé

On the north side of Gaspé, hemmed in between a foggy sea and the scarcely penetrable mountains, live, perhaps, the most primitive civilized people of North America. They are of quite mixed origin, as shown by occasional families having bright red hair and blue eyes and by names such as Macdonald, Robinson and Maloney, not to speak of Langlois, but they speak almost entirely French and have most completely the habitant's attitude toward life and the world. Their French is archaic, with words and pronunciations very puzzling to one who has studied only Parisian French. Their one road runs close to the sea shore, usually on a marine terrace but sometimes on the actual beach within reach of the waves; and their little settlements scarcely stray from the road, thickening up at the mouth of every creek and river and thinning out or ceasing altogether where the mountains crowd too closely to the sea. The road begins bravely on the West, where even automobiles raise clouds of dust upon it, but becomes less and less navigable for wheeled vehicles until near Riviere a la Martre and beyond it is a mere track on the beach, unusable at high tide when the waves beat against the foot of the lofty cliffs.

On this endless road, with villages strung upon it like beads, only one-horse conveyances are seen. A team is never used. In each village or hamlet there is a great church, like a hen brooding over chickens, and on Sunday morning every family, even from the most remote ends of the parish, is to be seen in the indispensable covered carriage on the way to Mass or on the way from it. The most certain method of encountering a man who is entirely elusive on week days is to watch for him at the church door after Mass on Sunday.

In spite of the severe climate and primitive conditions the people live comfortably. One of my guides, for instance, had a little farm, all but a few acres of which was very infertile, but which provided hay and pasture for his horse and cows and a few sheep, one or two of which were, as in most habitant flocks, black. The little dilapidated barn sheltered them all in winter. A pig, of whose excessive fatness

Joe was very proud, occupied a sty near the house; and a few fowls scratched near a small stack in the barnyard. In their season the fields yielded hay mixed with many marguerites and there were some patches of wheat and barley and oats, brilliant with yellow mustard flowers, and also a half-acre of potatoes. A little fishing in the proper month supplied dried cod for Fridays and fast days, and a trap net projecting from the shore secured for him excellent salmon and sea trout on their way to spawn in the river. When the winter snows arrived, Joe betook himself *a la montagne* and, tramping on his raquettes to a little cabane twenty miles in the woods, generally managed to secure a moose, which when frozen provided fresh meat for the family during the winter with the help of the fat pig slaughtered some time before.

The house was poorly built and the wind entered it in places, but wood for the stove cost nothing more than cutting on the forest-covered mountains in the rear. In spring Joe tapped a few maple trees up the river valley, supplying the family with sweets. A braid or two of *tabac Canadien*, raised in a sheltered corner of a neighbour's garden, soothed his leisure moments both summer and winter. Joe needed a little money, of course, which could be earned either by trapping a few furs or by working in the lumber camp in the mountains which supplied the logs for the small mill at the river mouth.

In the house the women did all needful work, besides carding and spinning wool, mixed of white and black, to be knitted into warm grey socks and mitts. There was a loom, also, on which homespun was woven.

In summer the women and children gathered buckets of splendid red strawberries in the meadows, the most delicious of fruits, and wild cherries and *des poires* (service berries) could be had in sheltered spots in the valley.

It will be seen that Joe and his family lived in rude comfort with hardly any money on the bounties of the sea and the land and the mountains. Reading matter Joe did not require, since his education had been practical, at sea and in the fields and in the mountains. He had never learned to read or write. He was, however, a fluent and attractive speaker. One night in the men's house at the fishing camp up the river a dozen husky river men were sitting on a bench or on the edges of bunks telling tales and spitting conspicuously on the planks of the floor near the hot stove. Joe's yarns roused much more laughter and enthusiasm than those of any of the others. What they were about my imperfect acquaintance with habitant French prevented me from knowing certainly, though the words *carabine* and *caribou* suggested hunting.

My first visit to Northern Gaspé was in 1878, my next forty years later, and no very striking changes had come in the interval. Perhaps the most impressive changes were of a mechanical kind. One hears the beat of the motor boat saving the fisherman the toil of the oar, the whine of the cream separator morning and evening. These are new and universal sounds. But most things were unchanged when one passed the Western part of the main road on which automobiles could travel. One saw the same small wooden houses with the dormer windows and the outward curve of the eaves inherited from Old France, though there were a few more of them. The outdoor ovens of stones and clay were still in use to bake excellent bread; the gaunt six rayed or eight rayed windmills still faced the north-western gales; the long underwater fences of the traps reached out to sea as of yore and the drying nets and the long fish flakes shingled with flattened cod were spread at every inlet along the coast; while the overpowering fragrance of decaying fish assailed one's nostrils everywhere. The gray sea was the same, and the green woods and the mountains and the driving fogs were unchanged; and the men, women and children and the dogs and horses were very little different from the people and the dogs and the horses of forty years ago.

There are still seigneuries in Gaspé, as in the days of Bigot and Champlain, but the seigneurial rights have diminished. The people are still, as a rule, polite and respectful toward strangers. The school boys doff their caps and the little girls bow and say "*bon jour*" or "*bon soir, monsieur*" when you meet them on the road. The church is still as powerful a factor in the lives of the people as in olden days, though the well-to-do driver of your carriage may tell you regretfully, as you admire the splendid new Church built of a mosaic of Archaian boulders, that it cost $100,000 instead of the $68,000 which had been estimated. Morals are perhaps even more closely watched than in the past and the fisherman who delights you with his violin playing in the evening tells you with a somewhat sarcastic smile that the priest has forbidden dancing in the parish, so that now he can only play to amuse himself.

The Gaspesians are a hospitable people and when one gets beyond the villages with their little hotels, usually clean and comfortable, some thrifty family will always take one in for a meal or for a night. The bread may be of home grown rye and the pea soup may be followed by the fattest of fat bacon, but there will be cream and rich strawberry jam and some kind of cake for desert. On Friday there will certainly be fish, perhaps cod for breakfast and salmon for dinner and herring for supper, all fresh out of the water, or perhaps nothing but salt herring will appear on the table, but there will never be meat. Usually a comfortably fitted room will be available at night, though the family may have to adjust itself to the undivided upper story. On the walls of the room you will probably find a crucifix and religious pictures, the latter very crude; while on the walls of the sitting room there are apt to be grotesque enlargements of family portraits and very sentimental coloured advertisements in which pretty girls and mothers with babies play a large part. In the morning the man of the house will offer his services to drive you to the next parish, from eight to fifteen miles away, and will be shocked and puzzled to learn that a geologist prefers to walk.

In some of the houses, small as they are, four generations may be represented and you may see a great-grandmother with bent back and wrinkled face, a well-preserved middle-aged grandfather with his careworn wife, who is the manager of the house, and husky young men and comely women of the third generation, one of them nursing a fat baby of the fourth. How they are all accommodated in addition to a guest is a wonder. In the cool of evening neighbours come in and sit round the stove in the combined kitchen and living-room and jokes pass or arguments take place, but no one seems crowded.

It may be thought that the northern Gaspesians are contented because they know nothing of any other world, but this is not wholly true. Now and then one is encountered who speaks English and who tells you of his nine year's stay at Fall River or elsewhere in the New England States. He has no very convincing reason to give why he left the gay life of the city for the hard and lonely existence on the coast of Gaspé with seven months winter, but there seems a charm in the white birch and the snow laden branches of the spruce and in the mild sunshine when the fog lifts from the sea that is potent enough to bring back at least some of the wanderers from far countries.

These primitive features of the northern Gaspesian civilization have changed but little within forty years, while all around modern commerce and industrial life have been changing things enormously. How much longer will this isolated population keep aloof from the world about it? Will it still retain its dialect, its ballads, its homely mode of living and its mediaeval point of view while the rest of the world moves forward?

Certain physical features, due to the geology of the region, make a longer isolation probable. The lack of harbours prevents the building of seaports where the outside world can stir up curiosity and ambition. The lack of great water-powers, like those on the north side of the St. Lawrence, will prevent the growth of important industrial centres which would be disturbing elements. The only pulp mill on the north side of Gaspé is at the falls of Madeleine river, seven miles from the sea, and it does not promise great expansion. Unless some other, still unknown, geological factor, such as the finding of a great mining region in the Shickshocks, arises, northern Gaspé seems destined to remain a peaceful, contented, unenterprising backwater of civilization, where a fringe of settlers cut the white birch for spool wood and the spruce for some sawmill, cultivate poorly a few acres of soil and catch the cod in its season, while the mountains just in their rear remain a wilderness, the home of moose and caribou and bear seldom molested by a sportsman.

The rising flood of mechanical invention and of restless travel and excitement bid fair to pass on either side somewhat as the lobes of the great ice sheet did, leaving the Gaspé mountains as a scarcely touched island between them. It will be no misfortune if Gaspé should remain as a sample of what has been, as the home of an almost forgotten simplicity of pioneer life once pervading the whole of Canada. It may remain a restful and picturesque oasis in the arid desert of mechanical progress. Perhaps it should be isolated even a little more than nature has arranged for, so as to preserve one stage of the evolution of modern civilization; somewhat as Roche Percé and Bonaventure island have been made sanctuaries for the sea birds which otherwise might soon have vanished.

APPENDIX B

ANNUAL POPULAR LECTURE

RECENT ADVANCES IN PHYSICS

BY

J. C. McLENNAN, Ph.D., F.R.S.

RECENT ADVANCES IN PHYSICS

In the introductory portion of his lecture Professor McLennan dwelt on the importance, from the point of view of the national welfare, of developing Scientific and Industrial Research in Canada.

He briefly described the various steps which had been taken which led up to the creation in 1916 of The Advisory Council for Scientific and Industrial Research.

In emphasizing the work already accomplished by this Council the lecturer referred briefly to the system of Fellowships. Scholarships and Bursaries which had been established by the Council for the training of Research workers in our Universities.

The importance to Manitoba and Saskatchewan of the investigation on the briquetting of lignites in Southern Manitoba, which was about to culminate in the erection of a works for the supply of fuel of high thermal efficiency, was also pointed out.

The main part of the lecture was, however, taken up with an account of the research work on Helium with which Professor McLennan had been more immediately connected.

In dealing with this subject the lecturer asked his hearers to keep in mind that he chose to particularize in this way with the object of illustrating how scientific research work forms a substantial basis on which to develop existing industries or to build up new ones. From the national point of view it was desirable to add to the wealth of the community at the present in every way possible and no surer method was available than one which applied science and scientific knowledge in such a way as to utilize as many as possible of our natural resources.

Shortly after the commencement of the war in 1914 it became evident that if helium were available in sufficient quantities to replace hydrogen in naval and military airships losses in life and equipment would be very greatly lessened.

The fact that helium is both non-inflammable, non-explosive, and possesses 92 per cent. of the lifting power of hydrogen, makes it a most suitable filling for airship envelopes. By the use of helium the engines of airships can be placed within the envelope if desired. A further advantage possessed by helium over hydrogen is that the buoyancy may be increased or decreased at will by heating and cooling the gas by electric or other means, which fact may possibly lead to considerable modification in the technique of airship manœuvring and navigation. Moreover, the loss of gas from diffusion through the envelope is less with helium than with hydrogen to the extent of about 30 per cent.

Although there are indications that proposals had been put forward during the war by men of science in allied and enemy countries, as well as in the British Empire, regarding the development of supplies of helium for aeronautical purposes, it should be stated that the movement that led up to the investigation which it was his privilege to undertake was initiated by Sir Richard Threlfall. The existence in America of supplies of natural gas containing helium in varying amounts was known to him and others, and preliminary calculations as to the cost of production, transportation, etc., which he made led him to believe that there was substantial ground for thinking that helium could be obtained in large quantities at a cost which would not be prohibitive.

His proposals were laid before the Board of Invention and Research of the British Admiralty, and in the autumn of 1915 the lecturer was asked by that Board to determine the helium content of the supplies of natural gas in Canada, to carry out a series of experiments on a semi-commercial scale with the helium supplies which were available, and also to work out all technical details in connection with the production of helium in quantity, as well as those relating to the repurification, on a large scale, of such supplies as might be delivered and become contaminated with air in service.

Composition of the Natural Gases Investigated

In commencing the investigation a survey was made of all the natural gases available in larger or smaller quantities within the Empire with a view to ascertain their helium content. Natural gases from Ontario and Alberta, Canada, were found to be the richest in helium, and these sources, it was found, could supply from 10,000,000 to 12,000,000 cubic feet of helium per year. The following is a summary of the results obtained from the analyses of a number of the gases investigated. They include, it will be seen, a few samples from outside the Empire. For a complete account of this part of the investigation the reader is referred to Bulletin No. 31 of the Mines Branch, Department of Mines, Canada, 1920.

(*a*) *Ontario Gases.*—The anlysis made by Professors Ellis, Bain, and Ardagh (Report of Bureau of Mines of Ontario, 1914) of the natural gases supplied to the experimental station, initially set up at Hamilton, Ontario (Blackheath System), is as follows:

Methane	80 per cent.
Ethane	12 " "
Nitrogen	8 " "

It was found, however, on operating with this gas that the percentage assigned to methane really included a considerable proportion of gasoline, pentane, and butane as well. The helium content of the gas was found to be 0.34 per cent.

(b) *Alberta Gases.*—Gas taken from the mains leading from the Bow Island supply to Calgary was found to be quite free from the heavier hydrocarbons. At times it contained slight amounts or water vapour and occasionally a trace of carbon dioxide as well. Its approximate composition is given under I.

	I	II
Helium	0.33 per cent.	0.36 per cent.
Methane	87.6 " "	91.6 " "
Ethane	0.9 " "	1.9 " "
Nitrogen	11.2 " "	6.14 " "
Carbon dioxide	trace	trace
Water vapour	trace	trace

One well in particular, namely, No. 25 Barnwell, which has recently been driven, and now supplies gas to the system, was found to have a product of the composition II.

(c) *New Brunswick Gases.*—Some natural gases obtained from wells struck near Moncton, New Brunswick, Canada, were examined and found to have the following composition:

Methane	80.0 per cent.
Ethane	7.2 " "
Carbon dioxide	None
Oxygen	None
Nitrogen	12.8 per cent.
Helium	0.064 " "

An interesting observation was made in connection with natural gases obtained from Pitt Meadows, Fraser River Valley, and Pender Island, in the Gulf of Georgia, British Columbia. Both these gases were found to have a nitrogen content of more than 99 per cent. The lecturer pointed out how this nitrogen, if it should be found to exist in large quantities, might be used as a basis for the manufacture of explosives and artificially made fertilizers. A market for such products lay near at hand in the Fraser Valley, in the Sacramento Valley, and also in China.

Soon after taking up the investigation it was found, as mentioned above, that large supplies of helium were available in the natural gas fields of Southern Alberta, and that a small supply could be obtained from a gas field situated about twenty-five miles to the south-west of the city of Hamilton, in Ontario. In 1917 the Board of Invention and Research decided to endeavour to exploit these sources of supply, and operations were begun by setting up, as already stated, a small experimental station near the city of Hamilton.

At this station efforts were directed towards constructing a machine which would efficiently and economically separate out the helium from the other constituents present in the natural gas. The carrying out of this work expeditiously was made possible through the hearty co-operation of L'Air Liquide Société of Paris and Toronto, who generously lent, free of cost, a Claude oxygen column and the necessary auxiliary liquefying equipment for the investigation.

By making suitable additions to, and modifications in, this oxygen rectifying column, it was ascertained that the problem of separating, on a commercial scale, the helium which was present in this crude gas to the extent of only 0.33 per cent. was one capable of satisfactory solution. Early in 1918 it was found possible to raise the percentage of helium in the gas to 5.0 by passing it through the special rectifying column only, and as the gas obtained in this way consisted of nitrogen and helium with a small percentage of methane, it became, therefore, a comparatively simple matter to obtain helium of a high degree of purity. In one particular set of experiments on this final rectification helium of 87 per cent. purity was obtained.

Experimental Station at Calgary, Alberta

In order to operate on the natural gas of the Bow Island system in Southern Alberta an experimental station was established at Calgary in the autumn of 1918, and, starting with the knowledge acquired through the preliminary operations at Hamilton, rapid progress was made in developing a rectification and purifying column, together with the requisite auxiliary equipment, which would efficiently and cheaply separate the helium from the natural gas. A machine was therefore designed, constructed, and supplied with piping which possessed great flexibility, and, in its general scheme, followed the lines of the Claude oxygen-producing column. It was unnecessary, the lecturer stated, to go into details regarding the operation of this machine. It would suffice to say that it was tested under a variety of conditions. Notes were taken of the temperatures reached at different points in the machine under equilibrium conditions when the gas was passed through it in various ways. As a result of this procedure it was soon found what parts of the machine could be eliminated and what parts could be modified with advantage. When those changes were made, which seemed desirable in the light of the experience gained, it was found that a machine had been evolved which would give highly satisfactory results.

A sketch of the experimental machine as it was finally constructed was exhibited.

Miscellaneous Investigations

In the course of the investigation on the development of a machine for extracting helium from natural gas, supplies of helium of varying degrees of purity became available. These were highly purified, and were used for the investigation of certain collateral problems which demanded solution. Among the results obtained it was found that for aeronautical purposes hydrogen could be mixed with helium to the extent of 15 per cent. without the mixture becoming inflammable or explosive in air. Mixtures containing even as much as 20 per cent. of hydrogen could be burnt or exploded only when treated in an exceptional manner. The permeability of rubbered balloon fabrics for helium was shown to be about 0.71 of its value for hydrogen. For skin-lined fabrics the permeability to hydrogen and helium was about the same. Thin soap films were found to be about one hundred times more permeable to hydrogen and helium than rubbered balloon fabrics, but untreated cotton fabrics, when wetted with distilled water, were but feebly permeable to these gases. It was found that rapid estimations of the amount of helium in a gas mixture could be made with a pivoted silica balance, a Shakspear katharometer or a Jamin interferometer.

The latent heats of methane and ethane have been determined, as has also the composition of the vapour and liquid phases of the system methane-nitrogen. It has also been shown that helium containing as much as 20 per cent. of air, oxygen, or nitrogen can be highly purified in large quantities by simply passing it at slightly above atmospheric pressure through a few tubes of cocoanut charcoal kept at the temperature of liquid air. In the spectroscopy of the ultraviolet helium has been found to be exceptionally useful. Arcs in helium between tungsten terminals can be easily established and maintained. In a particular investigation with a vacuum grating spectrograph it was found that, by the use of arcs in helium under 30 cm. pressure, illumination could be maintained continuously for hours, and with such arcs spectra could easily be obtained extending to below 1,000 A.U.

Although it is known that free electrons can exist in highly purified helium to an amount easily measurable it was found that pure helium, under a pressure of more than 80 atmospheres, did not exhibit anything in the nature of metallic conduction. Moreover, the mobilities of both positive and negative ions formed by a-rays in helium under this high pressure were found to have about one-third the value expected on the basis of an inverse pressure law.

The Uses of Helium

The investigation into the problem of producing helium in large quantities was originally undertaken with a view to the utilization of the gas in aeronautical warfare. The investigation showed that it could be produced at a cost which is not excessive, but it had also been shown that from the sources in the Empire, which are known and have been examined, the supply of helium cannot be greater than about 12,000,000 cubic feet per year. This quantity clearly would be sufficient to keep only a very few of our airships of the larger type in commission, even if the gas were diluted to the extent of 15 per cent. with hydrogen. This amount would, however, suffice to keep a number of the smaller aircraft supplied. Moreover, it might be used to fill fireproof compartments adjacent to the engines if it were ever decided to instal these within the envelopes of our larger airships.

Since it has been demonstrated that helium could be produced in quantity, one was led naturally to consider in what directions one could hope to use the gas other than that originally intended. In industry it may be used as a filling for thermionic amplifying valves of the ionization type. It may also be used for filling tungsten incandescent filament lamps, especially for signalling purposes where rapid dimming is an essential, and for producing gas arc lamps in which tungsten terminals are used, as in the "Pointolite" type. Both of these varieties of lamps possess the defect, however, of soon becoming dull owing to the ease with which incandescent tungsten volatilizes in helium, and deposits on the surface of the enclosing glass bulbs. As regards illumination, helium arc lamps possess an advantage over mercury arc lamps in that the radiation emitted has strong intensities in the red and yellow portion of the spectrum.

It has been shown by Nutting (*Electrician*, March, 1912) that Geissler tubes filled with helium are eminently suitable, under certain conditions, for light standards in spectrophotometry, but the amount of the gas which could be used in this way is very small.

In spectroscopy, especially for investigations in the ultraviolet region, helium is invaluable. Doubtless its use in this field will be rapidly extended. The use of the gas in physical laboratories generally, and especially where certain investigations on the properties of matter are carried out, will also be greatly increased.

It has recently been proposed to use helium in place of oil for surrounding the switches and circuit-breakers of high-tension electric transmission lines and for building certain types of transformers. If the gas should prove suitable for this purpose large quantities could be utilized, but it has yet to be demonstrated (and it is not clear that it can be) that in this field helium possesses any advantage over the oils now used.

It is probable, however, that in the field of low temperature research helium will immediately find its widest application. For this work helium is unique in that, when liquefied and possibly solidified, it enables one to reach the lowest temperatures attainable. Every effort should be directed towards the exploitation of its use in this direction.

One point that is important and should not be overlooked is that the supplies of natural gas from which helium can be extracted are being rapidly used up. When our natural gas fields are depleted it would appear that our main source of supply of helium will have disappeared. Careful consideration should, therefore, be given to the problem of producing helium in large quantities while it is still available, and of storing it up for future use. As already stated it nay be that in the future it will be of paramount importance to have even a moderate supply of the gas available.

A Cryogenic Laboratory

To chemists and physicists especially the discovery that helium can be produced in quantity at a moderate cost opens up a vista in the realm of low temperature research of surpassing interest. By means of liquid oxygen the properties of substances can be studied down to a temperature of 182.5°. Liquid nitrogen provides us with a temperature of −193.5°, and hydrogen, which was originally liquefied in 1898 by Sir James Dewar, enables us to reach −252.8°. It is but a few years since Onnes, after prolonged effort, secured sufficient helium to enable him to liquefy this gas too. In a brilliantly conceived research he succeeded in accomplishing this feat in 1908, and in doing it reached a temperature within approximately 1° or 2° of the absolute zero.

The amount of liquid helium which Onnes obtained in his investigation was small, but it sufficed to enable him to show that a number of the elements possessed a remarkable "super-conductivity" at this low temperature. Mercury, in particular, at the temperature of liquid helium, possessed an electrical conductivity ten million times greater than at ordinary room temperature, and currents started by induction in a coil of lead wire at the temperature of liquid helium maintained their intensity for more than an hour with but little diminution in magnitude.

The results obtained by Onnes, although limited in number, are of great importance, for they show that if liquid helium were rendered available in quantity, fundamental information of the greatest value on such problems as those connected with electrical and thermal conduction, with specific and atomic heats, with magnetism and the magnetic properties of substances, with phosphorescence, with the origin of radiation, and with atomic structure, could be obtained.

In spectroscopy supplies of liquid helium would enable us to extend our knowledge of the fine structure of spectral lines and thereby enable us to obtain clearer ideas regarding the electronic orbits existing in the atoms of the simpler elements. This would lead naturally to clearer views on the subject of atomic structure generally.

In other fields, too, important information could be obtained by the use of temperatures between that of liquid hydrogen and that of liquid helium. What of radioactivity? Would this property be lost by uranium, thorium, radium, and other similar elements at temperatures attainable with liquid helium? Would all chemical action cease at these temperatures? Would photochemical action disappear completely? Would photoelectric action cease or be maintained at such low temperatures?

In the fields of biological and botanical research information on problems pressing for solution could be gained also. For example, would all life in spores and bacteria be extinguished by subjecting them to temperatures in the neighbourhood of absolute zero?

The list of problems rendered capable of attack by the use of liquid helium might be easily extended, but those cited already will serve to show that the field is large, and that it is well worth while for us to make a special effort to secure adequate financial support for the equipment and maintenance of a cryogenic laboratory within the Empire. In this connection the lecturer pointed out a beginning had already been made.

Through financial aid received from the Honorary Advisory Council for Scientific and Industrial Research of Canada, supplemented by a considerable grant from the University of Toronto and by assistance from the British Admiralty and the Hydro-Electric Commission of Ontario an equipment consisting of motors, compressing pumps, gas purifiers and liquefiers had been secured and were being installed in the Physical Laboratory at Toronto.

Already the Liquid Air Machine was in operation and was capable of producing as much as 600 pounds of liquid air a day.

The hydrogen liquefying machine was installed and had already been used on several occasions for producing quantities of liquid hydrogen.

The helium liquefying machine was in process of construction and erection and it was expected that it would soon be ready to produce liquid helium. From the progress which had been made so far it would be seen that as a result of the research on helium the basis had been laid for the establishment of an industry capable of producing helium in quantity, sufficient to meet the needs, to a considerable extent, of the Empire in aeronautical warfare.

Further, the researches had shown that there was considerable promise of helium being likely to be useful for the construction of lamps of certain types.

In the Cryogenic laboratory, established in the University of Toronto, it would be possible by the aid of liquid helium and liquid hydrogen to carry on numerous investigations on the properties of matter at temperatures almost as low as absolute zero.

In the course of his lecture Professor McLennan showed a number of experiments with liquid air and in dealing with the question of the utilization of helium in lamps he showed a number of beautiful experiments on the phenomena of fluorescence. This phenomenon, he pointed out, constituted the foundation of many of the researches which were now being vigorously prosecuted with the object of producing illuminating devices more efficient than even the best of the lamps now in use.

In the course of his lecture Professor McLennan expressed his appreciation of the assistance he had received in the Helium Research from Professors Satterly, Burton, Dawes and McTaggart, and from Mr. John Patterson, of the Meteorological Office, Toronto, as well as from Messrs. Lang, Ainslie, Foreman and Shrum, of the University of Toronto, and Mr. Elworthy, of the Mines Branch, Ottawa.

APPENDIX C

THE METEOROLOGICAL SERVICE OF CANADA

BY

SIR FREDERIC STUPART, Kt., F.R.S.C.
Director, Dominion Meteorological Service

METEOROLOGICAL SERVICE OF CANADA

During the past year meteorological observations have been taken by 634 observers connected with the Government Service, and reports from them have been received at the Central Office, either daily by wire or monthly by mail.

The weather reporting stations are in two divisions, the first of which includes 364 stations where the observing is performed voluntarily by observers who keep a record of the weather, using meteorological instruments supplied by the Goverment.

The work at the Central Office has been steadily increasing. The establishment of six pilot balloon stations for obtaining data necessary to the aviator and incidentally for the study of the upper air currents has made further assistance imperative. The railways call upon the Service with ever increasing frequency for meteorological data required in the settlement of claims against them; legal firms ask for many certified statements and investigators in the many branches of science connected with agriculture and forest and plant growth solicit the assistance of the Meteorological Service in obtaining data indispensable for the solution of various problems.

Until last year, with the exception of occasions when storms were expected, no forecasts were issued either on Saturday night or Sunday morning, but now forecasts are issued twice every day during the season of navigation to the Dominion Wireless stations for transmission to ships both on the Great Lakes and at sea.

Forecasts have been issued twice daily for all parts of the Dominion and Newfoundland and the percentage of verification has been 84 per cent.

The storm warning service was maintained throughout the year in the Maritime Provinces and during the season of navigation on the Great Lakes and Gulf of St. Lawrence. Of the total number of warnings issued 84.4 per cent. were verified.

Magnetic Observations

During the fiscal year 1920-21 continuous photographic records of the Magnetic elements at Agincourt were secured without material loss. Magnetic disturbances were less frequent than for several years being synchronous with fewer sun spots and auroras. The more pronounced disturbances occurred on the following dates: 1920—April 15; September 28, 29. During the latter of these the recording limits of the instruments were exceeded for short intervals.

Absolute observations made weekly kept good control of the value of the base line of the differential instruments.

Tables showing the magnetic character of each day were prepared and copies forwarded to the International Commission on Terrestrial Magnetism. The "selected days" of the Commission are used in the analysis of the Magnetic data for the Annual Magnetic Report. The 1919 Report is now in course of preparation.

At the request of the Surveyor-General, index corrections for compasses attached to 65 surveyors' theodolites were determined and the results forwarded to him. Assistance was also given to several members of his staff in determining the constants of their Total Force instruments both before and after their summer field work.

Mr. French and Major Pearce, of the Dominion Observatory staff, were also assisted in standardizing their magnetometers both before and after their field work.

At Meanook the photographic records of Declination were obtained with only slight loss. During the very cold weather difficulty was again experienced in maintaining continuous operation of the clocks. This would, to a great extent, be overcome if the differential apparatus were placed underground as at Agincourt.

The weekly observations of Declination and Inclination were continued throughout the year and twice monthly observations of Horizontal Force.

The Meanook traces were loaned to the Surveyor-General, and the Agincourt traces to the Dominion Observatory for use in the reduction of their field work.

The accompanying tables give a summary of the results obtained at Agincourt and Meanook during the fiscal year 1920-21.

Summary of Results of Magnetic Observations Made at Meanook During the Fiscal Year 1920-21

Month	Mean Monthly Values			
	D East	H	Z	I
1920	° ′	γ	γ	° ′
April	27 38.0	12908	60228	77 54.2
May	39.0	08	142	53.2
June	38.0	40	266	52.9
July	38.3	15	141	52.8
August	38.1	11	182	53.5
September	38.7	20	258	53.9
October	38.7	26	260	53.6
November	37.7	26	277	53.8
December	37.0	28	218	53.0
1921				
January	37.0	34	246	53.0
February	36.5	20	198	53.2
March	36.2	16	197	53.4

Meanook Daily and Monthly Ranges of D

Month	From hourly readings	From Max. and Min.	Absolute Monthly range
1920	′	′	° ′
April	17.8	50.9	3 49.9
May	16.2	44.1	2 58.3
June	17.1	28.8	1 56.5
July	17.3	30.6	2 19.3
August	17.6	38.9	1 52.6
September	12.6	60.0	2 57.4
October	11.3	43.0	3 12.3
November	8.8	30.5	2 05.0
December	10.4	32.4	4 17.1
1921			
January	6.8	23.1	0 57.6
February	6.6	22.3	1 35.4
March	9.1	34.4	2 07.8

Summary of Results of Magnetic Observations Made at Agincourt During the Fiscal Year 1920-21

Month	Mean Monthly Values			
	D West	H	Z	I
1920	° ′	γ	γ	° ′
April	6 44.5	15864	58202	74 45.2
May	44.7	76	179	44.2
June	44.1	77	164	43.9
July	45.1	72	146	43.9
August	46.3	67	139	44.1
September	46.9	49	129	44.9
October	47.1	46	122	45.0
November	47.2	51	115	44.6
December	47.5	56	122	44.5
1921				
January	48.2	55	110	44.3
February	48.2	57	107	44.2
March	49.1	53	099	44.3

Agincourt Daily and Monthly Ranges

Month	D			H			Z		
	Mean Daily Range		Absolute Monthly Range	Mean D. Range		Absolute Monthly Range	Mean D. Range		Absolute Monthly Range
	From Hourly Readings	From Max. & Min.		From hourly read'gs	From Max. & Min.		From hourly readings	From Max. & Min.	
1920	′	′	° ′	γ	γ	γ	γ	γ	γ
April	11.9	24.9	1 11.1	50	106	455	25	67	413
May	12.9	20.4	0 46.3	49	94	385	18	50	245
June	13.5	19.0	0 36.3	43	70	253	14	33	173
July	14.2	20.6	0 54.2	46	77	210	16	36	205
Aug.	13.9	23.1	1 17.8	48	82	424	17	52	375
Sept.	11.9	28.1	1 57.0	58	146	826	37	100	572
Oct.	9.2	20.8	1 14.2	42	80	419	15	34	229
Nov.	8.7	16.0	0 50.7	29	55	140	12	29	269
Dec.	6.5	15.9	1 11.2	28	56	190	10	22	187
1921									
Jan.	6.6	13.4	0 37.9	26	44	108	4	11	42
Feb.	6.7	12.9	0 34.3	25	45	102	4	12	46
March	10.4	19.3	0 47.2	36	63	200	10	24	125

Physics Branch

This section was occupied chiefly with the establishment of pilot balloon stations at the aerodromes of the Air Board. The equipment and balloons were furnished by the Meteorological Service and the staff at the aerodromes did the work. The single theodolite method for following the balloons was adopted. This method assumes that a balloon will rise at a constant rate depending on the weight of the balloon and the free lift, "The weight that the balloon will just lift." The results of many series of observations have shown that after the first 5 or 6 minutes the rate is very constant as the gradual loss of hydrogen just balances the increased velocity due to diminished air pressure. The rate of ascent adopted for the balloons was 160 metres per minute (525 ft. per minute) and this requires a free lift of from 80 to 100 grammes.

Stations were opened at Vancouver, B.C.; Morley, Alta.; Camp Borden, Toronto and Ottawa, Ont., and Roberval, Que. Toronto and Camp Borden were opened in June; Vancouver and Morley about the end of August, and Ottawa and Roberval in October. All the stations were closed during the winter and the one at Morley has been moved to High River, Alta.

Balloons were despatched from these stations daily unless the day was foggy or the cloud very low. The ascents were made in the morning and at Toronto the results were obtained in time to be used in the forecasts. The highest flight obtained at Toronto was on September 4th; the balloon was followed for 94 minutes and had reached a height of nearly 50,000 feet when it burst.

Instruments and equipment for pilot balloon and magnetic observations have been made in the office for a station at Fort Good Hope to be operated for a year or more in connection with the International work of the Amunsden expedition.

It was impossible to get the large balloons for carrying instruments until January of this year and some flights were made from Kingston, but only about 25 per cent. of the balloons were recovered and the attempt had to be abandoned; future ascents will take place from Woodstock as before. The Department desires to take this opportunity of thanking Professor Clark, Ph.D., of Queen's University, for superintending the ascents at Kingston.

The apparatus for atmospheric electricity has been redesigned and partly reconstructed but there was not time with the other work that had to be done, to test it out.

A satisfactory design of resistance thermometers for taking the temperature of ocean water on board ship has been worked out and it is hoped to equip some of the Pacific ships with them this year. Considerable progress has been made with the installation of thermometers for earth temperatures.

Seismological Observations

The Seismographs at Toronto and Victoria have continued in operation with little loss of record throughout the fiscal year. 138 disturbances were recorded in Toronto, the greater number being of small amplitude. This is 47 greater than the normal number and is in striking contrast to the small yearly number recorded from 1900 to 1913. The largest monthly total, 19, occurred in March, and the least, 7, in November. The principal movements were on September 20th and December 16th, the latter being one of the largest ever recorded here, possibly next to the San Francisco quake of April 18th, 1906. The seat of the disturbance was in China, the provinces of Shensi, Kansu and Szechwan being particularly affected. Damage to life and property was appalling, whole families were completely wiped out, hills came down into ravines and thousands of people, as well as their animals, were completely buried alive. Streets opened up causing the houses on both sides to fall together.

We continue to forward abstracts of our observations to various seismological centres throughout the world and receive a large number of bulletins in return. We also furnish the *Associated Press* by request with information regarding the distance, character, etc., of any large earthquake.

Investigation regarding the correlation of microseisms and meteorological phenomena has been regularly carried out as well as the plotting of large earthquakes.

The new Milne Shaw instruments referred to in our last report have not yet arrived.

Climatology and Agricultural Meteorology

In the Monthly Record have been compiled and published hourly or bi-hourly records from the principal stations, daily records from fifty-two telegraph stations, and monthly means and extremes for some five hundred stations of the second class, for about eighty-five precipitation stations, and about sixty sunshine stations.

Preparing statements of the weather for legal claims in actions-at-law or for similar purposes have become a great burden to this Division. Commencing with the January number for 1921, to obviate the necessity for so much copying, we are publishing, in the Monthly Record, the daily maximum and minimum temperatures and daily rainfall or snowfall for some two hundred stations in addition to the fifty telegraph stations. This arrangement will allow public carriers and their customers to gather in future from the pages of the Monthly Record practically all the data needed to settle disputes involving the weather.

A report on the climate of the Western Provinces, with sixteen large meteorological maps, has been issued. A report on the climate of Ontario is in preparation.

Special articles for other departments or for provincial governments, tables, maps and diagrams have been prepared during the year.

Research is continuing into the effect of weather changes on crops, as to yield and quality. Better arrangements have been made for gathering observational material and for its analysis. Mr. Connor attended a Meteorological Conference in Washington and made preliminary arrangements for an interchange of certain data on crop growth which will be of great assistance to this Division.

A study of tree sections in relation to contemporaneous weather changes has been begun and it is hoped that later we may be able to carry back the meteorological history of the dry regions of the West beyond the earliest observations in the early eighties, and so to gain a better idea of the probable incidence and severity of droughts in various districts of the wheat regions. Mr. McDougall's previous training and experience in forestry will be of great value in this particular field.

Time Service

During the year ending March 31st, 1921, seventy-two determinations for time have been made with the Troughton and Simms transit instrument of 3 inch aperture.

The positions of the stars have mostly been taken from the American Ephemeris and British Nautical Almanac.

The usual observations have been taken frequently to determine the instrumental errors of the transit instrument in azimuth, level and collimation.

Inquiries for time, both mean and sidereal, have been numerous and the rating of chronometers and watches, both sidereal and mean time, has been carried on throughout the year.

The sidereal and mean time clocks have given great satisfaction. These clocks have been in use since the establishment of the Observatory and are still in good order and performing well.

The usual 11.55 a.m. signal on the fire alarm system has been continued throughout the year.

Time has been given weekly to the Magnetic Observatory at Agincourt.

Visitors and others have been very numerous and accorded privileges of viewing the heavenly bodies whenever opportunities offered with the 6 inch telescope.

The time exchanges between Toronto and Quebec, Montreal and St. John, N.B., have been made as usual, being recorded on the chronographs at Toronto, Montreal and St. John.

The errors of the clocks have been computed from the latest observations.

Phenological Observations, Canada, 1920

The following report on the phenological observations of 1920 is presented by Mr. F. F. Payne of the Central Office of the Meteorological Service.

In British Columbia vegetation made slow progress during the spring and the dates of flowering of plants were much later than usual. In Alberta, Saskatchewan and Manitoba the dates of flowering of early plants were delayed, but after May 15th normal conditions prevailed. In Ontario and Quebec the delay in spring growth of plants was considerably more marked than in the Western Provinces. In the Maritime Provinces the growth of plants, which usually flower early, did not differ much from the normal but later flowering plants were somewhat retarded in their growth.

In most districts a somewhat flagging interest in phenological observations was noticeable and, excepting in Saskatchewan where, under the kind assistance of Mr. W. H. Magee, Inspector of Schools, the number of observers was increased, the observations were fewer than usual.

In the Province of Nova Scotia, where phenological observations form a part of nature study in all the schools and where the reports are supplied by the teachers, these reports are always numerous. From the list of these schedules the tables are computed by a staff of science teachers and we are indebted to Dr. A. H. Mackay, Superintendent of Education for this province, for this valuable portion of this report.

The Province of Nova Scotia is divided into its main climatic slopes or regions which are not in some cases co-terminous with the boundaries of the counties. Slopes, especially those to the coast, are subdivided into (*a*) coast belts, (*b*) inland belts, and (*c*) high inland belts. Where these letters appear in the tables they refer to these slopes or regions. Dates for slopes IX and X were combined in computing the average for the province. The following regions are marked out, proceeding from south to north and from east to west as orderly as it is possible.

	Region of Slopes	Belts
I.	Yarmouth and Digby Counties......	(*a*) Coast, (*b*) Low inlands, (*c*) High inlands.
II.	Shelburne, Queens & Lunen'g Co.'s...	" "
III.	Annapolis and Kings Counties.......	(*a*) South Mts.,(*b*) Annapolis Valley, (*c*) Cornwallis Valley, (*d*) South Mts.
IV.	Hants and Colchester Counties, South to Cobequid Bay......	(*a*) Coast, (*b*) Low inlands, (*c*) High ininlands.
V.	Halifax and Guysboro Counties......	" "
VI.	(A) Cobequid Slope to S (B) Chignecto Slope to N.W.....................	(*a*) Coast, (*b*) Inlands.
VII.	North'rland Sts. Slopes (to the north).	(*a*) Coast, (*b*) Low inlands, (*c*) High Inlands.
VIII.	Richmond & Cape Breton Co.'s......	" "
IX.	Bras d'Or Slope (to the southeast)...	" "
X.	Inverness Slope (to Gulf, northwest).	" "

Owing to the great number of observers and others taking part in the production of the tables for Nova Scotia, their names are omitted from the following list:

List of Stations and Observers

W. S. Moore, Agassiz, B.C.
Stanley Bayne, Alberni, B.C.
A. B. Taylor, Atlin, B.C.
Alexander C. Murray, Fort St. James, B.C.
Mrs. Hugh Hunter, Princeton, B.C.

John Strand, Quesnel, B.C.
Geo. W. Johnson, Summerland, B.C.
A. S. Barton, Victoria, B.C.
Mrs. W. L. Fulton, Halkirk, Alta.
Mrs. M. E. Brown and pupils, Armadale, Sask.
Misses B. Adams and M. Waterhouse, Battleford, Sask.
Clarksdale School, Rabbit Lake, Sask.
Eagle Valley School, Eagle Valley, Sask.
L. B. Potter, Eastend, Sask.
Fitzgerald School, Fitzgerald, Sask.
R. H. Carter, Fort Qu'Appelle, Sask.
Geo. Lang, Indian Head, Sask.
North Battleford School, North Battleford, Sask.
Miss V. G. Armatage, Prince, Sask.
A. M. Calder, Richard, Sask.
M. Milliken, Scott, Sask.
C. W. Bryden, Shelbrook, Sask.
William Irvine, Almasippi, Man.
A. Goodridge, Oak Bank, Man.
Miss Mary Moffat and pupils, Cape Croker, Ont.
W. E. McDonald, Lucknow, Ont.
H. M. Meighen, Perth, Ont.
M. A. Thompson, Queensboro, Ont.
F. F. Payne, Toronto, Ont.
David McKenzie, Abitibi, Que.
T. F. Ritchie, Lennoxville, Que.
W. H. Moore, Scotch Lake, N.B.

Phenological Observations, Canada, 1920

Year 1920

Day of year corresponds to last day of each month

January	31	July	213
February	60	August	244
March	91	September	274
April	121	October	305
May	152	November	335
June	182	December	366

When first seen

Year 1920		Agassiz, B.C.	Alberni, B.C.	Atlin, B.C.	Fort St. James, B.C.	Princeton, B.C.	Quesnel, B.C.	Summerland, B.C.	Victoria, B.C.	Halkirk, Alta.	Armadale, Sask.	Battleford, Sask.
1. Alder (Alnus incana)	Shedding pollen	98	70	135		86						
2. Canada Thistle (Cirsium arvense)	Flowering	182	176					171	196			197
3. Trailing Aebutus (Epigaea repens)	"			157								
4. Dandelion (Taraxacum officinale)	"	102	87	158	130	122	125	96	63	124	161	161
5. Violet, Blue (Viola palmata cucullata)	"	116	118	172	129	122	129		41		135	149
6. Violet, White (Viola blanda)	"					129	135		65	139		
7. Columbine (Aquilegia)	"	133	145	170	139	158		130				
8. Trees appear green		104	119	154		122		122	80	140	134	139
9. Red Clover (Trifolium pratense)	Flowering	154	156			185	164		150			
10. White Clover (Trifolium repens)	"	152	156			159	159		149			
11. Wild Raspberry (Rubus strigosus)	"		165			169	210	152				
12. Cultivated Currant (Ribes rubrum)	"	95	116			121	235		89	145		
13. Wild Rose (Rosa)	"	147	165	171	186	159	171		133	183	165	164
14. Trillium (Trillium)	"	80	103									
15. Anemone (Anemone)	"	120	154	119		150				126	115	
16. Maple (Acer)	"	138	118						90			167
17. Strawberry Wild (Fragaria Virginiana)		135	117		153	121			76	141	135	150
18. Strawberry Wild (Fragaria Virginiana)	Fruit ripe	150	154		193	160	187			182	178	
19. Crocus, Cultivated (Crocus)	Flowering	75	73						56			
20. Lilac (Syringa vulgaris)	"	128	137			161	161	135	124	168		
21. Apple (Pyrus malus)	"	118	130			143		128	123			
22. Plum, Cultivated (Prunus domestica)	"	116	129					128	99			
23. Cherry Wild (Prunus)	"	109	126				217		120			151
24. Cherry, Cultivated (Prunus cerasus)	"	113	118					119	101			

When becoming common

Year 1920		Agassiz, B.C.	Alberni, B.C.	Atlin, B.C.	Fort St. James, B.C.	Princeton, B.C.	Quesnel, B.C.	Summerland, B.C.	Victoria, B.C.	Halkirk, Alta.	Armadale, Sask.	Battleford, Sask.
1. Alder (Alnus incana)	Shedding pollen	105										
2. Canada Thistle (Cirsium arvense)	Flowering	195							212	155		205
3. Trailing Aebutus (Epigaea repens)	"											
4. Dandelion (Taraxacum officinale)	"	111	101			131	135		108	144	168	167
5. Violet, Blue (Viola palmata cucullata)	"	118	127			127	136		72		131	160
6. Violet, White (Viola blanda)	"					135	145		72			
7. Columbine (Aquilegia)	"	148				160						
8. Trees appear green		117				142			119		137	153
9. Red Clover (Trifolium pratense)	Flowering	164				189	172		177			
10. White Clover (Trifolium repens)	"	158				164	167		167			
11. Wild Raspberry (Rubus strigosus)	"		167			194						
12. Cultivated Currant (Ribes rubrum)	"	99				127			107	152		
13. Wild Rose (Rosa)	"	154				165	177		139		172	
14. Trillium (Trillium)	"	87	124						109			
15. Anemone (Anemone)	"	131				153				131	120	
16. Maple (Acer)	"	143	124						126			
17. Strawberry Wild (Fragaria Virginiana)		143	124			129			109	147	147	159
18. Strawberry Wild (Fragaria Virginiana)	Fruit ripe	157			207	169				182		
19. Crocus, Cultivated (Crocus)	Flowering	81							70			
20. Lilac (Syringa vulgaris)	"	133	153			168	167		132	170		
21. Apple (Pyrus malus)	"	131	142			146			134			
22. Plum, Cultivated (Prunus domestica)	"	124	130						122			
23. Cherry Wild (Prunus)	"	115	129						126			162
24. Cherry, Cultivated (Prunus cerasus)	"	116	124						123			

149	139	152		76	122	67	78	136	146		25. Buttercup (Ranunculus acris).................. "	154	142			87	131		111	141	156	
187											26. Yellow Pond Lilly (Nuphar advena)............ "	194	165									
153							62	170	171		27. Blue-eyed Grass (Sisyrinchium).......... "	157	166						75		178	
	131	167	214	120		117			145	149	28. Saskatoon (Amalanchier Canadensis)........... "		141			122			122		153	153
231				217	196			202	143		29. Golden Rod (Solidago)............... "	239				223	202			208		
	117	123	103	83	109	73	95	102	77	124	30. Wild Geese..									109	110	111
		113	102	59	100			101	78	106	31. Wild Ducks..					116				107	111	116
68	30	124		70	71	73		116	77	111	32. Robins (Merula)................................	88				77	86			118	111	136
116	79			60		55		110	84	105	33. Meadow Larks (Sturnella).....................	137									94	122
105		111	103	76	81	68	106		101	118	34. Blue Birds (Sialia sialis)................................	119	140			82	96				120	141
141		130								122	35. Flickers or Golden Woodpeckers (Colaptes auratus).......	152										
			123	78						116	36. Song Sparrows (Melospiza fasciata)......................					81						149
136	98	131		126	113	79	80				37. Swallows (Clivicola riparia)............................	151					136		107			
			84							111	38. Juncoes (Junco hyemalis)................................											125
				135				154			39. Orioles (Icterus galbula)................................					138						
	62					150				113	40. King Birds (Tyrannus tyrannus).........................											135
122	109			122	165	126	104				41. Humming Birds (Trochilus colubris)......................	151				135						
77	67	134		118		123	66	125	115	127	42. Frogs Piping..	99				120					123	131
76				95	112						43. Earth Worm Casts (frost out of ground.)..................	85						76				
		166	148							116	44. Lakes Open..											
				80	45	76				111	45. Rivers Open...											
68		137	145	91	117	76	41	110	117	120	46. Ploughing..	68				102			75		124	122
101	94			103	122	103	72	120	118	126	47. Sowing...	101				109			92	124	131	136
162	183		218	186	209	157	170	178		178	48. Hay Cutting...	162	208			193			187	212		229
204	227			223	251	205	217	229		238	49. Grain Cutting...	204	229			228			222	236		245
82	118	145		121	135	110	46	136	124	131	50. Potato Planting..	82	128			126			101	150	131	

PHENOLOGICAL OBSERVATIONS, CANADA, 1920

YEAR 1920

Day of year corresponding to last day of each month

January	31	July	213
February	60	August	244
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June	182	December	366

When first seen

	Rabbit Lake, Sask.	Eagle Valley, Sask.	Eastend, Sask.	Fitzgerald School, Sask.	Fort Qu'Appelle, Sask.	Indian Head, Sask.	North Battleford, Sask.	Prince, Sask.	Richard, Sask.	Scott, Sask.	Shellbrook, Sask.
1. Alder (Alnus incana)........ Shedding pollen									117		
2. Canada Thistle (Cirsium arvense)........ Flowering		186			190	203	215			186	
3. Trailing Arbutus (Epigaea repens)........ "											
4. Dandelion (Taraxacum officinale)........ "	166	159		159	138	131	139	159	172	139	142
5. Violet, Blue (Viola palmata cucullata)........ "	137	138	138		135	141	136	137	154	141	132
6. Violet, White (Viola blanda)........ "		151			141	153	194	149	160	162	
7. Columbine (Aquilegia)........ "				170						149	
8. Trees appear green........	134		137		130	138	123	139	136	172	133
9. Red Clover (Trifolium pratense)........ Flowering		164			170	185	225			184	
10. White Clover (Trifolium repens)........ "		180				167	157				191
11. Wild Raspberry (Rubus strigosus)........ "		175			180	154	180		197	174	173
12. Cultivated Currant (Ribes rubrum)........ "			143		168	139	151				
13. Wild Rose (Rosa)........ "	169	163		168	155	162	162	164	180	173	166
14. Trillium (Trillium)........ "							172	115			
15. Anemone (Anemone)........ "	128	169	122	169	114	122	180	165	118	118	123
16. Maple (Acer)........					145	137				178	
17. Strawberry Wild (Fragaria Virginiana)........	145	145			138	141	149	142	177	79	137
18. Strawberry Wild (Fragaria Virginiana) Fruit ripe........	155	170			175	169		174	192	188	171
19. Crocus, Cultivated (Crocus)........ Flowering		118					97				
20. Lilac (Syringa vulgaris)........ "				169	162	156	160			161	
21. Apple (Pyrus malus)........ "						150	164				
22. Plum, Cultivated (Prunus domestica)........ "						144				143	
23. Cherry, Wild (Prunus)........ "					144	142	145				142
24. Cherry, Cultivated (Prunus cerasus)........ "										148	

When becoming common

	Rabbit Lake, Sask.	Eagle Valley, Sask.	Eastend, Sask.	Fitzgerald School, Sask.	Fort Qu'Appelle, Sask.	Indian Head, Sask.	North Battleford, Sask.	Prince, Sask.	Richard, Sask.	Scott, Sask.	Shellbrook, Sask.
1. Alder (Alnus incana)........ Shedding pollen									131		
2. Canada Thistle (Cirsium arvense)........ Flowering		195			194	210	238			194	
3. Trailing Arbutus (Epigaea repens)........ "											
4. Dandelion (Taraxacum officinale)........ "		164		173	142	147	145	164		145	144
5. Violet, Blue (Viola palmata cucullata)........ "	146	145			141		143		162	145	140
6. Violet, White (Viola blanda)........ "				163	145	158	200		170		
7. Columbine (Aquilegia)........ "				177						164	
8. Trees appear green........	137				133	145	131			181	140
9. Red Clover (Trifolium pratense)........ Flowering					173	189	240			192	
10. White Clover (Trifolium repens)........ "						172	172				
11. Wild Raspberry (Rubus strigosus)........ "					183	158	190		202		
12. Cultivated Currant (Ribes rubrum)........ "							172				
13. Wild Rose (Rosa)........ "	175	168		172	158	168	170		187	183	
14. Trillium (Trillium)........ "							182				
15. Anemone (Anemone)........ "	136	174		177	120	128	187		124	130	128
16. Maple (Acer)........					149					183	
17. Strawberry Wild (Fragaria Virginiana)........	153	155			145	143	167		182	84	144
18. Strawberry Wild (Fragaria Virginiana) Fruit ripe........		192			182	175	192		202	194	
19. Crocus, Cultivated (Crocus)........ Flowering	134						117				
20. Lilac (Syringa vulgaris)........ "						162	170			169	
21. Apple (Pyrus malus)........ "						152	167				
22. Plum, Cultivated (Prunus domestica)........ "						151				153	
23. Cherry, Wild (Prunus)........ "					149	146	154				
24. Cherry, Cultivated (Prunus cerasus)........ "											

129	148			144	186	164	132	156	141	113	25. Buttercup (Ranunculus acris) .... ″	138	153			145	189	167			145	120
						162					26. Yellow Pond Lilly (Nuphar advena) .... ″							170				
169	167		174	165	170	159	174	184			27. Blue-eyed Grass (Sisyrinchium) ..... ″	176	174		179	172	178	162				
153	145	144		143	143	135	144	182	154	112	28. Saskatoon (Amalanchier Canadensis) .... ″	158	148			145	146	148				119
200	199			183	206	194		225	205	189	29. Golden Rod (Solidago) .... ″	206	207			198	212	207			214	192
117	122	138		81	101	75	107	98	113	108	30. Wild Geese		131				106	116		100	126	
112	118	92		101	101	80	110	98	108	111	31. Wild Ducks	123	122	70		107	104	117		100	115	
109	92	165		73	107	110	110	100	101	111	32. Robins (Merula)	121	114			111	110	117		106	111	
95		89		70	100	101	104	82	109	110	33. Meadow Larks (Sturnella)	114	106	70		111	105	117		92	122	
118	106	84		142	156	118	108	106	114	122	34. Blue Birds (Sialia sialis)		122	87				120		120		
134	131	105		111	120	116	102	111		124	35. Flickers or Goden Woodpeckers (Colaptes auratus)					120	124	120				
	92	104		124	100	129	143		107		36. Song Sparrows (Melospiza fasciata)					131	101	133			116	
185	137			136	149	110	120		147	135	37. Swallows (Clivicola riparia)		160			145		116				
		92		86	102	32	104	90	107		38. Juncoes (Junco hyemalis)			101		97	105	56			116	
	153			145	144	153		126			39. Orioles (Icterus galbula)					149	149	177				
140				142	142	126		111	115	131	40. King Birds (Tyrannus tyrannus)		131			145	145	141				
213					168						41. Humming Birds (Trochilus colubris)						168					
124	131	114		114	124	111		111	125	120	42. Frogs Piping	128	141			122	129	127		120	130	
		103		117	127				118		43. Earth Worm Casts (frost out of ground)											
	106			135	137	139		123		109	44. Lakes Open		111					143				
	118	114		118	127	116		127	113	112	45. Rivers Open		122					118				
128	153			111	119	111	115	139	118	117	46. Ploughing		153			113	123	126	118		124	
127	112			117	127	117	118	136	117	112	47. Sowing		116			119	131	125	128	145	126	
186	197				192	184		214	198	197	48. Hay Cutting	196	203				194	210			206	
231	223	230	231	217	215	237	225	228	226	230	49. Grain Cutting	239	229		235	222		245	230	231	236	235
	129	142		131	142	131		136	122	136	50. Potato Planting					136		145		145	142	145

Phenological Observations, Canada, 1920

Year 1920

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Month	Day	Month	Day
January	31	July	213
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When first seen

Year 1920	Almasippi, Man.	Oakbank, Man.	Cape Croker, Ont.	Lucknow, Ont.	Perth, Ont.	Queensboro, Ont.	Toronto, Ont.	Abitibi, Que.	Lennoxville, Que.	Scotch Lake, N.B.
1. Alder (Alnus incana) ... Shedding pollen					92	86	92	142	94	110
2. Canada Thistle (Cirsium arvense) ... Flowering				190	191	170	202		177	
3. Trailing Arbutus (Epigaea repens) ... "							124			131
4. Dandelion (Taraxacum officinale) ... "	137	139	116	113	126	127	133	157	138	140
5. Violet, Blue (Viola palmata cucullata) ... "	141	140		132	127	128	133		147	137
6. Violet, White (Viola blanda) ... "			138	132	127	131	133		147	137
7. Columbine (Aquilegia) ... "			153	151	142	141	150		153	159
8. Trees appear green ...	129	146	131	140	127	126	141	145	136	138
9. Red Clover (Trifolium pratense) ... Flowering		193	165	161	159	164			161	162
10. White Clover (Trifolium repens) ... "			165	162	155	161	158		171	141
11. Wild Raspberry (Rubus strigosus) ... "	157			160	161	154	164		158	
12. Cultivated Currant (Ribes rubrum) ... "				141	137	138	146		141	144
13. Wild Rose (Rosa) ... "	166	165	163		156	169	172		161	163
14. Trillium (Trillium) ... "			124	125	125	132	136		124	138
15. Anemone (Anemone) ... "	136	131			157	153			144	171
16. Maple (Acer) ... "	130		132	139	114	123	88		117	136
17. Strawberry Wild (Fragaria Virginiana) ...	146	122	125	116	127	129	141	157	142	140
18. Strawberry Wild (Fragaria Virginiana) Fruit ripe ...			162	158	160	158	168	180	167	166
19. Crocus, Cultivated (Crocus) ... Flowering				89	105	108	88		116	111
20. Lilac (Syringa vulgaris) ... "		151		150	145	145	143		149	155
21. Apple (Pyrus malus) ... "			150	145	141	140	145		148	154
22. Plum, Cultivated (Prunus domestica) ... "		142	139	143	137		144		141	145
23. Cherry, Wild (Prunus) ... "	143	142		143	148	140	142		139	144
24. Cherry, Cultivated (Prunus cerasus) ... "			145	141	141		140			

When becoming common

Year 1920	Almasippi, Man.	Oakbank, Man.	Cape Croker, Ont.	Lucknow, Ont.	Perth, Ont.	Queensboro, Ont.	Toronto, Ont.	Abitibi, Que.	Lennoxville, Que.	Scotch Lake, N.B.
1. Alder (Alnus incana) ... Shedding pollen					92	101	95			
2. Canada Thistle (Cirsium arvense) ... Flowering				197	193	206	205			
3. Trailing Arbutus (Epigaea repens) ... "							127			136
4. Dandelion (Taraxacum officinale) ... "	144	149	131	129	131	131	140		144	
5. Violet, Blue (Viola palmata cucullata) ... "	145	155	139	140	131	131	137			
6. Violet, White (Viola blanda) ... "				139	131	133	136		149	
7. Columbine (Aquilegia) ... "			156		144	143	158		164	
8. Trees appear green ...	133		138		131	130	141			139
9. Red Clover (Trifolium pratense) ... Flowering			173	164	164	169			167	
10. White Clover (Trifolium repens) ... "			172	165	164	165			175	
11. Wild Raspberry (Rubus strigosus) ... "	161			164	164	161	167			
12. Cultivated Currant (Ribes rubrum) ... "				144	138	141	149			
13. Wild Rose (Rosa) ... "	169		170		164	172	178			
14. Trillium (Trillium) ... "			144	128	127	137	138		129	
15. Anemone (Anemone) ... "	138				159	160			144	
16. Maple (Acer) ... "				141	116	131	101		120	
17. Strawberry Wild (Fragaria Virginiana) ...	154		134	129	131		149		145	
18. Strawberry Wild (Fragaria Virginiana) Fruit ripe ...			170	165	167		172		172	
19. Crocus, Cultivated (Crocus) ... Flowering				92	108	111	106		118	
20. Lilac (Syringa vulgaris) ... "				153	147	150	150		155	
21. Apple (Pyrus malus) ... "			153	148	143	145	149		153	
22. Plum, Cultivated (Prunus domestica) ... "		145	151	146	138		150		144	
23. Cherry, Wild (Prunus) ... "	145			146	149	143	150		142	
24. Cherry, Cultivated (Prunus cerasus) ... "			146	145	141		148			

129		142	126	149	155	160		165	164	25. Buttercup (Ranunculus acris) . . . . "	131		154	132	160	158	172	170
				166	155					26. Yellow Pond Lilly (Nuphar advena) . . . . "				157	166	163		
	159			148	155			160	162	27. Blue-eyed Grass (Sisyrinchium) . . . . . . "			166		148	161		167
	141				133					28. Saskatoon (Amalanchier Canadensis) . . . . "						136		
	215		216		214	217		215	215	29. Golden Rod (Solidago) . . . . "				220		225		221
107	83	91	82	88			108	92		30. Wild Geese	118		124		88			
106				84	81		108		111	31. Wild Ducks	118		86		84	92		
111	117	78	80	80	81	75	92	86	86	32. Robins (Merula)	114		84	82	89	83	92	92
112	119	86		83	83	84		113		33. Meadow Larks (Sturnella)	113		133		89	85	95	122
		79	82	80	82	82		84	139	34. Blue Birds (Sialia sialis)			110			82	93	90
118			92	102	83	108	125	111	122	35. Flickers or Golden Woodpeckers (Colaptes auratus)	122				105	85	120	126
101		96	83	84	82	84		87	98	36. Song Sparrows (Melospiza fasciata)	104		93		89	82	93	92
		120		95	110	128	118	128	97	37. Swallows (Clivicola riparia)			120			116	133	131
100				86	84			78	83	38. Juncoes (Junco hyemalis)	103		97		86	88	93	85
		143	137	125	135	137		147		39. Orioles (Icterus galbula)			145		138	138	140	151
		143	129	138	134	137	119	141	139	40. King Birds (Tyrannus tyrannus)					140	139	139	149
137		144	141	144	143			144		41. Humming Birds (Trochilus colubris)	147				144	149		151
110	110	87	82	85	80	100	125	109	124	42. Frogs Piping	116		91	85	107	99		117
129				85	118	89	144	114	129	43. Earth Worms Cast (frost out of ground)	131		112		93	125		120
				111			129		124	44. Lakes Open			98			127		
				88	81	74	110	87	106	45. Rivers Open						90		
110	123	88		102	97	93		107	127	46. Ploughing	112		104	107	117	111	111	111
113	131	116	111	119	122	131		128	136	47. Sowing	117		125	124	126	129	136	139
194	195		176	192	177	195		178	198	48. Hay Cutting	197	214		187	196	196	202	197
199	222		203		197	209		225	231	49. Grain Cutting	215					217		238
138	131	138	142	126	125	145		142	136	50. Potato Planting	140		147	147	145	133	156	153

Phenolorical Observations, Canada, 1920

Year 1920

Day of year corresponding to last day of each month

January	31	July	213
February	60	August	244
March	91	September	274
April	121	October	305
May	152	November	335
June	182	December	366

When first seen

	I. Yarmouth & Digby Counties, N.S.	II. Shel., Queens & Lun. Counties, N.S.	III. Annapolis & King Counties, N.S.	IV. Hants & Colchester Counties, N.S.	V. Halifax & Guysboro Counties, N.S.	VIA. Cobequid Slope, N.S.	VIB. Chignecto Slope, N.S.	VII. Northumberland Sts. Slope, N.S.	VIII. Rich. & Cape Breton Cos., N.S.	IX. & X. Inv. & Bras d'Or Slope, N.S.	Average Dates
1. Alder (Alnus incana, Wild)	101	102	96	89	92	112	108	95	109	110	101
2. Aspen (Populus tremuloides)		117	123	109	97	114	117	123	126	127	117
3. May Flower (Epigea repens, L.)	99	98	99	101	99	113	110	106	114	120	106
4. Field Horsetail (Equisetum arvense)	115	126	123	121	123	131		127	135	128	125
5. Blood Root (Sanguinaria Canadensis)			132	125	120	121		130	137		128
6. White Violet (Viola Blanda)	122	123	125	126	129	128	127	129	133	127	127
7. Blue Violet (Viola palmata, cucullata)	122	127	127	129	133	130	129	132	137	133	129
8. Hepatica (Hepatica triloba, etc.)		132	98	121	122			134		177	131
9. Red Maple (Acer rubrum)	123	133	130	134	136	141	130	133	136	137	133
10. Strawberry (Fragaria Virgianina	124	126	125	127	130	134	131	131	134	136	129
11. Strawberry (Fragaria Virginiana) Fruit ripe	153	161	158	159	164	161	160	163	167	166	161
12. Dandelion (Taraxacum officinale)	127	129	130	132	135	138	134	136	137	133	133
13. Adder's Tongue (Erythronium Americanum)	144		132	141	133	132	134	134	141	138	138
14. Gold Thread (Coptis trifolia)	133	135	136	142	136	140	138	138	142	140	138
15. Spring Beauty (Claytonia Caroliniana)			130	135	136	131	126	133	136	134	133
16. Ground Ivy (Nepeta Glechoma)	137	132	135	138	139	146	143	144	150	144	141
17. Indian Pear (Amelanchier Canadensis)	141	140	138	139	141	148	139	141	147	147	142
18. Indian Pear (Amelanchier Canadensis) Fruit ripe								212			212
19. Wild Red Cherry (Prunus Pennsylvanica)	141	144	143	143	146	144	142	144	153	151	145
20. Wild Red Cherry (Prunus Pennsylvanica) Fruit ripe								221	230		225
21. Blackberry (Vaccinium Can. and Penn.)	142	140	137	142	141	151	143	145	151	159	145
22. Blackberry (Vaccinium Can. and Penn) Fruit ripe								217	238		228
23. Buttercup (Ranunculus acris)	144	145	158	148	157	156	153	151	157	157	153
24. Tall Buttercup (R. Repens)	146	153	161	157	163	163	150	160	169	153	157

When becoming common

	Average Dates	I. Yarmouth & Digby Counties, N.S.	II. Shel., Queens & Lun. Counties, N.S.	III. Annapolis & King Counties, N.S.	IV. Hants & Colchester Counties, N.S.	V. Halifax & Guysboro Counties, N.S.	VIA. Cobequid Slope, N.S.	VIB. Chignecto Slope, N.S.	VII. Northumberland Sts. Slope, N.S.	VIII. Rich. & Cape Breton Cos., N.S.	IX. & X. Inv. & Bras d'Or Slope, N.S.
1. Alder (Alnus incana, Wild)	107	109	111	104	95	100	119	98	103	114	116
2. Aspen (Populus tremuloides)	124		124	127	115	110	120	120	131	131	137
3. May Flower (Epigea repens, L.)	116	107	110	109	111	111	126	123	116	120	128
4. Field Horsetail (Equisetum arvense)	133	126	131	129	134	129	136		133	141	136
5. Blood Root (Sanguinaria Canadensis)	135			135	130	132			136	144	
6. White Violet (Viola Blanda)	132	127	130	132	132	134	135	129	134	138	133
7. Blue Violet (Viola palmata, cucullata)	135	130	133	135	135	137	133	131	136	140	140
8. Hepatica (Hepatica triloba, etc.)	136		135	111		129			136		171
9. Red Maple (Acer rubrum)	139	130	140	137	139	139	146		138	141	142
10. Strawberry (Fragaria Virgianina	138	131	133	134	134	138	155	136	138	141	144
11. Strawberry (Fragaria Virginiana) Fruit ripe	170	169	169	172	170	169	169	167	171	173	174
12. Dandelion (Taraxacum officinale)	139	134	136	137	138	140	143	143	140	142	139
13. Adder's Tongue (Erythronium Americanum)	141			138	150	138	140	137	139	147	140
14. Gold Thread (Coptis trifolia)	143	139	140	142	146	142	144	143	143	146	145
15. Spring Beauty (Claytonia Caroliniana)	138			136	140	137	133	139	137	140	139
16. Ground Ivy (Nepeta Glechoma)	149	145	139	142	142	143	150	136	149	155	144
17. Indian Pear (Amelanchier Canadensis)	147	148	145	142	143	146	159	146	144	150	152
18. Indian Pear (Amelanchier Canadensis) Fruit ripe	215								215		
19. Wild Red Cherry (Prunus Pennsylvanica)	152	149	150	147	148	162	148	148	149	159	156
20. Wild Red Cherry (Prunus Pennsylvanica) Fruit ripe	227								224	230	
21. Blackberry (Vaccinium Can. and Penn.)	151	149	146	146	149	148	153	152	150	159	163
22. Blackberry (Vaccinium Can. and Penn) Fruit ripe	229								223	235	
23. Buttercup (Ranunculus acris)	157	153	156	152	155	160	157	159	157	164	161
24. Tall Buttercup (R. Repens)	163	156	158	164	162	170	166	154	165	173	158

141	147	141	147	146	145	140	146	159		146	25. Creeping Buttercup (Trill. erythrocarpum)	161	143	151	146	148	150	151	149	152	163	
143	146	145	143	150	151	150	149	156	167	150	26. Rhodora Rhododendron (Rhodora)................	155	153	154	148	152	154	156	150	154	164	159
145	151	150	148	150	152	149	150	156	158	151	27. Pigeon Berry (Cornus Canadensis)	157	153	157	159	154	155	161	156	156	160	160
							238			238	28. Pigeon Berry (Cornus Canadensis)..............Fruit ripe	238								241	235	
144	148	147	147	149	154	144	149	156	156	149	29. Star Flower (Trientalis Americana)................	155	150	153	153	152	156	158	155	154	162	162
146	150	145	139	155	160	146	156	160	150	150	30. Clintonia (Clintonia borealis).....................	156	151	156	151	160	159	160	154	160	163	154
157	148		159				159	158	151	155	31. Marsh Calla (Calla palustris).....................	165				164		170			168	160
156	152	157	156	155	165	166	154	156	160	157	32. Lady's Slipper (Cypripedium acaule)..................	161	162	160	151	162	161	167		163	162	162
151	156	148	155	158	160	165	159	164	164	158	33. Blue-Eyed Grass (Sisyrinchium angustifol)..............	163	157	162	157	160	163	168	167	164	168	170
161	162	162	160	167	158	175	157	160	158	162	34. Twin Flower (Linnaea borealis).....................	167	160	167	163	167	172	169	175	168	166	169
149	158	135	159	162	156	146	153	156	165	154	35. Pale Laurel (Kalmia glauca)......................	162	159	162	150	166	168	167		156	161	171
155	162	157	153		159	181	156	181	163	163	36. Lambkill (Kalmia augustifolia).....................	164	160	168	164	161		164		162		170
160	160	156	172	156	157	166	156	169	175	162	37. English Hawthorne (Crataegus oxyacantha)............	167	165	165	161	175	169	160	163	164	173	176
163	159	160	151	160	158		157		154	158	38. Scarlet Fruited Thorn (Crataegus coccinea, etc.).........	166	170	163	165	157	166	171		165		168
161	162	161	165	168	166	161	164	172	170	165	39. Blue Flag (Iris versicolor)........................	170	165	166	167	170	171	177	167	169	176	175
158	162	159	163	165	165	174	164	172	167	165	40. Ox-eye Daisy (Chrysanthemum Leucanth)..............	171	165	163	169	168	171	174	177	169	176	175
158	154	167	159	161	169	169	165	163	164	163	41. Yellow Pond Lilly (Nuphaf advena)...................	169	166	167	173	171	165	170	172	169		170
159	160	156	154	168	157	167	158	159		160	42. Raspberry (Rubus strigosus).......................	165			162	157	170	162	176	165	165	168
	213	220					204	195		208	43. Raspberry (Rubus strigosus)..................Fruit ripe	218			225					215	215	
165	169	167	159	169		180	168	170	159	167	44. Yellow Rattle (Rhinanthus Crista-galli)................	174	169	172	174		173		184		175	175
161	168	160	164	170	160	173	166		172	166	45. High Blackberry (Rubus villosus)....................	171			171	170	175	166	180	157		176
							232	236		234	46. High Blackberry (Rubus villosus).............Fruit ripe	242								240	243	
163	165	168	165	159	163		165	171		165	47. Pitcher Plant (Sarracenia purpurea)...................	170	174	164	173	169	164			170	176	
169	162	160	150	166	165		164			162	48. Heal All (Brunella vulgaris).......................	169		173	167	157		171	179	170		
171	169	167	169	175		151	168			167	49. Common Wild Rose (Rosa lucida)...................	170	167	171	173	175	180		153	172		
163	165	168	169	170	168	166	170	173		168	50. Fall Dandelion (Leontodon autumnale).................	174		177	176	175	175	173	171	171	177	
178	167		145	174	143		168		170	164	51. Butter and Eggs (Linaria vulgaris)...................	168					169	148		173		180
136	138	136	135	139	143	134	137	140	128	136	52. Expanding Leaves (Trees appear green)................	147	149	149	144	142	148	147	145	156	151	140
140	144	144	143	146	149		146	154	153	146	53. Red Currant (Ribes rubrum) (cultivated)	153			148	150	152	155		150	160	158
							200	210		205	54. Red Currant (Ribes rubrum)..................Fruit ripe	214								208	221	

Phenological Observations, Canada, 1920

Year 1920

Day of year corresponding to last day of each month

Month	Day	Month	Day
January	31	July	213
February	60	August	244
March	91	September	274
April	121	October	305
May	152	November	335
June	182	December	366

When first seen

	I. Yarmouth & Digby Counties, N.S.	II. Shel., Queens & Lun. Counties, N.S.	III. Annapolis & Kings Counties, N.S.	IV. Hants & Colchester Counties, N.S.	V. Halifax & Guysboro Counties, N.S.	VIA. Cobequid Slope, N.S.	VIB. Chignecto Slope, N.S.	VII. Northumberland Sts. Slope, N.S.	VIII. Rich. & Cape Breton Cos., N.S.	IX. & X. Inv. & Bras d'Or Slope, N.S.	Average Dates
55. Black Currant (R. nigrum (cultivated))	139	145	147	149	146	152	168	147	156	154	150
56. Black Currant (R. nigrum (cultivated)) Fruit ripe								206	194		200
57. Cherry (Prunus Cerasus)	144	151	144	149	154	154	149	148	156	154	150
58. Cherry (Prunus Cerasus) Fruit ripe								210	209		209
59. Plum (Prunus domestica)	153	153	145	143	154	160	151	149	163	155	153
60. Apple (Pyrus Malus)	148	150	146	148	153	155	154	154	162	157	153
61. Lilac (Syringa vulgaris)	157	161	153	164	162	165	162	156	170	159	161
62. White Clover (Trifolium repens)	155	159	158	164	159	165	162	161	161	164	160
63. Red Clover (Trifolium pratense)	147	154	153	156	160	163	158	160	163	168	158
64. Timothy (Phleum pratense)	167	147	152	159	173	168		165		165	162
65. Potato (Solanum tuberosum)		187						175	194		185
66. Ploughing first of season	109	113	108	125	128	126	122	130	123	119	120
67. Sowing	129	123	132	139	133	138	137	138	136	133	133
68. Potato-planting	122	120	129	142	137	140	133	139	132	136	133
69. Sheep-shearing	124	116	132	137	144	140	151	137	130	123	133
70. Hay-cutting		191	215					216	216		209
71. Grain-cutting		230	236					237	249		238
72. Potato-digging	256	270	260					267	269		264
73a. Opening of rivers	58	85	77	83	87	73	90	101	85	98	84
73b. Opening of lakes	97	89	79	108	112		107		94	134	103
74a. Last snow to whiten ground	114	111	119	113	118	118	119	118	114	123	116
74b. Last snow to fly in air	121	120	123	124	121	126	123	123	124	121	122
75a. Last spring frost—hard	98	142	100	124	168	137		127	150	124	130
75b. Last spring frost—hoar	151	142	153	151	165			165	171	146	155

When becoming common

	Average Dates	I. Yarmouth & Digby Counties, N.S.	II. Shel., Queens & Lun. Counties, N.S.	III. Annapolis & King Counties, N.S.	IV. Hants & Colchester Counties, N.S.	V. Halifax & Guysboro Counties, N.S.	VIA. Cobequid Slope, N.S.	VI.B Chignecto Slope, N.S.	VII. Northumberland Sts. Slope, N.S.	VIII. Rich. & Cape Breton Cos., N.S.	IX. & X. Inv. & Bras d'Or Slope, N.S.
55. Black Currant (R. nigrum (cultivated))	156	154	157	152	153	153	159		152	160	159
56. Black Currant (R. nigrum (cultivated)) Fruit ripe	205								209	201	
57. Cherry (Prunus Cerasus)	155	149	156	149	153	160	157	150	152	161	159
58. Cherry (Prunus Cerasus) Fruit ripe	214								211	217	
59. Plum (Prunus domestica)	158	152	159	150	156	158	166		154	168	161
60. Apple (Pyrus Malus)	156	155	157	153	164	160	159	152	154	167	134
61. Lilac (Syringa vulgaris)	166	162	165	162	164	169	166	168	164	172	166
62. White Clover (Trifolium repens)	166	161	165	168	162	167	167	170	167	165	171
63. Red Clover (Trifolium pratense)	166	156	161	163	168	164	166	173	167	167	173
64. Timothy (Phleum pratense)	168	175	170	135		180	175		172		167
65. Potato (Solanum tuberosum)	190								180	200	
66. Ploughing first of season	131	125	125	126	139	136	134	137	137	128	126
67. Sowing	141	136	133	142	141	142	146	144	145	142	141
68. Potato-planting	140	130	131	140	132	142	144	157	147	137	143
69. Sheep-shearing	144	142	123	141		155	152	167	146	137	132
70. Hay-cutting	243		196	234					223	221	
71. Grain-cutting	245		237	247					244	252	
72. Potato-digging	274		279	267					271	276	
73a. Opening of rivers											
73b. Opening of lakes											
74a. Last snow to whiten ground											
74b. Last snow to fly in air											
75a. Last spring frost—hard											
75b. Last spring frost—hoar											

	81	77	83	71	74		110	120	115	93	76a. Water in streams—high										
	286	293						280		286	76b. Water in streams—low										
	310	261					254	296		280	77a. First autumn frost—hoar										
265	283	301	263				299	306		286	77b. First autumn frost—hard										
312	315	306	310				301	304		308	78a. First snow to fly in air										
326	331	315	317				309	314		319	78b. First snow to whiten ground										
		355					307	326		329	79a. Closing of lakes										
		356					343	358		252	79b. Closing of rivers										
88	84	88	76	82	109	81	91	88	89	87	81a. Wild ducks migrating, N										
	291	294					317	281		296	81b. Wild ducks migrating, S										
87	83	87	71	80	101	81	86	85	86	85	82a. Wild geese migrating, N										
	333	295					279	279		296	82b. Wild geese migrating, S										
87	85	85	90	85	94	84	90	90	96	88	83. Song Sparrow (Melospiza fasciata) North migrating										
91	82	82	83	82	97	84	83	89	89	86	84. Robin (Turdus migratorius) "										
91	86	119	93	80	100	89	89	88	102	84	85. Junco (Junco hiemalis) "										
127	126	122	128	132	132		129	131	126	128	86. Spotted Sandpiper (Actitis macularia) "										
144	106	113	109				125	132	105	119	87. Meadow Lark (Sturnella magna) "										
118	125	126	129	131	136	124	129	126	130	126	88. Kingfisher (Ceryle Alcyon) "										
134	131	137	133	130	154	140	131	131		136	89. Myrtle Warbler (Dendroeca coronata) "										
135	134	140	141	147	129	133	144	140	137	138	90. Yellow Warbler (D. aestiva) "										
127	160	126	127	122	126		117	127	129	129	91. White-throated Warbler (Zonotrichia alba) "										
141	148	141	149	152	147	147	151	146	148	147	92. Humming Bird (Trochilus colubris) "										
144	136	138	138	144	144	149	142	144	154	143	93. King Bird (Tyrannus Carolinensis) "										
150	136	134	138	144	132	110	149	135	156	138	94. Bobolink (Dolychonyx oryzivorus) "										
145	141	147	147	147	149	150	142			146	95. American Goldfinch (Spinis tristis) "										
140	137	143	146	154		116	152		171	145	96. American Redstart (Setophaga ruticilla) "										
148	125	156	143	169			145			148	97. Cedar Waxwing (Ampelis cedrorum) "										
123	130	130	135	127	121	156	131	154	150	136	98. Night Hawk (Chordeiles Virginianus)										
88	96	93	96	98	115	115	102	94	118	102	99. First piping of frogs										
104	111	114	118	118	126	136	122	121	117	118	100. First appearance, snakes										

Mémoires de la Société Royale du Canada
SECTION I

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Un recensement inédit de Montréal, en 1741

Par E. - Z. Massicotte, M.S.R.C.

(Lu à la réunion de mai 1921)

Il existe, dans les archives du Palais de justice de Montréal, un volumineux document, grand in-folio, de 225 pages, encore inédit et dont les historiens devraient pouvoir tirer avantage.

Ce manuscrit copieux porte l'intitulé suivant:

> Recensement fait en cette ville par la Compagnie des Indes pour les indiennes et autres effets prohibés pour être marqués en vertu de l'ordonnance de messieurs le Gouverneur et Intendant.

On sait de quoi il s'agit? La Compagnie des Indes, fondation de Law (1719), avait hérité des privilèges et des droits de la Compagnie des Indes orientales, de la Compagnie de Chine et de la Compagnie d'Occident, ce qui signifie, relativement à l'Amérique, qu'elle seule pouvait exporter le castor du Canada et qu'elle seule pouvait y importer des marchandises fabriquées hors de la Nouvelle-France. (Grande encyclopédie et E. et O.R. vol. 1, pp. 377 et 401.)

Un tel monopole ne pouvait manquer d'exercer la sagacité et la cupidité des contrebandiers grands et petits. Aussi, le Conseil d'Etat fut-il dans l'obligation, à diverses reprises, de rendre des arrêts portant défense de troquer ou d'avoir en sa possession des marchandises venant de l'étranger. Mais comme le trafic clandestin persistait, on dut permettre à l'intendant et à la Compagnie des Indes de faire visiter les magasins et les habitations du pays "afin de confisquer lesdites marchandises et de les brûler publiquement." (E. et O.R., vol. I, années 1717, 1719, 1720, 1722 et 1726.)

Nous ne pouvons dire si l'on a, chaque fois consigné l'historique de ces visites et de ces autodafés dans des documents spéciaux, mais nous avons la preuve qu'il fut fait quelque chose dans ce sens, à Montréal, en 1741.

L'ordonnance autorisant les perquisitions

Le 12 mai 1741, le gouverneur général, Charles de Beauharnois et l'intendant Gilles Hocquart signèrent une ordonnance pour défendre de faire "aucuns nouveaux meubles d'étoffes étrangères ou toiles des Indes, ni de s'en servir dans les maisons." Par le même document la Compagnie des Indes était autorisée à faire des perquisitions chez les habitants des villes de Québec, des Trois-Rivières et de Montréal, de relever ce qu'il pouvait y avoir de tissus prohibés, puis de les marquer d'un cachet aux armes de la compagnie. Les tissus qui seraient trouvés non marqués, après cela, seraient confisqués.

Dans la ville et les faubourgs de Montréal, ces perquisitions commencèrent à la mi-juillet et on procéda avec un apparat dont le fonctionnarisme néo-français a laissé peu d'exemples du moins dans la métropole où l'on n'abusait pas trop des formalités.

Tout d'abord, François Daine, contrôleur de la Compagnie des Indes, monte de Québec à Montréal. Là, il s'adjoint Jacques de la Fontaine, membre du Conseil supérieur, juge intérimaire de Montréal et Antoine Trémond de Salvaye, commandant des gardes de la compagnie. Pour accompagner ces messieurs on choisit deux gardes, les nommés Brossard et Beaufrère.

Procès-verbaux des visites

Ces cinq représentants de l'autorité pénètrent dans chaque logis et chaque fois, un scribe dresse un procès-verbal de leur passage. Il inscrit le nom du propriétaire de la maison, le nom de l'occupant et celui de la personne qui reçoit les visiteurs, ensuite, il énumère les tissus qui ont été déclarés et marqués, puis tout le monde est invité à signer.

Une couple d'exemples suffiront pour donner au lecteur une idée de la formule adoptée pour ces procès-verbaux qui ne diffèrent entre eux que par quelques minces détails.

Procès-verbal numéro un:

> Premièrement, dans la maison du nommé La Chenay, maçon, s'est trouvé une courtepointe, indienne fond bland, à fleur bleux, une autre à fond bland, à fleur rouge, une autre mauvaise, fond bland et fleur rouge lesquels ont été marqué à chacun un coin du cachet de lad: Compagnie qui est tout ce

que led. La Chenay a dit avoir en sa maison et ailleurs à luy appartenant de marchandises étrangères et a, led. La Chenay déclaré ne sçavoir ecrire ny signé de ce enquis.

DAINE

DE LA FONTAINE

TRÉMOND.

PROCÈS-VERBAL NUMÉRO QUATRE:

Dans la maison du Sr Laffricain, occupée par le Sr Videné ses trouvé un tour de lit fond bland à petite fleur gris de lain, une courtepointe fond bland à fleur bleux lesquels tour de lits ainsy que la courtepointe ont été marqué comme cy devant et interpellé led. Sr Vildené de nous déclarer s'il n'avoit point d'autre marchandises ou étoffes étrangères a dit que non Et a signé.

VILLEDONNÉ

DAINE

DE LA FONTAINE

TRÉMOND

L'ITINÉRAIRE SUIVI

Les perquisiteurs commencent leur tâche le vendredi, 14 juillet 1741, à 7 heures du matin, à l'extrémité est de la rue Notre-Dame, c'est-à-dire au pied de la citadelle et ils se dirigent vers l'ouest en alternant d'un côté de rue à l'autre. Ensuite, ils descendent la rue Augustine, du nord au sud, puis ils s'engagent dans la rue Saint-Paul prenant la direction de l'est.

D'ailleurs, voici l'ordre dans lequel les perquisiteurs ont parcouru les rues et les faubourgs de la ville en 1741:

Rues — Directions

Notre-Dame—de l'est à l'ouest. (Nos 1 à 95.)
Augustine[1]—aujourd'hui McGill—du nord au sud. (Nos 96 à 98.)
Saint-Paul—de l'est à l'ouest. (Nos 99 à 253.)
Saint-Charles—aujourd'hui place Jacques-Cartier—du sud au nord. (Nos 254 à 257.)
Saint-Vincent—du nord au sud. (Nos 258 à 268.)

[1] Dans les documents de l'époque nous lisons Augustine. Plus tard on écrit Saint-Augustin.

Saint-Denis—aujourd'hui Vaudreuil—du sud au nord. (Nos 269 à 271.)
Sainte-Thérèse—de l'est à l'ouest. (Nos 272 à 276.)
Saint-Gabriel—du sud au nord. (Nos 277 à 291.)
Saint-Jacques—de l'est à l'ouest. (Nos 292 à 315.)
Saint-François—du nord au sud. (Nos 316 à 348.)
Neuve-Saint-Louis—partie ouest de la rue Capital—de l'ouest à l'est. (Nos 349 à 354.)
Capital—de l'ouest à l'est. (Nos 355 à 363.)
Saint-Joseph—aujourd'hui Saint-Sulpice—du sud au nord. (Nos 364 à 373.)
Saint-Jean-Baptiste—du sud au nord. (Nos 374 à 384.)
Hôpital—de l'est à l'ouest. (Nos 385 à 397.)
Saint-Alexis—du nord au sud. (Nos 398 à 400).
Saint-Sacrement—de l'ouest à l'est. (Nos 401 à 411.)
Saint-Jean—du sud au nord. (Nos 412 à 415.)
Saint-Eloy—du nord au sud. (Nos 416 à 420).
Saint-Pierre—du nord au sud. (Nos 421 à 433.)

Faubourgs:

Saint-Joseph—C'est-à-dire la campagne à l'ouest de la rue Augustine dans ou vers le domaine Saint-Joseph, ainsi appelé parce qu'il appartenait aux Religieuses de l'Hôtel-Dieu. (Nos 434 à 483.)
Saint-Louis—On paraît désigner ainsi le territoire sis au nord des murs de la ville et à l'est du chemin conduisant à la paroisse Saint-Laurent. (Nos 484 à 498.)
Sainte-Marie—Vulgairement: faubourg Québec, autrement dit faubourg de la porte du chemin de Québec.

A vrai dire on ne saurait imaginer ville plus démocratique que Montréal à cette époque, car la maisonnette du journalier ou la boutique de l'artisan voisine très souvent la demeure du bourgeois ou l'hôtel du gentilhomme. Cependant, on aperçoit que les fonctionnaires et les négociants semblent se grouper dans les rues qui débouchent sur la place du Marché—aujourd'hui place Royale.

Temps consacré aux visites

Le recensement dura du 14 au 24 juillet. Sur ces dix jours il y eut relâche un lundi avant-midi, un mardi après-midi et deux dimanches. Cela fait sept jours de besogne. A cette date la journée de travail était de dix heures, même pour les fonctionnaires les plus haut placés,[1] il s'ensuit que la tâche fut accomplie en un peu moins de 70 heures, car il est évident, par le texte du rapport, que l'on termina avant la fin dè l'après-midi, le 24 juillet.

Chaque jour, à l'angelus, le scribe note que midi est arrivé et que la visite est suspendue jusqu'à 2 heures de relevée; le soir, à 7 heures, autre note indiquant la cessation des travaux et leur reprise, tel autre jour, à telle heure.

Le tableau exact du temps consacré aux perquisitions s'établit comme suit:

Vendredi, 14 juillet—de 7h. du matin à midi et de 2h. de relevée à 7h. du soir.
Samedi, 15 juillet—de 7h. du matin à midi et de 2h. de relevée à 7h. du soir.
Lundi, 17 juillet—de 2h. de relevée à 7h. du soir.
Mardi, 18 juillet—de 7h. du matin à midi.
Mercredi, 19 juillet—de 7h. du matin à midi et de 2h. de relevée à 7h. du soir.
Jeudi, 20 juillet—de 7h. du matin à midi et de 2h. de relevée à 7h. du soir.
Vendredi, 21 juillet—de 7h. du matin à midi et de 2h. de relevée à 7h. du soir.
Samedi, 22 juillet—de 7h. du matin à midi et de 2h. relevée à 7h. du soir.
Lundi, 24 juillet—de 7h. du matin à midi et de 2h. de relevée à......,
(L'heure à laquelle les travaux ont pris fin n'est pas indiquée.

L'ENREGISTREMENT DES NOMS

Comme ils ne faisaient pas le recensement des habitants de la ville, les perquisiteurs se sont contentés de mentionner ceux qu'ils visitent d'une façon plutôt sommaire, c'est-à-dire en n'inscrivant que les noms de famille ou les sobriquets: *le nommé Pistolet, la veuve Dufaux, le sieur Cavelier*: rarement, ils ajoutent la qualité ou la profession. Cette méthode rend l'identification assez ardue et souvent impossible, car bien des gens portent le même nom et le même surnom.

Les signatures auraient pu aider, malheureusement, quelques visités refusent d'apposer leurs griffes, d'autres prétendent qu'ils ne savent pas signer, d'autres encore signent à la bonne franquette, telle: *la veuve Garaut, la veuve St Dizier* ce qui n'est pas suffisant pour guider.

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[1] Dans sa relation de voyage au Canada, Kalm n'a-t-il pas noté que le gouverneur général de la Nouvelle-France, en 1749, donnait des audiences dès 7 heures du matin.

Si l'on est curieux de savoir combien de gens ont voulu écrire leurs noms dans cette circonstance, nous en avons les chiffres. Sur les 506 personnes qui répondent aux perquisiteurs,

Ont déclaré ne savoir signer	298
Ont signé	171
Ont refusé de signer	19
N'ont pas déclaré s'ils savaient signer ou non	15
N'ont pu signer pour cause	3
Total	506

La marque des effets

La cachet de la compagnie dont il est question ci-dessus n'était autre que celui de la défunte Compagnie d'Occident. On y avait gravé des "armoiries" dont on trouve la description suivante dans les *Edits et ordonnances royaux*, vol. I, p. 386:

> De sinople à la pointe ondée d'argent sur laquelle est couché un fleuve au naturel appuyé sur une corne d'abondance d'or; au chef d'azur, semé de fleurs de lis d'or soutenu d'une face en demie (*c'est-à-dire d'une divise*) aussi d'or, ayant deux sauvages pour supports et une couronne trefflée.

Plusieurs échantillons de ce cachet sur cire rouge sont conservés dans les archives judiciaires de Montréal.

Les meubles et tissus qui furent marqués

Sur les 506 logis visités, 57 occupants n'avaient rien à déclarer. Partout ailleurs les perquisiteurs eurent à apposer le sceau de la Compagnie et nous avons dressé un bref état des meubles et effets marqués:

Bergères garnies de calmande anglaise.

Cabinets tapissés d'indienne.

Canapés de calmande anglaise.

Chaises garnies d'indienne ou couvertes de calmande anglaise.

Courtepointes (*a*) en indienne d'une même sorte ou de différents morceaux; (*b*) en serge unie ou à fleurs, presque toujours, verte; (*c*) en taffetas doublé d'indienne ou entouré d'indienne ou avec bords en *perse* anglaise; (*d*) *en perse*; (*e*) en damas avec un tour en indienne; (*f*) en satin avec un tour en indienne; (*g*) en calmande anglaise; (*h*) en calenderie seule ou mi-calenderie et mi-indienne ou mi-calenderie et mi-calmande. Les courtepointes sont en vogue, tout le monde en a.

COUVREPIEDS. Par contre cette pièce de literie est assez rare. On les faits en indienne ou en calenderie piquée.

FAUTEUILS. Ils sont couverts en serge, en calmande, en indiennes.

HOUSSES. On écrit "ousses." Il y en a pour fauteuils et pour tabourets.

LITS. A plusieurs reprises on rencontre l'expression "lits en tombaux." Tous sont en indienne. Voir aussi "tour de lits."

MATELAS. En un logis se trouvent un matelas, un canapé et un traversin en calmande anglaise.

MOUCHOIRS. Servant pour couvrir des fauteuils ou des cadres.

OREILLERS. La plupart sont en calmande, en calenderie ou en indienne et semblent destinées à des chaises ou à des bergères. Il y a aussi des dessus d'oreillers en calmande.

RIDEAUX de portes ou de fenêtres en indiennes, en serge, en calenderie ou en calmande.

TAIES D'OREILLERS. Fort souvent le scribe écrit "têtes d'oreillers" preuve que nos gens du peuple parlent comme les officiers de plume d'autrefois. Les taies qui attirent l'attention de la compagnie des Indes sont en indienne, en calenderie ou en calmande.

TABERNACLES. Le pavillon du tabernacle au Séminaire de Montréal était d'une étoffe prohibée qu'on ne nomme pas, mais elle ne fut pas marquée. Chez les Soeurs de la Congrégation on a marqué le surtout du tabernacle de l'église des Dames et celui du tabernacle de la chapelle de Notre-Dame-de-Victoire. Dans la chapelle des RR.PP. Récollets, il y avait quatre petits rideaux d'indienne au tabernacle.

TAPIS. Ils sont petits et en calmande, en serge ou en indienne.

TAPISSERIE. Dans une maison, il y a deux morceaux d'indienne en tapisserie.

TABOURETS. A un (endroit), on note "deux ousses de tabouré" d'indienne.

TOURS DE LITS. En presque totalité, ils sont en indienne; deux sont en calmande, et un autre est décrit en ces termes: "tour de lit ciel Bonne Grâce."

Quant aux tissus, leurs couleurs et leurs ornements, ils se distinguent de la façon qui suit:

CALENDERIE. On devait appeler ainsi des tissus passés à la calandre, appareil à cylindres qui lissait la surface de certains tissus, tels que les draps, les toiles et les taffetas.

CALMANDE (ou Calamande). Sorte d'étoffe lustrée d'un seul côté en laine ou en soie et laine, employée surtout pour les ameublements et parfois pour les vêtements. On ne prohibait que la calmande anglaise.

DAMAS. Ce tissu n'apparaît ici que parce qu'il est employé avec des indiennes.

INDIENNES. Les toiles peintes c'taient jusqu' alors tirées de la Perse et des Indes. La ville de Rouen ne commença à les fabriquer qu'en l'année 1756.[1]

Les modèles en vogue à Montréal se classent ainsi:

Indiennes fond blanc—à fleurs rouges, bleues, brunes, jaunes, gris de *lain*, violettes, noires, rouges et violettes ou moucheté de bleu.

Indiennes fond bleu—à fleurs blanches ou rouges ou moucheté de blanc.

Indiennes fond brun—à fleurs rouges ou blanches.

Indiennes fond gris—à fleurs rouges.

Indiennes fond violet—à fleurs rouges ou à fleurs rouges et blanches.

Indiennes fond rouge—à fleurs blanches ou brunes.

Indiennes à barres rouges et blanches ou à barres bleues et blanches.

PERSE. Sorte de toile peinte ou d'indienne qu'on apportait autrefois de l'Inde et à laquelle on attribuait une origine persane. (Nouveau Larousse.)

SATIN. Même remarque que pour le damas.

SERGE. On vise spécialement la serge anglaise. Elle est presque toujours verte, unie ou à fleurs.

TAFFETAS. Même remarque que pour le damas.

L'ANNOTATION DU DOCUMENT

Quoiqu'il en soit, de ce *recensement pour les indiennes*, nous avons essayé de faire un recensement nominal ou plutôt une liste raisonnée

[1] Ch. Ouin-Lacroix, *Historie des anciennes corporations d'arts et métiers*—p. 138.

des propriétaires et locataires de Montréal en nous aidant du *Dictionnaire* de Mgr Tanguay, du *Terrier de Montréal*, des actes notariés, des actes de l'état civil et des procédures de l'année 1741.

Aux noms et désignations provenant de chaque procès-verbal, nous ajoutons immédiatement au-dessous les renseignements essentiels que nous avons pu réunir.

Ainsi préparé, nous croyons que le document de la Compagnie des Indes devient un instrument qui, malgré ses imperfections, peut servir aux généalogistes et aux annalistes, puisqu'il donne une bonne idée de la population et de la distribution des habitations de Montréal, vers la moitié du XVIIIe siècle.

Nous renvoyons à l'appendice le texte du préambule et de la conclusion du procès-verbal global.

Ajoutons que l'on peut supposer que l'action des autorités eut un bon effet puisqu'il n'est plus question de semblables perquisitions dans la suite.

RUE NOTRE-DAME (de l'est à l'ouest)

(Nos 1 à 95)

1—LACHENAIE, maçon, n.s.s.[1]
Probablement[2] Esprit Senet dit Lachenaye. Il avait épousé Marguerite Brazeau fille de Nicolas. (Tanguay, VII, 168 et T. de M. no 216*a*; pl. 9, no 390.)

2—GABRIEL BOULRICE, n.s.s.
Gabriel Bourhis on Boulrice, marié à Geneviève Jetté. (Tanguay II, 429, et T. de M. no 204*b*3; pl. 9, no 368.)

3—LOUIS POITRAS, n.s.s.
Epoux de Madeleine Chevalier. (Tanguay, VI, 409 et T. de M. no 213, 213*b*; pl. 9, no 323 et 324.)

4—Maison de LAFRICAIN, occupée par le sieur VILDENE.
Il signe *Villedonné.*
Probablement Jacques Jouslau dit Lafricain. (T. de M. no 210*a*, pl. 9, no 320.)
Pierre de Villedonné, capitaine, avait épousé, le 2 mai 1741, Marguerite Damours de Louvières. (Tanguay, III, 412.)

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[1] Lorsqu'une personne a déclaré ne savoir signer, nous faisons toujours suivre son nom des lettres: n.s.s., c'est-à-dire: ne sait signer.

[2] Au risque d'ennuyer le lecteur, nous avons, partout, fait précéder nos notes des mots, *probablement* ou *peut-être*, lorsque nous avons quelque doute sur la valeur des renseignements que nous offrons.

5—Maison DETAILLY occupée par MADAME DE JONCAIRE. Présente: CATHERINE ALARIE, n.s.s.
J. B. Deneau dit Des Taillis. (T. de M. no. 213*a*, pl. 9, no. 323.) Probablement Madeleine Leguay de Beaulieu, épouse de Thomas de Joncaire, sieur de Chabert. (Tanguay, III, 283 et V, 18.)

6—Maison de BIZAILLON, occupée par FRANCOIS LALIMAUDIERE, n.s.s.
François Bisaillon. (T. de M. no 204*b*3; pl. 9, no 368.)
Peut-être François Lecompte de Bellegarde dit Lavimaudière, époux de Marguerite Laporte. (Tanguay, V, 247.)

7—Maison de LAFRICAIN, n.s.s.
Probablement Jacques Jouslau dit Lafricain époux de Marie-Louise Blanchon. On écrit son nom plus souvent: Jousselau et Jousselot. (T. de M. no 210*a*; pl. 9, no 320, et Tanguay, VII, 26.)

8—Maison de JACQUES LABONTÉ. Sa femme est présente.
Elle signe: *Marie Brosard.*
Jacques Marot dit Labonté, époux de Marie-Barbe Brossard. (Tanguay, V, 522 et T. de M. 211*a*1; pl. 9, no 322.)

9—Maison de PIGEON.—ANGELIQUE BOILEAU est présente, n.s.s.
Celle-ci est probablement une ménagère ou une domestique du sieur Bazile Pigeon. (Tanguay, VI, 356 et T. de M. no 210*b*; pl. 9, no 321.)

10—Maison de BENOIST fils, occupée par le nommé JOLICOEUR, n.s.s.
Claude Benoit était fils de Joseph Benoit, chirurgien et il pratiquait lui-même l'art de la médecine. (Tanguay, II, 217, 218 et T. de M. no 202; pl. 9, no 367.)

11—Maison de la veuve BROSSARD, n.s.s.
Probablement Barbe Hébert, veuve de Claude Brossard. (Tanguay, II, 481 et T. de M. no 209; pl. 9, no 318 et 319.)

12—Maison du nommé BRAZEAU, n.s.s.
Peut-être Nicolas Brazeau, époux de Marie-Anne Miville. (Tanguay, II, 457 et T. de M. no 203; pl. 9, no 367.)

13—Maison du nommé SARREAU.—Sa fille est présente.
Elle signe: *Marianne Saraut.*
Probablement Pierre Sarreau, époux de Marie-Anne Bourbon. (Tanguay, VII, 123 et T. de M. no 190*b*; pl. 9, no 316.)

14—Maison de M. de RAMEZAY, servant de logement à *M. l'intendant* et occupée par dame Lafond, concierge de la maison.
Elle signe: *Caterine Lafond.*
J. R. N. R. de Ramezay, marié en 1728, à Louise Godefroy de

Tonnancourt. (Tanguay, III, 351 et T. de M. no 200 *B*1; pl. 8, no 361.)

15—Maison de Madame veuve PORTNEUF, madame veuve de MUY est présente.
Elle signe: *veuve demuy.*
Probablement Marguerite-Philippe Daneau de Muy, veuve de René Robineau de Bécancour de Portneuf et Catherine d'Ailleboust, veuve de Nicolas Daneau de Muy. (Tanguay, III, 234, VII, 9 et T. de M. no 200*A*; pl. 8, no 357.)

16—Maison des REVERENDS PERES JESUITES.—Présent le R. P. RICHÉ, supérieur.
Il signe: *P. D. Richer, de la C. de Jésus.*
Mgr Tanguay dans son *Répertoire du Clergé* le prénomme Pierre-Daniel.

17—Maison du sieur DECOSTE. Sa femme est présente, n.s.s.
Probablement Jean-Baptiste Decoste, époux de Reine Marchand qui fut huissier à Montréal, entre 1731 et 1759. (Tanguay, III, 269; Massicotte, *Tribunaux et officiers de justice de Montréal*, p. 291 et T. de M. no 191 *A*2; pl. 8, no 347.)

18—Maison de la femme du nommé MENNESON, absent.
Elle signe: *Françoise Alari.*
Claude-Vincent Meunson ou Menneson, maître doreur. (Tanguay, VII, 18 et T. de M. no 187 *B*2; pl. 7, no 327.)

19—Maison de la PROMENADE occupée par la veuve BRUNET, n.s.s.
Probablement J. B. L'Archevêque dit la Promenade, époux de Marguerite Menesson, fille de Claude-Vincent Menesson. (Tanguay, V, 164 et T. de M. no 187*B*2; pl. 7, no 327.)
Nous ne pouvons identifier la dame Brunet.

20—Maison de la veuve ALARIE, occupée par le nommé CHANTELOUP, n.s.s.
Peut-être Barthélemi Chalut dit Chanteloup. (Tanguay, II, 605.)

21—Même maison, logement occupé par DESÈVE, n.s.s.
Jean-Baptiste ou Joseph-Denis ou François Desève. (Tanguay, III, 370-371.)

22—Maison de la veuve PHILIS, n.s.s.
Marie-Madeleine Plumereau veuve de Michel Kerrigou ou Guerigou de Fily. (Tanguay, IV, 32 et T. de M. no 187*B* 2*B* et 24; pl. 7, partie du no 314.)

23—Maison de la veuve PHILIS (Fily), occupée par JEAN BOULARD.
Il signe: *boulard.*

Antoine Jean-Baptiste Boulard, soldat, époux de Françoise Chaslu. (Tanguay, II, 405.)

24—Maison de M. de LIGNERIS. Présente: "la dame son épouse." Elle signe: *Lagauchetière Desligneris.*
François Marchand de Lignery, officier, époux de Marie-Thérèse Migeon de la Gauchetière. (Tanguay, V, 312 et T. de M. 187*A* 1; pl. 7, no 325.)

25—Maison du nommé JOBIN, occupée par le sr DORLET, aubergiste. Il signe: *Dorlet.*
Pierre François Dorlet, traiteur, époux de Rebecca Realens (et Hens). (Tanguay, III, 433.)
François Jobin, époux de Suzanne Jousset. (Tanguay, V, 4 et T. de M. no 187*B* 22; pl. 7, no 313-314.)

26—Maison du nommé JOBIN, n.s.s.
François Jobin, époux de Suzanne Jousset. (Tanguay, V, 4 et T. de M. no 187 *B*22; pl. 7, no 313-314.)

27—Maison du nommé CARIE où demeure le sieur MOUETTE. Celui-ci, n.s.s. L'autre signe: *Cary.*
Aucun renseignement sur ce Cary.
Didace Mouet de Moras, époux de M. Louise de la Porte de Louvigny. (Tanguay, VI, 125.)

28—Maison du sieur CHAUFOUR.
Présente sa femme:
Elle signe: *Angélique Boiseau.*
Jean-Baptiste Chaufour, chapelier, époux d'Angélique Boisseau. (Tanguay, III, 42 et T. de M. no 181 *EE*2; pl. 7, no 291.)

29—Maison de M. CABANA, officier, occupée par la veuve DUVAL et par la veuve MARCHAND.
Elles signent: *veuve Duval* et *veuve Marchat* (*sic.*).
François Déjordy de Cabanac, époux de Thérèse de Tonty après avoir habité Montréal depuis 1734 à 1740 était allé demeurer à Champlain. Sa femme avait reçu l'immeuble de son père Alphonse de Tonty, baron de Paludy. (Tanguay, III, 329 et VII 319 et T. de M. no 181 *Y*; pl. 7, nos 294, 295, 296, 302.)

30—Maison du Sieur SILVAIN, occupée par la veuve DENIS.
Elle signe: *La veuve Denis.*
Timothée Sylvain (ou Sullivan) chirurgien. (Tanguay, I, 555 et VII, 235 aussi T. de M. nos 181*m*, 181*n*, 181*o*, 181*p*, 181*x*; pl. 7, nos 294, 299, 300.)

31—Maison du Sieur SILVAIN, occupée par JEANNOT, n.s.s.
Sur sieur Silvain, voir la note du no précédent.

32—Maison du sieur DUBOIS, n.s.s.
Probablement Pierre Dubois, époux de Thérèse Quesdra (ou Quéri). (Tanguay, III, 473 et T. de M. no 181*Aa* 2, pl. 7, no 289.)

33—Maison du sieur BENOIST.
Il signe: *Benoist.*

34—Maison de la veuve LENOIR, occupée par JOSEPH DESÈVE, n.s.s.
Pour "veuve Lenoir" voir la note au no suivant.
Joseph Denis Desève. (Tanguay, III, 371.)

35—Maison de la veuve LENOIR, n.s.s.
Peut-être Marie Galipeau, épouse de Vincent Lenoir, menuisier. (Tanguay, V, 341 et T. de M. no 181*T*; pl. 7, nos 292 et 293.)

36—Maison du sieur LENOIR, n.s.s.
Probablement un des fils de Vincent Lenoir dont il est question au no ci-dessus.

37—Maison des SOEURS DE LA CONGRÉGATION.
Présente: la dame de la Présentation supérieure.
Elle signe: *Sr de la Présentation, Spre.*
Marguerite Amiot, fille de Jean Amiot et de Marguerite Poulain, en religion soeur de la Présentation, fut supérieure de 1740 à 1746. (T. de M. nos 177, 179*A*; pl. 6, nos 254, 256.)

38—Maison du sieur POMMEREAU.
Il signe: *Paumereau.*
Aussi présente: la veuve SAINT-OLIVE.
Elle signe: *St. Olive veuxve.*
Jacques-Pierre Paumereau, marchand, époux de Françoise Nafrechoux.
Madeleine Nafrechoux, veuve de Claude Boiteux de Saint-Olive, chirurgien et apothicaire. (Tanguay, VII, 227, et T. de M. no 168; pl. 6, no 244.)

39—"LES PRISONS ROYAUX" où est logé le sieur LE PALLIEUR.
Présente: sa femme qui n.s.s.
Le géolier des prisons était alors Charles-René Le Pallieur, époux de Madeleine Le Normand. (Tanguay, V, 349, aussi T. de M. nos 163 *C*6 et 167; pl. 6, no 235.)

40—Maison du sieur ISTRE.
Il signe: *Istre.*
Joseph Istre, chirurgien. (Tanguay, IV, 570 et T. de M. no 176; pl. 6, no 253.)

41—Maison de REBOUST dit LEVEILLE.
Il signe: *Rebou.*

Toussaint Rebou dit Léveillé, maître perruquier. (Tanguay, VI, 529 et T. de M. no 175 *B*; pl. 6, no 252.)
Certains scribes écrivent *Rebour* et d'autres *Reboul*,

42—Maison du sieur GERVAIS, occupée par le sieur SÉGUIN.
Présente: sa femme.
Elle signe: *Hervieux Séguin*.
Guillaume Séguin dit Bellerose, écrivain, époux de Geneviève Hervieux. (Tanguay, VII, 157 et Simonnet, 8 mais 1741.

43—Maison du sieur DUCHOUQUET.
Il signe: *Duchouquet*.
Louis-Joseph Lefebvre Duchouquet, époux d'Elisabeth Lemire-Marsollet. (Tanguay, V, 273 et T. de M. no 176*a*; pl. 6, no 251.)

44—Maison du sieur D'ARGENTEUIL, occupée par VAUQUAISE.
Il signe: *Vauquier*.
Jean d'Ailleboust, sieur d'Argenteuil. (T. de M. nos 165 et 165*c*; pl. 6, nos 240 et 241.)
Nicolas Vauquier. (Tanguay, VII, 433.)

45—Maison de la veuve LAFANTESIE, n.s.s.
Madeleine Dumouchel veuve de Claude Maurice dit Lafantaisie. (Tanguay, V, 580 et T. de M. no 174; pl. 6, no 250.)

46—Maison de la veuve LAFANTESIE, occupée par le sieur D'AILLEBOUST de la MADELEINE. Présente: sa femme.
Elle signe: *Linctot de la Madeleine*.
Veuve Claude Maurice dit Lafantaisie. (Voir la note à l'article précédent et T. de M. no 173; pl. 6, no 249.)
François d'Ailleboust sieur de la Madeleine, époux de Marie Charlotte Godefroy de Linctot. (Tanguay, III, 224.)

47—Maison du sieur D'ARGENTEUIL, occupée par le nommé CHABOT, n.s.s.
Sur le sieur d'Argenteuil, voir la note à l'article 44, ci-dessus.

48—Maison de la veuve D'ARGENTEUIL.
Elle signe: *Dargenteuil*.
La dame de la Valtrie et le sr d'Argenteuil, fils, ont aussi des effets dans cette maison.
Marie-Louise de la Ronde, veuve de Pierre d'Ailleboust d'Argenteuil. Elle naquit en 1671 et mourut en 1747. (Fauteux, *Famille d'Ailleboust*, p. 46.)
Jean d'Ailleboust d'Argenteuil, fils du précédent. Il naquit en 1694 et mourut célibataire, après 1787. (Fauteux, *ibid*, p. 96 et T. de M. no 165*a*; pl. 6, no 240.)

49—Maison de dame D'ARGENTEUIL, occupée par la femme du sieur COURTEVILLE, absent.
Elle signe: *De Courteville.*
Barthélemi-Charles de Courteville marié à Elisabeth Demers. (Tanguay, III, 270.)
Voir note à l'article 48.

50—Maison du sieur FRENIERE BIRON.
Il signe: *Fresniere Biron.*
Jean Fresnière Biron, marchand bourgeois, demeurant rue Notre-Dame. (Adhémar, 22 juillet 1741 et T. de M., nos 164*B*, 164*C*; pl. 6, nos 238 et 239.)

51—Maison du sieur AUGÉ BIRON, n.s.s.
Voir T. de M. nos 164*B* et 164*C*; pl. 6 nos 239 et 238.
Peut-être Jacques Auger Biron, époux de Marie Heurtebise. (Tanguay, II, 269.)

52—Maison de la veuve RUPALAIS.
Elle signe: *De Rupalay.*
Probablement Anne Lemire veuve de Marc-Antoine de Rupalley ou Marie-Charlotte Leriger, épouse de Charles de Rupalley de Gonneville. (Tanguay, III, 356 et T. de M. nos 164*A* et 164*B*; pl. 6, nos 238 et 239.

53—Dans une maison des SOEURS DE LA CONGRÉGATION, occupée par le nommé ROLLAND.
Il signe: *Charle Rolland.*
Philippe-Charles Rolland. (Tanguay, VII, 31.)

54—Maison de CARDINAL, cordonnier, n.s.s.
Un Jacques Cardinal, époux de Jeanne Duguay, était propriétaire du lot voisin de celui du coin de la rue Notre-Dame et de la place d'Armes, en 1740, mais il résidait à Détroit. (Tanguay, II, 543 et T. de M. 162*G* 2; pl. 6, no 237.)

55—Maison de CHARLES TESSIER. Présente: sa femme.
Elle signe: *Magdeleine Laforce.*
Dans une chambre loge, MADAME GAUCHER.
Elle signe: *Catalongue Gauché.*
Charles Tessier marié en troisièmes noces à Marie-Madeleine Pepin dit Laforce. (Tanguay, VII, 276.)
Michel Gamelin dit Gaucher, voyageur ,époux de Charlotte Julie de Catalogne. (Tanguay, IV, 167.)

56—Maison de TESSIER, occupée par la veuve LALIBERTE, n.s.s.

57—Maison de JACQUES LAVIGNE, occupée par SAINT-LAURENT, n.s.s.

58—Maison de LAPALME. Présente: sa femme, n.s.s.
Dominique Janson dit Lapalme, architecte, époux de Marie-Joseph Couturier. Fut grand voyer à Québec, en 1761, où il mourut en 1762. (Tanguay, IV, 586 et T. de M. no 161*d*; pl. 5, no 217.)

59—Maison de M. de NOYELLE.
Il signe: *Noyelle.*
Occupée aussi par Mlle. de LA VERENDRY.
Elle signe: *C. Laverendrye.*
Nicolas Joseph de Noyelle de Fleurimont ou son fils Charles-Joseph. (Tanguay, III, 346 et T. de M. no 128*B*; pl. 5, no 147.)
Peut-être Marie-Catherine Gautier de la Verendrye qui épouse Jean Le Ber de Senneville en 1743. (Tanguay, IV, 208 et V, 220.)

60—Maison de CORON, occupée par madame veuve DUFIGUÉE.
Elle signe: *Marianne Largenterie du figuier.*
Charles-François Coron, notaire. (Tanguay, III, 132 et T. de M. no 129; pl. 5, no 148.)
Marie-Anne de Miray de l'Argenterie, veuve de René-Louis Le Fournier du Figuier. (Tanguay, V, 289 et III, 330.)

61—Dans l'autre côté de la même maison, occupé par SANSOUCY, n.s.s.

62—Maison de Mr de CUISY, occupée par Mr MAUGRAS.
Présente: son épouse.
Elle signe: *M. Lajemerais Maugras.*
Paul-Alexandre d'Ailleboust de Cuisy, né en 1696, mort en 1782. Il avait épousé Thérèse de Fournier du Vivier. (Fauteux, *Fam. d'Ailleboust*, p. 97.)
Pierre Gamelin dit Maugras, époux de Marie-Clémence du Frost de la Jemerais. (Tanguay, III, 310 et IV, 167.)

63—Maison de Mr D'AILLEBOUST. Madame VEUVE DU VIVIER, présente.
Elle signe: *Thérèse Gadois de Vivier.*
Il y a aussi des effets appartenant à une dame de Lignerie.
Le propriétaire doit être M. d'Ailleboust de Cuisy. Voir no 62.
Madeleine-Thérèse Gadois veuve de Jules Le Fournier du Vivier. (Tanguay, I, 368 et T. de M. no 129*c*; pl. 5, no 150.)

64—Le SEMINAIRE DE MESSIEURS LES SEIGNEURS. Présent: M. de Clerimbert économe.
Il signe: *Clerimbert prêtre.*
Laurent Riverie de Clerimbert (Gauthier, *La Compagnie de St-Sulpice*, p. 40 et T. de M. no 126; pl. 5, no 151.)

65—Maison de sieur SAINT-CÔME. Présente: sa femme, n.s.s.
Pierre Cosme dit Saint-Cosme, négociant. (Simonnet, 15 juin 1741.)
Probablement un Buisson de Saint-Cosme, mais lequel?

66—Maison de Mr. BOUATE, occupée par le sieur J. B. GUILLON.
Il signe: *J. Bte. Guillon.*
Feu François-Marie Bouat, ancien juge. (Tanguay, IV, 363.)
Probablement Jean Guillon (ou Guyon) époux de Marguerite Provancher. (Tanguay, IV, 432.)

67—Maison de LAVALLÉE forgeron. Sa femme est présente.
Elle signe: *Lavalée.*
Dans la même maison habite le sieur FARLY dont la femme est présente. n.s.s.
Probablement Jacques Lavallée, époux d'Elisabeth Cabazié. (Tanguay, V, 201.)
Jacques-Philippe Farly, voyageur, époux de Marie-Josephe Dumouchel. (Tanguay, IV, 9.)

68—Maison de JACQUES CAVELIER.
Il signe: *J. Cavelier.*
Jacques Cavelier, maître armurier. (Tanguay, II, 587 et T. de M. no 124 *A*1; pl. 4, no 51.)

69—Maison de PISTOLLET. Il est présent, ainsi que son fils.
Ils signent: *Antoine Boumount-Antoine beaumont di pistolet.*
(Tanguay, VI, 173 et T. de M. no 116*F*; pl. 4, no 82 et Simonnet, 27 mai 1741. Antoine Beaumont, fils, était ferblantier.

70—Maison du sieur DULOMPRÉ FORESTIER. Présente: sa femme.
Elle signe: *Louise Grosbois Dulonpré.*
Jean-Baptiste Forestier sieur Dulongpré, époux de Louise Boucher de Grosbois. (Tanguay, IV, 64.)

71—Maison de PICARD, n.s.s.
Peut-être François Picard, époux de Marguerite Cusson. (Tanguay, VI, 345 et T. de M. no 116*E*; pl. 4, no 81.)

72—Maison de M. MARIN, occupée par M. de BLAINVILLE. Présente, Sa femme.
Elle signe: *Langloiserie de Blainville.*
Paul Marin de la Malgue, époux de Marie-Josephe Guyon. (Tanguay, V, 514 et T. de M. no 121*B* et 122; pl. 4, no 49.)
J. Bte. Céloron de Blainville époux de Suzanne Piot de Langloiserie. (Tanguay, II, 591.)

73—Maison de LAMARCHE, maçon, n.s.s.
Toussaint Périneau dit Lamarche, époux de Marie-Joseph

Cusson. (Tanguay, VI, 305 et T. de M. no 116*D*; pl. 4, partie de no 80*A*.)

74—Maison de sieur PIERRE VOISIN dit LA CROIX, n.s.s.
Pierre Voisin dit La croix, sergent. (Tanguay, VII, 480.)

75—Maison de la veuve FORESTIER.
Elle signe: *veuve Forestier.*

76—Même maison, dans un appartement occupé par la dame veuve LAFFERTÉ.
Elle signe: *Caterine Lapalieur.*
Catherine-Gertrude Jérémie, veuve de François-Michel Le Pallieur de Laferté, qui fut huissier, géolier, notaire, substitut du procureur du roi et greffier intérimaire.

77—Maison de LOUIS CAVELIER.
Il signe: *Louis Cavelier.*
Probablement Louis Cavelier époux de Catherine Lemire. (Tanguay, II, 587.)

78—Maison de MALOIN, n.s.s.
Nicolas Kergrecolet dit Malouin, époux de Jeanne Hébert. (Tanguay, V, 42 et T. de M. 105*L*2; pl. 4, no 79.)

79—Maison de RABOT, menuisier.
Il signe: *P. Gautier, menui.*
Pierre Gautier, dit Rabot, marié à M.-Anne Boileau vécut à Montréal de 1717 à 1754. Son mariage, eut lieu le 8 juin 1716 à la Pointe-Claire. Tanguay n'a pas cette dernière date. (Tanguay, IV, 209, et T. de M. no 105*L* ler; pl. 4, no 78).

80—Maison du sieur AUGER, tisserand.
Il signe: *Pierre Auger.*
Probablement Pierre Auger époux de Marguerite Foretier. (Tanguay, II, 82 et T. de M. no 106 *C*1, nos 45 et 46.)
Dans le *Terrier* on le nomme Auger-Desnoyers.

81—Maison de la veuve POUGET, n.s.s.
Il y avait deux veuves Pouget alors à Montréal: Marthe Brossard veuve du colon et Gabrielle Dugast veuve du fils du colon. Les deux défunts avaient été tailleurs. (Tanguay, VI, 423.)

82—Maison de BAPTISTE CAVELIER, n.s.s.
Peut-être J. B. Cavelier, époux de Marie-Charlotte Pigeon. (Tanguay, II, 581.)

83—Maison de la veuve BEAUVAIS, n.s.s.
Probablement Elisabeth Turpin, veuve de Raphael Beauvais. (Tanguay, II, 178 et T. de M. no 1050; pl. 4, no 62.)

84—Maison de MADAME LEVERRIER, occupée par MADAME YOUVILLE.
Présente: Dlle LOUISE LA SOURCE.
Elle signe: *Louise Lasource.*
Jeanne-Charlotte de Fleury Deschambault, veuve de François Le Verrier sieur de Rousson. (Tanguay, V, 395 et T. de M. nos 106*B*, 106*B*3 et 106*c*; pl. 4, nos 43 et 44.)
Marie-Marguerite Dufros de la Jemmerais veuve de Francois Madeleine You ou Youville, sieur de la Découverte, fondatrice de la communauté des Soeurs grises. (Tanguay, VII, 491.)
Marie-Louise Thaumur de la Source, née en 1708, une des premières compagnes de la vénérable dame Youville. (Tanguay VII, 288.)

85—Maison de PIERRE BOUGRET DIT DUFORT, n.s.s.
Pierre Bougret dit Dufort, époux de Louise Dudevoir. (Tanguay, II, 394 et T. de M. no 106*A*; pl. 4, no 41.)

86—Maison de JACQUES GARAUT, n.s.s.
Probablement Jacques-Philippe Garaut, époux de Marie Imbaut. (Tanguay, IV, 172 et T. de M. no 102-0; pl. 3, No 37.) Dans le terrier on lit Gareau dit Vadeboncoeur.

87—Maison de SAINT-JEAN, sergent, n.s.s.
Jean Latouche dit St-Jean et dit Soupras, époux d'Elisabeth Vallée; il décède au mois d'octobre 1741. (Tanguay, V, 184 et T. de M. 102 *MNO* et 102*n*; pl. 3, nos 35 et 36.)

88—Maison des héritiers de M. DE VILLIERS, occupée par JACQUES LASELLE. Présente: sa femme.
Elle signe: *Marian Lalande.*
Nicolas-Antoine Coulon de Villiers. (Tanguay, II, 167 et T. de M. no 102*mno*; pl. 3, no 35.)

89—Maison de CONTOIS, occupée par la veuve DUDEVOIR, n.s.s.
François Marc ou Mar dit Contois qui épousa en 1752 Marie Anne Gazal. (Tanguay, V, 484 et T. de M. no 102*L*, pl. 3, no 34.)
Angélique Ducharme veuve de Claude Dudevoir qui fut huissier royal de 1722 à 1734. (Tanguay, III, 499 et Massicotte *Tribunaux et officiers de justice*, 291.)

90—Maison de la veuve CHAMPAGNE, occupée par TOULOUSE, n.s.s.
Marie-Madeleine Arrivée veuve de Jean Fontenelle dit Champagne. Voir la note à l'article suivant.
Probablement Joseph Raymond dit Toulouse, époux de Marie Ondoyer. (Tanguay, VI, 518.)

91—Maison de la veuve CHAMPAGNE, n.s.s.
Marie-Madeleine Arrivée, veuve de Jean Fontenelle dit Champagne, soldat, puis menuisier. Leur mariage à *la gaumine,* en

1711 leur causa bien des ennuis et ils durent s'épouser régulièrement en 1720. (Tanguay, IV, 47 et B.R.H. 1919, p. 120; aussi T. de M. nos 102*G*, 102*H*, 102*i*; pl. 3, nos 31, 32, 33.)

92—Maison de DUPLANTY, occupée par ETIENNE LORANGE, n.s.s.
Jacques Hery-Duplanty, époux de Jeanne Vanier. (Tanguay, IV, 502 et T. de M. 102*H*; pl. 3, nos 32 et 33.)
Jean-Etienne Cluseau dit Lorange. (Tanguay, III. 102.)

93—Maison de DUPLANTY, occupée par LALIME.
Il signe: *Lalime*.
Sur Duplanty, voir l'article précédent.
Jean-Baptiste Sadé-Lalime, ancien soldat, époux de Geneviève Bluteau. (Tanguay, VII, 108.)

94—Maison de LA PROMENADE, n.s.s.
Jacques Larchevêque dit La promenade, époux de Madeleine Hayot. (Tanguay, V, 163.)

95—Le couvent des REVERENDS PERES RECOLLETS. Présent le R. P. PISCOT.
Signe: *F. Estienne Piscot, Récollet, Prestre.*
Le R. P. Etienne Piscot, après avoir été aumônier de l'Hôpital-général de Québec en 1729 et 1730, paraît avoir été supérieur de la maison de son ordre à Montréal en 1733.
Dans le *Terrier de Montréal*, le terrain des Récollets sis au coin des rues Notre-Dame et Saint-Pierre, ne porte aucun numéro.

RUE AUGUSTINE (du nord au sud)

nos 96 à 98

96—Maison D'YVON.
Il signe: *Gabriel Leber.*
Gabriel LeBer dit Yvon, cordonnier, à ce moment marié en 3e. noces avec Marie-Joseph Durand. (Tanguay, V, 319 et T. de M. no 101*E*; pl. 3, no 22.)
Le *Terrier* le nomme Hyvon et Yvon dit Leber.

97—Maison de PATENOTE, n.s.s.
Jean-Baptiste Patenotre, époux de Marie-Renée Leber Yvon. (Tanguay, VI, 250 et T. de M. no 101*D*; pl. 3, no 22.)

98—Maison de PARENT, occupée par ROCHEFORT. (Pàs d'indication s'il sait signer ou non.)
Joseph Parent, menuisier, époux de Marie-Françoise Mony. (Tanguay, VI, 234 et T. de M. no 101*c*; pl. 3, no 21.)
Probablement Bernard Audon dit Rochefort, époux de Marie-Joseph Desforges. (Tanguay, II, 79.)

RUE SAINT-PAUL (de l'ouest à l'est)

(nos 99 à 253)

99—Maison de DAME ST-DIZIER.
Elle signe: *la ve Saint-Dizier.*
Probablement Marie-Anne Prud'homme, veuve de Pierre Nivard dit Saint-Dizier. (Tanguay, VI, 150 et T. de M. no 31; pl. 3, no 1).

100—Dans un appartement, de la maison de la dite dame ST-DIZIER, occupé par le sieur DE LA CHOIVIGNERY. Présente: sa femme.
Elle signe: *St Blin la Chauvignery.*
Michel Maray de la Chauvignerie, interprète en langue iroquoise, époux de Marie-Josephe Raimbault de Saint-Blin. (Tanguay, V, 488.)

101—Dans une maison de MADAME Ve ST-DIZIER, occupée par ST ETIENNE. n.s.s.
Probablement Pierre Guignard (ou Rignan) dit St-Etienne, époux de Marie-Joseph Lebeuf. (Tanguay, IV, 408 et VI, 569.)

102—Maison de la veuve COCHOIS, occupée par DELISLE, n.s.s.
Elisabeth Prud'homme veuve de Jacques Cauchois. (Tanguay, II, 582 et T. de M. no 102*BB*; pl. 3, no 8.)

103—Maison de LECOUR.
Il signe: *Nicolas Le Court.*
Nicolas Lecourt, époux de Geneviève Courault. (Tanguay, V, 250 et T. de M. no 102*cc*; pl. 3, no 9.)

104—Maison de NICOLAS LECOURT, occupée par LARCHE, n.s.s.
Voir no 63.

105—Maison de la veuve LANGLOIS, n.s.s.
Marie-Renée Toupin-Dussault, veuve de Jacques Langlois. (Tanguay, V, 139 et T. de M. no 53; pl. 3, no 3.)

106—Maison de BOUTIN, n.s.s.
Pierre Boutin, forgeron, époux de Marie-Jeanne Langlois. (Tanguay, II, 437 et T. de M. no 34; pl. 3, no 4.)

107—Même maison—MADAME PREJEANT absente dans le moment.
Il y avait alors à Montréal ou à Lachine, la veuve Louis Prejeant et la veuve Jean-François Préjeant. (Tanguay, VI, 440, 441.)

108—Maison de GAGNÉ.
Il signe: *Pierre Gagnier.*
Pierre Gangnier, époux en secondes noces de Madeleine Baudreau. (Tanguay, IV, 120 et T. de M. no 34; pl. 3, no 5.)

109—Maison de DESCARIE, occupée par VENET, n.s.s.
Les héritiers Descarris possédaient alors les terrains aux coins nord-est et sud-est des rues Saint-Paul et Saint-Pierre. La maison, dont il est ici question ainsi que dans les items suivants (nos 111, 112 et 113), devait être celle qui s'élevait au coin sud-est. Voir *Terrier de Montréal*, no 35, pl. 4, nos 132, 133, 134, 107 et 109é). Tanguay, VI, 143, mentionne un Louis-René Nenet ou Venet, Blanzy écrit Venet, dans un acte du 20 mai 1752.

110—Même maison, dans un appartement occupé par MR LINCTOT.
Il signe: *Linctot.*
Probablement Louis-René Godefroy de Linctot officier, époux de Catherine-Apolline Blondeau. (Tanguay, IV, 314.)

111—Maison de DESCARIE, occupée par la dame épouse du sieur LESCUYER, n.s.s.
Sur Descarie, voir la note à l'item 109.

112—Même maison, dans un appartement occupé par les Dlles GIGUÈRE, n.s.s.

113—Même maison, dans l'étage d'en haut, occupé par les DESCARIS, n.s.s.

114—Maison de JETTE, n.s.s.
Joseph Jetté, époux de Louise Bouchard. (Tanguay, IV, 604 et T. de M. no 35, pl. 4, no 109.)

115—Dans un côté de la maison de LEFEB VRE occupé par le nommé CHAVAUDREUIL, n.s.s.
Ursin Dutalmé dit Chavaudreuil. (Tanguay, III, 578.)
Sur Lefevre voir l'item suivant.

116—Maison de LEFEBVRE, n.s.s.
Probablement Louis Lefebvre du Chouquet qui fut garde-magasin au Fort Frontenac, époux de Céleste-Alberte Petit-Boismorel. (Tanguay, 8 février, 1729 et T. de M. no 35; pl. 4, no 134.)

117—Maison de TOUPIN, n.s.s.
Noel Toupin, époux de Marie-Françoise Navers. (Tanguay, VII, 324 et T. de M. no 35; pl. 4, nos 109 et 110.)

118—Maison de CAVELIER.
Il signe: *Le Cavelier.*
Toussaint le Cavelier, époux de Marguerite Parant. (Tanguay, II, 587 et T. de M. no 36; pl. 4, no 135.)

119—"Françoise CHARLU, femme de BOULARD, ci-devant desnommé" fait son rapport aux commissaires, à ce moment. Elle était absente lors de la visite et son mari n'avait aucune connaissance

de quelques articles qu'elle déclare. Elle ne sait signer. On ne dit pas où elle demeure.
Aucun Boulard n'a été "ci-devant desnommé" dans le document. Le scribe l'avait omis. Par ailleurs, ce nom n'apparaît pas dans le *Terrier de Montréal.* Donc le sieur Boulard n'était que locataire d'une des maisons précédemment visitées. Voici ce que le *Dictionnaire généalogique* nous dit sur ce citadin: "Antoine Jean-Baptiste Boullard, soldat, marié à Françoise Chaslu" (et non Charlu). (Tanguay, II, 405.)

120—Est aussi comparue THERESE LA SERRE fille du nommé CHAUFOUR, desnommé ci-dessus. On ne dit pas où elle demeure.
Elle signe: *Thérèse Lasser.*
La comparante était belle-fille de J. B. Chaufour, celui-ci ayant épousé Angélique Boileau veuve de Guillamme Laserre. Thérèse devenue soeur grise décéda à l'Hôpital général en 1783. (Tanguay, V, 180.)

121—Maison de madame de TIERSAN, occupée par le sieur SARRASIN.
Il signe: *Sarasin.*
Marie-Joseph-Rose Fézeret épouse de François-Gabriel Thiersan de Genlis. (Tanguay, VII, 307 et T. de M. no 103*D*; pl. 4, nos 111 et 108.)

122—Maison de la veuve CUROT, aussi de madame TONTY.
L'une signe: *Veuve Curot,* et l'autre: *Dubuisson de Tonty.*
Louise Feron, épouse de Martin Curot (ou Curaux). (Tanguay, III, 210 et T. de M. no 37; pl. 4, no 136.)
Louise Renaud du Buisson, épouse de Charles-Henri-Joseph de Tonty. (Tanguay, VII, 319.)

123—Maison du sieur RIVARD. Présente: sa femme.
Elle signe: *Jenenief Jarevès.*
Julien Rivard marchand, époux de Geneviève Gervaise. (Tanguay, VI, 579 et T. de M. no 38; pl. 4, no 137.)

124—Maison du sieur MAUGÉ. Sa femme est présente.
Elle signe: *Mogé.*
Une chambre est habitée par Madame de NOYELLE, sa fille, qui est absente.
Jacques Gadois dit Mauger, époux de M. Madeleine Chorel et Marguerite Gadois-Maugé qui avait épousé le 22 mai 1741 Charles-Joseph de Noyelle de Fleurimont. (Tanguay, IV, 118 et T. de M. no 103*E*; pl. 4, partie du no 108.)

125—Maison du sieur GODET. Sa femme est présente.
Elle signe: *Marianne Cuillriée* (on dirait Cuillrice).

Dominique Godet époux de Marie-Anne Cuillerier. (Tanguay, IV, 311 et T. de M. no 103*F*; pl. 4, no 121.)

126—Maison du sieur HAMELIN. Sa femme est présente.
Le scribe déclare qu'elle signe, mais on lit: *hamelin pour ma mère.*
Sans doute c'est un enfant qui a signé pour sa mère.
Devait occuper le terrain no 111, pl. 4, no 118, T. de M.

127—Maison de Mr le CHEVALIER DE LA CORNE.
Il signe: *Le chev. de la Corne.*
Devait occuper le terrain no 4*d*; pl. 4, no 138.

128—Maison de la veuve SAINT-OLIVE occupée par le sieur POUDRET, n.s.s.
Madeleine Nafrechoux, veuve de Claude Boiteux de Saint-Olive, apothicaire. (Tanguay, VII, 227 et T. de M. no 112; pl. 4, no 123.)
Probablement Antoine Poudret, époux de M. Elizabeth Foron. (Tanguay, VI, 422.)

129—Maison du sieur de TAILLY, n.s.s.
Joseph Denau de Tailly, époux de Marie-Anne Adhémar. (Tanguay, III, 332, et T. de M. no 40; pl. 4, no 139.)

130—Même maison, appartement occupé par LOUIS ARCHAMBAULT, n.s.s.
Peut-être Louis Archambault, époux de Thérèse Baudreau. (Tanguay, II, 46.)

131—Même maison. Appartement occupé par la veuve LAFONTAINE, n.s.s.

132—Maison du sieur DIELLE, occupé par le sieur LA SAUSSAYE. Sa femme présente.
Elle signe: *Raimbault de la Saussaye.*
Jacques Diel, forgeron, marié à Marie-Anne Crépin. (Tanguay, III, 416.)
Pierre Dagneau Douville de la Saussaye, marié à Madeleine Raimbault. (Tanguay, III, 218.)

133—Maison de madame veuve BABY.
Elle signe: *Veuve Baby.*
Thérèse Lecompte, veuve de Raymond Baby. (Tanguay, II, 93 et T. de M. no 118; pl. 4, no 131.)

134—Maison de CAMPAUT. Appartement occupé par la femme de NEVEU, absent, n.s.s.
Probablement Jacques Campaut, époux de Jeanne-Cécile Catin. (Tanguay, II, 531 et T. de M. no 41; pl. 4, no 141.)

135—Même maison. Appartement occupé par FRANCOIS GUILLEMIN, n.s.s.
François Guillemin, soldat, époux de Françoise Laisné. (Tanguay, IV, 417.)

136—Maison de M. DAUTEUIL, occupée par le sr CATIN représenté par sa femme.
Elle signe: *Marianne Chauvin.*
Charles Ruet d'Auteuil, époux de Thérèse Catin. (Tanguay, III, 252 et T. de M. no 119*B*; pl. 4, no 129.)
Henri-Nicolas Catin, voyageur, marié à Marie-Anne Chauvin. (Tanguay, II, 580.)

137—Maison de Mr MALHIOT. Sa femme est présente.
Elle signe: *Gamelin Mahiot.*
Jean-François Malhiot, lieutenant particulier c'est-à-dire juge suppléant, à Montréal, marié à Charlotte Gamelin. (Tanguay, V, 463 et T. de M. no 42*d*; pl. 4, no 141, 142.)

138—Maison de Mr BLONDEAU occupée par Mr ADHEMAR. Son épouse est présente.
Elle signe: *Caterine Adhémar.*
Maurice Blondeau, veuf de Suzanne Charbonnier. (Tanguay, II, 316 et T. de M. no 42*c*, pl. 4, no 142.)
Jean-Baptiste Adhémar, notaire royal, ancien greffier du tribunal, marié à Catherine Moreau. (Tanguay, II, 6.)

139—Maison de M. d'AUTEUIL, occupée par Madame BUSQUET.
Elle signe: *Le Villiers Busquet.*
Sur M. d'Auteuil, voir no 136.
Antoine Busquet marié à Louise Petit Le Villiers. (Tanguay, II, 508 et T. de M. no 119*B*; pl. 4, no 129.)

140—Maison de madame VEUVE DE REPENTIGNY, occupée par M. DUPLESSY.
Il signe: *Duplessy.*
T. de M. no 140 à 141; pl. 5, nos 183, 184, 185.

141—Maison du sieur RENÉ DE COUAGNE.
Il signe: *R. Decouagne.*
René de Couagne, époux de Louise Pothier. (Tanguay, III, 269 et T. de M. no 13*B*; pl. 5, nos 185*a*, 186*a*.)

142—Même maison, appartement occupé par le sieur LACROIX dont l'épouse est présente.
Pierre Hubert dit Lacroix, voyageur, marié à Catherine Pothier dit Laverdure. (Tanguay, IV, 532.)

143—Maison de Mr. NEVEU.
Il signe: *B. Neveû.*

T. de M. no 14; pl. 5, no 186*a*. Peut-être J. B. Neveu de la Bretonnière, marié en secondes noces à Françoise Le Gras. (Tanguay, VI, 144 et T. de M. no 14; pl. 5, no 186*a*)

144—Maison, de Madame VEUVE BONDY, occupée par le sieur LEGRAS. Sa femme est présente.
Elle signe: *Genvi Gamelin legras.*
Catherine Testard, veuve d'Augustin Douaire de Bondy. (Tanguay, III, 436 et T. de M. no 141 et 142*A*; pl. 5, no 186.)
J. Bte Le Gras, marchand, marié à Geneviève Gamelin. (Tanguay, V, 300.)

145—Même maison. Effets appartenant à Dlle Louise Legras.
Elle signe: *Louise legras.*
Probablement Louise Legras, née en 1700 qui épouse, en 1753, Françoise Poirier, à Chambly. (Tanguay, V, 300.)

146—Même maison. Un appartement occupé par Madame VEUVE BONDY.
Elle signe: *Bondy.*
Voir no 144.

147—Maison des Sr. VOLANT, occupée par Sr. METIVIE.
Il signe: *Métivié.*
Peut-être François et Nicolas Volant Tanguay, VII, 481 et T. de M. no 16; pl. 5, no 187*A*.
Probablement Barthélemi Métivier, époux de Marguerite Chauvin. (Tanguay, VI, 11.)

148—Maison de la veuve MAURISSEAUX.
Elle signe: *Veuve Marisseaux.*
Suzanne Petit veuve de J. B. Maurisseaux, vivant, interprète. (Tanguay, VI, 118 et T. de M. no 142*B*; pl. 5, no 187.)

149—Maison du sr LACOSTE. Sa femme est présente. Il s'y trouve des marchandises appartenent à MARIN HURTEBISE.
Madame La Coste refuse de signer.
Pierre Couraud dit Lacoste, marié en secondes noces à Marguerite Aubuchon. (Tanguay, III, 169 et T. de M. no 143*A*; pl. 5, nos 174*A* et 174.)

150—Maison du sieur ROCBERT, occupée par DUROZEAU, n.s.s.
Antoine Durozeau, forgeron, époux de Louise-Claire Marchand. (Tanguay, III, 573.)

151—Maison de DU SERMON, occupée par DLLE MARIE-ANNE LA FAYETTE.
Elle refuse de signer.
Charles Demers Dessermons marié en troisièmes noces à Made-

leine Cauchon-Blery. (Tanguay, III, 523 et T. de M. no 18; pl. 5, nos 188 et 190.)
Probablement Marie-Anne Faille dit Lafayette, née en 1691 et qui épouse, en 1750, J. B. Douaire. (Tanguay, IV, 5.)

152—Maison du sieur FONBLANCHE. Sa fille est présente.
Elle signe: *Catherine fomblanche.*
Probablement Jacques-François Quesnel dit Fonblanche marié en secondes noces à Marie-Anne Franquelin et Catherine Quesnel dit Fonblanche, née en 1721 d'un premier mariage. (Tanguay, VI, 481 et T. de M. no 19; pl. 5, no 192.)

153—Maison du sieur ROSE occupée par le sieur HERVIEUX FILS. Sa femme est présente.
Elle ne peut signer "étant estropiée à la main."
Nicolas Rose, époux de Marie-Joseph Prud'homme. (Tanguay, VII, 39 et T. de M. no 143*B*; pl. 5, no 174*A*.)

154—Maison des héritiers BOUATE occupée par le sieur HERY.
Sa femme est présente et refuse de signer.
Héritiers de F. M. Bouat, ancien juge de Montréal. (Tanguay, II, 363; Massicotte, *Tribunaux and officiers de justice,* p. 284, et T. de M. nos 144, 145; pl. 5, no 172.
Jacques Hery-Duplanty, époux en secondes noces de Jeanne Vanier. (Tanguay, IV, 502.)

155—Même maison. Présente Dame VEUVE CUROT.
Il n'est pas question de sa signature.
Probablement Madeleine Cauchois veuve de Martin Curot ou Curaux. (Tanguay, III, 209.)

156—Maison de TOUSSAINT POTHIER.
Il signe: *Tousst. Pothier.*
Probablement Toussaint Pothier, époux de Geneviève Hervieux. (Tanguay, VI, 421 et T. de M. no 9; pl. 5, nos 209 et 210; aussi no 24; pl. 5, no 203.)

157—Maison de sieur Le COMPTE DUPRE. Sa femme présente.
Elle signe: *Marianne Hervieux.*
Jean Lecompte, dit Dupré, époux de Marie-Anne Hervieux. (Tanguay, V, 247 et T. de M. no 148; pl. 5, no 168.)

158—Maison des héritiers DESRIVIERES, occupée par M. SIMONNET.
Il signe: *Fr. Simonnet* (avec paraphe).
Probablement les héritiers de Julien Trottier-Desrivières. (Tanguay, VII, 355 et T. de M. no 150*A*; pl. 5, nos 167 et 169.)
François Simonnet, notaire royal, (Massicotte, *Tribunaux et officiers de justice,* p. 297, et Tanguay, VII, 195.)

159—Maison du sieur JOSEPH DOUAIRE. Sa femme présente.
Elle refuse de signer.
Probablement Joseph Douaire, époux de Catherine Raimbault. (Tanguay, III, 437 et sans doute, T. de M. no 146*B*; pl. 5, no 173-172 en qualité d'héritier Raimbault.)

160—Maison de Dame veuve LESPERENCE.
Ses filles sont présentes. Elles refusent de signer.
Probablement Jean-Antoine Magnan dit Lespérance, époux de Louise Lecompte Dupré. (Tanguay, V, 451 et T. de M. no 23*d*; pl. 5, no 199, 201.)

161—Maison de M. LAMARQUE. Sa femme est présente.
Elle signe: *M. St. Pierre Lamarque.*
Charles Lamarque, époux de Marie Saint-Pierre. (Tanguay, V, 106 et T. de M. no 150*B*; pl. 5, no 166.)

162—Maison de M. HERVIEUX. Sa femme est présente.
Elle refuse de signer.
Pierre J. B. Hervieux, époux de Charlotte Marin La Marque. (Tanguay, IV, 501 et T. de M. no 24; pl. 5, nos 203 et 204.)

163—Maison de Mr. SAINT-ANGE CHARLY.
Il refuse de signer.
J. B. Charly Saint-Ange, époux en secondes noces de Catherine d'Ailleboust de Manthet. (Tanguay, III, 19 et T. de M. no 23*A*; pl. 5, no 202.)

164—Maison de M. GUILLET. Sa femme est présente, n.s.s.
Dlle CUILLERIÉ, a aussi des effets dans ce logement.
Probablement Paul Guillet marié à Catherine Pinguet. (Tanguay, IV, 418 et T. de M. no 25; pl. 5, no 205.)

165—Maison de M. GAMELIN. Sa femme présente.
Une dame veuve Gamelin a aussi des effets au même endroit.
L'une signe: *Ls Lagemerais Gamelin.*
Marie-Louise du Frost de la Jemmeraye, épouse d'Ignace Gamelin et soeur de la fondatrice des Soeurs Grises. (Tanguay, IV, 166 et T. de M. no 48*a*; pl. 6, no 284.)

166—Maison de M. MONIERE. Sa femme est présente et aussi Mlle MARIE-FRANCOISE DE COUAGNE.
Elles signent: *M. J. de Couagne-Marie-Françoise de Couagne.*
Probablement Jean-Alexis Le Moine-Monière, époux de Marie-Joseph de Couagne. (Tanguay, V, 337 et T. de M. no 27; pl. 5, no 208.)

167—Maison du nommé DURIVAGE, occupée par le sieur BEAUVAIS, n.s.s.

Joseph-Etienne dit Durivage, veuf, de Marie-Angélique Harel (Tanguay, III, 600 et T. de M. no 152*c*; pl. 5, no 162.)

168—Maison du sieur SAINT-ONGE GARAUT, n.s.s.
Jean Gareau dit St-Onge. (T. de M. no 152*D*; pl. 5, no 161.)

169—Maison de M. BEREY. Sa fille est présente.
Elle signe: *Berey.*
Peut-être la fille de Thomas Berey. (Tanguay, II, 224 et T. de M. no 474; pl. 6, nos 259 and 47*d*; pl. 6, no 267.)

170—Maison de Dame VEUVE FRANCHEVILLE.
Elle signe: *Marguerite de Couagne.*
Thérèse de Couagne, veuve de François Poulin dit Francheville. (Tanguay, VII, 425, et T. de M. no 47*c*; pl. 6, no 260.)

171—L'HOTEL-DIEU des Dames Religieuses de cette ville.
La Soeur supérieure est présente
Elle signe: *Anne Françoise Leduc, sup're.*
Il y a aussi des articles appartenant à Mlle VILLIERS. (T. de M. no 178; pl. 6, no 255*K*, etc.)

172—Maison de Mr. MONFORT.
Il signe: *Monfort.*
Peut-être François Dumay dit Montfort époux de Marie-Catherine Thunay. (Tanguay, III, 528 et T. de M. 47*c*; pl. 6, no 261.)

173—Maison de CHARLES DOUAIRE. Sa femme présente.
Elle refuse de signer.
Doit être Charles-Dominique Douaire de Bondy, époux de Catherine Catin. (Tanguay, III, 436 et T. de M. no 47*G*, pl. 6, no 262.

174—Maison du sieur LATOUR. Sa femme est présente.
Elle refuse de signer.
Probablement Jean Latour, marchand, époux de Jeanne Tailhandier. (Tanguay, V, 185 et T. de M. no 47*H*; pl. 6, nos 262 et 263.)

175—Maison de GACIEN. Sa femme est présente, n.s.s.
Probablement Pierre-René Gatien, époux de Marguerite Gautier. (Tanguay, IV, p. 184 et T. de M. no 48*c*; pl. 6, no 265.)

176—Même maison, appartement occupé par GRENIL, n.s.s.
Probablement Joseph Greenhill dit Grenil marié à Marie-Françoise Boyer et qui décède en avril 1742 à Montréal. (Tanguay, IV, p. 356.)

177—Maison du sieur AUGER. Sa femme est présente, n.s.s.

178—Maison du sieur GUY.
Il signe: *Guy.*

Probablement Pierre-Théodore Guy, marchand, époux de Jeanne Trullier-Lacombe. (Tanguay, IV, 428.)

179—Maison de Lestage.
Il signe: *Lestage.*
Pierre de Lestage, sieur Despeiroux, marchand. (Tanguay, III, 314 et T. de M. no 48*F*; pl. 6, no 270.)

180—Maison de Mr. Foucher. Sa femme présente.
Elle signe: *Le Gardeur Foucher.*
François Foucher, époux de Marie-Joseph Le Gardeur de Courtemanche, procureur et conseiller du roi, au tribunal de Montréal. (Tanguay, IV, 79; Massicotte, *les Tribunaux et les officiers de justice* à Montréal, p. 286, et T. de M. no 51, pl. 6, no 272.)

181—Maison de Francois-Marie de Couagne.
Il signe: *F. M. de Couagne.*
François-Marie de Couagne, époux de Marie-Louise Lemoine dit Monier. (Tanguay, III, 270 et T. de M. no 52; pl. 7, no 273.)

182—Maison du sieur de Sermont. Sa femme présente.
Elle signe: *Thérèse Pougete de sermons.*
Charles Dumay ou Demers de Sermont, époux de Thérèse Pouget. (Tanguay, III, 526, fait erreur au sujet de cette dernière, en écrivant que son mari avait convolé avec une demoiselle Durand avant 1725; aussi T. de M. no 183*B*4; pl. 7, no 276.)

183—Maison de la veuve Laurent Trudeau, occupée par le sieur Juillet. Tous deux présents, n.s.s.
Marie-Anne Billeron veuve de Laurent Truteau (ou Trudeau). (Tanguay, VII, 376 et T. de M. no 182*B*; pl. 7, no 279.)

184—Maison de la veuve Lafrenay, n.s.s.
René Mignau (ou Mignot) dit La Frenaye, époux de Cécile Ozou, Sep. 25 nov. 1740. (Tanguay, VI, 30 T. de M. no 53; pl. 7, no 273*A*.)

185—Même maison. Dlle Legras.
Il n'est pas question de sa signature.

186—Maison de la veuve Pougé, occupée par Lionnois, sergent, n.s.s.
J. B. Pouget, tailleur, décédé en 1736, époux de Gabrielle Dugas (Tanguay, VI, p. 423 et T. de M. no 54; pl. 7, no 274.)

187—Même maison. Appartement occupé par Lamarche.
Il signe: *Barito.*
Probablement François-Julien Baritault dit Lamarche.
(Tanguay, II, 126.)

188—Maison de JOSEPH TRUDEAU, n.s.s.
Joseph Trudeau (ou Truteau), époux de M. Geneviève Lamarre Belisle. (Tanguay, VII, 376 et T. de M. no 55; pl. 275.)

189—Maison de M. de PERIGNY. Sa femme est présente.
Elle signe: *Louise de Perigny.*
Paul d'Ailleboust de Périgny, époux de Madeleine-Louise Margane de la Valtrie. (Tanguay, III, 223 et T. de M. no 58; pl. 349.)

190—Maison de GUILLORY. Sa femme présente.
Elle signe: *Marie Alix Guillory.*
Aussi mention d'un BENOIST fils.
Simon Guillory, époux de Marie Alix. (Tanguay, IV, 421 et T. de M. no 57; pl. 7, no 348; et no 184*d*; pl. 7, no 337.)

191—Maison de LATOUR, n.s.s.
Charles Deséry dit Latour, marié à Françoise Leroux dit La Chaussée. (Tanguay, III, 370 et T. de M. no 184*E*; pl. 7, no 338.)

192—Maison de DUCHARME, n.s.s.
Louis Ducharme, époux en secondes noces de Jeanne Pion. (Tanguay, III, 491 et T. de M. no 59; pl. 7, no 350.)

193—Maison de MORANT, sa femme présente.
Appartement occupé par MME DE CLIGNANCOURT.
" " " l'épouse de Sr NEVEU, FILS.
" " " l'épouse de Sr LEFEBVRE.
Mention de GILETTE, servante.
Tous refusent de signer.
Nicolas Morant, charpentier et maître de pension. (Tanguay, VI, 82 et T. de M. no 185*D*; pl. 7, no 339.)

194—Maison de DULUDE, n.s.s.

195—Maison de POUGE.
Signe: *Louis Pouget.*
Louis Pouget, tailleur, époux de Catherine Hotesse. (Tanguay, VI, 423 et T. de M. no 60; pl. 7, no 350.)

196—Maison de LA BROSSE. Appartement occupé par BEAUCOUR.
Il signe: *Paul de Beaucour, sergt de Beaujeu.*
Probablement Paul Jourdain dit Labrosse. (Tanguay, V, 34 et T. de M. no 185*G*; pl. 7, no 340.)
Paul Malepart Beaucour, sergent. Il avait marié Marguerite Haguenier en 1737. (Tanguay, V, 478 et T. de M. no 185*G*; pl. 7, no 340.)

197—Maison de veuve de LAUNAY.
Elle signe: *delaunay veuve.*

Marie-Anne Legras, veuve de Charles Delaunay. (Tanguay, I, 172 et III, 298, aussi T. de M. no 62; pl. 7, no 352.)

198—Maison de La Brosse père, n.s.s.
Denis Jourdain dit La Brosse, menuisier. (Tanguay, V, 23 et T. de M. no 185; pl. 7, nos 340, 341.)

199—Maison de Joseph Parens, n.s.s.
Joseph Parans ou Parant, époux de Madeleine Maret. (Tanguay, VI, 230 et T. de M. nos 63, 64; pl. 7, no 353.)
Voir aussi no 211.

200—Maison de Daguille, n.s.s.
J. B. Dagueil ou Daguille, dit l'Eguille, époux de Priscille Story. (Tanguay, III, 221 et T. de M. no 186*B* et *C*; pl. 8, no 346.)

201—Maison de Belhumeur.
Il n'est pas question de sa signature.
Bernard Philippe dit Belhumeur, époux de Anne Gallien. (Tanguay, VI, 340 et T. de M. no 65; pl. 8, nos 354 et 355.)

202—Maison de Viger, n.s.s.
Jacques Viger, cordonnier, époux en secondes noces de Marie-Louise Ridday-Beauceron. (Tanguay, VII, 464 et T. de M. no 186*c*; pl. 8, no 346.)

203—Maison de Baptiste Trudeau, Appartement occupé par la veuve Vincennes.
Elle signe: *Marguerite Forrestié.*
Marguerite Fortier, veuve de J. B. Bissot, sr de Vincennes, officier.
J. B. Trudeau ou Truteau, forgeron, époux de Madeleine Parant. (Tanguay, VII, 375 et T. de M. no 67; pl. 8, nos 355-356).

204—Même maison. Le dit B. Trudeau déclare, n.s.s.
Voir ci-dessus

205—Maison de Louis Trudeau, n.s.s.
Louis Trudeau (ou Truteau), époux de Marie-Joseph Roy. (Tanguay, VII, 376 et T. de M. no 65; pl. 8, no 356.)

206—Dans le château de M. De Vaudreuil, où loge M. Le Gouverneur Général, un appartement est occupé par la demoiselle Olivier et un autre par M. De Léry, ingénieur.
Tous deux refusent de signer.
Le gouverneur-général, alors, était le marquis Charles de Beauharnois.
Gaspard Chaussegros de Lery, ingénieur de la marine, chevalier. (Tanguay, III, 44 et T. de M. nos 191-193; pl. 8, no 347.)

207—Maison de M. DESNOYERS occupée par MME DE RAMEZAY.
Elle refuse de signer.
Louise Godfroy de Tonnancourt, épouse de Jean-Baptiste-Nicolas-Roch de Ramezay. Voir no 14, ci-dessus.

208—Maison de M. DE VERCHERES. Sa femme présente.
Elle signe: *Verchère.*
Probablement Jean Jarret de Verchères, chevalier, époux de Madeleine d'Ailleboust de Manthet. (Tanguay, IV, 589 et T. de M. no 194*D*2; pl. 8, no 359.)

209—Maison du Sr MOQUIN. Sa femme est présente.
Elle signe: *la moquin.*
Même maison, mention de la femme de LACOMBE fils.
Probablement Jacques Moquin, époux en secondes noces de Marie Joseph Trullier-Lacombe. (Tanguay, VI, 80 et T. de M. no 196*B*1; pl. 8, no 366.)

210—Maison de CAMPAU.
Il signe: *Henry Campau.*
Henri Campau, époux de Marguerite Lanthier. (Tanguay, II, 532 et T. de M. no 71-3; pl. 8, no 380.)

211—Maison de PARENS, armurier, n.s.s.
Joseph Parent, T de M. no 195*A* et 195*A*1; pl. 8, nos 362-363.)
Voir aussi le no 199, ci-dessus.

212—Maison de M. CHAUMONT.
Il signe: *Chaumont.*
Nicolas-Augustin Guillet de Chaumont, notaire, époux de Félicité d'Ailleboust. (Tanguay, IV, 418 et T. de M. no 195*A*2; pl. 8, no 362, 196*A*1.)

213—Même maison. Appartement occupé par madame MENTHET.
Elle signe: *De goutin de Manthet.*
Marie-Jeanne de Goutins, époux de Pierre-Joseph d'Ailleboust de Manthet (voir no 214). (Fauteux, *Famille d'Ailleboust,* p. 148.)
Mme de Manthet était à la veille de donner naissance à un fils et c'est pourquoi, sans doute, elle loge chez sa belle-sœur Mme de Chaumont.

214—Maison de ROY, occupée par M. MENTHET. Pas question de la signature.
Pierre-Joseph d'Ailleboust de Manthet des Musseaux née en 1696; marié à Mlle de Goutins en 1739; mort en 1768. (Fauteux, *Famille d'Ailleboust,* p. 148.)
Probablement Pierre Roy, époux de Catherine Ducharme. (Tanguay, VII, 68 et T. de M. no 72; pl. 8, 382.)

215—Maison de Roy. Sa femme présente.
Elle signe: *femme de françois Roi.*
Probablement François Roy, fils de Pierre, époux de Madeleine Truteau. (Tanguay, VII, 80.)
Voir le no 214, ci-dessus.

216—Maison de LaBrosse, n.s.s.
Peut-être Denis Jourdain dit Labrosse, époux de Marie Blau (1726). (Tanguay, II, 312 et T. de M. no 196*A*2; pl. 8, no 364.)

217—Même maison. Appartement occupé par Madame Veuve La Corne.
Elle signe: *Marie Pécaudie.*
Marie Pécaudy de Contrecoeur veuve de Jean-Louis de Chapt de la Corne. (Tanguay, I, 167 et III, 285.)

218—Maison de Parent, occupée par M. de Saint-Ours. Sa femme présente.
Elle signe: *Douville de St-Ours.*
Pierre de Saint-Ours, époux de Marie-Claire Dagnau Douville. (Tanguay, III, 402.)

219—Maison des héritiers Chaumine, occupée par M. de Beaucourt, gouverneur de cette ville. Sa femme est présente.
Elle signe: *Aubert Du bois berthelot.*
Paul Tessier dit Chaumine. (Tanguay, I, 562 et VII, 274.)
Josué Bois Berthelot de Beaucourt, alors gouverneur de Montréal, époux de Gabrielle-Françoise Aubert. (Tanguay, I, 14 et III, 472.)

220—Maison de Massy, occupée par Mr Salvaille.
Il signe: *Salvaille.*

221—Maison de Guerin, n.s.s.
Probablement Joseph Guérin, époux de Marie-Françoise Goguet. (Tanguay, IV, 399 et T. de M. no 196*B*2-11, et *B*2-2; pl. 9, nos 376 et 377.)

222—Maison de Lefebvre, occupée par M. Duviviers. Mention en plus de madame de Montigny & de M. Villedenay.
Madame Duviviers signe comme suit: *C. Damours de Louviere dévivier.*
Louis-Hector Le Fournier du Vivier, époux de Charlotte Damours de Louvière. (Tanguay, III, 228 et V 289.)
Madame de Montigny doit être Marie-Anne de la Porte de Louvigny. (Tanguay, VII, 284.)
Nicolas Lefebvre, époux de Marie-Anne Ducharme. (Tanguay, V, 268 et T. de M. no 199*A*; pl. 9, no 373.)

223—Maison de Mr SILVAIN.
Il refuse de signer.
Timothée Silvain (ou Sullivan), médecin, époux de Marie-Renée Gauthier veuve de Christophe Dufros de la Jemmerais. (Tanguay, VII, 235 et T. de M. no 74; pl. 9, no 386.)

224—Maison des héritiers DESPRES, occupée par MADAME VEUVE SENNEVILLE.
Elle signe: *Veuve Senneville.*
Marie-Louise de Miray d'Argenterie, veuve de Joachim-Jacques Le Ber de Senneville.

225—Maison de Mr SENNEVILLE. Sa femme est présente.
Elle signe: *Soumande Senneville.*
Joseph-Hypolite LeBer de Senneville, époux de Anne-Marguerite Soumande. (Tanguay, V, 219 et T. de M. no 75; pl. 9, no 387.)

226—Maison de BEAUSERONT, n.s.s.
Jean Ridé dit Beauceron, époux de Louise-Catherine Dubeau. (Tanguay, VI, 566 et T. de M. no 199*A*; pl. 9, no 373.)

227—Maison de BOULRICE, n.s.s.
Gabriel Boulrice ou Bourlisse, époux de Geneviève Jetté. (Tanguay, II, 429 et T. de M. no 199*b*; pl. 9, no 372, et no 207*A*; pl. 9, no 371.)

228—Maison de PERILLARD, n.s.s.
Peut-être Nicolas Perillard, époux de Catherine Papineau. (Tanguay, VI, 304.)

229—Maison de ROCBERT père. Présente, Madame BEGON.
Elle refuse de signer.
Etienne Rocbert de la Morandière. (Tanguay, I, 524 et VII, 4.)
Marie-Elisabeth Rocbert, épouse de Claude-Michel Bégon, commissaire-ordonnateur des Trois-Rivières. (Tanguay, II, 188.)

230—Maison de BIZET, n.s.s.

231—Maison de la VEUVE CHEVALIER, n.s.s.
Peur-être Agathe-Barbe Campeau, épouse de Paul Chevalier ou Françoise Alavoine, épouse de J. B. Chevalier. (Tanguay, III, 56.)

232—Maison de MADAME DEMONTIGNY.
Présente: MARIE JEANNE, domestique, n.s.s.
Marie-Anne de la Porte veuve de Jacques Testard de Montigny. (Tanguay, VII, 283, et T. de M. no 79; pl. 406*a*.)

233—Maison de BAPTISTE BRAZEAU, n.s.s.
Probablement J. B. Brazeau, époux de Geneviève Tartre. (Tanguay, II, 457 et T. de M. no 216*F*; pl. 9, no 394.)

234—Maison de M. DE CONTRECOEUR. Sa fille est présente.
Elle signe: *Lisette Contrecoeur.*
Françoise-Antoine Pécody de Contrecoeur et sa fille Louise. (Tanguay, VI, 272 et T. de M. no 80; pl. 9, no 406*a*.)

235—Maison de LAFLEURE POUPART, occupée par DAVAINE. Sa femme est présente, n.s.s.
Charles Poupart dit Lafleur, époux d'Agnès Brazeau. (Tanguay, VI, 435 et T. de M. no 216*i* et 216*L*; pl. 9, no 395.)

236—Maison de VIGER. n.s.s
René Viger, charpentier du roi, époux de Marie-Anne Lefebvre. (Tanguay, VII, 464 et T. de M. no 217*A*; pl. 9, no 396.)

237—Maison de MORANT, tailleur.
Il signe: *Morant.*
Probablement Vincent Morand dit Lacharpente, époux en secondes noces d'Angélique Jusseaume. (Tanguay, VI, 83 et T. de M. no 217*B*; pl. 10, no 397.)

238—Maison de CHEDEVILLE. Sa femme présente, n.s.s.
Michel Demers dit Chedeville. (T. de M. no 217*C*; pl. 10, no 398.)

239—Maison de BROSSARD, n.s.s.

240—Maison de COQUILLARD, n.s.s.
Cérat dit Coquillard.

241—Maison de VIGER père. Sa femme présente, n.s.s.

242—Maison de veuve LAUZON, n.s.s.
T de M. no 87; pl. 10, no 415.

243—Maison de SÉRAPHIN LAUZON, occupée par Mlle PRÉRIE. (?)
Probablement Séraphin Lauzon, époux de Thérèse-Geneviève Jetté. (Voir no 244.)

244—Même maison, appartement occupé par SÉRAPHIN LAUZON, n.s.s.
(Voir no précédent.)

245—Maison de DUMAINE, n.s.s.
Probablement François Bonneron dit Dumaine, époux de Marie-Charlotte St-Aubin. (Tanguay, II, 356 et T. de M. no 220*B*; pl. 10, no 402.)

246—Maison de BAPTISTE VALADE, n.s.s.
J. B. Valade, époux de Marie Biétry. (Tanguay, VII, 403 et T. de M. no 221; pl. 10, nos 403 et 404.)

247—Maison de VIGER, occupée par GENDREAU, n.s.s.

248—Maison de VIGER FILS, n.s.s.
Charles Viger, constructeur des bateaux du roi, époux de Marie-Madeleine Lefebvre. (Tanguay, VII, 464 et T. de M. no 219; pl. 10, nos 399 et 400.)

249—Maison de PAUL CHEVALIER, n.s.s.
Peut-être Paul Chevalier, époux de Marie Laperche. (Tanguay, III, 58.)

250—Maison de SENÉCAL, n.s.s.
T. de M. no 222; pl. 10, partie no 404.)

251—Maison de DUBAUT CHEVALIER, n.s.s.
Pierre Chevalier dit Dubaut ou Pierre Dubeau dit Chevalier, époux de Marguerite Campeau. (Tanguay, III, 56 et T. de M. nos 93, 94; pl. 10, vis-à-vis les nos 408 et 409.)

252—Maison de MOQUIN, n.s.s.

253—Dans le bas de la maison de ROY, occupé par LATULIPPE, n.s.s.

RUE SAINT-CHARLES (du sud au nord)

(nos 254 à 257)

254—Maison de MALIDOR.
Il signe: *Malidor.*
Sébastien-Victor-Louis Malidor dit Lasonde, marié en 1722, à Louis Vacher. (Tanguay, V, 479 et T. de M. no 194*c*; pl. no 8; partie de no 359.)

255—Maison de BOULLAY, n.s.s.
Probablement Nicolas Boulé, perruquier, marié en 1724 à Montréal, à Marie Marillac. Le terrier le prénomme Nicolas-Louis. (Tanguay, II, 401 et T. de M. no 184*B*; pl. 8, no 360 et 359.)

256—Maison de DUBOIS. "Orlogeur."
Il signe: *Jean Filiot.*
J. B. Filiau dit Dubois, horloger, marié à Geneviève Viger en 1720. (Tanguay, IV, 25 et T. de M. no 193*B*; pl. 8, no 347.)

257—Maison de PRAT.
Il signe: *Prat.*
Mgr Tanguay le nomme Jean-Marie Duprat. Cependant, il dit aussi qu'il se marie à Montréal en 1736, à Madeleine Charlotte Godet, sous le nom de Prat. (Tanguay, III, 551 et T. de M. no 194*A*; pl. 8, no 358.)

RUE SAINT-VINCENT (du nord au sud)

(nos 258 à 268)

258—Maison de la SABLONNIERE.

Il signe: *Jean Brunet La Sablonnière.*

Probablement Jean Brunet dit la Sablonnière, époux de Louise Maugue. (Tanguay, II, 494 et T. de M. no 187*B*6-1; pl. 7, no 328.)

259—Maison de SANSCARTIER.

Il signe: *Brebion.*

François Brebion dit Sanscartier marié à Marie-Catherine Angélique Gouin, en 1730, ancien soldat, originaire de St-Cybar, diocèse d'Angoulesne. Il est inhumé, le 7 mars 1773, à l'Hôpital-général. (Tanguay, II, 459.)

260—Maison de LETELLIER LESPERENCE.

Il signe: *Letellier.*

Antoine Letellier dit Lespérance, ancien soldat, époux d'Antoinette Larchevêque Larche. (Tanguay, V, 379.)

261—Maison de la veuve DES GRANGES, n.s.s.

Probablement Françoise Martineau, veuve depuis le mois précédent, de Léonard Casmin dit Desgranges. (Tanguay, II, 575.)

262—Maison de la dame veuve CATALOGNE.

Elle "n'a pu signer."

Marie-Anne Lemire, veuve de Gédéon de Catalogne. (Tanguay, III, 265 et T. de M. nos 187-*B*12, 187-*B*16; pl. 7, nos 329, 334.)

263—Maison de PAUL BROSSARD, occupée par RAINVILLE, n.s.s.

Probablement Paul Brossard, époux de Marie-Renée Maret. (Tanguay, II, 481 et T. de M. no 187*B*13; pl. 8, no 344.)

264—Maison de LA BROSSE occupée par GUYARD. Sa femme présente, n.s.s.

Jean-Baptiste Guyart, époux d'Elisabeth Jobin. (Tanguay, IV, 429.) Il était admis huissier, à Montréal, depuis le 20 février 1741. (Massicotte, *Tribunaux* et *officiers de justice*, p. 292.)

265—Maison de COITEUX, occupée par DESÈVE POITEVIN, n.s.s.

François Coiteux était décédé depuis 1736. Son emplacement devait alors être en possession de ses héritiers. (T. de M. no 187, *B*16-1; pl. 7, no 334.)

266—Maison de Dame Veuve DUBUISSON.

Elle signe: *Bizard, veuve de Dubuisson.*

Louise Bizard, fille de major Jacques Bizard et petite fille de

Lambert Closse. Elle épousa le capitaine Charles du Buisson en 1717. (Tanguay, I, 56 et III, 488, aussi T. de M. no 186*a*; pl. 8, nos 346, 5, 4.)

267—Maison de LEPINE, n.s.s.
Jean Marest (ou Marette) dit Lépine, époux de Marie-Anne Brunet. (Tanguay, V, 509 et T. de M. no 185*i*; pl. 7, no 340.)

268—Maison de PICARD, n.s.s.
Peut-être Alexis Picard, époux de Louise Brunet. (Tanguay. VI, 345 et T. de M. no 185*L*; pl. 7, no 340.)

RUE SAINT-DENIS (du sud au nord)
(nos 269 à 271)

269—Maison de LA BROSSE, n.s.s.

270—Maison de DAVELUY LAROSE, n.s.s.
Doit être Jean-Paul Daveluy dit Larose, époux de Marie-Françoise French, née en la Nouvelle-Angleterre. (Tanguay, III, 253 et T. de M. no 185*c*; pl. 7, no 339.)

271—Maison de HUBERT LACROIX, n.s.s.
Doit être Pierre Hubert dit Lacroix, époux de Catherine Demers. (Tanguay, IV, 532 et T. de M. no 185*F*; pl. 7, no 340.)

RUE SAINTE-THÉRÈSE (de l'est à l'ouest)
(nos 272 à 276)

272—Maison de LA SABLONIERE, occupée par LA MARINE, n.s.s.
Peut-être Jean Brunet dit La Sablonnière, époux de Louise Maugue. (Tanguay, II, 494 et T. de M. no 187*B*, 16-2; pl. 7, no 333.)
Charles Pitalier dit La marine, époux de Madeleine Thouin Rocque. (Tanguay, VI, 377.)

273—Maison de DUBOIS, n.s.s.
François Filiau dit Dubois, menuisier, époux de Thérèse Viger. (Tanguay, IV, 25 et T. de M. no 187, *B*16-3; pl, 7, no 332 et Simonnet, 27 août 1741.)

274—Même maison "dans un côté" occupé par FRANCOEUR, n.s.s.

275—Maison de dame VEUVE DESROCHES, n.s.s.
Probablement Marie Beaudry, veuve de Pierre Desroches. (Tanguay, III, 394 et T. de M. no 185*A*; pl. 7, no 336.)

276—Maison de DUMEST. Sa femme présente, n.s.s.
Peut-être François Dumest ou Demers, cordonnier. (T. de M. no 182*b*; pl. 7, no 279 et Simonnet, 1741.)

RUE SAINT-GABRIEL (du sud au nord)

(nos 277 à 291)

277—Maison de GUICHARD.
Il signe: *Guichard.*
Jean Guichard, chirurgien, alors âgé de 75 ans, époux de Marguerite Gerbaut. (Tanguay, IV, 406 et T. de M. no 182*A*; pl. 7, nos 283 et 282.)

278—Maison de TOULOUSE, n.s.s.
Antoine Cadiliest dit Toulouse. (T. de M. no 184*A*; pl. 7, no 335.) Tanguay, III, 202, mentionne un Pierre Crisaque, Cressac ou Crésac dit Toulouse.

279—Maison de DUMEST et dans un appartement occupé par FRANÇOIS GASTINEAU.
Il signe: *F. Gatineau.*
François Gastineau dit La règle. (Tanguay, IV, 183.)

280—Même maison "et chez" DUMEST.
Sa femme présente, n.s.s.
Voir no 276, ci-dessus.

281—Maison de CHICOUAGNE, occupée par la veuve LEPINE, n.s.s.
Pierre Chicoine, époux en secondes noces de Marie-Anne Bourgaux. (Tanguay, III, 65 et T. de M. no 181 *Ii*; pl. 7, no 285.)

282—Maison de LEBEAUT. Sa femme présente.
Elle signe: *Marguerite de sell.*
J. B. Lebeau, maître menuisier, époux en secondes noces de Marguerite DeCelles dit Duclos. (Tanguay, V, 211 et T. de M. no 181 *Hh*; pl. 7, no 285.

283—Maison de DUMEST occupée par TELLIER, n.s.s.
T. de M. no 181, *Gg*; pl. 7, no 288.

284—Maison de la veuve JEAURET, n.s.s.

285—Maison de LAFRENIERE. Sa femme est présente: mais ce doit être sa fille qui signe comme suit: *pour Madame Lafreniere. thérèse La frenière.*
T. de M. no 187*B*5; pl. 7, no 325.

286—Maison de BROSSARD, n.s.s.

287—Maison occupée par M. de SERMONVILLE. Sa femme présente.
Elle signe: *Sermonville.*
Probablement Christophe Sabrevois de Sermonville, époux d'Agathe Hertel. (Tanguay, VII, 107.)

288—Maison occupée par QUINPERE, n.s.s.
Louis Divelec ou Divelac dit Quimper, marié à Marie-Joseph

Viau. (Tanguay, III, 424 et T. de M. no 181, *B*20; pl. 7, no 311.)

289—Maison de PROVOST, n.s.s.
T. de M. no 181*Q* et 181*R*; pl. 7, nos 301-302.

290—Maison de la veuve CHEVALIER, n.s.s.

291—Maison de dame HERTEL, occupée par SAINT-JEAN, n.s.s.
T. de M. no 187, *B*18; pl, 7, no 309.

RUE SAINT-JACQUES (de l'est à l'ouest)

(nos 292 à 315)

292—Maison de BAPTISTE PROVOST, n.s.s.
Probablement Jean-Baptiste Provost, époux en secondes noces, de Catherine Jolive. (Tanguay, VI, 445 et T. de M. no 181*F*; pl. 7, no 307 et no 181*G*, pl. 7, no 307.)

293—Maison de la veuve ST-AMOUR, occupée par NOLE, n.s.s.
Thérèse Poirier dite Lajeunesse, veuve de Jean Payet dit Saint-Amour, décédé au mois d'avril précédent. (Tanguay, VI, 267 et T. de M. no 181*A*; pl. 7, no 303.)
Peut-être Jean-François Nolet, époux de Marguerite Monciau. (Tanguay, VI, 156.)

294—Même maison, dans un appartement occupé par la veuve SAINT-AMOUR, n.s.s.
(T. de M. no 181*A*; pl. no 303 et no 181*E*; pl. 7, no 306.)

295—Maison de BAILLARD, n.s.s.
Jacques Bayard, époux de Marie Valade. (Tanguay, II, 158 et T. de M. no 181*D*; pl. 7, no 305.)

296—Maison de MARINEAU, occupée par M. de MUY. Sa femme présente.
Elle refuse de signer.
Pierre Hostin dit Marineau, forgeron, époux de Catherine-Gertrude Lecompte de la Vimaudière. (Tanguay, IV, 512 et T. de M. no 181*m*; pl. 7, no 299; aussi no 181*N*; pl. 7, no 300.)
En 1741, Pierre Hostain ne résidait plus à Montréal, il travaillait aux forges de Saint-Maurice. Voir Sulte, *Les Forges Saint-Maurice*, p. 66.

297—Maison de BAILLARD, occupée par LAVALLEE, n.s.s.
(T. de M. no 181*D*; pl. 7, no 305.)

298—Maison de Marineau. Présente: "la femme du vieux Marineau," n.s.s.
Il doit s'agir ici, de Jeanne Tardif, épouse de Jean Hostain et

mère de Pierre dont il est question ci-dessus, au no 296. (Tanguay, IV, 512 et T. de M. no 181*n*; pl. 7, no 300.)

299—Maison de la veuve LENOIR occupée par DEVAUX, n.s.s.
(T. de M. no 181*L*; pl. 7, no 299.)

300—Maison de SERRÉ, n.s.s.
Jean Serré, boucher, époux de Marguerite Filde-Sergent.
(Tanguay, VII, 171 et T. de M. no 181*B*; pl. 7, no 303.)

301—Maison de DOBERTIN, n.s.s.
J. B. Aubertin ou Hobertin, époux de Marie-Anne Gatien.
(Tanguay, IV, 508 et T. de M. no 181*Ii*; pl. 7, no 298.)

302—Maison de la veuve GACIEN, n.s.s.
Probablement Marie-Madeleine Gignard, veuve de Pierre Gatien ou Gassien. (Tanguay, IV, 184 et T. de M. no 181*H*; pl. 7, no 297.)

303—Maison de BERTRAND, n.s.s.
Jacques Bertrand, époux de Marie-Louise Dumouchel. (Tanguay, IV, 258 et T. de M. no 181*I*[2]; pl. 7, no 297.)

304—Maison de LOUIS GERVAIS, occupée par PIERRE NOEL.
Il signe: *Noel.*
Pierre Noël, époux de Marguerite Dubois. (Tanguay, VI, 151.)
(Voir aussi; T. de M. no 163*B*1; pl. 6, no 228.)

305—Maison de BARRÉ, occupée par *Regne,* (?) n.s.s.
Peut-être Michel Barré, époux de Cunégonde Goyer. (Tanguay, II, 130.)

306—Maison de PIERRE GERVAIS, occupée par ST. JACQUES, n.s.s.
Probablement Pierre Gervais, tailleur. (Tanguay, IV, 258 et T. de M. no 163*A*; pl. 6, nos 225, 226, 227.)

307—Maison de CHARLES GERVAIS père. Sa femme présente, n.s.s.
Un article s'y trouve qui appartient à un nommé RICHARD.
Charles Gervais, époux de Marie Boyer. (Tanguay, IV, 257 et T. de M. no 163*c*5; pl. 6, no 234.)

308—Maison de PAUL TESSIER LAVIGNE, n.s.s.
Paul Tessier dit Lavigne, maçon, tailleur de pierre, époux de Jeanne Lefebvre. (Tanguay, VII, 277 et T. de M. no 163*c*4; pl. no 233 et Simonnet, 29 mai, 1741.)

309—Maison de DUMEST, occupée par GIROUX, n.s.s.
Eustache Dumest. (T. de M. no 163*c*3; pl. 6, no 232, 233.)

310—Maison de RENAUD.
Il signe: *Charle Renaud.*
Charles Renaud, époux de Marguerite Bau. (Tanguay, VI, 542 et T. de M. no 163*c*2; pl. 6, no 232.)

311—Maison de BARRON. Sa femme est présente, n.s.s.
Joseph Lupien dit Baron. (T. de M. no 163*c*1; pl. 6, no 231 ou Pierre Lupien-Barron, époux d'Angélique Courault, charpentier, Simonnet, 26 mai, 1741.)

312—Maison de JOURDAIN, n.s.s.

313—Maison de SANS CHAGRIN, n.s.s.

314—Maison de GERVAIS, occupée par LA COMBLE, n.s.s.

315—Maison de JARRY, occupée par ROY, n.s.s.
(T. de M. no 124*B*2; pl. 4, no 57.)

RUE SAINT-FRANCOIS (du nord au sud)
(nos 316 à 348)

316—Maison de veuve DUMOUCHEL, dans un appartement occupé par LAMARCHE, n.s.s.
(T. de M. no 127*E*; pl. 5, no 146*A*.)

317—Même maison, appartement occupé par la VEUVE DUMOUCHEL, n.s.s.

318—Maison de DECELLE, occupée par PROVANÇAL, n.s.s.

319—Maison de LAMOTHE. Sa femme présente, n.s.s.
(T. de M. no 125*B*1; pl. 4, no 59.

320—Maison du greffe occupé par Mr PORLIER. Sa femme présente. Elle signe: *La porlier.*
Claude-Cyprien-Jacques Porlier, époux d'Angélique Cuillerier. (Tanguay, VI, 417.) Le sr Porlier fut greffier du tribunal de Montréal de 1732 à sa mort, en 1744. (Massicotte, *Tribunaux et officiers de justice*, p. 287.)

321—Dans une maison des Prestres (St-Sulpice), occupée par ROSSIGNOL, n.s.s.

322—Dans une autre maison des PRESTRES (St-Sulpice), occupée par la veuve HAY, n.s.s.
Probablement Marie Campeau, veuve de Pierre Hay, sculpteur, (Tanguay, I, 300 et IV, 470.)

323—Dans une autre maison des PRESTRES (St-Sulpice), occupée par MONGINEAU. Sa femme présente, n.s.s.

324—Maison de la veuve STE-FOY, n.s.s.
François La fargue dit Sainte-Foy. (T. de M. no 120*c*4; pl. 4, no 84.)

325—Même maison, dans un appartement occupé par MAGUET. Sa femme présente, n.s.s.

326—Même maison, dans un appartement occupé par LAVALLÉ. Sa femme présente, n.s.s.

327—Maison des héritiers DARPENTIGNY, occupée par JACQUES CHARLY.

Il refuse de signer.

Jacques Charly, époux de Thérèse Charets. (Tanguay, III, 19 et T. de M. no 117*Bi*; pl. 4, nos 90 et 89.)

328—Maison de QUENNEVILLE, occupée par le sieur PETIT, n.s.s. (T. de M. no 126 et 130*B*; pl. 5, no 176.)

329—Maison de DEPUY, n.s.s.

330—Maison de QUENNEVILLE, occupée par BARTHE. Sa femme présente, n.s.s.

Théophile Barthe dit Bardet, armurier du roi, époux de Marguerite-Charlotte Alavoine. (Tanguay, II, 133.)

331—Maison de la veuve SUBTIL, n.s.s.

Elisabeth Brunel, veuve de Pierre Buisson ou Dubuisson dit Subtil. (Tanguay, II, 504 et T. de M. no 131; pl. 5, no 177.)

332—Maison de la veuve ROBITAILLE, occupée par BERTHIAUME, n.s.s.

333—Maison de LA COMBE.

Il signe: *Truillié La Combe.*

Jean Truillier ou Trullier dit Lacombe veuf d'Elisabeth Delguel. (Tanguay, VII, 373 et T. de N. no 132*a*; pl. 5, no 178.)

334—Maison de la veuve COCHOIS, n.s.s.

Marie Gagnon veuve de J. B. Cauchois. (Tanguay, II, 582 et T. de M. no 134; pl. 5, no 180).

335—Même maison, dans un appartement occupé par BEAUPARLANT, n.s.s.

336—Maison de la veuve GIASSON, n.s.s.

Marie-Anne Lemoine, veuve de Jean Giasson. (Tanguay, IV, 260 et T. de M. no 135; pl. 5, no 180.)

337—Maison d'AMIOT, occupée par SAULQUIN. Sa femme présente, n.s.s.

Probablement J. B. Amiot, époux de Geneviève Guilmat. (Tanguay, II, 32 et T. de M. no 136; pl. 5, no 181.)

Sur Saulquin, voir no 413 ci-après.

338—Maison de la veuve LA SOURCE.

Il n'est pas question de sa signature.

Jeanne Prud'homme, veuve de Dominique Thaumur de la Source, chirurgien. (Tanguay, VII, 288 et T. de M. no 137; pl. 5, no 182.)

339—Même maison, dans un appartement occupé par LA HAY. Sa femme présente.

Elle signe: *Cauchois la haye.*

Pierre Lepelé de la haie, époux de Marie-Josephe Cauchois. (Tanguay, V, 350.)

340—Maison de DUFRESNE. Sa femme présente, n.s.s.
Antoine Thunay dit Dufresne, époux d'Angélique Roy. (Tanguay, VII, 311 et T. de M. no 120*A*4; pl. 4, no 126.)

341—Maison de POUPART LAFLEURE. Sa femme présente.
Elle signe: *Marguerite Poudret Lafleur.*
Jean Poupart dit Lafleur, époux de Marguerite Poudret. (Tanguay, VI, 435 et T. de M. no 120*A*2; pl. 4, no 127.)

342—Maison de Dame veuve LAFATIGUE.
Elle signe: *veuve Billeron.*
Jeanne Delguel, épouse en secondes noces de feu Pierre Billeron dit Lafatigue. (Tanguay, II, 280 et T. de M. no 138; pl. 5, no 183 et no 139; pl. 5, no 183.)

343—Maison du sieur FONBLANCHE. Sa femme présente.
"N'a pu signer."
Jacques Quesnel dit Fonblanche. (T. de M. no 120*A*1; pl. 4, no 127.)

344—Maison de LA CAYADE. Sa femme présente, n.s.s.
Jean Coderre ou Gaudère dit LA CAILLADE, marié à Anne Favron (ou Féron). (Tanguay, III, 104 et T. de M. no 139; pl. 5, no 183.)

345—Maison de Dame DE REPENTIGNY, occupée par JANIS.
Pas question de signature.
(T. de M. no 140*A*; pl. 5, no 184.)

346—Maison de Dame DE REPENTIGNY, occupée par LARGEOT.
Pas question de signature.
Jacques Largeau dit Saint-Jacques. (Tanguay, V, 166 et T. de M. no 140*B*; pl. 5, no 185.)

347—Maison de DUVERNAY. Il refuse de signer.
Jacques Crevier Duvernay, époux de Thérèse Prud'homme. (Tanguay, III, 200 et T. de M. no 45; pl. 4, no 142.)

348—Maison de M. de SENNEVILLE, occupée par la veuve TOUSSAINT POTHIER, n.s.s.
Marguerite Thunay, veuve de Toussaint Pothier. (Tanguay, VI, 420 et T. de M. no 1; pl. 5, no 193.)

RUE NEUVE SAINT-LOUIS (de l'ouest à l'est)

(nos 349 à 354)

349—Maison de LESCUYER, occupée par LAJEUNESSE. Pas question de signature.

Joseph-Marie Lescuyer, veuf de Catherine Heurtebise. (Tanguay, V, 366 et T. de M. no 3; pl. 5, no 195.)

350—Maison de DESPREZ. Sa femme présente. Il n'est pas question de signature.
Probablement Joseph Guyon-Després, époux de Madeleine Petit Boismorel. (Tanguay, IV, 431 et T. de M. no 5; pl. 5, no 196.)

351—Maison de ROCBERT fils.
Il signe: *Rocbert.*
Deux Rocbert fils sont alors mariés et résident à Montréal. (T. de M. no 7; pl. 5, no 197.)

352—Maison de DUROCHEZ. Sa femme présente.
Elle signe: *la Duroché.*
(T de M. no 23*c*; pl. 5, 199, 201.)

353—Maison du sieur AUGÉ. Sa femme présente.
Elle signe: *Charlote Lemir augé.*
François Augé, époux de Charlotte Lemyre. (Tanguay, II, 82 et T. de M. no 23*B*; pl. 5, no 200.)

354—Maison de St. ANGE CHARLY, occupée par M. de RAMEZAY. Sa femme présente.
Elle refuse de signer
(T. de M. no 23*A*; pl. 5, no 202.)

RUE CAPITALE
(nos 355 à 363)

355—Maison de DANRÉ.
Il signe: *Danré de Blanzy.*
Louis-Claude Danré de Blanzy, d'abord procureur des particuliers auprès des tribunaux; il devint notaire en 1738, puis greffier du tribunal en 1744. Il conserva cette charge jusqu'à la cession. (Massicotte, *Tribunaux et officiers de justice,* pp. 287, 298 et T. de M. no 10; pl. 5, no 210.)

356—Maison de CAMPION dit LABONTÉ.
Pas question de signature.
Etienne Campion dit Labonté, époux de Marie-Charlotte Pepin (Tanguay, II, 535 et T. de M. no 10; pl. 5, no 211.)

357—Maison de DESPOINTE.
Pas question de signature.
François Harel dit Despointes, époux de Cécile Thaumur de la Source. (Tanguay, IV, 465 et T. de M. no 25; pl. 5, no 205.)

358—Maison des héritiers BROSSARD, occupée par SANSCRAINTE, n.s.s. (T. de M. no 25; pl. 5, no 206.)

359—Maison de PRUDHOMME. Sa femme présente, n.s.s.
Probablement Louis Prud'homme, époux de Louise Marin de la Massière. (Tanguay, VI, 467 et T. de M. no 11; pl. 5, no 212.)

360—Maison des héritiers de MUSSEAU, occupée par ST. LAURENT. Sa femme présente, n.s.s.
Héritiers de Charles d'Ailleboust des Musseaux. (Voir Fauteux, *Fam. d'Ailleboust*, p. 32 et T. de M. no 26; pl. 5, no 207.)

361—Maison des héritiers DEZONIERS, occupée par BOUVET. Sa femme présente, n.s.s.
Feu Pierre Trotier dit Desaulniers, décédé en 1736, époux de Catherine Charest. (Tanguay, VII, 354 et T. de M. no 12; pl. 5, no 213.)

362—Maison des héritiers des Sr et dame DEZONIERS, occupée par le Sr DEZONIERS fils. Présent: DESNOYÉ domestique, n.s.s.
Voir no 361.

363—Maison du Sieur DELORME.
Il signe: *Soumand Delorme.*
Probablement François-Marie Soumande dit Delorme, époux d'Elisabeth Gautier de Varennes. (Tanguay, VII, 207 et T. de M. no 27, pl. 5, no 208.)

RUE SAINT-JOSEPH (du sud au nord)

(nos 364 à 373)

364—Maison du nommé LA CHAUSSE, occupée par DUFFAUT. Sa femme présente.
Elle signe: *fame de Josepf Dufaux.*
Probablement Jean Mainguy dit La Chaussée, caporal, époux de Marie Gladu. (Tanguay, V, 471 et T. de M. no 47*D*; pl. 6, no 267.)
Joseph Dufaut, époux de Marie-Anne Harel. (Tanguay III, 501.)

365—Maison de M. ST. ANGE CHARLY, occupée par GUIGNARD.
Pas question de signature.
Louis Charly dit Saint-Ange, époux d'Ursule Godfroy de Tonnancour. (Tanguay, III, 19 et T. de M. no 152*E*; pl. 5, nos 162, 161.)
Arthur Laurent Guignard, fut caporal dans les troupes, puis huissier. (Massicotte, *Tribunaux et officiers de justice*, p. 292.)

366—Maison de la veuve LAFAVERY.
Elle signe: *Veve Lafavry.*
René Bissonnet dit Lafavery, époux défunt d'Elisabeth Lemyre. (Tanguay, II, 297 et T. de M. no 152*F*; pl. 5, 160.)

367—Maison de M. DE VARENNES.
Il signe: *De Varenn.*
Famille Gautier de Varennes. (T. de M. no 153; pl. 5, no 157, 158, 159.)

368—Maison de MARSOLLET. Sa fille présente.
Elle refuse de signer.
Il y a aussi des effets appartenant au Sieur BAILLARGÉ et au Sieur MARSOLLET fils.
Probablement Jean Lemire dit Marsolet, époux d'Elizabeth Bareau et J. B. Lemire Marsolet, époux de Louise Guyon Desprès. (Tanguay, V, 332 et T. de M. no 154; pl. 5, no 156.) Jean-Baptiste Joliet-Baillargé, marchand-voyageur, époux de Marie-Josephe Robert dit Watson. (Tanguay, 5, 14.)

369—Maison de M. de PUYBAREAU. Présente, MARIE DUVAL demeurant dans la dite maison, n.s.s.
Pierre Puibarau de Maisonneuve, chirurgien, époux de Marie-Anne Lorin. (Tanguay, VI, 471 et T. de M. no 155; pl. 5, no 155.)
Marie Duval est, sans doute, la ménagère. Serait-elle la fille d'un ancien voisin feu Claude Duval. Voir no 371, ci-après.

370—Maison du sieur PERAS, n.s.s.
Pierre Perras, époux de Marie Crépin. (Tanguay, VI, 307 et T. de M. no 156*B*; pl. 5, no 154 et no 156*d*; pl. 5, no 156.)

371—Maison du Sieur DUVAL, n.s.s.
Probablement l'héritier de feu Claude Duval décédé le 18 février 1741, vivant, époux de Charlotte Harlay. (Tanguay, III, 583 et T. de M. no 156*A*; pl. 5, no 153.)

372—Maison de BOURASSA, occupée par JOANIS. Sa femme présente, n.s.s.
René Bourassa, époux en secondes noces de M. Catherine Lériger de Laplante. (Tanguay, II, 407 et T. de M. no 169; pl. 6, no 246.)

373—Maison de CARON, n.s.s.
Claude Caron, époux de Madeleine Gervaise. (Tanguay, II, 550 et T. de M. no 170; pl. 6, no 247.)

RUE SAINT-JEAN-BAPTISTE (du sud au nord)
(nos 374 à 384)

374—Maison de CAMPAULT, n.s.s.
Il signe: *E. Campaute.*
Etienne Campeau, époux de Marie-Louise Boheur dite Bosché. (Tanguay, II, 531 et T. de M. no 180*D*; pl. 6, no 258.)

375—Maison de MÉNARD, n.s.s.
Probablement Louis Ménard, cordonnier, époux en troisièmes noces d'Ursule Demers Desermont. (Tanguay, V, 592 et T. de M. no 183B^3; pl, 7, nos 280-281.)

376—Maison de LABADIE, n.s.s.
Pierre Descomps dit Labadie, marchand-voyageur, époux d'Angélique dela Celle. (Tanguay, III, 368 et T. de M. no 183*B*2; pl. 7, no 282.)

377—Maison de BERTRAND TRUDEAU. Sa femme présente.
Elle signe: *Marie Anne Gervaise.*
Bertrand Trudeau, époux de Marie-Anne Gervaise. (Tanguay, VII, 375 et T. de M.no 183*Bi*; pl. 7, no 282.)

378—Maison de DUPLESSY, boulanger, n.s.s.
Noël Guillon-Duplessis, époux d'Angélique Zacharie. (Tanguay, IV, 421 et T. de M. no 181*DD*2; pl. 7, no 284.)

379—Maison du sieur GODEFROY. Sa fille présente.
Elle refuse de signer.
J. B. Godefroy, sieur de Vieuxpont. (T. de M. no 181*dd*1; pl. 7, no 284.)

380—Maison de PREVILLE, occupée par LAPROMENADE. Sa femme présente.
Elle signe: *Marguerite Menson.*
Philippe Vinet dit Préville. (Tanguay, VII, 475 et T. de M. no 181*cc*; pl. 7, no 287.)
Jean-Baptiste L'Archevêque dit Lapromenade, voyageur, époux de Marguerite Menesson ou Melson. (Tanguay, V, 164.)

381—Maison de LESPERANCE. Sa femme présente, n.s.s.
Pierre Compain dit Lespérance, perruquier, époux de Françoise Vacher. (Tanguay, III, 119 et T. de M. no 181*cc*1; pl. 7, no 287.)

382—Maison de LAPRISE.
Il signe: *Charle Laprise.*
Charles Drouillard dit Laprise, époux d'Elisabeth Demers. (Tanguay, III, 452 et T. de M. no 181*B*, 181*BB*1, 181*BB*2, 181*BB*3; pl. 7, nos 287-289.)

383—Maison de la veuve BOURGY, n.s.s.
384—Maison de DOUILLARD (*sic*), n.s.s.
Héritiers de René Drouillard dit Laprise. (T. de M. no 181*BB*2; pl. 7, no 289.)

RUE DE L'HOPITAL (de l'est à l'ouest)

385—Maison des héritiers de REPENTIGNY, occupée par LAFORCE. Sa fille présente.
Elle signe: *Catherine Laforce.*
Probablement Pierre Pepin dit Laforce, époux de Michelle Lebert, dont une fille, Catherine, était née en 1723. (Tanguay, VI, 295 et T. de M. no 117*Bi*; pl. 4, nos 89 et 90.)
386—Maison de RAINVILLE, occupée par LAJEUNESSE, n.s.s.
Probablement Charles de Rainville, époux en secondes noces, de Marguerite Gaudin. (Tanguay, III, 349.)
387—Maison de LA MORENDIÈRE. Sa femme présente.
Elle signe: *Puigibaut de la morendière.*
Etienne Rocbert de la Morendière, époux de Marguerite Puygibaut. (Tanguay, VII, 15 et T. de M. no 116*B*; pl. 4, no 88.)
388—Maison de la FOSSE, occupée par CASTONGUAY. Sa femme présente, n.s.s.
Antoine Puypéroux de la Fosse fut huissier à Montréal, de 1715 à 1725. En cette année, il devint notaire et il exerça jusqu'en 1744 sur la côte nord du Saint-Laurent. (Massicotte, *Tribunaux et officiers de justice*, p. 291 et T. de M. no 115*B*; pl. 4, nos 100 et 101.)
389—Maison de LACHAPELLE, n.s.s.
J. B. Bourg dit Lachapelle, époux d'Angélique Becquet. (Tanguay, II, 419 et T. de M. no 115*A*2; pl. 4, no 99.)
390—Maison de CAMPAUT. Sa femme présente, n.s.s.
Pierre Campault, époux de Thérèse Robillard. (Tanguay, II, 532 et T. de M. no 115*A*1; pl. 4, no 96.)
391—Maison de SAINT-MAURICE, n.s.s.
Peut-être Paul Desforges dit St. Maurice, armurier, fils de Jean. (Tanguay, III, 372 et T. de M. no 105-14; pl. 4, no 75.)
392—Maison de GIBAULT, n.s.s.
Gabriel Gibault, époux de Marguerite Dumets. (Tanguay, IV, 262 et T. de M. no 105*L*4; pl. 4, no 87.) Ce no est omis dans le texte du terrier. Il est à l'index des plans.
393—Maison de MADAME LASELLE, occupée par SAINT-MARTIN, n.s.s.
Peut-être Marie-Anne Lalande, épouse de Jacques Laselle fils. (Tanguay, V, 63 et T. de M. no 105*L*, 5; pl. 4, no 91.)

394—Maison de MADOX. Sa femme présente.
Elle signe: *Louise de la Selle Madox.*
Joseph-Daniel Madox (et Maddon), anglais, époux en secondes noces de Marie-Louise Lacelle. (Tanguay, V, 449 et T. de M. no 105*L*5; pl. 4, no 91.)

395—Maison de la veuve LASELLE, n.s.s. Aussi, articles appartenant à la veuve BENARD, n.s.s.
Probablement Angélique Gibaut qui avait épousé Jacques Laselle père. (Tanguay, III, 285 et V, 63; aussi T. de M. no 105*L*5; pl. 4, no 91.)

396—Maison de CRESPAUX. Sa femme présente, n.s.s.
Pierre Crespeau, brasseur, époux de Marie Leduc, en secondes noces. (Tanguay, III, 195 et T. de M. no 105-*I* 6; pl. 4, no 72.)

397—Maison de MIVILLE. Sa femme présente, n.s.s.
Peut-être Charles Miville, époux en troisièmes noces de Jeanne Labadie. (Tanguay, VI, 50 et T de M. no 105*E*; pl. 4, no 69.)

RUE SAINT-ALEXIS (du nord au sud)
(nos 398 à 400)

398—Maison de CAYÉ, n.s.s.
Jacques Caillé, époux de Thérèse Castignon. (Tanguay, II, 523 et T. de M. no 105*i*3; pl. 4, no 74, ou no 105*F*; pl. 4, no 68).

399—Maison de VALADE, n.s.s.
Guillaume Valade, maître-maçon, époux de Marie-Joseph Deguire. (Tanguay, VII, 403 et T. de M. no 105*i*3; pl. 4, no 74 ou no 1051*IH*; pl. 4, no 76.)

400—Maison de la veuve VALADE, occupée par BELLEGARDE, n.s.s.
Sur Valade, voir no 403, ci-après.
Probablement un des Gerbaut dit Bellegarde. Voir Tanguay IV, 248.

RUE SAINT-SACREMENT (de l'ouest à l'est)
(nos 401 à 411)

401—Maison de DUGAST, n.s.s.
Joseph Dugast, cordonnier, époux de Geneviève Catin. (Tanguay, III, 510*G* et T. de M. no 105*G* et *H*; pl. 4, no 67.)

402—Maison de la veuve VALADE, n.s.s. Aussi article appartenant à CHRISTINE BERTRAND.
Probablement Christine Bertrand-Jérome, épouse en troisièmes noces de Charles Valade, vivant, maçon. (Tanguay, VII, 403 et T. de M. no 105*L*1; pl. 4, no 76.)

403—Maison du Sieur DE COUAGNE, occupée par DESLORIEZ, n.s.s.
Probablement René de Couagne, époux de Louise Pothier. (Tanguay, III, 269 et T. de M. no 104*M*; pl. 4, no 106.)

404—Maison de DUFRESNE, occupée par LARCHE, n.s.s.
Antoine Thunay dit Dufresne, époux d'Angélique Roy. (Tanguay, VII, 311 et T. de M. 120*A*4; pl. 4, no 126.)

405—Maison de BRUNET, n.s.s.

406—Maison de PARENS, n.s.s.
Probablement J. B. Parent, époux de Geneviève Aubert. (Tanguay, VI, 232 et T. de M. no 105*M*6; pl. 4, no 97.)

407—Maison de LAPISTOL, n.s.s.
Probablement Louis-Joseph Varin dit Lapistolle, orfèvre. (Tanguay, VII, 427 et T. de M. no 104 *N*3 et 114*F*; pl. 4, no 113.)

408—Maison de COLLET.
Il signe: *Collet.*
Claude Collet, marié en secondes noces à Angélique Sarault. (Tanguay, III, 112, 113 et T. de M. no 114*K*2; pl. 4, no 126.)

409—Maison de Madame DE COUAGNE, occupée par M. LINCTOT. Sa femme présente.
Elle signe: *Colonge Linctôt.*
René Godefroy de Linctôt, époux en secondes noces de Marie Catherine d'Ailleboust de Coulonge. (Tanguay, IV, 313 et T. de M. no 114*Q*; pl. 4, no 98.)

410—Même maison, "dans un appartement dans le bas," occupé par la veuve LARIVIERE, n.s.s.

411—Maison du sieur LAROCHE. Sa femme présente.
Elle signe: *la laroche.*
Jean Laroche, époux de Suzanne Turpin. (Tanguay, V, 169 et T. de M. no 120*A*5; pl. 4, no 126.)

RUE SAINT-JEAN (du sud au nord)

(nos 412 à 414)

412—Maison de SAINT-PIERRE, n.s.s.
Léonard Jusseau ou Jusseaume ou Jousseaume dit Saint-Pierre, époux d'Angélique Laporte. (Tanguay, V, 38 et T. de M. no 105*M*4 et *M*5; pl. 4, nos 94, 95.)

413—Maison de SAULQUIN, occupée par SAINT-LO, n.s.s.
Joseph Saulquin dit Saint-Joseph, époux en secondes noces de Marie Gour. Il fut huissier à Montréal de 1732 à 1760. (Tan-

guay, VII, 127. Massicotte, *Tribunaux et officiers de justice*, p. 292.) Voir no 337 ci-avant.
Guillaume Jourdan dit Saint-Lo ou Saint-Lou. (Tanguay, V, 25.)

414—Maison de FRANCOEUR, n.s.s.
Pierre Charland dit Francoeur, époux d'Angélique Hardouin. (Tanguay, III, II et T. de M. no 105*M*1; pl. 4, no 92.)

415—Maison de FORTIN.
Il signe: *P. Fortin.*
Pierre Fortin, époux de Marie-Catherine Bonhomme, (Tanguay, IV, 6.) ou Pierre-Nicolas Fortin, époux de Françoise LePallieur. (Tanguay, IV, 71 et T. de M. 105*M*3; pl. 4, no 93.)

RUE SAINT-ELOY (du nord au sud)

(Nos 416 à 420)

416—Maison de BEAUBIN, n.s.s.
Hubert Baubin, soldat, époux de Catherine Roy, veuve Marcheteau-Desnoyers. (Tanguay écrit Baubin, vol. II, p. 136 et Robin, vol. VII, p. 7. T. de M. no 114*E*; pl. 4, no 113.)

417—Maison de BEAULIEU. Sa femme présente, n.s.s.
Il s'y trouve aussi un article appartenant à la PENSÉE.
Probablement Michel Parmier dit Beaulieu, époux de Marie-Marguerite Roy. (Tanguay, VI, 254 et T. de M. no 114*H*; p. 4, no 127.)

418—Maison de DALANSON, n.s.s.
Nicolas L'Hermite dit D'Alençon, marié, en 1730, à Marie-Joseph Raymond. (Tanguay, V, 407.)
Il devait occuper une maison sise sur les emplacements désignés dans le T. de M. sous le no 114; pl. 4, no 120-121 et possédés par Jos. Marcheteau dit Desnoyers.

419—Maison de BIGEAU, n.s.s.
Jacques Bigeot dit la Giroflée, sergent, veuf de Marie-Madeleine Dupont. (Tanguay, II, 276 et T. de M. 114*K*1 et *K*2; pl. 4, nos 125 et 126.)
Le *Terrier* le nomme Bigot.

420—Maison de LA PISTOL, n.s.s.
Nicolas Varin dit la Pistole, époux en secondes noces de Marie-Suzanne Daunet. (Tanguay, VII, 427 et T. de M. no 114*A*; pl. 4, no 122.)

RUE SAINT-PIERRE (du nord au sud)

(Nos 421 à 433)

421—Maison de PETIT, occupée par LEBOEUF. Sa femme présente.
Elle signe: *Marie Hains Lebeuf.*
Pierre-René Lebeuf dit Boutet, époux de Marie-Françoise Hains. (Tanguay, V, 221 et T. de M. no 105*B*1 et *B2i*; pl. 4, nos 63 et 64.)

422—Même maison, dans un appartement occupé par ledit PETIT, n.s.s.
Peut-être Etienne Petit-Boismorel, voyageur, époux d'Anne Chauvin. (Tanguay, VI, 330). Ou Louis Petit, dit Rossignol, époux de Marie-Joseph Dambourney. (Tanguay, VI, 329.)

423—Maison de la veuve FRANCOIS PETIT.
Elle signe: *La veuve Petit.*
Probablement Elisabeth Belleperche veuve de François Petit, décédé au mois de juin précédent. (Tanguay, VI, 328 et T. de M. no 105*Bi*; pl. 4, no 64.)

424—Maison de la veuve BONVOULLOIR, occupée par LECOMPTE, n.s.s.
Marthe Daragon, veuve de Julien Delières dit Bonvouloir. (Tanguay, III, 316 et T. de M. no 105*Ai*; pl. 4, no 66.)

425—Même maison dans un appartement occupé par SAINT-HYLAIRE, n.s.s.

426—Maison de SOUSTE. Sa femme est présente.
Elle signe: *Louise Clérin.*
André Souste, fabricant de bas et qui devint notaire en 1745, avait épousé Marie-Louise d'Estienne de Clérin. (Tanguay, VII, 208. Massicotte, *Tribunaux et officiers de justice,* p. 298; T. de M. no 102*S* et T; pl. 3, no 17.)

427—Maison de LAVENTURE, occupée par SANSOUCY. Sa femme est présente, n.s.s.
Doit être Antoine Hus dit Laventure, ancien soldat, époux de Marie-Anne Fourneau dit Brindamour. (Tanguay, IV, 561.)

428—Même maison, appartement occupé par MARGUERITE LANGLOIS, n.s.s.

429—Même maison, dans un appartement occupé par LAVENTURE, n.s.s.
Voir au no 427.

430—Maison de HUBERDEAU.
Il signe: *Huberdeau.*
J. B. Huberdeau dit La france, perruquier, ancien soldat, époux

de Charlotte-Gertrude Roulleau. (Tanguay, IV, 529 et T. de M. no 102*X*; pl. 3, no 15.)

431—Maison de GACIEN, n.s.s.
Pierre-René Gassien ou Gatien dit Tourangeau, époux de Marguerite Gautier. (Tanguay, IV, 184 et T. de M. no 102*Y* et *Z*; pl. 3, nos 14 et 15.)

432—Maison de dame veuve BLAINVILLE.
Elle signe: *Blinville.*
Geneviève-Gertrude Legardeur de Tilly, veuve de J. B. Céloron de Blainville. (Tanguay, II, 591 et T. de M. no 102*E.E*; pl. 3, nos 10, 11, 12, 13.)

433—Maison de DENIS LECOUR, n.s.s.
Denis Lecourt, époux de Madeleine Surault dite Blondin. (Tanguay, V, 251.)
Auparavant, Lecourt avait possédé les terrains no 101*I* et 101*L*; pl. 3, nos 24 et 25 à l'extrémité ouest de la rue Notre-Dame. Voir *Terrier de Montréal.*

FAUBOURG SAINT-JOSEPH

(Nos 434 à 483)

434—Maison de LECOMPTE, n.s.s.

435—Maison de JÉALTOT, n.s.s.
Jacques Jalateau ou Jalteau, tisserand, marié en 1741 à Marie-Joseph Robidou. (Tanguay, IV, 578 et Simonnet, 21 septembre 1741.)

436—Maison de TOURANGEAU, n.s.s.
Doit être J. B. Dany dit Tourangeau, époux d'Elisabeth Trottier, ou Antoine Tourangeau, époux d'Angélique L'Escuyer. (Tanguay, III, 238.)

437—Maison de CHAMPIGNY. Sa femme présente, n.s.s.
Probablement, Pierre Deslandes dit Champigny, époux de Marguerite Lecompte. (Tanguay, III, 380.)

438—Maison de ROBIDOUX. Sa femme présente, n.s.s.
Un acte de Simonnet, du 21 septembre 1741, nous apprend qu'un François Robidoux, cordonnier, époux de Thérèse Lehou, demeurait audit faubourg. Au même lieu, réside aussi Guillaume Robidoux, aubergiste.

439—Maison de LARIVIERE, occupée par BOURON. Sa femme Présente, n.s.s.
Probablement Antoine-Joseph Bouron, époux de Marie-Joseph Boyer. Celle-ci devint veuve peu après, car elle convole, le

2 juillet 1742 avec Jean Dumouchel, à Montréal. (Tanguay, II, 429.)

440—Maison de la dame veuve De Selle.
Elle signe: *Marguerite Perro.*
Marguerite Perrot dit Vildaigre, veuve d'Alexandre Decelle-Duclos. (Tanguay, II, 590.)

441—Maison de Martial Charon. Sa femme est présente, n.s.s.
Martial Charon, époux de Marie-Anne Vacher. (Tanguay, III, 21.)

442—Maison de Lamarche, occupée par Balan, n.s.s.
Peut-être Etienne Balan, époux de Marie-Madeleine Brassard ou Etienne Balan, époux de Marie-Elisabeth Houée. (Tanguay, II, 104.)

443—Maison de Laselle, occupée par Robidoux, fils, n.s.s.

444—Maison de Rencontre, n.s.s.

445—Maison de Deno, n.s.s.

446—Maison de la veuve Juillet, occupée par Hubert Lacroix, n.s.s.
Peut-être Catherine-Celles Duclos, veuve de Louis Juillet.

447—Maison de Biron.
Il signe: *Pierre Biron.*
Pierre Biron, veuf de Catherine Leduc. (Tanguay, II, 289.)

448—Maison de Suzanne Leduc, occupé par Boyé, n.s.s.
Probablement Suzanne Leduc, fille de Joseph Leduc et de Catherine Cuillerier, née en 1699, belle-soeur de Pierre Biron, ci-dessus mentionné. (Tanguay, I, 364.)

449—Maison de Lacombe. Sa femme présente, n.s.s.

450—Maison de la veuve Prudhomme, n.s.s. Présentation d'un article appartenant à Madame Desfonds.
Peut-être Cécile Gervaise, veuve depuis le mois d'avril 1741 de François-Xavier Prud'homme. (Tanguay, VI, 466.)
Peut-être Marie-Agnès Emond, épouse de Pierre Defontrouver dit Desfonds. (Tanguay, III, 272.)

451—Maison de dame Deganne, occupée par Jeaudoin, n.s.s.
Probablement Marguerite Nafrechoux, épouse de François de Gannes de Falaise. (Tanguay, III, 274.)

452—Maison du sieur Herbin. Sa femme présente.
Elle signe: *Dumont Herbin.*
Frédéric-Louis Herbin, marié à Louise Françoise Lambert-Dumont. (Tanguay, IV, 492.)

453—Maison de Sieur Dufort. Sa femme présente.
Elle signe: *la Dufor.*
Peut-être Pierre Bougret dit Dufort, époux de Louise Dudevoir

ou François Bougret, époux de Geneviève Chevalier. (Tanguay, II, 394.)

454—Maison de MERCEREAU, occupée par BERTRAND. Sa femme présente, n.s.s.

Mercereau? Sans doute, un des héritiers de Pierre Mercereau et Louis Guilmot tous deux décédés quelques années auparavant. (Tanguay, V, 603.)

455—Maison PARANS. Sa femme présente, n.s.s.

456—Maison de LA COUTURE, n.s.s.

Peut-être René Goneau dit Lacouture, époux de Marie André Heurtebise. (Tanguay, IV, 420.)

457—Maison de SAINT-JULIEN, n.s.s.

458—Maison de LA COUTURE, occupée par le sieur de CROIZIL.

Il signe: *Croissille fils.*

Lacouture. Voir no 456.

Probablement Bonaventure Le Gardeur de Croisil, époux de Marie-Joseph Mary de la Chauvignerie. (Tanguay, V, 294.)

459—Maison de dame LA CHAUVIGNERIE.

Elle signe: *veuve de la Chovignerie.*

Catherine Dagneau-Douville, veuve de Louis Maray de la Chauvignerie. (Tanguay, V, 487-8.)

460—Maison de RELLE, n.s.s.

Probablement Paschal Harel, époux de Marie-Madeleine Demers. (Tanguay, IV, 465.)

461—Maison de SANSOUCY. Sa femme présente, n.s.s.

462—Maison de DEBIEN. Sa femme présente, n.s.s.

Jean B. Debien, époux de Marie-Joseph Goujon ou Frs Debien, époux de Marie-Jeanne Goujon. (Tanguay, III, 259.)

463—Maison de ROY, n.s.s.

464—Maison de JEAN-MARIE LARIVIÈRE, n.s.s.

465—Maison de FRANÇOIS LATOUR, n.s.s.

466—Maison de LIONNOIS. Sa femme présente, n.s.s.

467—Maison de PIERRE MINVILLE, n.s.s.

Pierre Miville (ou Minville), époux de Marguerite Hunault dit Deschamps. (Tanguay, VI, 52.)

468—Maison de Charles LAFANTESIE. Sa femme présente, n.s.s.

Charles-Marie Maurice dit Lafantaisie, époux de Catherine Cardinal. (Tanguay, V, 581.)

469—Maison de LOMBART. Sa femme présente, n.s.s. Aussi article appartenant à SAINT-AUBIN.

Joseph Lombard, époux de Marie-Catherine Marion. (Tanguay, V, 426.)

470—Même maison, dans un appartement dans le côté, occupé par BIBEAU, n.s.s.
Probablement J. B. Bibaud, marié en secondes noces à Madeleine Durand. (Tanguay, II, 272.)

471—Maison de CHEVAUDIER, n.s.s.
Probablement, Joseph Chevaudier dit Lepine marié en secondes noces à Marie-Charlotte Guyonet ou Dionet dit Lafleur. (Tanguay, III, 61.)

472—Maison de GENTIL. Sa femme présente, n.s.s.

473—Maison de la veuve BRUNET, occupée par *Lionnois*. Sa femme présente, n.s.s.

474—Maison de BAPTISTE LARIVIERE, n.s.s.

475—Maison de MONTRAIL CHARON, n.s.s.
Il y a à Montréal, en 1741, (*a*) René Etienne Montret ou Montrais. (Tanguay, VI, 78.) (*b*) J. B. Sédilot dit Montreuil qui se marie le 21 novembre 1741. (Tanguay, VII, 154.)

476—Maison appartenent aux Frères CHARON, occupée par la femme de MARIN HURTEBISE, n.s.s.
Marie Anne Trottier-Desruisseaux, époux de Marien Heurtebise. (Tanguay, IV, 504.)

477—Maison de DUBUQUE, n.s.s.
Peut-être André Dubuc, époux de Cécile Langevin, qui demeurait alors à Montréal. (Tanguay, III, 487.)

478—Communauté des FRERES HOSPITALIERS.
Signe: *frère jeantôt, supérieur.*
Hôpital général des Frères hospitaliers dela Croix, connus sous le nom de Frères Charon. Le supérieur Jean Jeantôt fut à la tête de sa communauté de 1732 à 1745.

479—Maison de LAVIGNE, n.s.s. Aussi article appartenant à Beaulieu. n.s.s.
Peut-être Charles Beaulieu, époux de Marie Augé. (Tanguay, II, 172.)

480—Maison de ROCH, n.s.s.

481—Maison de SAINT-MICHEL, n.s.s.

482—Maison de BLOT. Sa femme est présente, n.s.s.
Dans un acte de Simonnet, des 17 septembre 1741, ou voit qu'un Etienne Blot, demeurait "sur le pointe de Callières, près de la ville."

483—Maison des héritiers PETIT, "occupée par plusieurs Lanaudière," n.s.s.
S'agirait-il des enfants de Pierre-Thomas Tarieu de Lanaudière et de Marie-Madeleine Jarret de Verchères? (Tanguay, VII, 262.)

FAUBOURG SAINT-LOUIS

(Nos 484 à 498)

484—Maison de MORIN. Sa femme est présente, n.s.s.

485—Maison de FORESTIER.
Il signe: *Foretier.* Il y a aussi un article appartenant à JOSEPH CHANTELOUP.
Tanguay mentionne un François Chalut dit Chanteloup, mais il ne dit rien de Joseph.

486—Maison de LATOULIPE.
Il signe: *Latulipe.*

487—Maison de HOTESSE, n.s.s.
A cette époque vivaient: Marie-Anne Caron, 3eme femme de feu Paul Hotesse ou Otis, Paul-Nicolas Otis fils, né en 1712 et Louis né en 1716. Voir Malchelosse. *Généalogie de la famille Otis,* pp. 20-21 et Tanguay, IV, 513.

488—Maison de ROY. Sa femme est présente, n.s.s.

489—Maison de DUMOUCHEL, n.s.s.
Bernard Dumouchel, époux de Marie-Anne Tessier ou Louis Joseph Dumouchel, époux de M. Louise Leclerc. (Tanguay, III, 538-539.)

490—Maison de PISTOLLET.
Il signe: *François Beaumont.*
François Beaumont, époux de Françoise Boucher. (Tanguay, II, 174.)

491—Maison de TINTAMARRE. Sa femme est présente, n.s.s.
François Roy dit Tintamarre, époux de Marie-Angélique Poitevin. (Tanguay, VII, 76-77.)

492—Maison de M. LIGNERY, occupée par LAPIERRE, n.s.s.
Probablement François Marchand de Lignery, époux de Marie-Thérèse Migeon de la Gauchetière. (Tanguay, V, 312.)

493—Maison de la DELLIETTE, n.s.s.
Probablement Charles-Henri-Joseph Tonty sieur de Liette, ancien gouverneur du fort Saint-Louis, époux de Louise Renaud du Buisson. (Tanguay, VII, 319.)

494—Maison de MATHIEU LARCHE, n.s.s.
Mathieu Larche (ou Larchevèque), époux de Catherine Achin. (Tanguay, V, 163.)

495—Maison de LATREILLE, occupée par PIERRE MERCIER, n.s.s.
Peut-être Pierre Mercier, forgeron. (Tanguay, V, 606.)

496—Maison de URBAIN BROSSARD, n.s.s.
Urbain Brossard, voyageur, époux de Marie-Françoise Sérat. (Tanguay, II, 481.)

497—Maison de PAUL BROSSARD, n.s.s.
Paul Brossard, époux de Marie-Renée Maret. (Tanguay, II, 481.)

498—Maison de PEREAU, n.s.s.

FAUBOURG SAINTE-MARIE

(Nos 499 à 506)

499—Maison de DUFRESNE, n.s.s.

500—Maison de DUMAINE, n.s.s.
François Dumaine, époux de Charlotte Saint-Aubin. (Tanguay, III, 516.)

501—Maison de LAROCHE, n.s.s.

502—Maison de MOREAU, n.s.s.
Probablement Edme Moreau, époux de Françoise Fortier ou l'un de ses descendants. (Tanguay, VI, 88.)

503—Maison de DUFRESNE, n.s.s.

504—Maison de DUVAL. Pas question de signature.
Est-ce un fils de Claude Duval (voir no 371) ou bien ce Louis Duval né en 1680 qui fut inhumé en 1755 à Montréal. (Tanguay, III, 584.)

505—Même maison, dans un appartement occupé par BRION. Sa femme présente, n.s.s.
Peut-être Jean Billon, serrurier, qui dans un acte de Simonnet, du 17 Septembre 1741, est dit demeurer au faubourg Saint-Louis.

506—Maison de CAMPAUT, n.s.s.

APPENDICE

Recensement fait en cette ville par la Compagnie des Indes pour les indiennes et autres effets prohibés pour être marqués en vertu de l'ordonnance de messieurs le gouverneur général et intendant.

L'an mil sept cent quarante-un, le quatorze juillet, nous François Daine, controleur général de la Compagnie des Indes, en vertu de l'ordonnance rendue par Messeigneurs le marquis de Beauharnois Gouverneur et Lieutenant Général et Hocquart Intendant en toute la nouvelle France, en datte du douze May dernier publiée en cette ville Le (un blanc) aussy dernier et enregistrée au Greffe de cette jurisdiction le 14 dud. mois de juillet, aux fins de procéder à la reconnaissance des meubles de toille peinte et autres étoffes étrangères dans les trois villes de la colonie, et iceux meubles marquer d'un cachet ou empreinte aux armes de la compagnie des Indes Nous nous sommes transportés dans chaque maison des domiciliers et habitants de cette ville et des fauxbourgs d'icelle, ou étant en présence de MM. Jacques de la Fontaine, conseiller du Roy au Conseil supérieur de Québec faisant les fonctions de lieutenant Général en cette jurisdiction Royale de Montréal Requis par nous pour se transporter dans les maisons et assisté de Antoine Trémont, sieur de Salvaye, commandant les gardes de lad. Compagnie et des nommés Brossard et Beaufrère, gardes de lad. Compagnie. Et nous avons procédé à lad. Reconnoissance et apposition de la marque aux armes de lad. Compagnie sur les meubles et étoffes étrangères trouvés dans chaqu'une maison de cette ville et déclarée et mis en évidence par les cy après nommés ainsy qu'il ensuit:

(à chaque visite il est dressé un procès-verbal dont nous donnons deux exemples dans l'introduction. Le document se termine par la déclaration suivante:)

Ce fait et après avoir vacqué auxd. représentations de meubles de marchandises étrangères dans toutes les maisons de cette ville et faubourgs d'icelle. Nous François Daine, présence et assisté comme dit est avons clos et arresté le présent procès-verbal pour estre Ensuite déposé au Greffe de cette jurisdiction au désir de lad. Ordonnance du 12 mai dernier, lequel nous certifions véritable suivant les représentations et déclarations qui nous en ont été faites. A Montréal, ce vingt-quatre juillet 1741.

De la Fontaine Daine.

Veu les procès-verbaux cy dessus et des autres parts nous ordonnons que copie d'yceux seront déposés au Greffe de la jurisdiction de Montréal. Et autre copie au Bureau de la Compagnie des Indes pour y avoir recours En cas de besoin. Mandons, &c., fait à Montréal, le 30 juillet 1741.

MICHEL.[1]

[1] Honoré Michel, sieur de la Rouvillière, subdélégué de l'intendant et commissaire ordonnateur.

Madeleine de Verchères, plaideuse.

Par PIERRE-GEORGES ROY, M.S.R.C.

(Lu à la réunion de mai 1921.)

Que ce titre de *Madeleine de Verchères, plaideuse,* ne scandalise personne!

Tous les saints sont des héros, mais tous les héros ne sont pas des saints.

Comme Madeleine de Verchères était plutôt une héroïne qu'une sainte elle avait certains petits défauts. Que ceux et celles qui sont sans défauts lui jettent la pierre!

Le plus grand défaut de Madeleine de Verchères était—pardonnez-nous l'expression—d'être une plaideuse enragée. On connait cette prière quotidienne d'un vieux normand: Seigneur, je ne vous demande pas de biens, mais je vous supplie de me donner des voisins qui en ont. Je saurai ensuite me tirer d'affaires.

Nous ignorons si Madeleine de Verchères adressait la même prière au Seigneur, mais il est un fait certain c'est que pendant ses trente années de mariage elle trouva le moyen d'avoir, chaque année, un, deux et quelquefois trois procès avec ces voisins.

Madeleine de Verchères devint, en septembre 1706, l'épouse de Pierre-Thomas Tarieu, sieur de la Pérade, officier dans les troupes de la colonie et seigneur de Sainte-Anne.

M. de la Pérade s'était marié à l'âge de trente ans. Avant son mariage il n'avait jamais eu un mot avec personne. Il connaissait les tribunaux pour ce qu'il en avait lu dans les livres et entendu parler par ses parents et ses amis. A peine fut-il dans les liens du mariage qu'il entra dans les procès pour n'en sortir qu'à la mort de sa femme, la belliqueuse Madeleine de Verchères.

Si on peut dire des hommes qui accomplissent les moindres petits caprices de leurs femmes qu'ils sont des maris exemplaires, M. de la Pérade sur ce point était véritablement digne d'éloges car d'un tempérament plutôt tranquille il se lança dans toutes sortes de procès pour faire plaisir à sa femme—ou plutôt afin de satisfaire le goût de celle-ci, pour la chicane.

Le premier procès de M. de la Pérade eut lieu six mois après son mariage. La seigneurie de la Pérade avait été concédée conjointement à M. de Lanaudière, père de M. de la Pérade, et à M. de Suève, son compagnon d'armes. Voisins de puis vingt ans, ils n'avaient jamais eu un mot ensemble. A peine Madeleine de Verchères était-elle entrée au manoir de la Pérade que la chicane commença entre les deux voisins au sujet des bornes respectives de leurs concessions. Le procès dura un an. M. de la Pérade gagna son point mais il dût débourser un joli montant pour payer les frais du procès et les déplacements de l'arpenteur qui délimita sa concession et celle de son voisin.

L'année suivante, en 1708, M. de la Pérade entrait dans un nouveau procès. Cette fois c'est au seigneur des Grondines, un autre de ses voisins, qu'il s'en prit. Il gagna son point, mais dut payer un quart des frais du procès.

En 1708, Mme. de la Pérade était citée devant la Prévôté de Québec pour s'être portée à des voies de faits sur un nommé Ricard. Madeleine de Verchères qui n'avait pas eu peur de toute une troupe d'Iroquois ne craignait aucun de ses censitaires. Aussi ceux-ci étaient obligés de filer doux avec leur seigneuresse qui n'était pas un modèle de patience et recourait vite aux arguments frappants quand les choses n'allaient pas à son goût ou à celui de M. de la Pérade.

En 1709, madame de la Pérade, à la suite d'une altercation avec son engagé, le nommé Jean Cousineau, l'avait mis hors de chez elle. Cousineau entra au service de Noël Trottier dit la Bissonnière. Madame de la Pérade, s'étant aperçue que certains effets étaient disparus de chez elle pendant l'engagement de Cousineau, demanda à Trottier de la Bissonnière de retenir cinq ou six livres sur les gages de Cousineau afin de l'indemniser pour ses effets disparus. Trottier de la Bissonnière refusa de se prêter à ce marché. C'est alors que M. de la Pérade intervint. Avec l'aide de M. de Crisafy, gouverneur des Trois-Rivières, il réussit si bien à terroriser le malheureux Trottier de la Bissonnière qu'il lui signa un billet de dix-huit livres.

Mais, mieux informé, Trottier de la Bissonnière, en appela à l'intendant, et, le 19 juin 1709, M. Raudot faisait défense à M. de la Pérade de faire aucunes poursuites contre Trottier de la Bissonnière pour son billet, celui-ci ne l'ayant signé que pour s'éviter ses violences.

En 1710, M. de la Pérade intentait un procès à M. Chorel Dorvilliers, co-seigneur de Sainte-Anne, au sujet des îles qui étaient en face de leur seigneurie. Il prétendait qu' il était unique propriétaire de ces îles. Après bien des procédures, l'intendant Raudot, le 28 mars 1710, rendait jugement en faveur de M. de la Pérade. Le succès de ce dernier fut cependant de courte durée. Le lendemain, 29 mars 1710, l'intendant modifiait considérablement son ordonnance de la veille au profit de M. Dorvilliers. Le domaine que M. de la Pérade s'était taillé dans la seigneurie de Sainte-Anne au détriment de son co-seigneur était diminué de moitié.

En 1711, M. et madame de la Pérade étaient poursuivis par François Baribault, un brave cultivateur de Sainte-Anne à qui ils avaient loué l'île St-Ignace. Baribault prouva si clairement qu'il ne pourrait jamais s'accorder avec M. de la Pérade et sa femme qui, disait-il, les menaçaient à tout instant de voies de fait, que l'intendant Raudot, le 29 avril 1711, annulait le bail consenti par M. de la Pérade à Baribault et permettait au seigneur de disposer de l'île Saint-Ignace comme il l'entendrait.

En 1715, nouvelles difficultés entre MM. de la Pérade et Chorel Dorvilliers, seigneurs conjoints de Sainte-Anne. M. de la Pérade avait construit le moulin banal et en retirait de ce fait tous les revenus. Le 15 février 1715, l'intendant Raudot permettait à M. Chorel Dorvilliers de construire, lui aussi, un moulin dans sa partie de seigneurie. L'intendant établissait en même temps un règlement entre les deux seigneurs afin d'empêcher les contestations à l'avenir.

En 1715, M. de la Pérade intentait aux habitants de sa seigneurie de Sainte-Anne, un procès qui devait durer plusieurs années. Les habitants de Sainte-Anne, depuis plus de vingt-cinq ans, faisaient paccager et herbager leurs bestiaux sur l'île au Sable qui appartenait à M. de la Pérade. Les habitants prétendaient que l'île au Sable dépendait de la commune qui leur avait été accordée par leurs titres de concession. Après cinq années de procédures et d'interventions de toutes sortes, le 16 août 1720, l'intendant Bégon rendait son jugement. Il maintenait les habitants de Sainte-Anne dans la jouissance de l'île au Sable. Le jugement de M. Bégon fut porté au conseil du Roi par M. de la Pérade. Huit ans plus tard, le 22 mai 1739, un arrêt du Conseil d'Etat cassait l'ordonnance de M. Bégon et remettait M. de la Pérade dans la propriété de l'île au Sable. Le litige avait duré de 1715 à 1728, soit treize ans! Si, de nos jours, les plaideurs attendent parfois quelques années pour avoir justice, ils peuvent au moins se consoler en songeant qu'il y a des précédents à ces longues attentes.

Dans l'automne de cette même année 1715, M. et Mme de la Pérade firent une petite apparition devant le tribunal de la Prévôté de Québec pour avoir administré une raclée des mieux conditionnées à toute une famille de Sainte-Anne. M. de la Pérade avait fait marché avec un de ses censitaires, Jean Ricard, pour couper ses blés. Au jour fixé, Ricard et toute sa famille se rendirent chez le seigneur de Sainte-Anne pour commencer leur ouvrage. Le chien de Ricard les avait suivi. Un des enfants de M. de la Pérade ayant cruellement battu le pauvre animal, la bru de Ricard ne put s'empêcher de remarquer:—Voilà un enfant qui est bien malin. M. de la Pérade qui, ce matin là, s'était levé de mauvaise humeur, se fâcha tout rouge et frappa la jeune femme. Le père Ricard et ses fils s'étant interposés pour protéger leur parente, Mme de la Pérade, qui était dans les environs, se mit de la partie, et le seigneur et la seigneuresse de Sainte-Anne administrèrent maintes taloches à Ricard et aux siens. Tous les membres de la famille au nombre de sept reçurent leur part de horions et s'en retournèrent les yeux au beurre noir. Ricard se rendit à Québec et porta plainte devant la Prévôté contre M. et Madame de la Pérade. Outre les dommages pour les voies de faits commises contre lui et les siens, il demanda d'être déchargé de l'obligation de couper les foins de M. de la Pérade, affirmant que sa vie était en danger s'il retournait chez lui. Ricard, lors de son altercation avec M. et Mme de la Pérade, avait vu tant de chandelles qu'il exagérait un peu sur le compte de son seigneur.

En 1722, Mme de la Pérade insultée par deux Abénakis ivres et qui étaient venus faire la loi à son mari retenu au manoir par la maladie, ne prit pas la peine de recourir aux tribunaux pour mettre les enfants des bois à l'ordre. L'un d'eux ayant menacé son mari d'un casse-tête, elle le lui enleva des mains et lui cassa les reins en le jetant à ses pieds. Elle raconte elle-même cet épisode de la façon suivante:

"Je volai vers ce sauvage. J'empoigne son casse-tête, je le désarme. Il veut monter sur un coffre, je lui casse les reins avec son casse-tête et je le vois tomber à mes pieds. Je ne fus jamais plus surprise que de me voir enveloppée à l'instant par quatre sauvagesses. L'une me prend à la gorge, l'autre aux cheveux, après avoir arraché ma coiffe; les deux autres me saisissent par le corps pour me jeter dans le feu. A ce moment, un peintre me voyant aurait bien pu tirer le portrait d'une Madeleine; décoiffée, mes cheveux épars et mal arrangés, mes habits tout déchirés n'ayant rien sur moi qui ne fût par morceaux, je ressemblais pas mal à cette sainte aux larmes près, qui ne coulèrent jamais de mes yeux."

Cette dernière phrase peint Madeleine de Verchères mieux qu'aucun peintre, même avec le talent d'un Léonard de Vinci ou d'un David, n'aurait pu le faire. Les larmes ne coulèrent jamais de mes yeux! Nous avons là toute la vie de Madeleine de Verchères. Cette jeune femme à l'apparence si frêle et si délicate était douée de tant d'énergie que la crainte et la peur, deux sentiments pourtant bien naturels à son sexe, n'eurent jamais de place dans son âme.

Mais revenons aux procès de Madeleine de Verchères puisque c'est comme *plaideuse* que nous l'étudions pour le moment.

En 1727, M. Voyer, curé de Sainte-Anne, ayant eu le malheur de faire couper quelques arbres sur l'île au Sable, qui appartenait à M. et Mme de la Pérade, ceux-ci le poursuivirent devant la Prévôté. Le 14 janvier 1727, le curé de Sainte-Anne était condamné pour ce crime à cinq livres d'amende envers le roi et aux dépens du procès.

Comme conséquence de ce jugement, le 21 mars 1727, M. de la Pérade obtenait de l'intendant Dupuy une ordonnance exécutoire contre le curé Voyer pour la somme de 225 livres, montant des dépens dans son affaire avec lui.

L'huissier Normandin ayant négligé de mettre à exécution l'ordonnance obtenue contre le curé Voyer par M. de la Pérade, celui-ci intenta un procès contre l'officier public et réussit à le faire interdire.

En 1728, nouveau procès entre M. de la Pérade et M. Chorel Dorvilliers. C'était le cinquième procès entre les deux voisins depuis quatre ans. M. de la Pérade réclamait à M. Chorel Dorvilliers des cens et rentes dûs sur des terres qu'il possédait dans l'île Saint-Ignace.

Une des principales obligations des censitaires sous le régime français était de faire moudre leurs grains au moulin banal. Le moulin de M. de la Pérade devait avoir bien des défauts puisque les habitants de Sainte-Anne, le curé en tête, allaient faire moudre leurs grains dans la seigneurie voisine. Déjà en 1707, M. de la Pérade avait obtenu une ordonnance obligeant ses habitants à se servir du moulin banal de sa seigneurie. En 1728, les habitants de Sainte-Anne se croyant moins surveillés recommencèrent leurs visites au moulin de Saint-Pierre. Mais le seigneur de Sainte-Anne veillait au grain. Et, en août 1728, il réussissait à faire saisir à son profit les blés portés au moulin de Saint-Pierre par le curé de Sainte-Anne et une dizaine de ses paroissiens.

Nos historiens nous ont longuement entretenu de la querelle survenue à la mort de Mgr de St-Vallier au sujet des cures inamovibles. M. Voyer, missionnaire de Sainte-Anne, avait été un de ceux qui avaient été nommés cures inamovibles. Il refusa de remettre sa cure lorsqu'il en fut requis un peu plus tard. M. et Mme de la Pérade trouvèrent le moyen d'entrer dans cette querelle qui les regardait comme les affaires municipales de Québec peuvent intéresser les habitants de l'Océanie.

Mais tous les procès qu'avaient soutenus jusque là M. et Mme de la Pérade étaient des vétilles à côté de celui qu'ils eurent en 1730.

Il faudrait un gros volume pour raconter ce procès par le détail. Essayons toutefois de le résumer en quelques mots.

Dans l'été de 1730, M. Gervais Lefebvre, curé de Batiscan, citait M. et Mme de la Pérade devant la Prévôté de Québec. Il les accusait d'avoir fait circuler des faussetés sur son compte.

Si M. Lefebvre croyait avoir la partie belle avec le seigneur de Sainte-Anne et sa femme, il ne les connaissait pas ou les connaissait mal. Ils se défendirent avec une énergie digne d'une meilleure cause. Ils amenèrent devant la Prévôté une foule de témoins qui avaient des griefs plus ou moins justifiés contre M. Lefebvre et donnèrent des témoignages qui n'avaient pas rapport à la cause mais préjugèrent le juge contre le curé de Batiscan.

La Prévôté de Québec renvoya la plainte de M. Lefebvre et le condamna même à 200 livres de dommages et intérêts pour avoir traduit en justice mal à propos M. et Mme de la Pérade.

M. Lefebvre en appela au Conseil Supérieur de cette étrange sentence et le Conseil Supérieur la renversa et condamna M. et Mme de la Pérade à payer tous les frais du procès.

On peut croire sans peine que le seigneur de Sainte-Anne et sa femme ne furent pas satisfaits de ce jugement. C'était le premier échec sérieux qu'ils rencontraient dans leur carrière déjà assez longue de plaideurs et leur amour-propre en fut vivement atteint.

Il n'y avait pas d'autre juridiction dans la Nouvelle-France, mais il y avait le Conseil du Roi dans la vieille France. Les frais d'un semblable appel étaient élevés, mais pour des plaideurs avisés comme le seigneur de Sainte-Anne et sa femme pareille considération n'entrait pas en ligne de compte.

Madeleine de Verchères avait bien confiance dans les avocats qu'elle avait choisis là-bas, mais elle se décida à passer elle-même en France afin d'y surveiller ses intérêts de plus près.

Elle s'embarqua à l'automne de 1732.

Les hauts faits de Madeleine de Verchères étaient bien connus en France. Elle recevait depuis plusieurs années une pension du roi pour sa belle défense du fort de Verchères. Les portes des différents ministères lui furent toutes grandes ouvertes. Le président du Conseil de marine, entre autres, la reçut avec le plus vif intérêt. Mais à l'examen du dossier il constata que le Conseil Supérieur avait bien jugé et que M. et Mme de la Pérade étaient dans le tort. Il refusa l'appel au Conseil du Roi et, pour rendre la pilule moins amère, il fit toutes sortes de belles promesses à Madeleine de Verchères. Les bonnes paroles coûtent peu et les ministre du grand roi en étaient prodigues.

Madame de la Pérade s'embarqua pour la Nouvelle-France au printemps de 1733. Le ministre avait poussé l'amabilité jusqu'à lui permettre de revenir au pays sur un vaisseau du roi. C'est une faveur qui s'accordait bien peu souvent alors.

Pendant le séjour de Madeleine de Verchères en France, le ministre avait écrit au gouverneur de Beauharnois et l'avait prié de régler cette affaire à l'amiable au plus tôt. C'est ce qui eut lieu peu après l'arrivée de Mme de la Pérade.

Le 21 octobre 1733, M. Joachim Fornel, chanoine de la cathédrale de Québec, au nom et comme fondé de pouvoir de M. Gervais Lefebvre, docteur en théologie et curé de Batiscan, et Marie-Madeleine Jarret de Verchères, tant pour elle que pour son mari Pierre-Thomas Tarieu de la Pérade, signaient l'accord suivant: Pardevant les notaires royaux en la prévosté de cette ville de Québec sont comparus Me. Joachim Fornel, prêtre, chanoine de la cathédrale de cette ditte ville, au nom et comme fondé du pouvoir soubs sein privé en datte du premier octobre dernier de Me. Gervais Lefebvre, aussy prêtre et docteur en théologie, et dame Jarret de Verchère faisant tant pour elle que se faisant fort de faire ratiffier le contenu en ces présentes par Pierre-Thomas Tarrieu Eser sieur de la Pérade, offer dans les troupes du détachement de la marine entretenue en ce pays pour le service du Roy, son époux, lesquels sieur Fornel et dame de la Pérade es noms nous ont dits et déclarés que nos seigneurs marquis de Beauharnois, commandeur de l'ordre royal et militaire de St-Louis, gouverneur et lieutenant-général en ce pays, Gilles Hocquart, chevalier coner du Roy, en ses conseils, intendant de justice, police et finances en ce dit pays, ont bien voulu les concilier et accomoder sur l'affaire qu'ils ont eus au conseil dont arrest est intervenu le 23 décembre 1730—en conséquence duquel a été decerné exécutoire pour les depends le sixième aoust 1731 et qu'au moyen de cette consiliation et accomodement faits par nos dits seigneurs le dit sieur Fornel au dit nom tient quitte et décharge les dits sieur et dame de la Pérade des condamnations portées par le dit arrest et exécutoire dont et de quoy les parties nous ont requis acte que nous leur avons octroyés, voulant et promettant qu'il ne soit plus parlé ny question des différents cy-devant mus et de faire cesser tous reproches en cette occasion au moyen de la présente transaction, s'obligeant mon dit sieur Fournel de faire ratiffier par mon dit sieur Lefebvre la présente transaction toutes fois et quantes, car ainsy etc, promettant etc obligeant etc Renonçant etc Fait et à Québec au Palais du Roy dans un des appartements de mon dit seigneur l'intendant après-midy le vingt-unième jour d'octobre mil sept cent trente trois, et ont les dites parties signées avec nous dits notaires. Fornel Ptre, Marie de Verchère de la Pérade, Louet, Hiché."[1]

Le procès du curé Lefebvre contre M. et Mme de la Pérade avait passionné les esprits pendant trois ans mais on ne peut blâmer M. Lefebvre d'avoir revendiqué son honneur. Il était curé d'une importante paroisse et sa réputation devait être intacte pour y exercer son ministère avec fruit.

Cette aventure coûteuse aurait pourtant dû guérir M. et Mme de la Pérade de leur penchant pour les procès. Mais tous deux étaient de sang normand et on dit que dans cette belle et ancienne province du royaume de France il n'est pas nécessaire de mettre de la graine en terre pour récolter des procès. Ils naissent tous seulx comme des champignons dans notre pays.

En 1728, nous voyons encore M. et Mme de la Pérade entrer en procès avec M. Chorel Dorvilliers, au sujet des bornes de leurs seigneuries. Ce procès dura trois ou quatre ans.

En 1736, M. et Mme de la Pérade plaident avec un de leurs censitaires, Pierre Rivard Lanouette. Celui-ci les traîna de juridiction en juridiction et réussit à leur faire dépenser beaucoup de temps et d'argent pour obtenir bien peu.

En 1737, 1738, 1739, 1740, 1741, 1742, 1743, 1744, M. et Mme de la Pérade eurent en moyenne deux et trois procès par année, soit avec les seigneurs voisins soit avec leurs censitaires. Quelques-uns de ces procès furent jugés à leur profit mais dans la plupart des cas ils eurent à subir des pertes assez fortes car alors comme aujourd'hui celui qui casse les verres les paye.

Le 8 août 1747, le deuil entrait dans le manoir de Sainte-Anne de la Pérade. Marie-Madeleine de Verchères, l'héroïne popularisée par le roman, la poésie, le bronze et, disons-le, un peu par les procès, décédait à l'âge de 69 ans.

Après la mort de madame de la Pérade nous cherchons vainement le nom de son mari dans les papiers poussiéreux de nos anciens tribunaux. Son ardeur pour la procédure s'était éteinte avec la mort de celle qui pendant trente ans avait été sa compagne fidèle.

L'honorable M. de Lanaudière, le fils aîné, de Madeleine de Verchères, avait hérité de sa mère son goût pour les procès. Le juge-en-chef Dorion racontait à son sujet une anecdote typique qui mérite d'être reproduite ici:

M. de Lanaudière, quoique bon et assez conciliant, était pourtant quelque peu processif. De temps à autre, lorsqu'il habitait sa

[1]Acte d'accord reçu par Henry Hiché, notaire à Québec, 21 Octobre 1733.

seigneurie de Sainte-Anne, il allait vider ses querelles à Québec, devant les tribunaux. Son principal adversaire était M. Dorion, important marchand de Sainte-Anne. M. de Lanaudière se rendait toujours à Québec en compagnie de son adversaire qu'il faisait monter dans sa voiture. Arrivés à la capitale, ils se séparaient pour se rencontrer devant les juges saisis de leurs griefs respectifs, et, quel que fut le résultat du procès, tous les deux s'en retournaient ensemble à Sainte-Anne, d'aussi bonne humeur que si jamais procès n'avait existé entre eux.

Que cette anecdote nous serve de leçon pour juger la grande héroïne. Mettons d'un côté de la balance, son petit défaut, qui consistait à aimer peut-être un peu trop les procès, et dans l'autre plateau déposons son héroïsme, sa bravoure, son esprit de foi, son patriotisme, son dévouement pour son mari et ses enfants, et ces qualités feront bien vite pencher la balance en sa faveur. Car, encore une fois, elle était femme, et les femmes,—il faut bien l'avouer,—pas plus que les hommes d'ailleurs, ne sont absolument parfaites.

Les Canadiens au lendemain de la capitulation de Montréal (8 septembre 1760).

Par L'ABBÉ IVANHOE CARON, M.S.R.C.

(Lu à la réunion de mai 1921.)

Le 8 septembre 1760, le marquis de Vaudreuil signait à Montréal, la capitulation qui mettait fin à la domination française au Canada. D'un trait de plume, les Canadiens étaient détachés de la mère-patrie, la vieille France, et mis sous la domination d'une puissance étrangère, dont toutes les institutions leur étaient absolument antipathiques. Décimés par la guerre, réduits à la misère, privés de leurs chefs naturels, nos ancêtres avaient tout à craindre et pas grande chose à espérer de leurs vainqueurs. Ces derniers établirent de suite un gouvernement provisoire.

Le généralissime anglais, Sir Jeffrey Amherst en traça lui-même les grandes lignes avant de quitter le pays, pour retourner à New York. Les trois divisions administratives d'avant la conquête furent conservées. Le 16 septembre, le général Gage était nommé gouverneur de Montréal, le colonel Burton[1] gouverneur des Trois-Rivières. Le général Murray qui administrait le district de Québec, depuis la reddition de la ville, fut maintenu dans sa charge. Ils avaient tous trois comme secrétaires, des Suisses ou des Français: Louis Cramahé, à Québec; Joseph Bruyère, aux Trois-Rivières; George Maturin, à Montréal, et leurs ordonnances étaient généralement rendues en langue française.

Dans un placard, daté du 22 septembre, Amherst donnait l'ébauche d'une première législation aux nouveaux sujets. Ceux-ci étaient invités à faire leur soumission, remettre leurs armes et prêter le serment d'allégéance. Le commerce était déclaré libre; seulement les commerçants devaient demander des passeports aux gouverneurs. Amherst indiquait la procédure à suivre dans les procès, enjoignait "aux troupes de vivre avec l'habitant en bonne harmonie et intelligence" et recommandait "pareillement à l'habitant de recevoir et de traiter les troupes en frères et Concitoyens." [1] Cette proclamation concernait les gouvernements de Montréal et des Trois-Rivières, et

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[1]*Documents relating to the Constitutional History of Canada* (1759-1791), selected and edited with notes by Adam Shortt and A. G. Doughty. Second and revised edition, by the Historical Documents publication Board (Pubs-Canadian Archives), Ottawa, 1918, pp. 38-40. Nous citons ordinairement l'édition française de 1911.

visait principalement à l'organisation des cours de justice. Dans ces deux districts les capitaines de milice furent chargés de régler les différends entre habitants. Un tribunal d'appel, présidé par le gouverneur, et dont les membres étaient des officiers de l'armée siégeait à Montréal et aux Trois-Rivières. Dans le district de Québec, le général Murray avait nommé dès le 16 janvier 1760, Jacques Allier juge civil et criminel pour toutes les paroisses, depuis Berthier jusqu'à Kamouraska, et le colonel Young dans la même fonction pour la ville de Québec et les paroisses environnantes.[2]

Le 2 novembre 1760, il établissait à Québec une "Cour et un Conseil Supérieur" formés d'officiers de l'armée anglaise, ayant voix délibérative dans les procès. Deux procureurs-généraux furent aussi nommés, pour les affaires de tutelle et de curatelle, l'apposition des scellés, les inventaires et procès-verbaux, ainsi que pour l'entretien des chemins publics.[3] Ces procureurs, canadiens-français tous deux, étaient aussi chargés de diriger la procédure devant le "Conseil Supérieur." Le greffier de la Cour de Québec, était également un canadien-français, Jean Claude Panet, de même, celui de la Cour de Montréal, Pierre Panet. Toute cette organisation judiciaire, n'avait de militaire que le nom, et était nullement oppressive: "Tout y était français, moins les juges qui paraissent s'être assez bien accommodés de la Coutume de Paris, sans avoir eu la prétention de vouloir y mêler d'aucune manière les lois de l'Angleterre." [4]

Des rapports de sympathie ne tardèrent pas à s'établir entre le peuple et ses nouveaux maîtres. Une chose s'imposait: c'était d'apporter quelque soulagement à la misère générale. Amherst avait écrit aux gouverneurs des colonies voisines, leur demandant d'envoyer "toutes sortes de denrées et de rafraichissements" que les habitants pourraient acheter "au prix courant et sans impots." [5] Au mois d'octobre 1761, M. Briand, vicaire général, dans une lettre adressée à tous les curés du diocèse, leur demandait d'envoyer une liste des familles pauvres de leurs paroisses: "Son coeur rempli d'humanité et naturellement compatissant pour les malheureux, disaitil, en parlant de Murray, lui a suggéré un moyen de leur procurer des secours, qui lui a réussi au-delà de l'espérance." En effet, le gouverneur avait prié les officiers de l'armée anglaise de faire une souscription parmi les troupes, dont le produit fut distribué aux plus indigents.

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[2]*Doc. const. Hist. Canada* (1759-1791), 36-37.

[3]*Cours d'Histoire du Canada*, par Thomas Chapais, t. I (1760-1791), p. 6.

[4]Philias Gagnon, Nos anciennes Cours d'Appel. Dans le *Bul. rech. hist.*, v. XXVI, 1920, 348.

[5]*Doc. const. Hist. Canada* (1759-1791), p. 39.

De plus, chaque militaire donna une journée de ration par mois pour faire face aux nécessités les plus pressantes.[6]

Les paysans avaient prêté sans trop mauvaise grâce le serment d'allégéance; le désarmement leur fut bien plus sensible. C'était quelque chose d'eux-mêmes qu'on leur prenait en leur enlevant le vieux fusil, le compagnon inséparable des courses d'autrefois, le témoin de leurs exploits sur les champs de bataille, un héritage de famille souvent. Heureusement que là encore il y eut des adoucissements. Le général Amherst ordonna "afin de maintenir le bon ordre et la police dans chaque paroisse ou district" de remettre "aux officiers de milice leurs armes" et il ajoutait que "si par la suite il y avait quelquun des habitants qui désireraient en avoir pour la chasse, il devront en demander la permission au Gouverneur signé par led. gouverneur ou ses subdélegué afin que L'officier des troupes commandant du district où ces habitants seront résidant puisse scavoir qu'ils ont droit de porter des armes." [7] Et de fait l'on voit que dans le district des Trois-Rivières, par exemple, la permission de garder leurs fusils fut accordée à cinq, six et même dix habitants, par paroisse Les soldats anglais cantonnés dans les campagnes s'entendaient très bien avec les habitants. "L'Anglais et le Canadien, dit Gage, sont sur le même pied et considérés au même degré sujets d'un même prince; les soldats vivent en paix avec les habitants et de ce contact naissent des sentiments d'affection reciproque." [8]

Lord Egremont, secrétaire d'Etat pour le département des Colonies, avait demandé à Amherst d'avertir les gouverneurs "de donner des ordres précis et très exprès pour empêcher qu'aucun soldat, matelot, ou autre, n'insulte les habitans français qui sont maintenant sujets du même prince; défendant à qui que ce soit de les offenser en leur rappelant d'une façon peu généreuse cette infériorité à laquelle le sort des armes les a réduit, ou en faisant des remarques insultantes sur leur langage, leurs habillemens, leurs modes, leurs coutumes et leurs pays, ou des réflexions peu charitables et peu chrétiennes sur la religion qu'ils professent." [9]

Gage note que pendant toute la durée de son administration, il s'est "appliqué avec le plus grand soin et la plus constante attention à

[6]*Mandements, lettres, pastorales et circulaire des évêques de Québec publiés*, par Mgr. Têtu et l'abbé C. O. Gagnon (1887-1890), T. II, p. 149.

[7]Placart du général Amherst, 22 septembre 1760 (*Report of the Public Archives for the year* 1918, 20).

[8]Rapport du Général Gage concernant le gouvernement de Montréal, 20 mars 1762. (*Const. Hist. Canada* (1759-1791), ed. française, Ottawa, 1911, p. 54.

[9]Lord Egremont à Sir Jeffrey Amherst, 12 septembre 1761, *Archives Canadiennes*, B. 37, p. 10.

ce que les Canadiens fussent traités conformément aux sentiments de bonté et d'humanité de Sa Majesté à leur égard. Aucun empiètement sur leurs propriétés, aucune insulte à leur personne n'ont été laissés impunis; les moqueries au sujet de la sujétion que leur a imposée le sort des armes, les remarques injurieuses à l'égard de leurs coutumes ou de leur pays et les réflexions concernant leur religion ont été réprimées et interdites."[10]

La politique d'Amherst et des gouverneurs fut donc de ne rien bouleverser, de ne rien faire qui indiquât en quelque chose la volonté d'opprimer les vaincus. Au contraite, on perçoit chez le vainqueur le désir sincère de s'attacher les nouveaux sujets par toutes sortes de bons procédés. Comment nos pères acceptèrent le nouveau régime, quelles furent leurs impressions, leurs craintes, leurs espérances en face de la réalité: voilà ce qui est intéressant à étudier.

Ici, il faut distinguer; il y a des nuances dans les sentiments. Les paysans, les nobles, les chefs religieux n'envisagent pas les choses du même point de vue, et leur état d'âme diffère d'autant.

Les paysans avaient beaucoup souffert pendant les dernières campagnes; trainés d'un champ de bataille à l'autre, la guerre avec ses maux, avait pesé sur eux de tout son poids. Aussi, la paix fut pour eux une délivrance. Au lendemain de la capitulation de Montréal, ils s'empressent de retourner sur leurs fermes, heureux de jouir enfin de la tranquillité qu'ils désirent depuis si longtemps. Murray les admire: "Ils constituent, dit-il, une race forte et pleine de santé. Ces gens se vêtent sans recherche, sont vertueux dans leurs moeurs et tempérants dans leur genre de vie."[11] "Les habitants, particulièrement, les paysans, dit Burton, paraissent très satisfaits d'avoir changé de maîtres. Jouissant du libre exercice de leur religion, ils conmencent à comprendre qu'ils ne sont plus des esclaves et qu'ils jouissent complétement des bienfaits et des bontés de cet excellent gouvernement qui fait la félicité particulière de tous les sujets de l'empire britannique."[12] Burton généralise peut-être un peu trop. Au fond, les vieux canadiens gardent le souvenir de la mère-patrie, et pendant longtemps, il restera vivace dans leur coeur. Dire qu' "ils paraissent très satisfaits," c'est leur prêter un sentiment qu'ils n'ont pas encore eu le temps d'analyser. Pour le moment, ils acceptent volontiers le nouvel état de chose, tout en escomptant qu'il n'est pas définitif.

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[10]Rapport du général Gage, *loc. cit.*, p. 54.

[11]Rapport du général Murray concernant le gouvernement de Québec, au Canada, 5 juin 1762, *Doc. const. Hist. Canada* (1759-1791), ed. française, 1911, 45.

[12]Rapport du colonel Burton concernant l'état du gouvernement des Trois-Rivières, avril 1762, *Doc. const. Hist. Canada* (1759-1791), ed. française, 1911, 51.

Une chose qui ne leur déplait certainement pas, c'est d'être débarrassés des concussionnaires comme Bigot et ses complices, qui les ont si vilement pressurés dans les dernières années de l'ancien régime. Laboureurs, avant tout, ils se sont remis à la culture de la terre, avec plus d'ardeur que jamais. Haldimand écrivait au mois d'août 1762, qu'ils prisaient leur liberté et faisaient paisiblement leur récolte.[13] Les facilités offertes aux habitants pour écouler leurs produits, les encourageaient à travailler et à étendre leurs cultures. La vieille monnaie de papier, avait été remplacée par de belles pièces d'argent, et des ordres sévères avaient été donnés aux troupes anglaises cantonnées dans les campagnes de payer ce qu'elles achetaient des habitants "en argent comptant et espèces sonnantes." Les produits de la terre se vendent bien et les pièces d'argent tombent à profusion dans le gousset des paysans. Ils sont devenus tellement âpres au gain, qu'à la demande de Murray, M. Briand prie les curés, de présider eux-mêmes à la déclaration des blés, durant l'hiver de 1760-61, afin qu'elle se fasse avec plus de précision "Peut-être que l'espérance, écrit le grand-vicaire, de vendre leurs blés plus cher le printemps prochain les tentera d'être infidèles dans leur déclaration; mais outre que vous ne vous en rapporterez pas trop à leur bonne foi, vous pouvez les prévenir que M. notre Gouverneur prend des arrangements qui détruiront leur espérance. Vous pourriez encore ajouter à plusieurs d'entre eux que la charité n'est pas la seule vertu qui demande qu'ils retranchent même sur leur nécessaire, pour le soutien de tant de concitoyens réduits à l'extrême nécessité, et que ce serait un moyen pour eux de réparer bien des injustices dont ils se sont rendus coupables ci-devant par une trop grande avidité du gain, le prix excessif qu'ils ont exigé pour les choses les plus nécessaires à la vie."[14]

Voilà ce qui console pas mal nos paysans du changement de régime. Les uns trouvent un bon marché pour écouler leurs produits, les autres sont secourus dans leur dénuement: l'aisance revient, et avec elle, la joie et le bonheur. Gens simplistes, vivant dans un horizon très restreint, ils amassent la manne qui tombe, et ne se préoccupent pas trop de l'avenir. Haldimand le constate, et met un peu d'emphase pour nous l'apprendre: "Les habitants, écrit-il à Amherst seraient au désespoir de voir arriver une Flotte et des Troupes Françaises . . . ils commencent trop à goûter le prix de la liberté pour être la duppe des Français dans un pareil cas. . . ."[15]

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[13]Haldimand à Amherst, Trois-Rivières, 25 août 1762, *Arc. can.*, B. I, fol. 216.

[14]*Mand. des év. de Québec.* Circulaire du 18 janvier 1761. T. II, p. 153.

[15]Haldimand à Amherst, Trois-Rivières, 26 décembre 1762, *Arch. can.*, B. I, fol. 262.

Confiné dans les cadres de sa petite paroisse, le paysan y retrouve d'ailleurs presque toutes les institutions de l'ancien régime. S'il a des différends avec son voisin, c'est devant les capitaines de milice, que se vide la querelle; il va rarement devant le tribunal d'appel, le plus souvent c'est le curé qui règle l'affaire. Ce sont encore les capitaines de milice qui promulguent les ordonnances des gouverneurs, et voient à leur observation. Ces ordonnances ressemblent à s'y méprendre à celles des anciens intendants français; elles sont calquées sur celles de l'ancien régime, rédigées dans le même style. L'orthographe seule indique qu'elles émanent de quelqu'un incomplêtement familiarisé avec la langue française.

Les soldats de l'occupation sont d'ailleurs les seuls gens de langue anglaise que l'on rencontre dans les campagnes. Les marchands venus de l'Angleterre et des Etats limitrophes de la Nouvelle-Angleterre, s'établissent de préférence dans les villes. Rien donc n'était changé dans les us et coutumes de la campagne. La vie paroissiale avait repris son cours habituel. Groupés autour du clocher du village, les paysans s'occupaient fort peu de ce qui se passait au dehors, et vivaient dans une heureuse quiétude.

Les nobles voient les choses sous un autre jour. Murray trace d'eux un portrait qui est loin d'être flatteur. "Les nobles, dit-il, sont généralement pauvres, exceptés ceux qui ont exercé des commandements aux postes éloignés où ils ont ordinairement réalisé une fortune dans l'espace de trois ou quatre ans. La croix de Saint-Louis suffisait à peu près à mettre le comble à leur bonheur. Ils sont extrêmement vaniteux et témoignent le plus grand mépris pour la classe commerciale de ce pays, bien qu'ils ne se soient fait aucun scrupule de se livrer au commerce assez activement même, lorsqu'une occasion favorable leur permettait d'en retirer des avantages. C'étaient de grands tyrans pour leurs vassaux qui obtenaient rarement de faire cesser les abus, quelque justes que fussent leurs plaintes.

"Cesse classe ne s'attachera pas au gouvernement anglais dont elle ne pourra obtenir ni les mêmes charges ni les mêmes douceurs dont elle jouissait sous le régime français."[16] Murray modifiera à la longue ce jugement un peu prématuré, et verra qu'il y a lieu de faire ici une distinction.

Parmi ces nobles, plusieurs sont venus dernièrement de France. Il est évident que ceux-ci se rallieront difficilement à l'administration nouvelle. La plupart, cependant, sont les descendants d'anciens seigneurs du pays. Propriétaires eux-mêmes de beaux lopins de terre, ils ont négligé jusqu'ici l'exploitation agricole, pour se livrer à la

[16]Rapport sur le gouvernement de Québec, *loc. cit.*, pp. 44-45.

traite des fourrures, tenir un poste de commandant dans les régions de l'ouest, ou occuper une situation quelconque dans l'armée. La carrière militaire surtout, en même temps qu'elle leur ouvrait le chemin des honneurs, leur procurait les appointements suffisants pour vivre à la ville, loin de leurs censitaires. La vie fastueuse qu'ils y menaient, les avait mal préparés au coup qui les frappait. Les voilà désarçonnés en voyant tomber l'échafaudage administratif de l'ancien régime. Toutes les positions leur sont maintenant fermées et à leur place, s'installent des marchands, des fonctionnaires anglais, dont la morgue hautaine les humilie profondément.

On vient de voir avec quelle ironie Murray se moquait des *Croix de Saint-Louis*. Haldimand dira quelque mois plus tard qu'il voudrait bien être débarrassé de toutes les *Croix de Saint-Louis* et des prêtres.[17]

Evidemment les nobles n'ont pas la faveur des gouverneurs, et ne peuvent compter sur leurs bonnes grâces pour le moment. Que faire? Plusieurs songent à émigrer, à aller chercher fortune en France. "La haute classe seule, dit Burton, aura peut-être l'intention de quitter le pays, s'il reste sous le gouvernement de la Grande-Bretagne."[18] En effet, dès l'automne de 1761 quelques familles s'étaient embarquées pour la France. Malheureusement le navire qui les portrait, *l'Auguste*, s'était jeté sur les récifs de l'ile du Cap-Breton, et tous à l'exception de quelques hommes de l'équipage et de Louis Luc de La Corne, sieur de Saint-Luc, avaient péri misérablement.[19]

Ces départs ne se généralisent pas, car la plupart des membres de la noblesse sont bien décidés de rester au pays. Du reste, dès le début les gouverneurs manifestent l'intention de maintenir en vigueur, le vieux régime féodal. C'est ainsi que Gage ordonne dans l'hiver de 1761, à un certain nombre des censitaires des seigneuries de Saint-Ours, de Vaudreueil, de l'ile Perrot, de Longeueil, de Montarville, de Varennes, de Contrecoeur et de l'ile Jésus, d'aller résider sur les lots qui leur ont été concédés.[20] Bien plus, on veut conserver aux seigneurs leurs privilèges et leurs droits, comme il appert par une ordonnance de Gage (2 avril 1762), émise à propos de l'achat qu'avait fait le sieur Baron, de la seigneurie de l'ile Saint-Paul. Le

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[17]Haldimand à Gage, Trois-Rivières, 15 avril 1764 (*Arc. can.*, B. 22, fol. 9).

[18]Rapport sur le gouvernement des Trois-Rivières, *loc. cit.*, p. 51.

[19]*Journal de voyage de M. de St. Luc, dans le navire l'Auguste en l'an 1761*, seconde édition, 1863.

[20]*Report of the Public Archives for the year* 1918, Ottawa, 1920. Ordonnances and proclamations of the Règne militaire, pp. 41 et 101.

gouverneur déclare qu'il accorde "aud. S. Baron et ses enfants le même droit et privilège quon toujours jouis tous les seigneurs et Gentilhomme de ce pays et qu'il ne recevra aucune ordre pour aucune article du Service du Roy que par une particulière du Gouverneur ou de quelquun muni de son pouvoir."[21]

Les seigneurs retournent donc sur leurs domaines. Réduits, pour la plupart, à la misère, leur prestige d'autrefois a considérablement diminué, tout de même, le paysan respecte leur malheur, et leur garde son affection. Pendant longtemps encore, le seigneur sera le principal personnage de la paroisse.

Il reste un autre élément: le clergé. Murray se rend compte immédiatement de sa puissance. "L'influence du clergé sur le peuple, écrit-il, a été et est encore très grande."[22] Gage ajoute qu'il faudra compter largement sur le clergé pour faire disparaître "le sentiment de jalousie" qui existe dans le pays contre les Anglais, et il suggère "de prendre le moyen de confier la charge des cures à des prêtres bien intentionnés."[23] Murray et Gage disaient vrai; c'était le clergé qui allait prendre la direction de la petite nation abandonnée de la France. Un historien contemporain peu "suspect de complaisance" M. André Siegfried a écrit: "L'Eglise tient, sur les bords du Saint-Laurent, une place à part, elle a été de tout temps pour ses disciples une protection fidèle et puissante; notre race et notre langue lui doivent peut-être leur survivance en Amérique. . . . Sans l'appui du prêtre, nos compatriotes d'Amérique auraient sans doute été dispersés ou absorbés. C'est le clocher du village qui leur a fourni un centre, alors que leur ancienne métropole les abandonnait totalement et leur retirait même les autorité sociales autour desquelles ils auraient pu grouper leur résistance; c'est le curé de campagne qui, par son enseignement de chaque jour, a perpétué chez eux ces façons de penser et ces manières de vivre qui font l'individualité de la civilisation canadienne; c'est l'Eglise enfin qui, prenant en main les intérêts collectifs de notre peuple, lui a, plus que quiconque, permis de se défendre avec succès contre les persécutions ou les tentations britanniques."[24]

L'Eglise du Canada se trouvait alors dans une position critique. Son premier pasteur, Mgr de Pontbriand était décédé quelques mois avant la capitulation de Montréal. La nomination d'un nouvel évêque n'était pas possible dans le moment, et la vacance du siège

[21]*Idem*, p. 54.
[22]Rapport sur le gouvernement de Québec, *loc. cit.*, p. 45.
[23]Rapport concernant le gouvernement de Montréal, *loc. cit.*, p. 57.
[24]André Siegfried, *Le Canada, les deux races*, pp. 12-67.

de Québec, devait se prolonger jusqu'au 21 janvier 1766, par suite d'évènements dont on pourra lire la trame ailleurs.[25] Celui-là même qui devait être l'élu du Seigneur, M. Briand, avait été chargé de la direction du diocèse par ses confrères. Son tact, sa prudence, sa bonté devaient lui gagner immédiatement la confiance et l'estime de Murray. Nous avons vu comment ils s'étaient entendus pour recueillir des aumônes, et secourir les nécessiteux dans les paroisses ravagées par la guerre. Murray prête son concours à M. Briand, dans des circonstances plus délicates. A la demande du vicaire capitulaire, le gouverneur oblige un curé à quitter sa paroisse, et M. Briand, le remercie en ces termes: "Recevez, je vous prie, mes très humbles et sincères remerciements pour la protection que vous donnez à l'autorité ecclésiastique. . . . Continuez à l'Eglise votre protection, ajoute-t-il. J'oserais presque vous dire que vous y êtes obligé, comme elle l'est de vous honorer. NON ENIM SINE CAUSA GLADIUM PORTAT, nous dit saint Paul, en parlant de la puissance séculière, laquelle doit se prêter au soutien de la religion, comme la puissance ecclésiastique à faire rendre aux peuples le respect et l'obéissance qu'ils doivent aux Princes et aux Supérieurs."[26] A l'occasion du couronnement de Georges III, de son mariage, en 1761, et de la naissance du Prince de Galles, en 1762, M. Briand et les grands vicaires des Trois-Rivières et de Montréal, MM. Perrault et Montgolfier, ordonnent des *Te Deum*, dans toutes les églises. "Il est juste, dit M. Briand, qu'en sujets fidèles nous prenions part à la joie des peuples qui le reconnaissent pour souverain, et que nous unissions nos voeux à ceux qu'ils adressent au Ciel pour le bonbeur de leurs Majestés."[27]

Ces bons procédés ne pouvaient manquer d'exercer une heureuse influence sur l'esprit des gouverneurs. Aussi pendant les trois années du Règne militaire, ceux-ci voient à ce que les Canadiens ne soient pas molestés dans l'exercice du culte. Les gouverneurs sont pleins de respect envers le clergé, et compte sur lui pour faire accepter le nouveau régime. Tous trois sont cependant d'accord pour déclarer qu'on ne doit fermer l'accès du pays aux prêtres d'origine étrangère. Imbus des préjugés de leur époque et de leur race, Murray, Gage et Burton consentent volontiers à tolérer le clergé indigène, mais lui permettre

[25]Voir notamment: Abbé Auguste Gosselin. *L'Eglise du Canada après la conquête.* Première partie (1760-1775), 1916. M. Thomas Chapais: *Cours d'histoire du Canada*, Tome I (1760-1791), 1919, p. 29 à 61. Abbé Lionel Groulx: *Lendemains de conquête*, 1920, p. 137 à 178.

[26]Abbé Auguste Gosselin, *op. cit.*, p. 22.

[27]*Mand. des évêques de Québec*, t. II, p. 160.

de se recruter, par l'appoint de prêtres venus de France, c'était mettre en danger la constitution anglaise. Ces deux questions de la nomination de l'évêque et du recrutement du clergé ne devaient prendre une tournure critique qu'au lendemain du traité de Paris. Pour le moment les autorités religieuses s'entendent à merveille, avec les autorités civiles. M. Briand le reconnait avec enthousiasme dans la belle lettre qu'il adresse au clergé et aux fidèles du gouvernement de Québec (4 juin 1763), pour leur annoncer la conclusion de la paix, qui confirmait la cession du pays à la Grande-Bretagne. "Nos voeux, écrit M. Briand, n'ont peut-être pas été exaucés dans leur étendue, le Canada avec toutes ses dépendances, ayant été irrévocablement cédé à la couronne de la Grande-Bretagne; mais rapportez-vous en, Nos Très Chers Frères, aux soins de l'adorable Providence, dont la conduite est très souvent d'autant plus miséricordieuse qu'elle est moins conforme à nos désirs, et flatte moins nos inclinations. N'en avons-nous pas une preuve manifeste dans la conduite que nos vainqueurs ont tenue à notre égard depuis la conquête de la colonie?

"La reddition de Québec vous laissait à la disposition d'une armée victorieuse; vous fûtes sans doute d'abord alarmés, effrayés, consternés. Vos alarmes étaient fondées; vous saviez ce qui se passait en Allemagne, et cous crûtes déjà voir fondre sur vous les mêmes malheurs. Vous ignoriez que l'aimable et toujours attentive providence vous avait préparé un gouverneur qui, par sa modération, son exacte justice, ses généreux sentiments d'humanité, sa tendre compassion pour le pauvre et le malheureux, et une rigide discipline à l'égard de ses troupes, devait faire disparaître toutes les horreurs de la guerre. Où sont en effet les vexations, les concussions, les pillages, les onéreuses contributions qui marchent ordinairement à la suite de la victoire? Ces nobles vainqueurs ne vous parurent-ils pas, dès qu'ils furent nos maîtres, oublier qu'ils avaient été nos ennemis, pour ne s'occuper que de nos besoins et des moyens d'y subvenir."[28]

Violà, nous semble-t-il, ce qui peint assez bien, l'état d'âme du clergé canadien, à cette époque. Les chefs religieux, et avec eux les nobles, avaient conservé l'espoir que le Canada retournerait à la couronne de France. C'est un rêve qu'ils caressaient et qui semblait devoir se réaliser. Mais voici que par un nouveau coup de la Providence, le sort de la Nouvelle-France, était irrévocablement fixé. Les Canadiens étaient suivant l'expression de M. Briand, "désormais agrégés" à la nation anglaise. C'est sans arrière-pensée que celui-ci demandait à tous d'accepter la décision finale. Et d'ailleurs con-

[28] *Mand. des Ev. de Québec*, t. II, p. 169.

venait-il de se livrer à des appréhensions funestes? Est-ce que la conduite des vainqueurs pendant les trois années qui viennent de s'écouler n'a pas été un indice de celle qu'ils suivront dans l'avenir? "Soyez donc exacts, continuait M. Briand, à remplir les devoirs de sujets fidèles et attachés à leur Prince, et vous aurez la consolation de trouver un Roi débonnaire, bienfaisant, appliqué à vous rendre heureux, et favorable à votre religion, à laquelle nous vous voyons avec une joie inexprimable si fortement attachés."[29]

Le libre exercice de la religion catholique, accordé par les capitulations de Québec et de Montréal, était garanti par le traité de Paris. N'y avait-il pas lieu de se réjouir, et de jurer une inviolable fidélité au nouveau monarque?

En somme, nos ancêtres paraissent s'être très bien accommodés du régime militaire, et en avoir conservé un agréable souvenir. C'est ce qu'ils admettaient quelques années plus tard dans une adresse au roi pour demander le rétablissement des lois françaises: "Notre reconnaissance, disaient-ils, nous force d'avouer que le spectacle effrayant d'avoir été conquis par les armes victorieuses de votre Majesté n'a pas longtemps excité nos regrets et nos larmes. Ils se sont dissipés à mesure que nous avons appris combien il est doux de vivre sous les constitutions sages de l'empire Britannique. En effet, loin de ressentir au moment de la conquête les tristes effets de la gêne et de la captivité, le sage et vertueux Général qui nous a conquis, digne image du souverain glorieux qui lui confia le commandement de ses armées, nous laissa en possession de nos loix et de nos coûtumes. Le libre exercice de notre religion nous fut conservé, et confirmé par le traité de paix: et nos anciens citoyens furent établis les juges de nos causes civiles. Nous n'oublirons jamais cet excès de bonté, ces traits généreux d'un si doux vainqueur seront conservés précieusement dans nos fastes; et nous les transmettrons d'âge en âge à nos derniers neveux."[30]

Nous ne pouvons rien ajouter à ces paroles un peu obséquieuses, il est vrai, mais qui, en réalité, confirment ce que nous venons de dire sur l'état d'âme des Canadiens, pendant la durée du Règne Militaire.

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[29]*Mand. des Ev. de Québec*, t. II, p. 171.

[30]Pétition des sujets français (décembre 1773). *Doc. const. Hist. Canada* (1759-1791), édition française, p. 335.

Guerres des Iroquois, 1670-1673.

Par BENJAMIN SULTE, M.S.R.C.

(Lu à la réunion de mai 1921.)

La paix dite générale, négociée de 1667 à 1669 et conclue en 1670, rendit la tranquillité au Bas-Canada mais ne fit que laisser le champ libre aux Iroquois pour continuer leurs conquêtes parmi les nations éloignées. Durant trente-six mois ils ne cessèrent de porter leurs armes autour d'eux et d'anéantir des campements, des villages, des tribus dont un certain nombre alliés des Français. Ces dévastations nous paraissent avoir été peu étudiées: on en trouvera le recit dans ces quelques pages.

I.

Commençons par placer les groupes de Sauvages dans leurs territoires respectifs.

Jean Nicolet, en 1634, traversa, du nord au sud, la baie dite des Puants depuis son entrée jusqu'à la rivière venant du sud qui se décharge dans cette nappe d'eau. Les Puants demeuraient sur le bas de la rivière et s'étendaient jusqu'au lac Winnibago qui porte leur nom: eau puante. Après trois journées de canots, il se trouva sur le site de la ville actuelle d'Oshkosh, puis continuant son chemin en remontant la rivière, qui est sinieuse, accidentée d'évasements, marais et anses ou baies, il parvint à l'endroit où s'établirent, vingt-trois ans plus tard, les Kikapous, les Miamis, les Maskoutins. Cette partie de la rivière était déserte. Les Outagamis ou Renards n'y étaient pas encore établis. Il faut se rendre à 1660 avant que de pauvoir dire "rivière des Renards." Les Puants seuls occupaient en 1634 le bas de ce cours d'eau.

Rendu à six journées de la grande baie, Nicolet se voyait vis-à-vis le coude de la rivière Wisconsin que l'on nomme le Portage. S'il eut franchi ce portage il aurait pu naviguer cent dix-huit milles sur la rivière Wisconsin avant que d'atteindre le Mississippi. C'est au moins trois jours de canot.

Au pays des Hurons, au lac Nipissing, à la côte nord de la baie Georgienne, les Puants étaient redoutés. On les disait méchants et ravageurs. Leur langue différait de toutes les autres. Ils eurent des conflits avec les Illinois qui demeuraient vers Chicago et qui n'étaient nullement belliqueux, mais ceux-ci finirent par se fâcher.

A partir de 1650, les Hurons et les Outaouas réfugiés à la baie one dû avoir connaissance de ces faits, particulièrement de l'invasion des Illinois, en 1653, qui se termina par le massacre des Puants, lesquels se voyant réduits à une petite bande d'individus, passèrent au fond de la baie et se tintent assez tranquilles par la suite.

Pourquoi les Français ont-ils toujours dit: "la baie des Puants" alors que, dès 1658, les Malhomines et les Poutéauatamis étaient plutôt les habitants de cette sorte de lac? Probablement parceque le nom des Puants leur était connus depuis 1634 au moins, et, en 1658, 1660, 1663, 1665, les voyant dans la baie, on me tient aucun compte du fait que, avant 1653, il avaient vécu sur la rivière. Les Poutéouatamis et les Malhomines étaient-ils des nouveaux venus? C'est possible.

En 1656, les Iroquois, ayant donné à entendre aux Français qu'ils ne leur feraient plus la guerre d'incursions qui durait depuis des années, tournèrent leurs armes contre les Eriés (de langue iroquoise) occupant le nord de l'Ohio jusqu'au lac Erié et les anéantirent en incorporant dans leurs tribus ceux qui échappèrent à la hache, puis, sans reprendre haleine, ils chassèrent du Michigan nord les Outagamis (Renards), les Maskoutins, les Kikapous, les Miamis, petites tribus algonquines, qui se retirèrent sur la rivière dite aux Renards (nom des Outagamis). Ce n'est pas tout: il y avait, aux environs de Chicago la grande nation des Illinois. Celle-ci, attaquée à son tour (1657) abandonna la contrée et alla s'établir dans l'Iowa, fuyant par la rivière Illinois et traversant le Mississipi.

Lorsque Chouart et Radisson, en 1658, parcoururent la rivière qui se decharge dans la baie Verte et la remontèrent le plus loin possible, ils firent connaissance avec ces peuplades nouvellement arrivées sur les lieux mais ils en parlent comme de gens établis depuis longtemps, ce qui a trompé les historiens.

En 1670, partant du sud, aux environs de Milwaukee, où étaient les Miamis, on rencontrait, en allant au nord les Makoutins, puis, sur la rivière aux Renards, les Oumamis (seule tribu illinois) ensuite les Outagamis ou Renards, puis les Poutéouatamis qui paraissent avoir aussi formé un groupe important vers l'entrée de la baie Verte, côté intérieur sud-est de cette nappe d'eau. Les Malhomines ou Folles-Avoines, ainsi que le reste des Puants occupaient le fond de la baie.

La mission Saint-Jacques fondée chez les Maskoutins en 1669 par le Père Allouez, était située près de Governor's Bend sur la rivière aux Renards et non pas aux environs de Chicago comme on l'a dit souvent. Ce peuple algonquin avait été signalé, dès 1615, comme habitant la région du Détroit, d'où les Iroquois le chassèrent en 1657. Il était rendu en haut de la rivière aux Renards en 1659 puisque Radisson et Chouart le visitèrent en cet endroit la même année. En 1660, la Père Menard donne à entendre qu'ils avaient un village ou campement à Chagouamigon, lac Supérieur, mais la tribu demeurait sur le haut de la rivière aux Renards. Il n'est pas possible que Nicolet, en 1634, les ait vus dans le voisinage du coude de la rivière Wisconsin puisqu'ils habitaient alors les terres du Détroit allant vers la baie de Saginaw. Une branche de la tribu vivait sur la rive sud du lac Supérieur, vers Chagouamigan, avec des Outaouas, en 1667. C'est alors qu'un bon nombre se firent chrétiens. Une branche portait le nom de Kikapous et un autre Kiskacons. On les retrouve en compagnie des autres peuples de la rivière aux Renards de la baie Verte et du sud du lac Supérieur. (La Potherie II. 49. Relation, 1658, p. 21; 1659, p. 19; 1667, p.17; 1670, pp. 87, 89, 100.)

Les missions établies avant 1672 étaient au nombre de neuf: Saint-Michel et Sainte-Thérèse que le Père Ménard commença en 1660 à Chagouamigon. La Pointe ou Sainte-Esprit dans la même contrée, œuvre du Père Allouez en 1665. La maison-mère du saut Sainte-Marie, 1670. Saint-François-Xavier chez les Poutéouatamis, au fond de la baie Verte. Un autre Saint-François à la rivière aux Renards, à cinq milles de la baie. On mentionne Saint-Marc chez les Poutéouatamis, Saint-Ignace à Michillimakinac, Saint-Simon sur l'île Manitoualine.

"Quatre nations de celles qui composent la mission de Saint-François-Xavier dans le baie des Puants, ont pris à la Pointe (sud-ouest du lac Supérieur) les premières teintures de la Foi, pendant le temps qu'elles y ont résidé fuyant la poursuite des Iroquois." (Le Père Marquette: *Relation*, 1670, p. 87.)

Les peuples de la baie Verte et de la rivière aux Renards vivaient de blé-d'Inde, courges, citrouilles, folle-avoine, buffle et autres gibiers, sans compter la pêche, aussi étaient-ils nombreux, sous les noms d'Outagamis, Mascoutins, Malhomines, Puants et Poutéouatamis, tous de langue algonquine sauf le Puants qui parlaient autrement que n'importe quelle autre nation et non pas un dialecte sioux comme on l'a cru.

Les Miamis, dans la région de Milwaukee, avaient de la poterie. Le Sauvage arrivé à la connaissance de cette fabrication est considéré comme entrant (par une porte étroite) dans la civilisation. Il est sur la voie où il se procurera d'autres ustensiles et tout cela l'invite à prendre une demeure stable, à cultiver la terre, à se donner une organisation sociale, en un mot à sortir de l'état sauvage. Les

Iroquois, les Hurons et les Sioux étaient plus avancés que les Miamis sous tous les rapports.

Les Hurons et les Outaouas, vers 1660 et jusqu'à 1670 et même plus tard, étaient principalement concentrés à la rive sud-ouest du lac Supérieur, à la Pointe du Saint-Esprit, à Kionconan ou Kewana aujourd'hui.

Les Sauteurs (saut Sainte-Marie) s'étaient sauvés au nord en 1650. De tout temps cette tribu ne compta que de cent cinquante à deux cents personnes. De retour au saut, en 1670, elle ne dépassait pas cent cinquante âmes. Les Maramego, autre petite lande, s'incorporèrent alors aux Sauteurs.

Les Mississagués, de la côté nord de la baie Georgienne et aussi de l'île Manitoualine s'étaient enfuis dans la profondeur des terres du nord en 1650, mais un certain nombre était entré dans le Haut-Canada et s'était installé dans le pays des Hurons. Ceux du nord rentrèrent chez eux à la côté d'Algoma en 1670, mais le contingent du pays des Hurons se répandit vers le lac Sainte-Claire et Cataracoui. Ils ne se gênaient pas d'attaquer les Iroquois quand l'occasion s'en présentait et même allaient inquièter leurs campements sur la rive nord du lac Ontario.

Les Nipissiriniens, réfugiés au nord, en 1650, chez les Gens des Terres, reprirent en 1670, leur pays du lac Nipissing et se répandirent un peu dans le Haut-Canada. Les Gens des Terres, langue algonquine comme les Mississagués, Sauteurs, Nipissiriniens, vivaient en nomades à égale distance de la baie d'Hudson et des lacs Supérieur, Huron, Nipissing.

II.

Talon écrivait, le 2 novembre 1671: "La paix est également profonde au dedans et dehors de cette colonie. Les Iroquois, après avoir un peu grondé contre les Sauvages (de l'ouest) qui se sont mis sous la protection du roi (juin 1671) et auxquels ils faisaient la guerre, se sont enfin contenus dans leur devoir et, quoiqu'il y ait entre (parmi) eux quelque brutal qui, dans l'ivroguerie, casse quelque tête, il y a lieu de croire que la communauté préférera toujour la paix à la guerre."

Les Iroquois se contenaient pour le moment sans renoncer à leur système de ravage, ayant autant qu'autrefois l'espoir de devenir la seule nation aborigène maîtresse des grands territoires de chasse.

Ce même automne de 1671, Marie de l'Incarnation disait: "Les Tsonnontouans ont remué pour faire la guerre aux Outaouak. Monsieur notre gouverneur a tellement intimidé les uns et les autres qu'il les a rendus amis, néanmoins, comme l'on ne peut se fier entièrement aux Sauvages, afin de leur faire voir qu'on les pourra humilier quand on voudra, il a pris, sans faire bruit, une troupe de Français et s'est embarqué avec eux en des bateaux et en des canots qu'il a conduits par des rapides et bouillons où jamais les Sauvages n'avaient pu passer, quoiqu'ils soient très habiles à canoter." Cette expédition avait remonté le Saint-Laurent jusqu'à Cataracoui.

Les Tsonnontouans (Senecas en anglais) étaient les Iroquois de Buffalo aujourd'hui. M. de Courcelles s'était rendu jusqu'à Cataracoui et la baie de Quinté avec beaucoup de gens armés. La religieuse ajoute: "Avant ces troubles les Tsonnontouans étaient d'intelligence avec les Anglais pour leur mener (amener) les Outaouaks, afin de frustrer la traite des Français, ce qui eût perdu tout le commerce (du Canada) mais les Anglais, ayant appris ce voyage de monsieur le gouverneur chez les Sauvages, ne furent pas moins effrayés que les Sauvages mêmes et eurent crainte qu'il n'allât les attaquer pour les chasser de leur lieu." Ceci est étrange puisque jamais les rois de France et d'Angleterre ne furent plus liés d'amitié qu'à cette époque. La Mère continue: "Tous les Iroquois sont si petits (abaissés) et si humiliés depuis que les Français les ont brulés (villages brulés en 1666) que, dans la crainte qu'ils ne le fassent encore, ils sont doux comme des agneaux et se laissent instruire comme des enfants."

Cette soumission portée du côté des Français n'empêchait pas de préparer des plans pour anéantir les nations de l'ouest, s'emparer du commerce des fourrures et le transporter aux Anglais des fleuve Hudson et des côtes de l'Atlantique.

III.

La première expédition militaire des Iroquois était déjà commencée au moment où Talon et la Mère ursuline écrivaient, mais non pas contre les peuples de l'ouest et voici pourquoi. En remontant à l'année 1600 on trouve les Hurons du Haut-Canada et les Andastes de la Pennsylvanie en rapports de commerce et d'amitié, étant de même race, langue, mœurs et coutumes, ce qui veut dire aussi qu'ils étaient comme les Iroquois. Or, la haîne de ces derniers envers les Hurons s'étendait aux Andastes et quand les bandes iroquoises n'attaquaient point les Hurons c'était qu'on les employait contre les Andastes. La campagne de 1672 se termina par l'anéantissement des Andastes, avec ceci de remarquable, nous dit Perrot (page 129 de son Mémoirs) que les Iroquois augmentèrent considérablement leurs forces "par le grand nombre d'enfants et autres prisonniers auxquels ils donnèrent la vie" et qui furent incorporés dans les cinq cantons. En plus, ceux des Andastes qui avaient échappé à ce massacre se rendirent aux vainqueure et grossirent encore le nombre de leurs familles. La même chose avait eu lieu chez les Hurons en 1650 et 1656 pour ne mentionner que ces deux dates.

Les Iroquois faisaient tout en grand. Ils avaient des vues à longue portée. Leurs calculs étaient si bien établis que, presque toujours, ils réussissaient. Comme les Romains, ils voulaient dominer partout. Avec un esprit politique rare chez des Sauvages, ils savaient agir d'après un plan d'ensemble dont aucun détail n'était négligé. Rien en se faisait chez eux sans des études soignées et la connaissance des situations. Chaque chose était si parfaitement ordonnée qu'il en résultait une discipline générale dont ils tiraient des ressources inouïes.

Pour compléter leurs forces ils se tournèrent du côté des Chouanons. Nicolas Perrot nous dit (p. 12, 79, 166) que, probablement vers 1560, les Iroquois de Montréal et des environs, fuyant les Algonquins, s'étaient rendus au lac Erié et y rencontrèrent les Chaouanons qui les reçurent mal, puis le refoulèrent le long du lac Ontario, rive orientale. On sait que les Iroquois, se pénétrant peu à peu du génie de l'organisation, devinrent formidables. Ils ne manquèrent pas d'aller attaquer les Chaouanons et ceux-ci durent se réfugier vers la Caroline ou dans cette direction. Perrot ajoute (pp. 129, 296) que, en 1670 ou un peu auparavant les Chaouanons se virent contraints de quitter la Caroline et de se réfugier dans la vallée de l'Ohio. Nous avons parlé, en 1670, de ce Chaouanon[1] capturé par les Iroquois qui le gardèrent avec eux dans une expédition au lac Supérieur où les Sauteux défirent toute la lande et délivrèrent le prisonnier. Celui-ci s'en retourna, chargé par les Poutéouatamis de marchandises françaises comme échantillons. Les Poutéouatamis espéraient que les Chaouanons ouvriraient des rapporte de commerce avec eux. En effet, par l'Ohio ils arrivaient au Wabash et de là pouvaient se rendre à la baie Verte. Nous savons que cette même année 1670, un Chaouanon avait descendu l'Ohio jusqu'au Mississipi, avait remonté ce fleuve et s'était arrêté dans l'Iowa chez les Illinois (Relation 1670, p. 91; 1672, p. 25) qui, dans leur langue, disaient Ontaougannha au lieu de Chaouanons.

Le Potherie (II. 131-133) a dû prendre de la bouche de Perrot ce qui va suivre; "Que ne firent point les Chaouanons sur le simple rapport de celui qui avait été délivré des moins des Iroquois par les Sauteurs. . . . . Ils surent qu'il y avait chez ces peuples (baie Verte et lac Supérieur) des gens qu'on appelait Français, qui avaient paru plus

[1] *Société Royale*, 1913, p. 89.

sociables que ceux de leur continent (les Suédois, Hollandais, Anglais) lesquel (les Français) fournissaient toute sorte de marchandies. C'en fut assez pour les engager à profiter de cet avantage. Quarante guerriers partirent pour s'établir auprès des Poutéouatamis."

Ceci devait avoir lieu en 1672. Les Iroquois, à peine débarrassés de leur guerre contre les Andastes, venaient d'envoyer une expédition pour faire coup dans la baie Verte parmi les alliés des Français, au mépris du traité de 1670. Leurs maraudes recommençaient et allaient se continuer. La Potherie ajoute: "Les quarante Chaouanons surprirent cette bande iroquoise dont ils tuèrent et amenèrent plusieurs. Ils passèrent par un village de Miamis qui leur firent un si bon accueil qu'ils ne surent se défendre de leur donner leurs prisonniers iroquois. Les Miamis envoyèrent ces captife aux Outagamis pour être mangés, en représailles de cinq cabanes que les Iroquois avaient enlevées peu de temps auparavant. Les Outagamis, voyant que cette conjecture était favorable pour en faire un échange, envoyèrent en embassade chez les Iroquois. Quand l'embassadeur eut fait le trajet du Michigan, il trouva huit cent Iroquois qui venaient en guerre pour enlever le premier village sur lequel ils tomberaient. Les Iroquois ne purent s'empêcher de calmer leur ressentiment (à la vue de leurs hommes libérés) et donnèrent leur parole à l'embassadeur qu'il y aurait dorénavant une barrière entre sa nation et la leur et que la rivière de Chigagou ferait la limite de leurs courses. Ils le renvoyèrent avec des présents, lui donnant un des leurs des plus considérables, avec un jeune guerrier, pour l'accompagner. Ce chef iroquois passa par les Miamis, les Maskoutechs et les Kikabous où il fut reçu avec les honneurs du calumet et comblé de présents de castors. Ces nations députèrent deux Miamis pour l'accompagner à son retour, afin d'y traiter la paix. Il vint chez les Outagamis qui s'efforcèrent de lui donner des preuves de leur estime et il arriva enfin à la Baie, où les peuples ne manquèrent pas de lui marquer la joie qu'ils avaient d'être de leurs amis. Ils lui firent présent de pelleteries et de deux grands canots pour emporter les présents qu'il avait reçus de toutes parts. Les Miamis qui accompagnaient l'Iroquois suivirent le lac et passèrent le grand portage de Ganatcitiagon par lequel ils se rendirent au lac Frontenac (Ontario) et à Kenté où il y avait une mission française et un grand village d'Iroquois. Ils furent de là au fort Frontenac où était M. de La Salle qui leur fit plusieurs présents, les assurant qu'il irait les voir dans leur pays."

La Potherie écrivait trente ans plus tard sans trop connaître les dates des choses dont il parle. Les Sauvages ont dû arriver à Cataracoui en 1673 au moment où Frontenac y était occupé à construire un fort. C'est ce gouverneur qui leur fit des présents. La Salle ne devint locataire du fort que deux années après et il est bien sûr que en 1673 il n'y était pas présent à la fondation.

Le Chaouanon (un chef sans doute, avec quelques hommes de sa nation) qui s'était rendu à l'Iowa en 1670 avait expliqué son itinéraire tant bien que mal aux Illinois qui le reçurent chez eux et, à leur tour, ces Sauvages tâchèrent de transmettre le renseignement aux Pères Allouez et Dablon dans un voyage qu'ils (les Illinois) firent au lac Supérieur, de sorte que les deux missionnaires en conclurent que le Mississipi se détournait à gauche et allait directement du côté de la Virginie. En 1673 on reconnut cette erreur lorsque Jolliet, descendant le Mississipi, passa devant l'embouchure de l'Ohio. Le Père Marquette note dans son récit (par ouï-dire) que, sur le haut de cette rivière, les Chaouanons comptent trente-huit villages; de plus que ce sont des gens peu ou point adonnés à la guerre et que les Iroquois sont acharnés à leur destruction. Cette dernière remarque pouvait se rapporter à une date un peu antérieure tout aussi bien qu'à l'année 1673, mais il n'en est pas moins vrai que les Chaouanons furent anéantis comme peuple en 1673 au moment où la Père en parlait.

Perrot (p. 129) dit que les Iroquois incorporèrent dans leurs tribus les Chaouanons qui survécurent au massacre. Il en échappa toutefois un certain nombre dont les descendants sa retrouvent à la Caroline en 1717. La Potherie (II. 133) dit que l'armée iroquoise comptait six cents guerriers dans cette campagne contre les Chaouanons.

Cette même année deux cents Iroquois partirent en guerre, passant le lac Erié et suivant la côté sud du lac Huron. La Potherie s'exprime-t-il d'une manière incorrecte à ce sujet? "les deux cents suivirent la rivière de Chigagou. Ils y rencontrèrent des Islinois qui revenaient de Michilimakinak avec quelques Outaouaks dont ils prirent et tuèrent dix-neuf." Faut-il croire que les Iroquois étaient déjà rendus sur la rivière Illinois et qu'ils défirent un parti d'Illinois et d'Outaouas revenant de Michillimakinac pour rentrer chez lui, ou bien que ce parti fut défait près de Michilimakinac et que, ensuite, les Iroquois allèrent à la rivière Illinois?

D'une façon ou d'une autre, il est certain que ces Illinois n'étaient pas les Oumamis de la rivière aux Renards et puisque les Iroquois avaient adopté pour objectif la rivière Illinois, déserte depuis 1656, c'est qu'ils connaissaient le retour tout récent des Illinois de l'Iowa dans leur ancien pays.

Jolliet et Marquette en 1673 ont vu les Illinois dans l'Iowa et, un peu plus tard, cette année, passant par la rivière Illinois ils ne disent rien de ce peuple. Malgre cela nous pensons que, en 1673, un contingent Illinois était déjà retourné aux environs de Chicago et ceux-là avaient été en traite à Michilimakinac avec des Outaouas. En 1674 le gros de la nation traversa le Mississipi et se fixa sur la rivière qui portait son nom. C'étaient les tribus Peorias, Kakakias, Cahokias, Moingouinas, Tamaroas. M. John Gilmany Shea (*State Historical Society of Wisconsin*, III. 128-129) semble croire que les Illinois ne reprirent possession de leur ancien pays qu'après l'arrivée de La Salle dans ces lieux, l'automne de 1679, mais, à cette date ils étaient nombreux sur l'Illinois et la Kenkakee, d'après les écrits de La Salle et de Hennepin. Le même auteur dit que les Metchigameas que Marquette trouva sur le Mississipi en 1673 s'associèrent pour la suite aux Illinois, bien qu'ils fussent d'une origine différente. Il oublie les Oumamis réfugiés en 1657 sur la rivière aux Renards et qui y demeurèrent constamment jusqu' après 1673.

"Les Illinois, après le coup de 1673, dit La Potherie, modérèrent leur ressentiment. Ils auraient pu aller attaquer les Iroquois mais ils envoyèrent à M. de Frontenac un paquet de castors par lequel ils se plaignaient que les Iroquois avaient violé la paix et qu' ayant eu peur de lui déplaire, ils n'avaient pas voulu les chercher pour leur livrer combat, et qu'ils lui demandaient cependant justice. Ce gouverneur leur envoya un collier par M. de la Forest qui leur marquait de se défendre s'ils étaient une autre fois attaqués, mais qu'ils ne se missent point en marche pour les aller trouver chez eux. L'on a beau faire la paix avec les Iroquois, quand ils peuvent attrapper quelqu'un à l'écart ils ne lui font point de quartier."

IV.

Le plan de conquête des Iroquois n'avait pas cessé d'être le même depuis 1636. Il consistait à dévorer, les unes après les autres, les nations sans discipline qui les entouraient afin de créer un empire à eux qui balancerait les influences françaises de l'ouest et hollandaises, anglaises, suédoises de l'Est. Ce n'était pas un rêve puisqu'il était réalisable, mais il n'aboutit qu'à des massacres parceque la colonie du Canada sut attirer dans son alliance toutes les nations de l'ouest.

La tenacité des Cinq-Cantons ne s'affaiblissait pas après les déclarations solennelles de 1669 et 1670. Les Iroquois se regardaient plutôt comme dégagés vis-à-vis des Français et d'autant plus libres de poursuivre la destruction des tribus sauvage, aussi les avons-nous vus, en 1671-1673, faisant disparaître les Andastes, chassant les Chaouanons, assaillant les Illinois.

"Les Iroquois commencèrent encore à donner sur les Illinois et autres nations, raconte Perrot (p. 131) car leurs forces augmentaient toujours. Ils voulurent même s'adresser (s'en prendre) aux Outaouas et Nepisings dont ils firent plusieurs prisonniers. M. de Frontenac étant parti (de Québec) pour aller au fort qu'il avait fait bâtir (à Cataracoui, 1673) fit assembler tous les chefs iroquois, auxquels il parla de manière qu'ils rendirent les prisonniers et demeurèrent en repos, promettant de ne plus faire d'incursions sur nos alliés compris dans la paix." Cette fois les Cinq-Cantons tinrent leur parole.

En ce qui concerne les Outaouas, notons que, dès 1669, les Iroquois avaient cherché à les faire traverser le Haut-Canada pour s'établir à la baie de Kenté où se formaient des villages iroquois. Le motif était de pouvoir se renconter plus facilement, acheter les pelleteries des Outaouas et les vendre aux Anglais d'Albany. La construction du fort Frontenac, en 1673, avait coupé court à ce projet. Les Nipissiriniens et les Outaouas redevenaient plus que jamais alliés des Français et par là se voyaient exposés à la colère des Cantons, comme Perrot le fait entendre dans le passage ci-dessus.

Dans la *Correspondance Générale* manuscrits, (F. 9, p. 351) il y a une lettre de Courcelle du 27 août 1670, disant que "dix-huit ou vingt Tsonnontouans ont attaqué un village nommé Apontigoumy chez les Outaouas et ont tué ou pris cent personnes grandes et petites."

Les Nipissiriniens s'étaient réfugiés au lac Nipigon, de 1650 à 1667, chassés par les Iroquois. Le Père Allouez les y rencontra cette dernière année. Vers 1670 ils étaient retournés au lac Nipissing, leur pays, et fréquentaient le centre du Haut-Canada.

Le lecteur est surpris de voir avec quelle rapidité les Iroquois exécutaient leurs courses militaires et les longues distances qu'ils parcouraient à travers les territoires des autres nations. Avant 1670 leurs bandes allaient sur le haut Saint-Maurice, au Saguenay, à Québec, au lac Supérieur, à la baie Verte, sur l'Ohio, dans la Pennsylvanie, comme dans le Haut-Canada. Elles apparaissaient brusquement, faisaient coup et s'évanouissaient en rien de temps. Le secret de ces opérations est tout dans la discipline particulière à ce peuple et que les tribus algonquines ne pratiquaient point. Celles-ci envoyaient leurs guerriers sans les munir de provisions de bouche, parcequ' elles n'en tenaient jamais en réserve et vivaient à l'aventure, de chasse et de pêche. Il fallait donc trouver le moyen, le temps nécessaire pour se nourrir en chemin. De plus, aucun plan de campagne, rarement un objectif déterminé d'avance. Le hasard faisait tout. De là des mécomptes perpétuels, des voyages marqués. L'Iroquois chargeait son canot de blé d'Inde, avec d'autres denrées, suivait une route bien définie, obéissait à un chef qui avait prévu les moindres détails et s'y tenait rigidement. La marche, le repos, l'attaque, la retraite étaient réglés dans un ordre parfait, mis à la connaissance de chaque homme et ne devait jamais varier à moins d'avis contraire donné instantanément. Le groupe ne formait qu'un corps et une âme, aussi agissait-il avec précision, rapidité, sans rompre son ensemble et rarement on l'a vu se tromper par une manœuvre maladroite. En un mot, l'Iroquois apportait à la guerre l'esprit de discipline qui régnait dans son village.

Tout cela avait lieu en dépit des conventions de 1670. Une menace de Frontenac en 1674 rendit la paix générale, comme les Français l'entendaient. Huit ou neuf ans plus tard, Frontenac étant parti, ces guerres reprirent leur cours et ne furent de nouveau suspendues que vers 1697.

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The Study of History and the Interpretation of Documents

By BRIG.-GENERAL E. A. CRUIKSHANK, LL.D., F.R.S.C.

(Read May Meeting, 1921)

"History," writes Jacob Burckhardt, "is the most unscientific of sciences." Other writers of even greater eminence have denied that it is entitled to be termed a science at all.

Yet as Motley remarked in one of his letters, "History-writing must be pursued honestly as a science, if it is to be permanently valuable, and not as a trade." "By such a course only can it be made," to use the language of Guizot, "a great school of truth, reason, and virtue."

By the ancients Clio was styled "the eldest daughter of Memory and the chief of the Muses."

Carlyle has told us in an eloquent passage that:

"History, as it lies at the root of all science, is also the first product of man's spiritual nature, his earliest expression of what can be called thought. . . . Let us search more and more into the past; let all men explore it as the true fountain of knowledge, by whose light alone, consciously or unconsciously employed, can the present or the future be interpreted or guessed at."

The study of history ought, therefore, not only to satisfy our curiosity about past events, but essentially modify our views of the present, as it deals with the great principles upon which the every-day life of the world is still carried on.

Whether the study or the writing of history can be regarded as an exact science in the literal sense of the word may be a subject of reasonable doubt, but it can hardly be disputed that there is an increasing tendency to treat both in a scientific spirit, just as there is similar inclination to treat the study of science, historically. This is undeniably a modern development. A century ago, history, treated as a science, was unknown, on this continent at least. What passed under that name was a mere collection of fables, of heroic and sentimental legends, of unauthenticated traditions, or records.

Within the memory of living men, the work of historical research has been immensely facilitated and the scientific spirit in its pursuit singularly stimulated by the introduction of scientific methods in the collection, arrangement, and care of the materials for history, the publication of guides, inventories, and calendars, as well as the textual reproduction of documents themselves by transcripts, photography, or in print, and by the publication of source-books.

Facts must necessarily constitute the staple raw material of history. It strives to be a transcript of the life that is now past. It treats of man in his proper sphere of activity, in his relations with the forces of nature and the efforts of other men. It is chiefly concerned with the workings of his intellect, his will, and his passions so far as they revealed in objective action. Its main purpose, therefore, is to promote an accurate knowledge of the activity of man's spiritual nature.

It should also endeavour to verify and test the truth of its own statements and conclusions.

History has been flippantly described as "an arid region abounding in dates." This saying has been probably inspired by a bitter memory of those useful compilations, known as school histories, which results in a conviction that history must necessarily be tedious and wearisome. The natural reaction from this view is responsible mainly for the production of the sentimental, emotional, unreliable popular history, in which the author attempts, as Gibbon said politely about Voltaire, "to cast a keen and lively glance over the surface of history."

Facts, by themselves, are, of course, not history. Historical materials or documents, standing alone, are not history. They must be organized, elaborated, and combined. This must be done with the proper spirit and in a judicial manner. A story has been told of a naval officer who beguiled the tedium of a long voyage by working out problems in navigation with the master of a merchant ship. A dispute arose between them on one occasion, and the officer, exhibiting gleefully the results of his calculation, remarked: "Figures won't lie." The other, looking it over critically, discovered an error, and, pointing it out, retorted: "Yes, figures won't lie if you work them right, but you must work them right." The same rule applies exactly to historical materials and facts. They won't lie if you work them right. But this must be done. Otherwise, "a little disproportion in the emphasis, a little exaggeration of colour, a little more or a little less limelight on this or that portion of the group, and the result will not be the truth, although each individual fact may be as indisputable as the multiplication table itself."[1]

History, beyond doubt, had its beginnings in a form of biography, or rather of autobiography. The mighty hunter or fisherman, the man of deeds, or uncommon skill and success, became inspired with an irresistible desire to make his actions known to his fellow-men and, if possible, to posterity. As generally they were known only to himself, he had to tell his own story, and it lost nothing in the telling. It was oft-repeated, sung or chanted, by him, by members of his family, or by his friends and followers. The deeds of Nimrod, of Hercules, or of Samson, and other mighty men were thus perpetuated in popular tradition, and handed down from generation to generation by word of mouth.

Frequently this man of action was not endowed with the faculty of oral expression, and the women of his family or clan, or some weaker male person, gifted in that way, took up the tale, embellished it and magnified it.

Gradually the deeds of the heroic individual almost insensibly became a portion of the biography of the patriarchal family, the most important product of human evolution in the early days of civilization. This community of kinsfolk thus became the first great history-making group.

In time this group was enlarged to the clan, the tribe, and the nation. The process of primitive history-making still went on in much the same way, having been largely taken in hand by the women, or by men, who were in some way physically unfitted for the chase.

As a rule primitive man, whose chief occupations are hunting and fighting, makes little, if any, distinction between war and the hunt. All other men, not belonging to his particular group, are foes, or at least trespassers on his hunting-grounds, and regarded by him just as he does other varieties of wild game, being only a more dangerous, and, consequently, a nobler quarry. All means and devices are right in his efforts to kill or capture them.

The biography of the nation, or the political society, or commonwealth finally evolved, became what we call history.

Next came the aspiration to record the notable deeds of the individual or clan in some more permanent and evident form than by mere oral repetition. For this purpose the rock-walls or cliffs of their native hills afforded at once the most prominent situation and most lasting material.

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[1] Mahan: From Sail to Steam, p. 168.

The invention of some form of writing enabled them to supplement a pictorial representation of these notable events by inscriptions giving an explanation. The eastern ruler seldom shrank from an effort to immortalize himself by the inscription or portrayal of his deeds of cruelty even in imperishable stone. Yet the truth of the record was considered a matter of the utmost importance. Rawlinson tells us that Darius states "his great fear that it may be thought that any part of the record he has set up may be falsely related" and that he has abstained from narrating certain events of his reign "lest to him who may hereafter peruse the tablet, the many deeds that have been done by him may seem to be falsely recorded." This counsel of perfection, it would seem, was honoured more in the breach than in the observance. The biographical element, however, was still strongly predominant.

To the actors, engrossed in this ceaseless warfare with the forces of nature or with other men, the influence of the rivers, mountains, forests, and plains, and other natural features of the country in aiding or impeding them, was taken so much as a matter of course that they seldom even referred to it. Consequently it has not always received the attention it deserves. It can only be ascertained by close and patient study.

Macaulay has recorded that when he first visited Rome, he hastened to the place where the Pons Sublicius once stood, to make sure how well his ballad of Horatius agreed with the topography. His biographer relates that he took care to see Glencoe in rain and in sunshine; that he paid a second visit to Killiecrankie; that he spent two full days at Londonderry, taking pains to sketch a good plan of the streets, walking alone or in company four times round the walls of the city. In one of his letters, referring to a change of plan as to his history, Macaulay says:

"I must visit Holland, Belgium, Scotland, Ireland, France. . . . I must see Londonderry, the Boyne, Aghrim, Limerick, Kinsale, Namur again, Landen, Steinkirk."

Many other great historians have been tireless students both of geography and topography.

Still more difficult to establish and yet of equal importance are the psychological and economic impulses responsible for the wandering of the nations and most great national and racial conflicts. Without a knowledge of their psychology, how can their history be properly understood or written? How can the facts be justly appreciated? How can the characters of the chief actors be fairly estimated? The motive forces of human history must be found in the moral constitution of humanity.

How great is the difficulty of forming an equitable judgment of the actions of public men when private emotions as well as reasons of state are found to influence them, and their actions may appear to result as much from private inclination as from national policy?

"In life, as we actually experience it," says a great writer, "motives slide one into the other, and the most careful analysis will fail adequately to sift them." And in another passage, "There are practices in the game of politics which the historian, in the name of morality, is bound to condemn, which nevertheless in this false and confused world, statesmen to the end of time will continue to repeat."[2]

Freeman, it is hardly necessary to recall, invented the catchphrase that "present history is past politics," which had a great vogue, but only states a partial truth. Buckle asserted that genuine historical evolution consists in intellectual progress. Most modern economists concur in the view that the dominating forces in historical development are economic. Many churchmen believe that the chief factor in history is religion.

Ethics certainly give to history its most rational goal. A living German philosopher declares that "a real understanding of history is not possible without ethics; universal history is the realization of the moral . . . within humanity." This seems a rather cryptic saying.

It must be admitted that the white man has been guilty of much cruelty and dishonesty to the savage but he does not like to speak of it and whenever necessity compels an unwilling reference, he has invariably some apology ready about manifest destiny, the advancement of civilization, or taking up the white man's burden, in which he yields an involuntary tribute to the higher ethical conscience.

As the religion of Buddha gained followers among the Hindus, Indian society gradually became impregnated with a conviction of the nothingness of life. To escape and not to dominate became the keynote of their faith. And as they believed human life to be insignificant, its history as a matter of course, seemed insignificant too. As Mr. Lowes Dickinson observes, it is not an accident, but a consequence that there are no Hindu historians.

Among more virile races, on the other hand, history from being a mere glorification of the chief or reigning monarch, developed into a form of ancestor-worship, or a filio-pietistic chronicle. And such it continued to be until comparatively recent times, and to a certain

[2] Froude: History of England.

extent, still is. To use Macaulay's words in one of his ballads, much popular history is little more than "a nurse's tale."

This has been a fruitful source of error and misrepresentation.

"For the study of history," said Charles Francis Adams in an address to the Massachusetts Historical Society, "there should be but one law for all. Patriotism, piety, and filial duty have nothing to do with it; they are, indeed, mere snares and sources of delusion. The rules and canons of criticism applied in one case and to one character must be sternly and scrupulously applied in all other similar cases and to all other characters; and while surrounding circumstances should, and, indeed, must be taken into careful consideration, they must be taken into equal consideration, no matter who is concerned. Patriotism in the study of history is but another name for provincialism. To see history truly and correctly, it must be viewed as a whole."

This is surely sound doctrine, and it may be remarked that nowhere had the "filio-pietistic method" of dealing with history taken firmer root or flourished more vigorously than in Massachusetts.

John Fiske, another son of New England, in a foot-note to his "Discovery of America," referring to the manner in which some discreditable event had been ignored by a Spanish chronicler, remarks with a touch of sarcasm: "That is the way history has too often been written. With most people it is only a kind of ancestor-worship. What may be called the Cosmopolitan school of history is, perhaps, a thing yet to be developed; for the fact is, our histories are all Catholic or Protestant—European or American—English, French, Spanish or German—Whig or Tory—Federalist, Democrat, or Republican. The historian invariably scrutinizes the record through eyes jaundiced by faith, or patriotism, or filial affection, or partizan zeal; and he is even lauded for doing so. He dilates on the blood-sealed devotion of the martyrs to the faith he professes, and the valour of the soldiers and sailors of the land of his birth; he execrates those who oppressed the one, and depreciates those who fought against the other . . . Ancestor-worship is the rule."

The conquered race, the beaten party, the lost cause seldom receives fair play and rarely has been given a hearing. Hannibal's own story or an account of his campaign in Italy by Brennus would probably throw some new light on Roman history.

The real actions of some remarkable persons in the past have been almost forgotten because their names have become inseparably associated with legends that are at best doubtful, and in some instances have been proven to be untrue.

Even the most recent history is not wholly free from such myths and legends, which have received wide circulation, and whose origin can scarcely be traced. I need only refer to the fables of the "Angels of Mons," of the "Crucified Canadian," and of the devastating effects of "turpinite." Already two good-sized volumes have been published in France dealing with the "legends, prophecies, and superstitions of the Great War."

The propensity for fabrication and exaggeration, even among writers of much talent and eminence, is by no means extinct. The fact that it is sometimes combined with superior abilities and attainments, and even with a certain sense of honour, is certainly a strange anomaly.

It has been said very truly that Michelet turned the whole history of France into a symbolical poem.

Gabriel Monod, on leaving the Ecole Normale, before visiting Italy on a journey of investigation, called to consult Taine, who was already famous as a writer and a lecturer at that celebrated training college. Taine in an instant revealed to the young student his own method of inquiry. "Take a seat, sir," he exclaimed. "What ideas are you going to verify in Italy?"

Taine visited England to obtain material for his last volume of the History of English Literature and met Frank Palgrave, a great friend of Tennyson, to whom he began talking about that poet. "Was he not in early youth, rich, luxurious, fond of pleasure, self-indulgent?" he asked. "I see it all," he continued, "in his early poems—his riot, his adoration of physical beauty, his delight in jewels, in the abandonment of all to pleasure, to wine and——" "Stop, stop," cried Palgrave, impatiently, "as a young man Tennyson was poor, his habits were simple as they are now, he has never known luxury in your sense, and if his early poems are luxurious in tone, it is because he is a poet and gifted with a poet's imagination." Taine seemed disconcerted, but thanked Palgrave and went away. When the book was published he found Tennyson was still painted as the young voluptuary and rich profligate of Taine's imagination.

From his youth Taine's method of composition was to seek out some general idea, formulate it, and then group about it in harmony the results of his later researches so far as they agreed with his theory.

Numberless are the romantic stories which have been fathered on slight authority upon Napoleon, Washington, Lincoln, Sir John Macdonald, and others, and but too readily accepted by the public.

Biographers are seldom candid with respect to the faults and failings of their subject. As Lord Jeffrey said in a review of Hardy's Life of Lord Charlemont: "The author's chief fault is *that he does not abuse anybody*, even when the dignity of history and of virtue calls loudly for such an infliction."

The eulogistic biographer is consequently responsible for the diffusion of much falsehood respecting historical events. We must remember that, to use the words of J. R. Green, "truth in history as well as truth in science is only part of that great circle of the Truth of God."

As regards autobiography, of which there is an ever-growing mass, Holmes somewhere remarks that there are only two individuals who can tell the true story of a man's or a woman's life. One is the person concerned and the other is the Recording Angel. The autobiographer cannot be trusted to tell the whole truth, even though he may tell nothing but the truth and the Angel does not allow the record out of his hands.

The value of oral tradition is constantly growing less and has become in many parts of the world nearly negligible. Still the transmission of historical information by oral repetition persists in a remarkable manner where population is fairly stable and undisturbed. The vicar of Radway, in a recent book about the Edge Hills in England, refers to three such items told to him "by a man over seventy, who heard them from his grandmother; who lived to be over ninety. She had them from her grandfather, who was a boy when the battle of Edge Hill was fought in the Civil War in 1642."

Yet it must be remembered that memory is never passive but that its activity is continuous and cannot be controlled. In certain respects it can scarcely be distinguished from the imagination, for which it furnishes materials, which are frequently already remoulded and changed. Never do we remember events exactly and fully in every minute particular. Our present state of mind always, or nearly always, modifies in our recollection what we felt, or what we did, or what we saw in the past.

Inscriptions still have a certain value as historical material, yet it must be duly checked and discounted, as many of them are liable to the faults of the over-friendly biographer, since they are usually designed to commemorate the importance of an event or the talents and virtues of a deceased individual. The mendacity of an epitaph has become proverbial. The eulogistic inscriptions on the tomb of Anthony Forster in Cumnor church and the wall-tablet in memory of

Sir George Prevost in Winchester cathedral are singularly at variance with the estimates generally accepted by the historian.

The chief and, indeed, almost the only sources of material for the history of modern times consist of written or printed documents. Written documents may be broadly divided into three classes: those that are official, those that are semi-official, and those that are non-official or private. Each class has its peculiar limitations as to credibility and trustworthiness. Official documents are usually marked by a certain restraint, which is found to a less degree in the semi-official, and still less in private correspondence, which is frequently coloured by the personal bias or passions of the writer.

In another way, they may be classified into those that are contemporary with the events they purport to relate, and those of a later date. Considering them from still another point of view, it is most important to know whether they contain the statements of an actual eye-witness or of some other person. In other words, is the evidence direct or hearsay? "One eyewitness," says W. E. Henley, "however dull and unprejudiced, is worth a wilderness of sentimental historians." But it must be remembered that eyewitnesses are seldom unprejudiced and that their statements are often much impaired by personal bias, by the nervous excitement of the moment, or by a limited range of observation. Then a subsequent narrative or report is often pieced together by some person, who was in a very limited sense, or quite possibly in no sense at all, an eyewitness, from the statements of several participants. So much inevitably depends on the personal point of view and individual facilities for seeing, hearing, and appreciating what actually took place. A curious example of this is reported to have occurred at the Congress of Psychologists held at Goettingen, shortly before the war. At an evening session, when all present, who were mostly lawyers, physicians or men of science, were in complete ignorance of the test to be made, a violent scene was enacted by two persons, supposed to have come into the hall from a neighbouring ball. It was very brief, lasting only for twenty seconds. Under a pretext that a judicial investigation might be held, the president requested each of the spectators to draw up an independent account of this little drama. Among forty reports that were handed in, only one contained less than twenty per cent. of errors, fourteen contained between twenty and forty per cent., twelve contained between forty and fifty per cent., and thirteen contained more than fifty per cent. In thirty-four reports, between ten and fifteen per cent. of the details were absolutely imaginary.

In general, however, written records vary in historical value in proportion to their proximity to the event. Accounts written long after by eyewitnesses, based solely on recollection and not upon a diary or other record made at the time, are seldom of great weight as historical material, except in the matter of corroboration.

The great historian of the Peloponnesian War states that in his work he had not followed either the first account or his own opinion, but related what he had either seen himself or learned from others with the utmost diligence. "To find the truth," he writes, "caused me great trouble for the writings of the various events were not agreed in their accounts, but both sides were affected by partizanship and failure of memory."

Such, indeed, must have been the experience of every subsequent seeker after truth. And the aim of every honest student of history and of every fair-minded writer of history must be the ascertainment and statement of the truth to the best of his ability.

A topographical or pictorial document similarly varies in value in proportion to the date of its execution. Maps and sketches, prepared from memory, after a considerable lapse of time, are seldom reliable.

Occasionally the genuineness of a document may be doubted or questioned. In times of stress, documents are sometimes forged or mutilated to serve national, or political, or personal ends. It has been proved, for instance, that so eminent a man as Benjamin Franklin resorted to an extensive fabrication of documents to discredit his adversaries and advance the revolutionary movement. Some of these were long accepted as being genuine.

The sources of error, even in the original documents, are very numerous.

The writer may have been self-deceived or may wish to deceive others.

The editor, or copyist, or printer, may have introduced errors or made omissions either purposely or unintentionally.

In the printing of contemporary official documents, it was, and probably still is, the practice to suppress or alter passages, the publication of which may appear indiscreet or impolitic at the time. Frequently certain documents are selected for publication and others suppressed. Sometimes two despatches or official letters are prepared, one for publication and the other to be kept secret.

The judicious editor has occasionally resorted to the same practice and omitted some statement, which he considered discreditable to the person or nation concerned. Jared Sparks was a notable offender in this respect.

The writer may have expressed himself vaguely or obscurely, or made use of words in a different sense from that in which they are now understood.

The evidence of the documents available is often conflicting, contradictory, or defective. Important documents may have been destroyed, mutilated, or lost sight of. Of many important negotiations and transactions no written record was preserved. Metternich relates in his Memoirs that at the Congress of Vienna "the most difficult affairs and the arrangements most complicated in their nature were, so to speak, negotiated from room to room, no sending of couriers, no written negotiation, no medium between the courts; all these things, so necessary in ordinary times, had disappeared . . . the courts concerned are without any written accounts of the most important negotiations."

Even the waste-paper baskets were carefully examined and their contents destroyed lest they should inadvertently reveal the secrets of the diplomats.

It is understood that the same practice prevailed to a great extent at the recent Conference of Versailles.

An eminent writer on the contemporary history of the United States says that the chronicle of the frauds connected with the manipulation of land grants to railways and the shameless sale of legal privileges cannot be written, because in most instances, no tangible records have been left.[3]

Contradictions and discrepancies abound everywhere in the written records. These may be largely ascribed to the individual point of view, or to the character or temperament of the writers.

The Autocrat of the Breakfast Table said that there were at least six personalities involved in a dialogue between any two individuals; for instance with respect to John and Thomas, there were:

Three Johns—
1. The real John, known only to his Maker.
2. John's ideal John; never the real one, and often very unlike him.
3. Thomas's ideal John; never the real John, nor John's John, and often very unlike either.

Three Thomases—
1. The real Thomas.
2. Thomas's ideal Thomas.
3. John's ideal Thomas.

[3] Beard: Contemporary American History, p. 31.

This apparently fantastical idea really applies with more force to the interpretation of documents and makes many historical characters problematical.

Contemporaries seldom know the exact truth or the whole truth of what is happening about them, and it is only after long and patient study that the historian of a later age may succeed in arriving at an approximately full and accurate comprehension of the sequence of events in their relations of cause and effect. Contemporaries can scarcely hope to do more than collect materials for those who may attempt in after years to write a true and faithful history of the past, with that judicial calmness and impartiality, which cannot be expected from those who have taken an active part in those events.

Account must be taken of the mutual connection of events, occurring approximately at the same time. As Carlyle has pointed out no person, however gifted and alert, can do more than observe, still less record, the series of his own impressions and sensations. "His observation, therefore, to say nothing of its other imperfections, must be *successive*, while the things done were often *simultaneous*; the things done were not a series but a group. It is not in acted, as it is in written history; acted events are in no wise so simply related to each other as a parent and offspring are; every single event is not the offspring of one but of all other events, prior or contemporaneous, and will in its turn combine with all others to give birth to new; it is an ever-living, ever-working chaos of being, wherein shape after shape bodies itself forth from innumerable events. . . . All narrative is, by its nature, of only one dimension; only travels toward one or toward successive points; narrative is linear, action is solid."

That variety of narrative, which is usually termed the philosophy of history, consisting of an attempt to trace the relation of events with each other, is just as much genuine history as the descriptions of battles, political struggles, economic changes, and all other salient occurrences, which it attempts to state. Facts of that kind are more difficult to ascertain, their connection is more uncertain, the writer is more likely to be deceived or to deceive himself; but they will ever continue to be a vital part of history.

The main task of the historian, then, is not so much a matter of vivid narrative and picturesque colouring as of a proper and honest grouping of events; of tracing the true sequence by which successive occurrences are seen to lead to an inevitable result, or causes, apparently remote and unrelated, converge to a common end.

There are many fundamental requisites. They may be generally summed up as thoroughness and accuracy of knowledge; an intimate acquaintance with the facts in all their numerous details; familiarity with the various sources of evidence; with the statements frequently conflicting or contradictory, sometimes even irreconcilable, of many witnesses, who have left their testimony as a legacy from the past. The critical faculty becomes an instrument to assist the student in the ascertainment and verification of the facts, and the appreciation of their relative importance. It acts the part at once of the judge and the jury at a trial in court; not only finding the facts but pronouncing upon their significance. The diligence, the tireless patience and labour, requisite for an exhaustive examination of the evidence, take the place of the opposing counsel, whose business it is to elicit the testimony of the witnesses on which the verdict is ultimately rendered.

Imagination, enthusiasm, emotion have their proper place. After all history cannot be truthfully and adequately written with the cold impartiality of a judge. These qualities may tend to bias, but bias may be controlled and corrected by critical analysis and just discrimination.

Imagination and enthusiasm, combined with the requisite facility and force of expression, can alone endow a narrative with life, but in the ideal historian they must be united with the scientific conscience, which regards the habit of accuracy, open-mindedness, impartiality of judgment, and the love of truth for its own sake as supreme virtues.

Governor Musgrave and Confederation

BY HIS HONOUR JUDGE F. W. HOWAY, LL.B., F.R.S.C.

(Read May Meeting, 1921)

In my paper last year I sketched the connection of Governor Seymour with the Confederation movement in British Columbia, showing that the Legislative Council, when the subject was first introduced in 1867, was unanimously in its favour; that before the opening of the session of 1868 the opinion of all the "official" and of certain of the "popular" members had cooled into apathy and indifference, (if no worse), which in the following year developed into downright opposition; and that the Governor was regarded, and rightly regarded, as the person mainly responsible for this altered attitude.

Seymour died on board H.M.S. *Sparrowhawk* at Bella Coola on 10th June, 1869. The news reached Victoria on the 14th and was immediately transmitted to Downing Street. The next day a notification was received from Lord Granville that Anthony Musgrave would be appointed in his stead. This unusual celerity was only indirectly connected with the late Governor's views on Confederation; Seymour, who was in poor health, had applied for leave of absence, and Musgrave had, in accordance with Sir John A. Macdonald's wish, been fixed upon as his successor.[1]

Musgrave was appointed 16th June, 1869. The official intimation of his appointment, dated the following day, contained this sentence: "I shall have occasion to address you on the question now in agitation of the incorporation of British Columbia with the Dominion of Canada." In pursuance of this intention Lord Granville, on 14th August, 1869, dealt with the subject in a lengthy despatch. "The question," he said, "therefore presents itself, whether this single colony should be excluded from the great body politic which is thus forming itself. On this question the colony itself does not appear to be unanimous. But as far as I can judge from the despatches which have reached me, I should conjecture that the prevailing opinion was in favour of union. I have no hesitation in stating that such is also the opinion of Her Majesty's Government." After marshalling the arguments in favour of Confederation he announced that he felt "bound on an occasion like the present to give for the consideration of the community and the guidance of Her

Majesty's servants a more unreserved expression of their wishes and judgment than might be elsewhere fitting." He requested that publicity be given to his despatch and authorized Musgrave to take such steps as he properly and constitutionally could for promoting the favourable consideration of the matter. In conclusion he added that the details must be settled by the people, but that the Governor should himself enter upon, amongst other things, the question of the future position of Government servants.[2]

The Secretary of State here puts his finger upon two facts: first, that, though Seymour had neglected to apprise the Colonial Office of the views of the colonists upon Confederation, the Home Authorities were aware, doubtless through the Dominion Government,[3] that the change was favoured by the Colony as a whole; and secondly, that the official members of the Legislative Council were the obstruction to the formal expression of that opinion.

Probably because of his work in Newfoundland, and, perhaps, for other reasons, the *Colonist*, as soon as the appointment was announced, said editorially: "There is no reason to doubt that Mr. Musgrave's mission is to steer British Columbia into the union. His task will be comparatively easy." [4]

The Governor arrived in Victoria on 23rd August, 1869. The hour had now come, and the man. The intervening territory had become a portion of Canada; the Dominion Government was anxious to add British Columbia to the union; the Imperial Government desired to see the change effected immediately; the people of the Colony were, speaking generally, in favour of Confederation; the pilot had stepped aboard.

After two weeks spent in social functions at the capital and in recuperating after his long voyage, Musgrave set out to visit the scattered communities of the mainland. The addresses presented to him dealt in every instance with the great question, unanimously declaring that the Colony was in favour of union on fair and equitable terms and expressing the hope that he might be the means to bring about the desired change. As soon as this general feeling was manifested he felt himself at liberty to publish the despatch from the Colonial Office expressing the desire of the Imperial Government.

The press of the Colony urged the people to abandon the discussion of the wisdom, or otherwise, of Confederation, and, accepting it as their destiny, to centre their attention upon the terms. As the *Colonist* put it: "Whatever may be asserted to the contrary there would appear to be no good reason for doubting that there is a very general desire throughout the Colony for a constitutional change, and that, as most people are convinced that Confederation is the destiny of the Colony, so most people are prepared to enter into the Dominion on terms fair and reasonable. Such being the general conviction and desire, what is to be gained by continuing longer to put off the work of considering the terms? Every month that passes brings us just so much nearer the possibility of being handed over upon terms arranged for us, not by us." [5]

Members of the Dominion Government were in constant communication with the supporters of Confederation, who took every opportunity of circulating statements of that Government's supposed views upon the subject. To quote one instance: "As a leading Cabinet Minister recently said in a letter to a correspondent in this Colony, 'Canada expects to lose money for some years by the admission of British Columbia and is prepared to deal liberally with her.'" [6] Musgrave soon found that this ill-advised course was only increasing his difficulties. In a despatch to the Colonial Office, dated 30th October, 1869, he refers to the seeming disrespect to the Legislative Council in his publication of the Secretary of State's letter of 14th August, 1869, before presenting it to that body, but justifies his conduct by saying that he has "reason to believe that the substance of that despatch has already been communicated to unofficial persons here by others in Canada to whom it had become officially known." He goes on to say: "There is some little irritation at the manner in which, it is supposed, persons in official authority in Canada endeavour to work in favour of the project through private correspondence with individuals here who have no official status and little social influence." [7]

After two months' study of the position in the Colony the Governor felt himself able to report on the state of public opinion on the question. He found it entangled with other matters, as, for instance, Responsible Government and a Free Port at Victoria. The Canadian-born residents were the mainstay of the movement; with them were associated many persons who wished, not so much the advent of union with Canada, as to obtain one or other of these objects; to them were added others who saw in the proposed change an improvement of their position by the relief it would afford from the grievous financial burden that the Colony was carrying. The large element of alien population favoured annexation to the United States. The immigrants from Great Britain were somewhat apathetic. The officials were opposed to the change, but he soon discovered that their attitude was based, as their opponents declared, on their fear for the safety of their positions under the new regime and hence if their obstruction could be overcome the great question would be the terms.[8]

In an early despatch in which he deals very generally with the subject for the purpose of showing the divergent influences operating to support the movement, and the resultant difficulty in framing terms to suit all shades of thought, Governor Musgrave points out that to some, Confederation meant the tariff question; to others freedom from debt and improved financial condition; to others, Responsible Government; to others, a Free Port.[9] The problem to be solved was: granting that the opposition of the official members of the Legislative Council could be overcome, how to prepare a proposal for union which should include such terms as the majority of the colonists would accept and at the same time be acceptable to the Dominion Government. On two terms he found unanimity in the Colony; they offered safe starting points. All the people—Confederationists and anti-Confederationists alike—were agreed that if union were to be consummated, an indispensable condition was adequate overland communication, which, being interpreted, meant a railway to connect the Pacific seaboard with the eastern provinces. DeCosmos' original plan of 1868 had only called for a wagon road; the Yale Convention of 1868 had not dared to go further than a request for a wagon road; and, though in the public mind the thought of a railroad had taken root, yet no one in an official position had yet had the hardihood to suggest a railway as a term. The absorption of the heavy colonial debt by Canada and special financial treatment were conditions upon which all insisted. The difference of opinion here lay in the quantum of the grant. The Free Port question offered greater difficulty; true, it was only asked for by Victoria, but practically one half of the population was resident there. The term, that from the outset promised most trouble, was Responsible Government. The struggle with the Legislative Council in the days of Governor Seymour had raised many advocates of Responsible Government who would not be placated with any suggestion of Representative Government. These two terms Governor Musgrave at the outset opposed. "When the leaders find," he writes, "that neither Responsible Government nor a stipulation for a Free Port can reasonably be made part of the programme, I am strongly of opinion that there will be much abatement of present enthusiasm." [10]

Confederation thus had two facets: Is it desirable? If so, what shall be the terms? Continued existence as a Crown Colony was quite impossible; the burden of the existing debt, the decreasing population, the gradual waning of the only real industry—gold mining, and the accumulation of annually recurring deficits settled that question. The choice was, therefore: annexation or confederation. In reality this was no choice. At heart the Colony, though grievously complaining of its treatment by the mother land, was always loyal. The annexationists were practically confined to the vicinity of Victoria. As the strength of this faction lay in the American element, the limiting of the suffrage to British subjects would, if resorted to, draw its fangs. The publication of Lord Granville's despatch of 14th August, 1869, solidified the general sentiment in favour of Confederation. The *Colonist* hailed with delight the news that the Right Reverend Bishop Hills had delivered an address in support of Confederation.[11]

The great stumbling block in obtaining a favourable decision of the Legislative Council lay in the officials, who, having been appointed by Governor Seymour in 1868 as members, were in a position to prevent such a result. Even if new magistrates were selected by Governor Musgrave, there were still five officials, to wit, the members of the Executive Council, who held their seats by virtue of the Imperial Order-in-Council.[12] And, in any event, the magistrates had been appointed, subject to the Crown's pleasure, for two years. Possibly some drastic alteration of the personnel of the magisterial members might have been made to secure the passage of a resolution in favour of Confederation; but such a course, objectionable from many points of view, would have delayed the project for nearly two years. Recognizing the situation, the Governor proceeded to obtain the support of the fourteen officials by the promise of suitable pensions to all those whose positions or emoluments would be affected by the union.[13] I shall allow the nine magistrates to state the case for themselves. "That without their votes that measure (Confederation) could not have been passed; that they were led to vote for that measure solely at the instance of the then Governor, Mr. Musgrave, on the distinct and repeated assurance from him as the representative of the Queen, that under the terms of Confederation they would be placed in the permanent service of the Dominion Government as County Court Judges and be totally independent of and without the control of the Provincial Government."[14] The stipulation for pensions for the officials was made a term of union, and in a lengthy despatch, dated 17th November, 1870, Musgrave discussed in detail the circumstances of each official.[15] These facts are mentioned somewhat out of the chronological sequence to show the meticulous care with which all phases of the matter were considered by the Governor.

The complaint against Governor Seymour had been hat he was indifferent, and, later, that he was passively, if not actively, hostile to the movement; the fear now arose that his successor might be carried away by his zeal for the cause of Confederation. It was a modern version of the fable of King Log and King Stork.

The *Colonist* soon gave voice to this apprehension. Confederation, it stated, was nearer than some people thought. Then, passing to the question of terms, it proceeded: "In truth there is no time to be lost. Unless the people make their voice heard now it may be too late. The whole matter will be negotiated by those who neither understand our wants nor possess feelings in common with the people. We would desire to avoid being misunderstood here. The Governor is, under all the circumstances, probably the most suitable and best qualified person to negotiate on the part of the Colony. It is not to that that we object, but it is to his being allowed to carry those negotiations beyond a certain point without giving the people an opportunity of being heard. If the main conditions are all arranged first, and the people consulted afterwards, as to mere matters of detail, as is plainly intimated in the despatch, we know what to expect."[16]

The impression prevailed in the Colony that the Governor was opposed to the Free Port, Responsible Government, and the Railway. The Free Port, if granted, would be of merely local benefit; its agitation in a colony whose constituent members—island and mainland—had been forcibly joined only three years before, and between which no real fusion yet existed, tended to raise half-buried local jealousies; moreover, the Free Trade policy, which had existed in the olden days of the Colony of Vancouver Island, had been somewhat trenched upon from financial necessity, and in the end its fragments had been voluntarily jettisoned in order to secure the union of the two colonies in 1866. The Governor took a firm stand in opposition to this proposed term. "Victoria," he said, "has never had, has not now, and is not likely to have for many years to come, any export trade to other places which could render it a substantial good to the Colony to establish a Free Port. It is admitted with almost unblushing readiness that abolition of all duties and port charges is desired for the facility which was formerly afforded for smuggling into the United States."[17] Responsible Government was a subject upon which the Colony was somewhat divided. Had Governor Seymour been a strong men, able to act firmly and capably at the time of union in 1866 and during the subsequent years of depression, the issue would probably not have come into being, or at any rate would scarcely have been heard. The *Colonist*, which championed this cause, admitted that "a large and influential class thought the country not yet prepared for this constitutional change." "But," continued the editor, "who are they? The governing classes —those who appear to have got the idea into their heads that they were born to rule. Who made them a ruler over us? The Colonial Office." [18] Governor Musgrave, on this question as on all others, spoke out plainly; he had none of the enigmatic language of his predecessor. In his view a Legislative Council in which the elected members were in the majority was the proper form of the law-making body. How great that majority should be he did not, at the outset, indicate. The resolution of 1868 had requested Governor Seymour to reconstitute the Council on the basis of two-thirds popular and one-third official;[19] but on that question, as on all others of importance, Seymour, even with his five years' experience in the Colony, had not been able "to see his way clear." "I must at once state," said Musgrave, "that it (Responsible Government) would be entirely inapplicable to a community so small and so constituted as this—a sparse population scattered over a vast area of country. There is scarcely the material even for the imperfect Legislative Chamber now existing, and any effective responsibility would be out of the question except of officials to the Lieutenant-Governor and of him to his official superiors." [20] The Governor's position towards the railroad is more uncertain. His earliest despatches show him carefully feeling his way upon this almost staggering proposal. He acknowledges the absolute necessity of "a line of communication at least by wagon road, if not by railroad." [21] Six months later he writes that this material bond of union "is the crux of the scheme." "If a railway could be promised, scarcely any other question would be allowed to be a difficulty. Without the certainty of overland communication through British territory within some reasonable time, I am not confident that even if all other stipulations were conceded, the community will decide upon union." After declaring that the advocates of Confederation had raised in the people the belief "that the construction of the railway is a certain matter of course," he expresses his conviction that unless connection "at least by coach road" be granted the union should not be consummated.[22]

In November, 1869, the *Colonist* indicated the principal terms to be striven for, as seen by the residents of Vancouver Island:

Responsible Government.

Early construction of an overland railway.

Liberal subsidy for an ocean mail service.

Improved inland mail service.
Liberal subsidy for the support of the Provincial Government.
Power to the Provincial Government to establish a Free Port.
The largest representation in the Federal Cabinet and Parliament that may be compatible with the general interests of the Dominion.[23]

And now, just when the officials of the Colony themselves had accepted Confederation as its destiny, and the public were discussing suitable terms, the Annexation faction raised its head. A petition was circulated and quite largely signed on Vancouver Island, addressed to U. S. Grant, the President of the United States, urging him to "endeavour to induce Her Majesty to consent to the transfer of the Colony to the United States." No trace of its having been forwarded to President Grant has been found. At any rate "the seditious prayer," as the *Colonist* dubbed it,[24] like the notorious Banks Bill of 1866, came to naught and was soon forgotten. The true sentiments of the Colony were expressed by Mr. Trutch: "They have never, as a people, had any inclination for the United States, or any proclivity towards the institutions of that country, and though there was at one time, in the year before last, an attempt on the part of a few disaffected persons to raise such an issue, it was so speedily hooted down that the very word, annexation, has been ever since tabooed among us."[25]

In his well-known Paris letter Governor Seymour had expressed the opinion that "it would be desirable that the Governor should have the power of appointing two unofficial members of the Legislative Council to the Executive Council."[26] He announced in December, 1868, nearly three years thereafter, that the permission had been granted, but once more he could "not see his way clear" to make the selection, and up to his death no action was taken. Governor Musgrave moved more quickly. On 1st January, 1870, about four months after his arrival, he announced the appointment of the two unofficial members, Dr. J. S. Helmcken, senior member for Victoria, the head of the anti-Confederation party, and Dr. R. W. W. Carrall, the member for Cariboo, a strong supporter of Confederation. The appointment of two persons of such opposite views was a wise one. Not only did they represent the two most populous constituencies in the Colony, but their presence in the Executive Council gave assurance of the consideration of the proposed terms of union from every angle.[22]

The support of the official members of the Legislative Council on the principle of Confederation having been secured Musgrave and his Executive undertook the heavy task of drafting the terms. The object aimed at, as the Governor expressed it, was to formulate such terms, as if offered by Canada, would be gladly accepted by British Columbia. The constant harping of the press upon the necessity of the people's having a voice in the arrangement of the terms evidently bore fruit; for Musgrave fixed upon the following line of action: first, to obtain the vote of the Legislative Council in favour of Confederation; secondly, to obtain the approval by that body of the terms prepared by himself and his Executive; thirdly, to secure the consent of the Dominion Government to these approved terms; fourthly, to reconstitute the Legislative Council so as to give predominance to the elective portion and at that election to afford the people an opportunity of passing final judgment upon the scheme as arranged by the two governments; thereafter there would remain only the mere formality of passing the necessary address to Her Majesty and Confederation would, as far as British Columbia was concerned, become an accomplished fact.

In accordance with this plan of campaign the Legislative Council met on 15th February, 1870. Its twenty-three members were, with one exception,[28] the same as those of the preceding year. On that occasion the House could, under Governor Seymour, muster but five supporters of Confederation.[29] It now fell to the lot of two of the official members, H. P. P. Crease and J. W. Trutch, to move that the Council proceed to consider the terms of union. It is not my purpose to enter into the details of this debate. The official members, who, under the pressure and promise of the Governor, were all prepared to support it, endeavoured to explain away their votes of 1868 and 1869, saying that they were always in favour of Confederation, but that the time was not then ripe. In reply Mr. DeCosmos touched the real spring of their conduct: "But, sir, what did I hear at that time (1868)? 'You pension the officials and we will all vote for Confederation;' and I think I could mention another Executive Councillor who said: 'Do you think we are such fools as to vote for Confederation without being provided for?' That was the kind of wisdom in vogue in 1868." [30] After three days of wordy warfare the motion to go into Committee to consider the terms was carried unanimously.

I do not intend to set out *seriatim* the draft terms submitted by Governor Musgrave. I shall touch only those that excited the chief interest in the Colony and were in the nature of special treatment. He fixed the population at 120,000; in reality, even including the Indians it scarcely amounted to one quarter of that number. He reached this figure by dividing the customs and excise duties paid in the Colony by the average contributions for such duties made by the population of Canada, arguing that British Columbia should come into the union with the privileges of, as she relinquished the revenue derived from, 120,000 inhabitants.[31] The railway term was a composite affair—part coach road and part railroad. It specified that Canada should within three years construct a coach road connecting the Cariboo road with Fort Garry (Winnipeg), and engage to use all possible means to complete a railway connection at the earliest date; that the surveys for the railroad should be commenced immediately; and as soon as the coach road was built not less than one million dollars should be annually expended in its actual construction. The only reference to Responsible Government was a provision that the existing constitution should continue until altered under the authority of the British North America Act; in view of Section 92 of that Act the necessity of this clause is not apparent. The representation in the Dominion Parliament was set at four Senators and eight members of the House of Commons. No stipulations were inserted on the much-debated questions of Free Port and Tariff concessions.[32]

As supplementary to these proposed terms a statement was prepared showing that under the British North America Act the Dominion would take $386,700 out of a total estimated revenue of $537,750 and would assume charges amounting to $301,726; that the subsidies demanded from the Dominion would be $213,000, and that in the result, besides being relieved from the repayment of her debt, the Colony would, after providing for local services, have more than $150,000 annually to be applied to the general work of development.[33]

These terms were debated in Committee for ten days; but the alterations made were unimportant. The chief amendment suggested that the proposed grant of $35,000 for the support of the Provincial Government should be increased to $75,000, and that, instead of the per capita grant becoming stationary at 400,000 it should continue to increase with each decennial census until the population reached 1,000,000.[34] Governor Musgrave's hold upon the official members of the Legislative Council is shown by the omission of any term dealing with Responsible Government, and by the defeat of Mr. Robson's motion that this form of government should come into effect with the union.[35] In truth, as the Governor stated in his despatches, the terms were a Government measure, and he was determined to get them through the House with practically no alteration. Two supplementary resolutions, the gist of which afterwards found a place in the terms were added in Committee, pointing out the injurious effect that the Canadian tariff would have upon the infant agricultural, manufacturing, and commercial interests of the Colony.[36]

The Legislative Council having approved of the terms the Governor intimated that he purposed to send three of its members to submit them with the necessary explanations to the Dominion Government.[37] This delegation consisted of three of his Executive Councillors—Mr. Trutch, Dr. Helmcken, and Dr. Carrall. Great surprise was expressed that neither Mr. Robson nor Mr. DeCosmos, both ardent supporters of Confederation, had been chosen. It, however, transpired later that Mr. Robson had been invited to act as one of the delegates, but, owing to private business, was unable to accept.[38]

Leaving Victoria by way of San Francisco on 10th May, 1870, the delegation arrived in Ottawa on 4th June. Accompanying them went Mr. H. E. Seelye in the interests of Responsible Government, for its supporters refused to regard the defeat in the Legislative Council as final. In Mr. Robson's words: "We shall fight for and have Responsible Government. . . . We shall enter Confederation with privileges equal to other Provinces."[39] The reasons for, and the result of, Mr. Seelye's mission are given by Sir Charles Tupper: "The late Hon. John Robson, the late Mr. H. E. Seelye, and Mr. D. W. Higgins held a conference and decided that in order to secure Parliamentary Government it would be necessary for one of their number to proceed to Ottawa and inform the Government there that unless Responsible Government was assured they would oppose the adoption of the terms altogether and thus delay Confederation. Mr. Seelye was selected as the delegate. He succeeded in convincing the Dominion Government that his contention that the Province was sufficiently advanced to entitle it to representative institutions was correct."[40]

In the discussions between the delegates and the Dominion Government the central points were the financial terms and the railway. The Government agreed to undertake the early construction of the railroad and press it to completion, but, having made this concession, objection was taken to the proposed coach road as an unnecessary expense; it was accordingly stricken out. The estimated population was reduced from 120,000 to 60,000. This and certain other changes reduced the total annual payments from Canada to about $100,000 less than the delegates could accept. A deadlock seemed to have been reached. Sir George Cartier, however, saved the situation. He proposed that, following the precedent of the offer to Newfoundland, British Columbia be given in perpetuity $100,000 a year for a belt of land twenty miles in width on each side of the railway. Though in form an equivalent for the land, it was in reality merely a means of increasing the financial grant.[41] The 11th Article of the terms of union (so much debated in later years) was then drafted by Mr. Trutch, whereby the Dominion undertook to commence within two years and complete within ten years a railroad to connect the seaboard of British Columbia with the railway system of Canada and providing for the grant of the railway belt to the Dominion in consideration of the annual payment of $100,000. The representation was reduced to three Senators and six members of the House of Commons. The other alterations were of no moment, with the exception of that dealing with Responsible Government. Mr. Seelye succeeded in adding to Article 14 clauses to the effect that the Canadian Government would "readily consent to the introduction of responsible government when desired by the inhabitants of British Columbia," and recording that it was the intention of Governor Musgrave "to amend the existing constitution of the Legislature by providing that a majority of its members shall be elective."[42]

The negotiations occupied almost a month and on 7th July Mr. Seelye sent the historic telegram: "Terms agreed upon. The delegates are satisfied. Canada is favourable and guarantees the railway. Trutch has gone to England. Carrall remains one month. Helmcken and your correspondent are on their way home." [43]

Mr. Trutch's visit to England was to oversee the passing of the British Columbia Act 1870 whereby authority was granted to reconstitute the Legislative Council by reducing it to fifteen members, of whom nine should be elected and six appointed. As soon as the Act and its ancillary Order-in-Council [44] were received Musgrave lost no time in forming the new Legislature, in which, for the first time, the people's voice should be supreme. To enable the House to meet at the accustomed time, the elections were hurriedly brought on in November, 1870. The issue was clear cut: Shall we have Confederation on the terms settled? In a considerable number of constituencies both candidates were supporters of Confederation on the agreed terms, and the contest degenerated into a mere matter of personal preference. The answer was decisive. All the elected persons were Confederationists, though only four had previously occupied seats in the Legislative Council.

No sooner was it certain that the battle was won and the matter settled so far as British Columbia was concerned that there sprang up one of those sectional jealousies that had slumbered under the influence of the great question. A delegation composed of influential citizens of Victoria presented to Governor Musgrave a petition signed by five hundred residents of that city and vicinity urging its advantages (though situated on an island), as a terminus of the proposed railroad, and asking the addition of a term to the effect that if the surveys should show it to be impracticable to continue the railway to Victoria, then a railway should nevertheless be built by the Dominion to connect Victoria and Nanaimo. In no part of his two years' work in British Columbia does Musgrave's sterling character appear more clearly than in his treatment of this proposition; and nowhere does his firmness stand out in greater contrast against the weakness and vacillation of his predecessor. He pointed out that Canada had undertaken an enormous task in the construction of a transcontinental railway, of which the engineering and finanical difficulties were as yet unknown; that in such a project any paper terms must fall before the imperious demands of grades and natural obstacles; and he calmly gave his opinion that the petition was "ridiculous, if not greedy." "I am amazed," he cried, "at the concessions that have been granted by the Canadian Government, and were it stipulated that the road should be brought across the straits it might not be built at all. I think the petition should be withdrawn." The delegation refused to accept his suggestion, and after further discussion, he said: "The terms now are better than we had any right to expect—better than I expected. The true policy would be to accept these terms and be confederated and then leave the natural flow of traffic to determine the terminus." When, despite all this, the petition was still pressed, he told the delegation that he could not and would not support it, that it was undignified and provocative of sectional disputes, and that it would "sow the seeds of perennial discord on the mainland." [45] This claim of Victoria as a terminus, it may be added parenthetically, underlay the war of the routes—Fraser Valley *vs.* Bute Inlet—that for almost ten years was a factor in retarding the ultimate construction of the railway.

When the reconstructed Legislative Council met on 5th January, 1871, nothing remained but to adopt, formally, the terms of union that had been drafted, debated, amended, and settled. In his opening speech Musgrave referred to them as being "as liberal as this Colony could equitably expect." Indeed, he added, in some respects the arrangements agreed upon were more advantageous than the scheme originally proposed. He referred, doubtless, to the earlier construction of the railway. "I submit them to you," he continued, "in every confidence that you will join with me in this conclusion; and I recommend to you at once to pass an Address to Her Majesty in accordance with the provisions of the British North America Act, 1867, praying for admission into the union on these terms and conditions. I have reason for believing that the community at large desire this course, and no minor or local interests which may quite as well be considered and protected hereafter, ought to be allowed to hinder the progress of the arrangements likely to be beneficial to the Colony in general." [46] He also discussed the introduction of Responsible Government, and, in referring to the amendment providing for this change, acknowledged the existence of the very general opinion in its favour. Even that subject, however, he emphasized, must not be allowed to delay the all-important matter of Confederation. It is plain that he still retained his conviction that the Colony was not fitted for this form of government. "But," he concluded, "if the House should be deliberately of opinion that this change is expedient, and that it will not be wiser to leave it for more leisurely consideration after union," he would, after the adoption of the terms of union, introduce a Bill to establish Responsible Government, and to provide for its coming into operation at the first session after union.[47]

On 18th January, 1870, Mr. Trutch, in a short speech, moved the House into Committee to consider the concluded terms and draft the necessary Address. He confined his remarks to an account of the discussions which had taken place in Ottawa regarding the financial terms and the railway. Dr. Helmcken seconded the motion in an even briefer speech.[48] No other member spoke, and the motion was carried unanimously. The *Colonist* pointedly remarked: "Our Legislature yesterday presented a strange study. Just think of it! A Legislature created, we might say, for the express purpose of deciding the great question of Confederation, giving a unanimous vote in silence, save only what was said by the mover and seconder.[49]

The champions of Responsible Government, having won their struggle to incorporate it as a term, seemed desirous of showing the Governor their strength, and, before adopting the terms of union, endeavoured to force through the House a resolution calling for its inauguration simultaneously with Confederation. They were, however, defeated by a combination of the officials and the two unofficial members of the Executive, who succeeded in carrying a motion asking the Governor to send down such a Bill at the time indicated in his speech.[50] Accordingly the Governor did not, and would not, move in the matter until the terms had been approved and the Address to Her Majesty passed. These pre-requisites, in the Governor's opinion, having been settled on 20th January, the much-desired Bill was introduced on 31st January.[51] Even then the Governor took care to include a clause suspending its operation until the Queen in Council had assented to the union. In trasnmitting the Act to the Colonial Office Musgrave made it plain that he doubted its wisdom, but had, perforce, yielded to the strong popular feeling. "I still believe," he writes, "that the system of Responsible Government is in advance of the development of the colony, and that the existing Legislative Constitution would be sufficient for all local purposes after the union if it were allowed to work without factious opposition." [52]

In proroguing the House Musgrave mentioned the satisfaction with which the Imperial Government had learned of the completion of the negotiations and expressed his confident anticipation of the early proclamation of the union. After some philosophical remarks upon the imperfections of all human inventions he reminded them that they might reflect with pride that to them had been confided the privilege of deciding upon the most important questions which had up to that time arisen, or were likely to rise for years to come, in the history of the Colony; to them belonged the honour of extending the limits of the British American Confederation to the shores of the Pacific, and of cementing the foundations of a great and prosperous state, whose future promised to be enlightened and progressive.

In conclusion he spoke of his pride in participating in the great work, and indicated that his official connection with the Colony must, as a result, soon be severed. "Whatever be my future fortune," he added, feelingly, "I shall carry away with me from British Columbia, and I hope you will retain, a pleasant recollection of good feeling and mutual assistance in accomplishing the work which we undertook to perform." [53]

Governor Musgrave had done his work well and quickly. The Imperial Order-in-Council, dated 6th May, 1871, fixed 20th July, 1871, as the date of the entry of British Columbia into the union; five days later Anthony Musgrave bade farewell to the new Province, and from the deck of H.M.S. *Sparrowhawk* saw the western shores of the Dominion sink below the horizon.

[1]Memoirs of Sir John A. Macdonald. By Joseph Pope. London, 1894, Vol. 2, p. 144.

[2]Papers on the Union of British Columbia with the Dominion of Canada, 3rd August, 1869, p. 30.

[3]"J. S. H." (Dr. Helmcken) in *Daily British Colonist*, 10th November, 1869.

[4]*Daily British Colonist*, 24th July, 1869.

[5]*Daily British Colonist*, 9th October, 1869.

[6]*Daily British Colonist*, 11th September, 1869.

[7]Despatch from Governor Musgrave to the Colonial Office, dated 30th October, 1869, in Department of Archives of Canada.

[8]*Id.*

[9]*Id.*

[10]*Id.*

[11]*Daily British Colonist*, 3rd October, 1869.

[12]Papers relating to Union of British Columbia and Vancouver Island, 1866, pp. 4-5.

[13]Article 6 of Terms of Union between Canada and British Columbia.

[14]Preserved in Department of Archives of Canada.

[15]Memorial of the County Court Judges, 23rd April, 1874, in Dominion and Provincial Legislation, 1867-1895 (Disallowance Report), p. 1030.

[16]*Daily British Colonist*, 4th November, 1869.

[17]Despatch from Governor Musgrave to the Colonial Office, dated 30th October, 1869, in Department of Archives of Canada.

[18]*Daily British Colonist*, 5th November, 1869.

[19]*British Columbian*, 2nd May, 1868.

[20]Despatch from Governor Musgrave to the Colonial Office, 30th October, 1869, in Department of Archives of Canada.

[21]*Id.*

[22]Despatch from Governor Musgrave to Colonial Office, 5th April, 1870.

[23]*Daily British Colonist*, 6th November, 1869.

[24]*Daily British Colonist*, 18th November, 1869.

[25]Complimentary Dinner to Hon. Mr. Trutch, 15th April, 1871, Montreal, 1871, p. 10.

[26]Governor Seymour to Colonial Office, 17th February, 1866, in papers relating to Union of British Columbia and Vancouver Island, Part I, p. 34 at p. 41.

[27]*Mainland Guardian*, 19th February, 1870.

[28]Dr. J. C. Davie, an opponent of Confederation had died, and Amos DeCosmos, a strong Confederationist, who had been defeated in Victoria City in 1868, was elected in his stead as member for Victoria District.

[29]The Attitude of Governor Seymour towards Confederation, in Transactions of Royal Society of Canada, 1920, Section II, p. 47.

[30]Debates on Confederation, 1870, Legislative Council, Victoria, 1870, p. 30.

[31]Sessional Papers of Canada, 1871, No. 18, p. 2; Complimentary Dinner to Hon. Mr. Trutch, 15th April, 1871, Montreal, 1871, p. 7.

[32]Sessional papers of Canada, 1871, No. 18, pp. 6-7.

[33]*Id.*, pp. 8-10.

[34]Journals of Legislative Council of British Columbia, 1870, p. 29.

[35]Debates on Confederation, 1870, Legislative Council, Victoria, 1870, pp. 94-124

[36]Journals of Legislative Council of British Columbia, 1870, p. 34.

[37]*Id*,. p. 41.

[38]*British Columbian*, 8th July, 1882.

[39]Debates on Confederation, 1870, Legislative Council, pp. 93-94.

[40]Recollections of Sixty Years in Canada, London, 1914, pp. 127-8.

[41]Island Railway, Debates and Correspondence, compiled by Amor DeCosmos, p. 232.

[42]Article 15 of Proposed Terms of Union, Article 14 of Terms of Union.

[43]Howay and Schollfield, History of British Columbia, vol. 2, p. 293.

[44]British Columbia Act, 1870, Chap. 66; Order-in-Council, 9th August, 1870.

[45]Sessional papers of Canada, 1871, No. 18, pp. 19-22.

[46]Journals of Legislative Council, 1871, p. 2.

[47]*Id.*, p. 3.

[48]*Id.*, p. 13.

[49]*Daily British Colonist*, 19th January, 1871.

[50]Journals of Legislative Council, 1871, p. 9, 12th January, 1871.

[51]*Id.*, p. 21.

[52]Despatch from Governor Musgrave to the Colonial Office, 18th February, 1871, in Department of Archives of Canada.

[53]Journals of Legislative Council, 1871, p. 50.

Earliest Route of Travel between Canada and Acadia. Olden-time Celebrities Who Used it.

By W. O. RAYMOND, M.A., LL.D., F.R.S.C.

(Read May Meeting, 1921)

In prehistoric days the River St. John and its tributaries furnished important links in the line of travel for the native races of Canada and Acadia, both in peace and war. When the first European explorers visited Acadia there were three well-known Indian villages, or towns, on the River St. John, viz., Ekpahawk (or Aukpaque) at the "head of the tide," a few miles above Fredericton; Medoctec, on the Middle St. John, eight miles below Woodstock; and Madoueska, at or near Edmundston on the Upper St. John. The pioneer white settlers, soon after their arrival in the country, learned from the aborigines their traditions of bloody conflicts in prehistoric days between the native tribes of Acadia and their hereditary foes, the Iroquois. A traditional incident in this warfare is related in the lately published *Histoire du Madawaska*, which is here quoted in translation.[1]

"The Madawaska tribe of Malacites occupied the valley of the Saint John from the Grand Falls as far up as Seven Islands, including the region of Lake Témiscouata. Their chief village, from time immemorial, was at the mouth of the river Madawaska. This Indian town was fortified by a strong palisade firmly planted in the earth, which constituted an enclosure almost impregnable to an enemy from without. The Indians of the Lower St. John and those of Penobscot and Kennebec also sometimes sought refuge in this redoubt on the occasion of any great incursion of the enemies of their tribe.

"Although far removed from their inveterate foes, the Iroquois, the latter on various occasions came to engage them in bloody conflict. Indian tradition tells of two great incursions on the part of the Mohawks, who burned their fort and massacred a great portion of the occupants. The most remarkable of these war raids was that of a party of two hundred Mohawks from Upper Canada, who came to exterminate the Malacites.

"The Iroquois reached the River St. John by way of the little river Etchemin. When they arrived at the village of the Madawaska

[1]See *Histoire du Madawaska*, by l'Abbé Thomas Albert, p. 12.

tribe, the brave Pemmyhaouet, grand sachem of the Malacites, with a hundred of his warriors, immediately prepared to defend the fort. The contest which ensued was one of the most memorable of which there is mention in the Indian legends. The brave Pemmyhaouet fell and his son was mortally wounded. In proportion as the defenders fell under the arrows and tomahawks of the assailants, their wives and daughters took their places. It was only after an engagement of several days that the brave defenders, overpowered by the arrows and spears of the foe, were forced to abandon the place.

"The ferocious Mohawks found in the ruined fort, crouched in a retired corner, two women, who demanded death as a deliverance: they were Necomah, the wife of the old chief, and Malobiannah, the betrothed of the son of Pemmyhaouet. The son of the sachem had succumbed to his wounds and the two women had braved the fury of the Mohawks to give burial to those they loved.

"The Iroquois, flushed with their success, resolved to pursue their ravages as far as the lower valley of the river, but they were not familiar with the navigation. They accordingly laid hold of the two captives and carried them along as guides of their expedition.

"When night had fallen the bark canoes were tied together, the river being here very tranquil, and left to the guidance of the young Malobiannah . . . Necomah, the wife of the old chief being already dead of grief.

"Malobiannah, weeping for her lover, weeping for the misfortunes of her people, but concealing in her heart the thought of revenge, resolved to sacrifice her life to avenge those whom she loved and at the same time to save her brothers of Medoctec and of Ekpahawk, the villages below, from the disaster that awaited them by directing the frail barks of the enemy over the murderous falls.[2]

"At some distance from the Gulf some of the Mohawk braves, worn out with fatigue, were in a profound slumber. Aroused by the roaring of the falls they asked their guide the cause of the strange rumbling noise that they heard. 'It is a fall at the mouth of a river that joins the Walloostook[3] here,' calmly replied the young Malacite. Meanwhile the flotilla was already sweeping rapidly on toward the abyss, but the Mohawks, reassured by the *sang-froid* of the captive, lay down again to sleep. It was now but a few hundred yards to the Gulf, and a current deep and strong—the current of death—bore them onward to the brink of the precipice. Realizing too late their imminent peril they sprang from their canoes. Hurling their male-

[2]The height of the Falls is 74 feet perpendicular.

[3]Indian name of the St. John river.

dictions at the maiden they disappeared in the foaming cataract, hearing still the cry of triumph of the heroic daughter of the vanquished tribe, in which she mingled the names of her betrothed and the nation she had avenged.

"The Malacite heroine's praise has been sung in verse in the languages of the Abenaki, the French and the English. But what a rich theme is here for the future writer of romance in Madawaska.

"Greek history, so prolific of deeds of chivalry of every kind, affords nothing more heroic or more sublime than the sacrifice—unpretentious and to-day so little regarded—of this obscure daughter of the forest."

The first white settlers of the River St. John found that the native Indians entertained a superstitious dread of "the gray wolves of Canada," as they termed the Mohawks. They had many legends to relate of their conflicts with these implacable foes. Indian mothers were wont to tell the disobedient little pappoose, "If you are not good the Mohawks will come and get you." Even within the period of the writer's own recollection the word *Mohawk* suddenly uttered was sufficient to startle a St. John river Indian. The late Edward Jack, C.E., who made quite a study of Indian habits and wrote much concerning them, once asked an Indian child: "What is a Mohawk?" The child replied very seriously: "A Mohawk is a bad Indian who kills people and eats them."

Another curious incident serves to illustrate the superstitious dread entertained of the Mohawks by the Malacites.

Frederick Dibblee, a Connecticut Loyalist and a graduate of Columbia College, was appointed by the New England Company in 1787 a missionary-teacher to the Indians of Medoctec. The Society for the Propagation of the Gospel sent out to him from England a quantity of Indian prayer books, "prepared by the late excellent Colonel Claus." These books, unfortunately, were in the Mohawk dialect and Parson Dibblee could make no use of them. He says in a letter to the S.P.G.: "That the Indians of the River St. John have the utmost dread and hatred for the Mohawks, by whom formerly they were almost extirpated, and whose language they are more ignorant of than they are of the English tongue. He could not persuade two or three of his Indian scholars to take any of the prayer books, they being fearful that it would bring on a quarrel with the Mohawks upon finding their books in their possession. He, therefore, not knowing what else to do, gave them to the poor of his parish."

Passing now from the period of legendry days to that of recorded time, it may be observed that, in prehistoric days, the Madawaska

River, Lake Témiscouata, and the River St. Francis were undoubtedly very important links in the route of communication between the Indian tribes of Canada and those of Acadia. Early French explorers and adventurers soon became familiar with the route.

In Champlain's map of 1612 we find crude indications of Lake Témiscouata, but the contour of the lake and the course of the River Madawaska are better displayed in the map of Laet in 1629. The name "Madoueska" does not appear until the Franquelin map of 1686. Meanwhile the word had found a place in the grant of the Seigniory of Madoueska in 1683 to Antoine and Marguerite Aubert, children of the Sieur de Chesnaye of Quebec. The present boundary between New Brunswick and Quebec follows the southern boundary of this ancient seigniory.

The Franquelin map, just mentioned, was designed to illustrate the tour of the Intendant Mon. de Meulles in Acadia in 1686. The map shows clearly the portage to rivière du Loup and shows Lake Témiscouata. Monseigneur de Saint-Vallier, the second bishop of Quebec, made a tour in Acadia in 1686, the incidents of which are related in his book published two years later in Paris, under the title, *Estat présent de l'Eglise et de la Colonie Francoise dans la Nouvelle France.*

Church and State were thus represented in the persons of de Meulles and Saint-Vallier, the first Quebec tourists in Acadia. This was not a matter of accident but of design, as we shall see. Mgr. de St. Vallier, finding that the River St. Francis (which enters the St. John 35 miles above the Madawaska) has its source in a lake only 12 miles from the St. Lawrence, decided to travel by this route. He describes in entertaining fashion his trip down this very lively stream, which now forms a part of the international boundary. The St. Francis may be described as a series of beautiful lakes and ponds linked together by very lively waterways. One of the lakes has a depth of 150 feet. Another of nearly equal depth bears the name Woolastookpectaagomic—a nice little word of twenty-one letters not yet recognized by the Geographical Board of Canada. The two lakes just mentioned are exceeded in depth by Lake Témiscouata (250 ft.), which is the deepest of the St. John river system. Mgr. St. Vallier tells us in his narrative, under date May 16, 1686: "On the second day of our navigation down the river Saint-Jean, we for the first time came across a cabin of Christian Indians, of Sillery, who in their hunting had encamped at the mouth of a river which they call Madaouesca and which we named Saint-François de Sales. It is impossible to tell how overjoyed these poor Christians were to see us, and how rejoiced we were to find them. . . . They made us a present of part of their provisions at a time when ours failed us. The same day we found others in much larger numbers in three cabins, who entertained us in like manner, and who asked us earnestly to send a missionary to teach them."

A little farther on in his book Mgr. St. Vallier gives the first description of the Grand Falls of the River St. John that has appeared in print. This we also quote in translation: "The sixteenth of May [1686] we arrived at the place called *le grand Sault Saint-Jean-Baptiste,* where the river falls from a height over lofty rocks into an abyss, making a wonderful cascade, the rising mist hides the water from sight, and the uproar of the falls warns from afar the navigators descending the river in their canoes."

Mon. de Meulles, the intendant, while on this tour visited all the new settlements in Acadia and caused a census to be taken, including the name and residence of every French settler, with other information. The total French population of Acadia was then only 915 souls, including the garrison of Port Royal. There were at this time only five or six French families living on the St. John river.

Bishop St. Vallier again writes in his journal: "The 18th [May, 1686] we slept at Medocteck, the first fort in Acadia, where I greatly cheered a hundred savages during my visit. I told them I came on purpose to establish a mission in the place for their benefit. It is to be wished that the French who live along this route were so exemplary in their habits as to draw these poor savages to Christianity; but we must hope that with time the reformation of the former will lead to the conversion of the latter."

The Marquis de Denonville, governor at Quebec, in his letter to the French minister announcing the safe return of the Bishop, after a most fatiguing journey, says: 'He will give you an account of the numerous disorders committed by the miserable outlaws [the *coureurs de bois*] who for a long while have lived like the Indians without doing anything at all towards the tilling of the soil."

The authorities at Quebec had already shown an interest in affairs on the River St. John, where Pierre de Joibert, seigneur de Soulanges, served as commander under Count Frontenac. The sieur de Soulanges was a native of the little town of Soulanges, in the old French province of Champagne, who, in recognition of "good and praiseworthy service to the King, both in Old and New France," was granted three valuable seigniories on the St. John, including in all more than a hundred square miles—the value of which at the present day would be difficult to estimate. One seigniory, at the mouth of the river, includes in its bounds the present city of St. John and its suburbs. Another, the seigniory at Nachouac, includes within its limits the sites of Fredericton, the capital of New Brunswick, and the neighbouring towns of Marysville and North and South Devon. The third seigniory, "Fort Gemsek," (midway between St. John and Fredericton, at the mouth of the Jemseg river) was the residence of the Sieur de Soulanges, and for ten years the head-quarters of French authority in Acadia. Here in 1673 was born Louise Elizabeth de Joibert, daughter of Soulanges, who, at the early age of seventeen years, became the wife of the Marquis de Vaudreuil, Governor General of Canada. She was baptized at Jemseg (probably by the Recollet missionary, Claude Moireau), and Count Frontenac was, by proxy, her godfather. Later she was educated at the convent of the Ursulines in Quebec. As Marquise de Vaudreuil she is described as a beautiful and clever woman, of rare sagacity and exquisite modesty and possessed of all the graces needed to shine in the most exalted circles. She was the mother of 12 children. Her husband was for twenty-two years Governor General at Quebec, and her son, the second Marquis de Vaudreuil, was the last Governor General of New France at the time of the conquest in 1759.

In the year 1674 a Dutch buccaneer named Aernouts pillaged and dismantled Fort Jemsek and carried off the commander. Frontenac at once sent a party in canoes to the River St. John to ascertain the state of affairs and to bring to Quebec the wife of the Sieur de Soulanges and her child, his god-daughter. The journey of the mother and her infant from Jemsek to Quebec, 400 miles, in an Indian bark canoe two centuries and a half ago is an incident unique in the recorded wilderness journeys of the time. The mother before her marriage was Marie Françoise, the daughter of Chartier de Lotbenière, attorney general of Quebec. The daughter, as Marquise de Vaudreuil, visited France in 1708 in a ship which was captured by the English, who, however, treated her with distinction and allowed her to proceed to her destination. She attracted much attention at the Court of Versailles and became a favourite both of Louis XIV and of Madame de Maintenon. The Marquise survived her husband and died in Paris in June, 1740. A romantic story truly is that of the little Louise Elizabeth Joibert, whose infant slumbers were disturbed by the rude Dutchmen at Fort Gemsek in the summer of 1674.

The first known representative of the English race to become acquainted with the route to Canada, so far as we know, was a lad, John Gyles by name, who was captured by St. John River Indians at Pemaquid, on the coast of Maine in 1689 and brought by his

Indian master to the Medoctec village where he remained six years a captive.

It was the custom of the Indians at the beginning of winter to break up into small hunting parties, and Gyles' description of his first winter's experience will serve to indicate the privations endured by the savages and the nature of travelling through the woods in the winter season.

"When the winter came on," he writes, "we went up the river till the ice came down, running thick in the river, when, according to the Indian custom, we laid up our canoes till spring. Then we travelled, sometimes on the ice and sometimes on land, till we came to a river that was open but not fordable, when we made a raft and passed over bag and baggage. I met with no abuse from them in this winter's hunting, though I was put to great hardships in carrying burdens and for want of food. But they underwent the same difficulty and would often encourage me by saying, 'By and by great deal moose.' Yet they could not answer any question I asked them; and knowing very little of their customs and ways of life, I thought it tedious to be constantly moving from place to place, yet it might be in some respects an advantage, for it ran in my mind that we were travelling to some settlement; and when my burden was over heavy, and the Indians left me behind, and the still evening came on, I fancied I could see through the bushes and hear the people of some great town, which might be some support to me by day, though I found not the town at night."

As Dr. Hannay observes, there is something inexpressively pathetic in this part of John Gyles' story. He was only a half-grown boy, ill-fed and scantily clad, when he had thus to bear his burden in mid-winter through the forest after his Indian master. The narrative continues:

"Thus we were hunting 300 miles from the sea and knew no man within 50 or 60 miles of us. We were eight or ten in number and had but two guns on which we wholly depended for food. If any disaster had happened we must all have perished. Sometimes we had no manner of sustenance for three or four days. . . . We moved still further up the country after the moose, so that by the spring we had got to the northward of the Lady Mountains (the mountains of Notre Dame overlooking the St. Lawrence).

"When the spring came and the rivers broke up we moved back to the head of St. John's river and there made canoes of moose hides, sewing three or four together and pitching the seams with balsam mixed with charcoal. Then we went down the river to a place called

Madawescok. There an old man lived and kept a sort of trading house, where we tarried several days. Then we went further down the river till we came to the greatest falls in these parts, which they call Checanekepeag[3] (the Grand Falls), where we carried a little way overland, and putting off our canoes again we went down stream still, and as we passed the mouths of any large branches we saw Indians. At length we arrived at the place where we left our canoes in the fall, and putting our baggage in them went down to the Medoctec Fort."

Gyles remained six years with the Indians. Then through the kindness of the Recollet missionary, Father Simon, he was taken into the family of Louis d'Amours, sieur de Chauffours, who lived at Fort Jemsek, where he continued three years, experiencing very kindly treatment, of which he writes gratefully in his narrative. He was then restored to his friends in New England who welcomed him, after his nine years' captivity, almost as one risen from the dead.

Next in order among the old time voyageurs we must place the French explorer, Lamothe Cadiallac, the founder of Detroit, who ascended the River St. John in 1692 and reported that 40 leagues above the Medoctec village he found another fort to which the Malacites were wont to retire when they feared some great calamity was impending. Cadiallac writes entertainingly and with enthusiasm of the noble river, which he ascended nearly 150 leagues in a birch canoe. He speaks of it as a well-known route of communication between the people of Acadia and those of Quebec. The Indians had used the route from time immemorial, both in war and peace, and the French followed their example as, at a later period, did the English.

The St. John River country may be considered as a "disputed territory" from the moment when the treaty of Utrecht was signed in 1713 until the capture of Quebec by Wolfe's army in 1759. The missionaries of this region, de l'Isle-Dieu, Germain, and le Loutre, not unnaturally were desirous of seeing French supremacy restored in Acadia, and Father Germain, the missionary to the Indians on the St. John, encouraged the Malacites in their hostility to the English. He proceeded to Quebec in 1743, returning with a supply of powder, lead and ball, for the Indian warriors at Ekpahawk, whom he accompanied in their mid-winter raid on Colonel Noble's post at Grand Pré. This raid, from the French point of view, was one of the most brilliant exploits in the annals of Acadia, and, what is better, the victors behaved with humanity to the vanquished.

Commissioners were now appointed by the contending parties to determine the limits of Acadia. They spent four years in fruitless

[3]The name signifies "a destroying giant."

discussion. The missionaries le Loutre and de l'Isle Dieu furnished the information which here follows for the use of the French Commissioners:

"It is very easy to maintain communication with Quebec, winter and summer, by the River St. John, and the route is convenient for detachments of troops needed either for attack or defence. The stations along the route from Quebec to Beauséjour, at the head of the Bay of Fundy, are as follows:

From Quebec to rivière du Loup.

From rivière du Loup by a portage of 18 leagues to Lake Témiscouata.

From Lake Témiscouata to Madoechka.

From Madoechka to the Grand Falls.

From the Grand Falls to Medoctek.

From Medocktek to Ecouba (Ekpahawk), post of the Indians of the missionary, Father Germain.

From Ecouba to Jemsec.

From Jemsec—leaving the River St. John and traversing Washademoak Lake, ascending by the river of the same name, thence by a portage of 6 leagues to the River Petkoudiak.

From Petkoudiak to Memeramcouk and by a portage of 3 leagues to Nechkak (Westcock).

From Nechkak to Beauséjour.

"By this route troops commanded by the Sieurs Marin and Montesson arrived at Beauséjour in less than a month from the time of their departure from Quebec, the distance being about 500 miles."

Early in 1745 the Sieur Marin appeared before the town of Port Royal (then in possession of the English) with a party of 600 French and Indians—among the latter were many from the River St. John and some Hurons from Canada. They captured two Boston schooners, one of which, the "Montague," had as master, William Pote, of Falmouth, Maine. Captain Pote and some others were taken by the Huron Indians to Quebec, where Pote remained three years a prisoner. During his captivity he contrived to keep a journal in which he records his capture and subsequent adventures. The journal was concealed by one of the female prisoners and afterwards restored to the captain. It passed through many hands and was discovered at Geneva, in Switzerland, in 1890, and published a few years since by Dodd, Mead & Co., of New York, in a sumptuous edition. Pote's narrative is exceedingly interesting, but our references to it must necessarily be brief.

Some of the prisoners were taken up the River St. John in the captured schooner to Ekpahawk, the others proceeded overland. Pote was among the latter. He and his fellows were taken up the Petitcodiac river in a small schooner until they arrived at the portage to the Washademoak, which they crossed and encamped. Soon afterwards the Abbé Germain arrived from the River St. John. Pote says: "The Priest asked ye Capt. of ye Indians who I was, and when he understood I was a prisoner, he asked me if I could speak French. I told him a little. . . . He told me to content myself in the condition that I was then in, for I was in ye hands of a Christian nation and it might prove very beneficial both to my body and soul. I was obliged to concur with his sentiments for fear of displeasing my masters."

Having made seven canoes of elm and ash bark the party proceeded down the Washademoak to the St. John and up the latter to the Indian village of Ekpahawk. On their way they caught some small fish which Pote tried to clean, but the Indians snatched them from him and boiled them, "slime and blood and all together." "This," said Pote, "put me in mind of ye old proverb, God sent meat and the Devil cooks." On another occasion, being overtaken by a violent thunderstorm, they were obliged to take shelter under the upturned canoes. Pote writes in his journal: "At this time it thundered exceedingly and ye Indians asked me if there was not people in my country sometimes destroyed by ye thunder and lightning. Yes, I told them, I had known several instances of that nature. They told me that never anything happened to the Indians of harm neither by thunder nor lightning, and they said it was a judgment on ye English and French for incroaching on their liberties in America." On his arrival at Ekpahawk, on the evening of the 6th July, Pote found that his schooner "Montague" had arrived some days before with the other prisoners. The newcomers received an unexpected reception, which we shall allow Capt. Pote to describe in his own words: "At this place the Squaws came down to the edge of ye river, dancing and behaving in the most brutish manner, and taking us prisoners by ye arms, one Squaw on each side of a prisoner, they led us up to their village and placed themselves in a large circle round us. After they had got all prepared for their dance they made us set down in a small circle, about 18 inches asunder, and began their frolick, dancing round us and striking of us in ye face with English scalps that caused ye blood to issue from our mouths and noses in a very great and plentiful manner, and tangled their hands in our hair and knocked our heads together with all their strength and vehemence, and when they was tired of this exercise they would take us by the hair and some by ye ears, and standing behind us, oblige us to keep our necks strong so as to bear their weight hanging by our hair and ears.

"In this manner they thumped us in ye back and sides with their knees and feet and twitched our hair and ears to such a degree that I am incapable to express it, and ye others that was dancing round, if they saw any man falter and did not hold up his neck, they dached ye scalps in our faces with such violence that every man endeavoured to bear them hanging by their hair in this manner rather than to have a double punishment. After they had finished their frolick, that lasted about two hours and a half, we was carried to one of their camps where we saw some of the prisoners that came in the "Montague." At this place we encamped that night with hungry belleys."

Unpleasant as was their experience, Pote and his fellows were lucky to escape with their lives. The previous year Capt. Gorham had brought to Annapolis Royal some Indian rangers, probably Mohawks, as allies of the English. These Indian rangers had killed some of the Malacites, and the tribe at Ekpahawk proposed to retaliate by putting the prisoners to death. A council was held and the St. John's Indians almost gained their point. The Hurons, however, being very desirous to save the lives of their captives, whom they probably wished to hold for ransom, prevailed on the Malacites to accept a considerable quantity of their spoils and spare the lives of the prisoners.

Their unhappy experience at Ekpahawk caused the captives to feel no regret when the Hurons took their departure up the river two days later. They had now come to the beginning of the swift water and their progress was more laborious. At the Meductic Rapids they were obliged to land and carry their baggage over clefts of rocks, fallen trees and other obstacles. Pote was informed that they would ere long arrive at the Indian village of Medoctec. He asked if they would be treated there as they had been at the last village. This question led to an immediate consultation of the Hurons. "I observed," writes Pote, "that they looked with a very serious countenance on me." He seized the opportunity to address them in French to the following effect:

"Gentlemen, you are all very sensible of the ill usage we met at the other village. which, I believe, was contrary to your inclination or permission, and as you call yourselves Christians and men of honour, I hope you'll use your prisoners accordingly, for I think it is contrary to the nature of a Christian to abuse men in the manner we was at the other village. There is no Christian nation that suffers their prisoners to be abused, after they have given them quarter, in the manner we have been."

Pote says that the Indians looked very serious and approved of what he said. They talked among themselves in Indian and his master told him that when they arrived at the village he must take care to keep close by him. Pote says: "I was very cáreful to observe my master's instructions and warned ye rest to do likewise." Their reception was not reassuring. We will again allow Captain Pote to tell the story in his own words:

"Tuesday, June 10. We arrive to ye Indian village of Medocatike about noon. As soon as the Squaws saw us coming in sight, and heard the cohoops, which signified ye number of prisoners, all ye Squaws prepared themselves with large rods of briars and nettles, etc., and met us at their landing, singing and dancing and yelling, and making such a hellish noise that I expected we should meet with a worse reception at this place than we had at the other."

The first canoe that landed was that of the captain of the Hurons, who had in his canoe but one prisoner, an Indian of Captain Gorham's company. He was not careful to keep by his master and in consequence: "The Squaws gathered round him and caught him by the hair, as many as could get hold of him, and halled him down to ye ground, ye rest with rods danced round him and wipted him over ye head and legs to such a degree that I thought they would have killed him on ye spot, or halled him in ye water and drownded him. They was so eager to have a stroak at him, each of them, that they halled him some one way and some another. Sometimes towards ye watter by ye hair of ye head as fast as they could run, then ye other party would have ye better and run with him another way. My master spoke to the Indians and told them to take the fellow out of their hands, for he believed they would certainly murther him in a very short time."

The Squaws advanced towards Pote, but his master spoke something to them in Indian in a very harsh manner that caused them to relinquish their purpose. The prisoners and their Indian masters were conducted to the camp of the captain of the village who, at their request, sent to relieve the unfortunate Mohawk from the abuse of the Squaws, and he was brought to them more dead than alive.

Pote himself did not entirely escape attention at the hands of *les sauvagesses de Medoctec* as we learn from his journal:

"Thursday, June 11. This day we remained in the Indian village called Medocatike. I observed the Squaws could not by any means content themselves without having their dance. They continued teasing my master to such a degree to have ye liberty to dance round me, that he consented they might if they would promise not to abuse me. They desired none of the rest but me, for what reason I cannot tell. When my master had given them liberty there came into the camp two large, strong Squaws. They caught hold of my arms with all their strength, and said something in Indian that I supposed was to tell me to come with them and halled me off my seat. I strugled with them and cleared myself of their hold, and set down by my master. They came upon me again verey vigorously, and as I was striving my master ordered me to go and told me they would not hurt me. At this I was obliged to surrender and went with them. They led me out of the camp, dancing and singing after their manner, and took me to one of their camps where there was a company of them gathered for their dance. They made me sit down on a Bear's skin in the middle of the camp and gave me a pipe and tobacoe and danced round me till the sweat trickled down their faces."

The appearance of one Squaw struck the Captain as so absurd that he could not forbear smiling, which gave offence to one of the old Squaws, who gave him two or three twitches by the hair, otherwise he escaped punishment. The following morning the Hurons began to make preparations for their journey and Pote says: "At about eight of ye clock we took our departure from Medockaticke for Canedy" and in due time the party arrived at Quebec.

They suffered at times from lack of food, though fish were abundant and on one occasion they caught in a weir that the Indians built in a small cove (a little below the mouth of the Tobique river) fifty-four salmon in a few hours. From Grand Falls they proceeded to "Little Falls," at the mouth of the Madawaska, and up that river to Lake Témiscouata; thence by way of the Tuladi stream to the St. Lawrence and up that river to Quebec.

In 1750 the Marquis de la Jouquière expended a considerable sum of money making a road from the St. Lawrence to the Upper St. John, via Rivière du Loup and Lake Témiscouata. This road, he informs the French Minister, will be very useful for forwarding the supplies stopped by the English blockade at the mouth of the St. Lawrence, and maintaining communication with Acadia. By this route war parties of French and Indians, under Boishébert and other commanders, passed from Canada to Acadia, and messages were often sent from Quebec to Beauséjour and Louisburg. It is said that with the water at flood the Indians were able to deliver messages from the Governor at Quebec to the commander at the mouth of the St. John in five days, a distance of 430 miles. That this was quite possible is shown by the fact that not many years ago the Messrs. Straton, of Fredericton, paddled in a bark canoe from the Grand Falls to Fredericton, 133 miles, in 14 hours and 46 minutes, the river being then at freshet height.

Among the early voyageurs who have left interesting accounts of their journey over this route we may mention Joseph Nicholas Gauthier, of Port Lajoie (Charlottetown, P.E.I.), who made the journey from Shediac to Quebec in the winter of 1756. From Medoctec he proceeded to the Grand Falls, partly on the ice and partly on land, hindered in his progress by the fact that the river had overflowed its banks and in places was not frozen. This distance of eighty miles took eleven days on account of the wretched state of travel. At the Grand Falls he found a French post furnished with provisions for travellers. Gauthier says that here they made a portage of half a league and resumed their journey above the falls. The distance of 36 miles to Little Falls occupied the next three days. He then ascended the river "Madouesca" on the ice ten leagues to a lake bearing the name of the river, but now called Lake Témiscouata. He journeyed four leagues on the lake and went ashore at the *grand portage* on the west side of the lake, where there was another French post established for the refreshment of travellers. From thence he proceeded via Rivière du Cap to l'Original, which empties into the St. Lawrence. This journey, which can now be made, from Charlottetown to Quebec, with all the ease and luxury of modern travelling, in less than 24 hours, occupied *le Captaine* Gauthier a month, and was extremely arduous and even perilous.

The story of the old post-route to Quebec in the English regime introduces some very interesting characters, but must be reserved for a supplementary paper.

The Phylogeny of Man From a New Angle

By CHARLES HILL-TOUT, F.R.S.C., F.R.A.I.; &c; &c.

(Read May Meeting, 1921)

Those who have followed the course of anthropological investigation during the eight or nine years which have elapsed since the discovery of the Piltdown remains will be aware that our views respecting the antiquity and the progressive evolution of man have undergone profound modification. Even before the discovery of Eoanthropus there had been a growing feeling among anthropologists that a new orientation of mind on these questions was becoming increasingly necessary.

The discovery at Combe Capelle, at Mentone and other places of the remains of a race of men with distinctly modern characters who were apparently living in Europe contemporaneously with the markedly-primitive Neanderthal men brought considerable confusion into our notions respecting the age of man and the course he had followed in his physical development.

Up to this time it had been very generally held and believed that man in his upward course had passed through an orderly series of evolutionary phases such as seemed to be indicated by the physical characters of Pithecanthropus *erectus*, the Mauer jaw and Neanderthal man, in which he had risen step by step from some primitive creature not greatly unlike the anthropoids of to-day, to his present human form; and that his past in his character of Homo sapiens, did not extend very greatly beyond the middle of the Pleistocene period.

Following the views enunciated by Darwin in his "Descent of Man" and their reinforcement by Huxley in his "Man's Place in Nature" and the very general acceptance of the evolutionary theory, it was scarcely possible to entertain any other opinion. And so, when Dubois in 1891-2 discovered the remains of that singular creature he named Pithecanthropus *erectus*, which combined in itself characters at once both human and simian, it was very naturally hailed and regarded as the "missing link," the anticipated transitional form connecting man with his hypothetical simian progenitors.

And this view was further strengthened when a little later other human remains of a type similar to the famous Neanderthal man were unearthed in different localities in Europe, thus making it possible to definitely and indubitably establish this type as a distinct and primitive race which, while considerably in advance of Pithecanthropus *erectus*, still exhibited marked simian characters; and scarcely anybody thereafter doubted that in the low-browed Neanderthalers, the heavy-jawed Heidelberg men and Dubois' Javan ape-man, we were viewing three of the successive stages through which man had passed in his evolutionary career.

The discovery, however, of the Crô-Magnon men with their strongly-marked modern characters, as partial contemporaries and immediate successors of the low, pithecoid Neanderthalers; and a critical re-examination in the light of our newer knowledge of the claims to antiquity of the pre-Mousterian High-terrace type of man—whose possession also of modern characters had thrown doubt upon their age as indicated by the geological formations in which they were found—completely upset this view; and when the Piltdown remains with their peculiar and, in some respects, astonishingly modern characters were discovered in sediments earlier in time, if anything, than those in which Dubois had found Pithecanthropus these views could no longer be entertained and a reconstruction of our ideas concerning the evolutionary phases of man's history became imperatively necessary.

If Pithecanthropus could no longer be regarded as standing in the direct line of man's ancestry—and additional evidence will be adduced in this paper to show that he could not be—and if Neanderthal man with his low, pithecoid characters must also be eliminated from our family tree, who then, it might fairly be asked, were our ancestors? What had been our descent? What the course of our evolutionary history; and what part have these rejected types of early humanity played in man's phylogeny; and can the lineage of any of the races of men on the earth today be traced back to any other of those palaeolithic races our researches have shown us to have existed in the dim and distant days of the middle and early Pleistocene period? If so, whence came they and what kind of progenitors were theirs?

These are all questions of the deepest interest to humanity and it is only natural to crave the fullest replies that science can give to them. But such answers as may be given at the present stage of our investigations will depend to a large extent upon the point of view we may take upon certain fundamental aspects of our subject and upon the interpretation we may give to the evidence which has been brought to light during the present century and particularly during the last decade. There is, unfortunately, anything but general agreement upon many aspects of this.

It is the intention in this paper to briefly review this evidence and see to what conclusions it may be said to fairly lead one in respect to any of these questions; and to offer in the course of our inquiry a line of evidence which, in the writer's opinion, has had too little attention paid to it hitherto and which seems to him capable of throwing very definite light upon some, at least, of the problems we have to deal with.

In spite of the fact that there exists considerable difference of opinion upon the significance of many of our later discoveries and that on many points of extreme importance our highest authorities are in direct conflict, the present century has seen a decided advance in many directions in our knowledge of ancient man.

One of the most outstanding and definite of the results of these researches, and one upon which there is now little or no difference of opinion has been the establishment of a series of successive cultural epochs in man's past reaching back from the Bronze age, which is directly linked with our own, to remotest Palæolithic times.

Some twelve of these epochs are generally recognized and are known to us under the terms Tardenoisian, Azilian, Magdalenian, Solutrian, Aurignacian, Mousterian, Acheulean, Chellean, Strepyan, Mesvinian, Mafflian and Reutelian. Of these, the first is regarded as the transitional epoch linking up the Neolithic with the earlier Palæolithic period. The others all fall within and extend over the whole Pleistocene era.

Beyond the Pleistocene and extending into the Pliocene and Upper Miocene is another long and somewhat ill-defined period, known broadly as the Eolithic, because the stone implements recovered from the geological beds of this period become relatively cruder and exhibit less and less skill as the recession of time goes on until it is no longer possible to say whether they are the work of man or the chance products of nature. Hence the term Dawn-stone period. This period is also, by some authorities, sub-divided into separate cultural epochs each marked by its own distinct term. These, in their chronological order, are Prestian, Kentian, Cantalian, and Fagnian.

The time embraced by these epochs is variously estimated at from one and a half to two and a half million years. Thus man's duration on the earth is now known to be much greater than was formerly supposed.

Accepting the higher estimate as approximately the more correct—for the greater our knowledge of man's past becomes the greater need there seems to be to draw larger drafts upon the bank of time—

one million of these years must be assigned to the Pleistocene and the other million and a half may be divided between the Pliocene and Miocene.

The evidence of man's presence throughout this long stretch of time is now generally regarded as clear and unmistakeable. For the later Pleistocene division it is absolutely indisputable. We find not only evidence of his presence in the abundance of his skilfully-fashioned stone and bone implements but also in the actual skeletal remains of man himself, under such conditions and in such circumstances, as to make it impossible to doubt the antiquity claimed for them.

For the earlier division of the Pliocene and Upper Miocene the evidence consists, in the main, of his stone implements. But the character of these is such that it leaves no room for doubt concerning their origin, and those investigators best qualified to express an opinion upon such matters are now generally agreed that the stone implements recovered from the Pliocene and Upper Miocene beds are the undoubted products of human effort and are unmistakeable evidence of man's presence on the earth in those remote times.

It should perhaps be mentioned here that some authorities claim that evidence of man's presence and his tool-making powers is found as far back as the Lower Miocene and even into the Oligocene. The human workmanship which, it is thought, is seen in these stones, however, is still a matter of dispute, though more recent discoveries in Upper Miocene beds at Aurillac in France of implements closely resembling the earliest types of Palæoliths seem to suggest that these claims may ultimately be sustained, but as they are still matters of dispute they need not be taken into consideration here.

Regarding, then, man's antiquity as firmly established and his presence as a tool-maker in those far-off Eolithic and Palæolithic days beyond dispute, let us now see what our researches have to tell us about the races of men who lived in those successive cultural epochs, their relations to one another and to the races of men on the earth today.

The human family as we know it today is commonly divided into four great groups—the Australian, the African, the Mongolian and the European. Of the first three of these groups our investigations have revealed to us little direct knowledge. What we have learned of them has been mainly indirect and inferential. This is because our records of Pleistocene man, if we except the pithecoid creature from Java, are all confined to European lands and deal with

European peoples. But while we have gathered but little directly of these other groups certain facts have come to light in the course of our investigations which have important bearings upon the history of all of them.

Thus, one fact in particular, has become increasingly clear and more firmly established as our researches have proceeded; and that is the remarkable persistence of human types and their slow modification over long periods of time. Tens of thousands of years are seen to elapse and still the same type persists, transmitting age by age the same physical characters through thousands of generations. We had caught a glimpse of this great truth from the monuments of ancient Egypt, whereon the artists of the early dynasties had depicted the features of men representative of the African, Asiatic and European peoples of their day, whose resemblance to individuals of the same races today, is so clear and unmistakeable that they might have been painted but yesterday. We learn from these pictures, for example, that the African of today differs in no respect perceivable to us from the African of those days, though there is an interval of from five to seven thousand years between our time and theirs.

But this important truth is far more strikingly brought out by our discover es of Pleistocene man, for these have revealed to us instances of this conservancy of type extending over vastly greater periods of time than the Egyptian examples.

A consideration of these facts, and the implications they carry, lead us irresistably to the conclusion that if the relatively slighter differences existing between the races we find in Europe to-day are the slow product or result of tens of thousands of years of differentiation, then the deeper and more fundamental differences which divide the four great groups of humanity one from the other must be the result, not merely of tens of thousands of years of variation, but of hundreds of thousands. This being so it is not surprising that when we endeavour to trace back the first three of these four groups to their original source we find ourselves lost in the mists of antiquity and can learn little concerning it or them.

It is altogether different when we come to deal with the European group. Here we are on surer ground and start from known facts.

Europe today is occupied by three great races now generally known to us as the Mediterranean, the Teutonic or Baltic and the Alpine or Celtic races; and of the relation of these to the races of the earliest historic period there is no question. Nor is there any doubt as to the connection between the early historic peoples and those of the preceding Bronze age. We can thus trace back the present European peoples to Neolithic times.

We find evidence on all sides of the presence of these three peoples in Europe in the Neolithic period, which, our archaelogical evidence seems to say, had its beginning about ten thousand years ago. Now what are the characteristics of these three pre-historic peoples and how are they distinguished one from the other? How can we be sure we are dealing with three different races, the predecessors of the present races of Europe? The evidence is indisputable. It presents itself under divers aspects, but chiefly we gather it from a comparison of their skull forms.

In seeking to establish a physical test of race, students of man, have proposed several criteria. Some of the earlier students, like Huxley and Virchow, regarded the color of the eyes and the hair as a reliable test. Today, however, the concensus of opinion favors the making of cranial characters the chief criterion of race; and of these experience has taught us that the most persistent and least variable is that expressed by the cephalic index; that is, the relation of the width to the length of the head. Retzius, who was the first to employ this method, recognized but two fundamental head forms, the long oval one which he termed the dolichocephalic and the short round one which he called the brachycephalic. Modern anthropometry, however, recognizes a third or intermediate one termed the mesocephalic. This form would appear to be the result of a blending or intermixture of the other two fundamental forms; for whenever there is an intermixture of the two extreme types the result seems to be not the development of a third type, with fixed ratios, but rather a form that tends to approximate to one or other of the parent types. That is to say, the skull-forms resulting from such intermixture of racial characters reveal a tendency to group themselves round one or other of Retzius' two type forms rather than to develop a definitely intermediate form. Notwithstanding this observed fact we find mesocephaly is the characteristic of certain well-defined racial groups of which the British, the Chinese and the Polynesians are noted examples. From which it would appear that a more or less permanent intermediate type has been evolved by the crossing of the two extreme types. That this crossing has taken place in the case of the British peoples we know for certain. We now, therefore, recognise three types of skull-form and apply them in the classification of the races of men. All skulls having a cephalic index below seventy-five per cent., that is, any whose breadth is less than seventy-five per cent. of their length, are termed dolichocephalic skulls. Those whose width ranges between seventy-five and eighty per cent. of their length are termed mesocephalic, and those whose width is above eighty per cent. constitute the brachycephalic type. It has been found that the British type is a remarkably constant one having an index ranging only between seventy-seven and seventy-nine per cent. It is thus seen to fall within the mesocephalic class and to reveal a slight tendency toward the dolichocephalic type. This is just what we should expect to find from the known history of the race. The British are a composite people, the result of the admixture of the three Neolithic races of Europe—two long-headed and one round-headed peoples. Hence their slight tendency toward dolichocephaly.

In the cephalic index, then, we have discovered a valuable and reliable test of race. By its means we distinguish the various peoples of Europe today and likewise the peoples of the past; and by its means we learn that the three great racial groups dwelling in modern Europe are the lineal descendents of the three pre-historic races that inhabited it in the Neolithic age, their respective cephalic indices corresponding one with the other in a very remarkable manner. Such being the case and keeping in mind the persistence of types, it is not difficult for us to discover what were the characteristics of these three Neolithic peoples from our knowledge of the physical characters of their modern representatives.

We learn that one of these races—the northernmost—was a fair, blue-eyed people, with rather narrow acquiline noses. Its stature was somewhat less in Neolithic times than it is now, stature being a variable character and subject to relatively rapid changes, but its head form was practically the same then as today—distinctly dolichocephalic. This is the race we now call the Teutonic or Baltic, or Nordic.

We learn also that the southernmost—the Mediterranean race—was in coloring the direct opposite of the northern race. They were a distinctly brunette people, with dark eyes and hair, rather broad noses and slender long heads of a marked dolichocephalic type.

Ripley holds the opinion that these two long-headed peoples, notwithstanding their marked differences in coloring, may have had a common origin; that is to say, both were probably derived from the earlier long-headed people who inhabited western Europe in Palæolithic times. He is inclined to regard them as variant types of one common stock and explains the distinctive fairness and greater stature of the Teutonic peoples of today as the result of a relatively long isolation in northern Europe, of the environmental influences there encountered and of artificial selection. Other students hold other opinions and derive them from different sources. The time is not yet come when we can speak with certainty of their origin and affiliations.

That the two races, Northern and Southern, dwelt side by side in Europe in earlier times Ripley holds as proved by archæological evidence. He sees in the Alpine race of middle Europe and France, a later intrusive people having decided Asiatic affinities, who had thrust themselves into the center of the earlier inhabitants and driven them asunder into two diverging groups, forcing one to the north and the other to the south, where their descendents are mainly found to this day.

This Alpine race is today, as it undoubtedly was also in Neolithic times, a round-headed, hazel-eyed, stocky people, with rather broad, heavy noses. Ripley seems to be justified in holding these views; for our researches assure us that the early inhabitants of western Europe, that is, the true Palæolithic peoples, were all of the long-headed type. There is not a single instance known of a typically brachycephalic man in Europe till late Palaeolithic times.

We can reconstruct fairly easily the salient features of the culture of the Neolithic peoples of Europe from the evidences they have left behind them in the remains of their lacustrine habitations, in the contents of their cave-shelters, in their midden-heaps and in their barrows or burial mounds. From these latter we certainly gather some very definite information. We find, for example, that they constructed these barrows in two distinct ways. To one, a long or oval form was given; to the other, a short round form. We learn, too, from the contents of these mounds that the long barrows are earlier in time than the round ones. For in the long barrows we find implements or objects of stone only. In the round barrows we find specimens of bronze objects as well. We may conclude, therefore, that the round barrows belong exclusively to the late Neolithic or early Bronze age. But this is not the only remarkable feature about these tumuli. There is another one even more significant and that is, that the long, oval barrows always contain dolichocephalic skulls and the short round barrows brachycephalic skulls. Scarcely any exception to this rule has ever been observed and when such an exception does occur it is found that a long-barrow has been opened for the interment of a member of the later round-headed race. Indeed, so invariable is our experience in this particular that an ethnic law has been founded upon it which is thus concisely expressed, —"long-barrow—long-skull. Round-barrow—round-skull."

Lord Avebury, in the recent edition of his "Pre-historic Times," informs us that the latest researches confirm the earlier in this respect. Long-barrows produce long-headed skulls and round-barrows round-headed skulls. Thus, for example, in sixty-seven skulls taken at random from long-barrows, fifty-five were of the dolichocephalic type, ranging between sixty-three and seventy-three in their indices. Twelve were mesocephalic, ranging between seventy-four and seventy-nine, and not one reached eighty. This variation is not greater than that commonly found in any race. A race is judged by its mean types—not by its extreme types. From the round-barrows seventy skulls were taken. Of these not one was below seventy-three. Twenty-six were between seventy-four and seventy-nine, and forty-four between eighty and eighty-nine.

From these facts Ripley seems justified in regarding these round-headed people, with their bronze implements implying a superior culture, as hailing from the east. It is obvious they could not have come from the west, so we naturally look to the east as their original home. We are confirmed in this view, moreover, by the fact that the general type of head of the millions of Asiatic peoples conforms to the Alpine type. Who they were and from what center of the east they came we have yet to learn. All we positively know is that today their descendents constitute about one half of the population of every state in Central Europe and that the manner of their settlement has been rather remarkable. They are always found in the mountainous districts—never or rarely in the low-lying, fertile plains. Hence their name of "Alpine" race. It would seem from this fact that after their first successful effort to effect a settlement in Europe they had gradually been forced by their predecessors into the less fertile regions of the country and had been obliged to content themselves with the possession of the hilly and mountainous districts.

However this may be, we find that the cephalic indices of the modern races of Europe follow the rise and fall of the land so regularly as to give to the fact the force of an ethnic law: High-land—short-heads; Low-land—long-heads.

Regarding the people of modern Europe as a whole we find that the only homology they share in common today is the character and texture of their hair. This singular fact seems to have a very important bearing upon their origin and ethnic relations.

The human hair, like the human skull-form, is found to assume two distinct types or characters. One is represented by the crisp, curly hair of the negro and the other by the straight, wirey hair of the Asiatic peoples and the Amerinds. Each is radically different in texture from the other. When a hair of the negro type is examined under a microscope a cross-section of it presents a flattened, elliptical form, without any distinguishable medullary or central pith tube. A cross-section of the straight, lank kind shows a round or cylindrical form, with a distinct, central, medullary tube, containing pith. Both kinds are invariably black. These characters are found to be as persistent as the cephalic index and when a racial crossing of the two types is effected we observe a result similar to that which follows the blending of the two typical head-forms—the evolution of a secondary or intermediate form; and this, like the intermediate head-forms, exhibits a varying tendency toward the characters of one or other of the primary types. The hair of the Europeans of today is characterized by these secondary qualities. It is neither altogether crisp and curly like that of the negro nor straight and lank like that of the Asiatic, but partakes in a varying degree of both these characters. In cross-section it is seen to be ovaloid in form, with a slightly distinguishable but rudimentary medullary tube which is wholly without pith. Its color is variable, ranging from fair to dark or quite black.

From these circumstances we are irresistably led to the conclusion that they are a people of mixed descent having Africanoid affinities on the one side and Asiatic on the other. The Asiatic characters we conclude they inherit from the brachycephalic people of the round-barrows who invaded Europe from the east in Neolithic times. From whence came the Africanoid affinities? We shall better be able to answer this question when we have learned what our researches can teach us of the earlier Palaeolithic peoples of Europe.

Thus far we have traced the modern races of Europe back to Neolithic times and seen that the appearance of one of them coincides with the Bronze age and that they entered Europe from the east and are undoubtedly of Asiatic origin. It remains now to learn what we may of the other two long-headed peoples whom Ripley regards as variant types of an earlier common stock.

We find that the Neolithic merges insensibly into the Palaeolithic —there is no recognizable break between the two. The people of the Tardenoisian—Azilian epochs link up the two periods into a continuous, unbroken whole. Just how early the first wave of Asiatic migration began is yet an open question. Osborn sees in the Furfooz-Grenelle type of man a new race of broad-headed people distinct from the Alpine stock proper. He thinks we may see six different races in Europe at the close of the Palaeolithic period. These he terms Teutonic or Baltic, Mediterranean, Alpine or Celtic, Furfooz-

Grenelle, Brünn-Predmost and Crô-Magnon. The first three are those of Ripley and other students. The last three are his own creation. Following Schliz he regards the Furfooz-Grenelle broad-head types as distinct from the Neolithic Alpine race. But the evidence does not seem to me to compel one to this view. It is by no means certain that the Furfooz-Grenelle skulls date back to Palaeolithic times. At any rate, the antiquity of the man of Grenelle is extremely doubtful and he may very well represent a Neolithic man of the Alpine stock from which he differs in no essential particulars. Osborn himself admits this. And if we admit the Furfooz skeletons as belonging to the late Palaeolithic they do not extend at most, as is evident from the faunal remains found with them, greatly beyond the transitional Tardenoisian epoch and there is consequently no difficulty in regarding them as part of that advanced wave of the Neolithic Alpine race which we seem to see making its way into Western Europe in late Palaeolithic times by way of the Danube, and which may have become modified in its cranial characters by intermixture with the long-headed Crômagniards before it reached Belgium. The lesser brachycephaly of the Furfooz skulls would seem to suggest this. The same argument applies to his second long-headed race—the Brünn-Predmost men. They do not differ in any marked manner from the long-headed Mediterranean people; and it seems better, in the present state of our knowledge, to follow Keith and regard them, and also his sixth race, the Crô-Magnon people, as locally-modified types of this stock. Advance waves of the Asiatic round-headed peoples and later waves of the Mediterranean race, may very well have taken place in late Palaeolithic times. It was the beginning of that great race movement which reached its full strength in Neolithic times, culminating in the settlement of western Europe with the ancestors of the races we find there today.

We have evidence that America was peopled in just this way. The northwest tribes plainly show their later arrival on this continent by a closer likeness to the modern Mongolian races of Eastern Asia than is seen in the tribes to the east and south of them, these latter representing earlier migratory waves of the same stock.

It does not seem to me that we gain anything by a multiplication of races at the dawn of the Neolithic period. Three great races make up the people of Europe to-day and we can trace these back to Neolithic times or even perhaps to late Pathaeolithic times. Two of these loom upon the European horizon then for the first time. One we know is a brachycephalic people of Asiatic origin. The other is the dolichocephalic Teutonic or Baltic race, whose place of origin and affiliations have yet to be determined. The third may be regarded as the aboriginal occupiers of western Europe. Wherever the members of this race are found they all possess the same general skull-form. They are the primitive long-headed people of this region. All conform more or less closely to the so-called "river-bed" type of men. This and the Mediterranean type are one and the same. It was the term by which these palaeolithic men were first known to us because the earliest skeletal remains we secured of them were found in the ancient beds of the rivers of England and France. Keith's critical examination of their cranial characters has made them very well known to us. Later, when so many remains of this type were found in the lands bordering on the Mediterranean Sergi suggested the name "Mediterranean" race for them, by which term they are now commonly known, notwithstanding the fact that we are now aware that this type of man was characteristic not only of the river beds of England and France and the Mediterranean shores, but also of the whole of western Europe—of Spain, of Switzerland, of north Germany and of Scandinavia. It had reached even to the shores of North Africa for the most ancient of the Egyptian stock must be classed as members of this same palaeolithic race.

Ripley sees in the Berbers of North Africa the purest representatives of this race today. If his contention is sound then Sergi's claim that the Mediterranean race is of African origin, whose original home, he thinks, was the region of the Great Lakes, is not without justification, for the Berbers are plainly a people of mixed descent, blending in themselves the characters of both negro and Asiatic. Such an origin satisfactorily explains why we find Africanoid characters in the hair of the modern European races. It also accounts for the strong negroid characters seen in the Crô-Magnon race, in particular those types from the Grimaldi caves. Viewed in this light we can follow Keith in his opinion that the Grimaldi skeletons need not be regarded as other than aberrant forms of the general Crô-Magnon type. These negroid affinities are not by any means confined to these two Grimaldi skeletons. They are seen in the limbs of the race generally. It has been found that their tibiae or leg-bones were relativelyl ong and their humeri or upper arm-bones short. These characters are common among negroid peoples today, but no other of the European peoples, save the Crô-Magnons, exhibit them. In modern Europeans the radius of the forearm is about seventy-four per cent. of the humeral or upper arm. In modern negroes it reaches to seventy-nine per cent. The radius of the Grimaldi lad is also seventy-nine per cent.; that of the woman is eighty-five per cent. These arm proportions hold good of the Crô-Magnon people generally. Sergi's claim of an African origin for the Mediterranean race of which the Crô-Magnons form a part, is thus not wholly without warrant; and Ripley's claim that the Berbers of today represent this ancient palaeolithic race of Europe most closely also receives support from the same evidence. We can thus provisionally derive this dark, dolichocephalic Crô-Magnon race from Africa, and account for the negroid affinities we discover in the hair of the modern European races in this way.

Thus, while we have no direct knowledge of ancient man in Asia or Africa, if we except the strange, pithecoid creature found in Java, we have discovered inferentially and, by the way, that these regions of the earth were probably the source of the ancient men whose skeletal remains have been found in Europe, at any rate, from Aurignacian times onward. What relation the Crô-Magnon race bore to the Mousterian Neanderthalers, if any, or to the pre-Mousterian High-terrace type of man, we have now to seek to determine.

From late Mousterian times to the Tardanoisian epoch Crô-Magnon man is the prevailing type in western Europe. The Aurignacian culture is characteristic of him. He appears to us quite suddenly upon the Palæloithic horizon toward the close of the preceding Mousterian epoch—the period of Neanderthal man. We have seen that he possessed negroid characters, in some instances quite marked, and may, as Sergi thinks, have had an African origin.

However this may be, physically and mentally, he stands out in marked contrast to his predecessors, the short, low-browed Neanderthalers as a glance at Figure I shows us. Keith calls the Crô-Magnon race the finest race the world has ever seen. They were of lofty stature, ranging in the men from five feet ten and a half inches to six feet, four and a half inches, with broad well-developed bodies. The best specimens of the Zulu race or of the South Sea Islanders approach most closely to them in these characters of modern races. The writer has seen just such men as the typical Crô-Magnons must have been among the Samoans and Tongans of today. Some writers liken them to the Sikhs of India, who also are a very fine type of men of a uniformly lofty stature. Their cranial capacity also was extraordinary. Broca estimated that of the "Old Man of Crô-Magnon" at 1590 cub c centimeters and Verneau found that five large male skulls from the Grimaldi grottos had an average capacity of 1800 cubic centimeters, the lowest being 1715 cubic centimeters and the highest 1880 cubic centimeters, a truly astonishing brain even when allowance is made for their great stature. Even the women of this race reached to 1550 cubic centimeters or more than 100 cubic centimeters in excess of the average brain capacity of the men of our day.

The Crô-Magnons were thus in brain and in stature a truly wonderful people and one is not surprised to learn that they were mighty hunters and had developed an artistic skill and a power and excellence in portrayal that were not surpassed by succeeding races till civilization had well advanced.

The valley of the Dordogne was the geographic center of this race in palaeolithic times and it is a remarkable coincidence that the same center is the home of the purest representatives of this same race today. The ancient and the modern Crô-Magnons are practically identical in respect to their cranial characters. There has been a falling off in stature. The present people do not reach to the proportions of their palaeolithic ancestors. This need not surprise us for stature is a very variable character in man and subject to relatively rapid changes. As a matter of fact, we find the race decreasing in stature immediately after Aurignacian times. The easy conditions and abundant food supplies of the genial interglacial period, in which the Aurignacian epoch falls, was conducive to great stature and bodily development generally; whereas the more rigorous conditions of the succeeding cold period, with its more limited food supplies, would naturally tend to produce the contrary effect.

The cephalic indices of the ancient people varied from seventy to seventy-three per cent. These figures in the living skull would be represented by seventy-two to seventy-five per cent., or two per cent. more. The modern Crô-Magnon indices are a little higher than this, seventy-six per cent. being about the average, though many individual skulls fall to the ancient low level. This rise in the average of the cephalic index may be accounted for by intermarriage with the round-headed Alpine stock. Ripley regards the modern Crô-Magnons as the direct descendants of the ancient people of Dordogne, with an unbroken lineage from Aurignacian times downward. If he is correct in this view the Cromagniards of today furnish us with the most striking example of persistence of type and population, extending over tens of thousands of years, that has ever been discovered. This same type of people is found in isolated groups elsewhere in Europe. According to Verneau the Crô-Magnon type was the common one among the extinct Guanches of the Canary Islands. It is said to be found also at Lannion in Brittany, at Landes in France and on the island of Oberon. Virchow has described a group of the same people in the islands of North Holland.

Whatever source we may derive the Crô-Magnon people from, whether Africa or elsewhere, one thing is quite certain—we cannot possibly relate them to their immediate predecessors, the low-browed, pithecoid men of the Mousterian epoch. The two types are essentially dissimilar and seem to share no feature in common. The fact that Mousterian man, though so low in type in other respects, possesses no negroid characters at all, seems sufficient of itself to preclude any relationship between the two peoples. We seem to suddenly find the two races, so strangely dissimilar, side by side in Western Europe toward the close of the Mousterian epoch and then as suddenly the earlier and less highly-developed race disappears from our ken entirely. No sooner is the Crô-Magnon culture established than Neanderthal man vanishes as if he never had been. From Aurignacian times onward no further trace of him is found. What happened to him? Was he driven out of Europe or was he completely extirpated by the incoming Crômagniards? Some writers hold one view; some the other. Others again think he was submerged by intermixture with the superior race. A comparison of the two races, however,—one a remarkably highly-developed race as we have seen; the other the lowest and most bestial type of man of which we have any knowledge—does not seem to lead one to this conclusion, but rather to the view that the inferior race was speedily exterminated by the superior one. Incidents of the kind have not infrequently happened in human history. It happened not so long ago, as we know, in the case of the natives of Tasmania. And yet, viewing the matter in the light of the Aryan invasion of India where the circumstances must have been very similar to those in this case, and remembering also the decrease in the stature of the Crô-Magnons after Aurignacian times, it does not seem altogether improbable that some kind of a mixture of the two races may have taken place.

Viewing the matter thus in the light of general history, what seems most likely to have taken place was the general extermination of the men of the inferior race and the sparing of the pick of their women. Such a procedure would be quite in accordance with the usage of primitive man.

This view seems to fit in best with the facts of the case. For if they had been forced into other regions—as, for example, the Alpine race was in Great Britain after the invasion of the later Baltic hordes—and not wholly extirpated or absorbed, we ought to find some evidence of the fact; but we do not, and nothing at present seems more certain than the absolute disappearance of Neanderthal man after the advent of the Crô-Magnons. Neanderthal man's end is thus striking and dramatic, if only on account of its apparent suddenness.

So much for his end. But what of his beginning? Where did he originate and what are his affiliations?

The answers we can give to these questions today must, in the light of our recent discoveries, be quite different from those formerly given and generally accepted.

As long as we regarded Pithecanthropus as standing in the direct line of man's ancestry and connecting us with our homosimian progenitors; and Neanderthal man as manifesting a later and further phase, along the same lines of development, his low, pithecoid characters were taken for granted and caused no surprise. Primitive man must have presented just such an appearance and possessed just such characters, it was thought; but when Eoanthropus came to light, with his vastly greater antiquity and yet exhibiting cranial characters strikingly modern in all respects save the thickness of the skull, such views could no longer be entertained and the presence of these low characters in Neanderthal man had to be otherwise accounted for. But more than that followed upon the discovery of Eoanthropus and made the problem before us more complex. It led to the reconsideration of the geological evidence of the antiquity of the High-terrace men, with the result that they were placed in their rightful order in the scale of time. Viewing Neanderthal man as we did, and finding him living in an age so relatively near to our own as the Mousterian epoch, we had done violence to the evidence of the antiquity of the High-terrace men because of their comparatively higher development and superior cranial characters and had regarded them as subsequent in time to Neanderthal man, in spite of the fact that all the geological evidence relative to their discovery bore witness to their greater age and pointed to a period antedating the Mousterian epoch by thousands of years.

These facts make the presence of so degenerate and pithecoid a race as Homo neanderthalensis, at so relatively late a period in human history, a still greater anomaly and a more perplexing problem. What then is the explanation of such a race as Neanderthal man, sandwiched in, as it were, between the relatively-advanced High-terrace men on the one hand and the highly-developed Crô-Magnons on the other?

The simplest explanation is to accept the view now becoming general, namely, that when man was in the making Nature turned out more than one specimen of him. In other words, we must give up our old monophyletic conception of man's descent and accept a polyphyletic one and see in the Heidelberg and Neanderthal men, in the 100-foot terrace men and possibly in Eoanthropus as well, types of men so widely differentiated one from the other as to constitute distinct species or even genera.

If we consider for a moment the parallel development of the anthropoid apes and observe their differentiation into distinct species and genera, we shall see that this is really what we might expect to find in the case of man. This has been Nature's method of working everywhere. Why should man in his physical development have proved an exception to her general rule? Assuredly he did not, and we get a clearer view of man's evolutionary history by frankly acknowledging this.

Let us now consider the question of the status of Pithecanthropus in the genealogical tree of man. Instead of regarding him as we did, and as some students seem inclined still to do, in spite of all the evidence to the contrary, as a transitional form relating us to the anthropoids and as representing one of the earliest stages man went through on the road toward humanity; let us rather see in him, as the veteran student Sergi has from his first discovery consistently seen, not a specimen of humanity at all, not even a semi-human forerunner of man, but rather one of the ancient anthropoids which followed more closely than some of his fellows the lines of human development, but which had departed too far therefrom when we know him to be classed with the Hominidae.

If we reflect for a moment with open minds we shall see that Sergi's view has all the elements of high probability about it and when presently we come to consider the evidence in support of it we shall realise that it is the only one in the circumstances that can be entertained. In the first place, it is extremely doubtful, as he long ago pointed out, if a true transitional form ever exists in the sense in which the term is applied to Pithecanthropus *erectus*. As far as we can see, it is not Nature's method of working. We have abundant evidence of progressive evolution on every hand, and of simple, generalised stocks giving rise to collateral divergent forms; but when once such forms have arisen and become more or less specialised, there can be no bridging over the gap between them by a so-called transitional form. No such form exists and none could exist, blending the specialised characters of the now divergent types, as Pithecanthropus was thought to do, except as the result of a mating of the two types; and that such a thing as this took place is so unlikely that few will be found to hold or advocate such a view.

Transitional forms of this kind are never found in nature, at any rate among the mammals. In nature species keep distinct and breed only with their kind. The horse and the ass existed together over a long period of time and never produced a mule by interbreeding till man domesticated and interbred them. Transitional forms blending the characters of two distinct species or families as Pithecanthropus is thought to blend the characters of man and the anthropoids, are the product of articifical selection, never of natural selection, and such form could no more exist naturally than did a mule or any other of the hybrids man has brought into existence by the interbreeding of different species.

We misread Nature's plan altogether when we see in Pithecanthropus a "missing link," a "transitional" form linking us up with the anthropoids. Man and the anthropoids are truly related, but not in this way. Their connection lies in their common descent and common ancestry; but when once a divergence had taken place and the two types had become specialised nothing could bring them together again but a retracing of all the steps they had taken; and that course, in the higher forms of life Nature has forbidden.

It is futile, then, to look for "missing links" and "transitional" forms. We shall never find them; they do not exist. What we may be lucky enough to find are types of men like Eoanthropus and types of apes like Pilgrim's Sivapithecus or others more closely resembling in their skull forms the young of the present-day apes. Thus far Eoanthropus is the most truly primitive type of man we have yet discovered and the one which most plainly suggests to us the type of being the ancestor common to man and the anthropoids must have been; and Pithecanthropus is the most human-like of the ancient apes we know of. We shall never see Pithecanthropus in the right perspective until we can clear our minds of the misleading notion that in looking for the first man, the really primitive human type, we have to seek for a form suggestive of the anthropoids as we know them today. The anthropoids and man together constitute two diverging lines of evolution sprung from a common source, The numerous anatomical and morphological resemblances between. the two leave no room for doubt on this point. Keith tells us, for example, that man shares with the chimpanzee 396 common characters with the gorilla, 385; with the orangoutang, 272, and with the gibbon, 188. It is clear, then, that the farther back we go in their phyletic history the closer will the two lines converge until there comes a time when we shall see no radical difference between them; but that does not at all mean that man will exhibit characters like those of the ape or even like those of Pithecanthropus as so many students still hold. Regarding the point purely as an abstract question, the contrary is just as likely to be true; that is, instead of finding man becoming more and more ape-like as we go back in time, we shall see the apes becoming more and more man-like; and when we come to consider all the evidence in favor of this view we discover that this is what has really taken place—at least in respect to their cranial characters. It is the anthropoids which have diverged most from the ancestral type—not man. They are, as far as their cranial characters are concerned, much more highly specialised and modified than he. Man has kept the ancestral head-form much more closely than the apes as a glance at Figure II in which the skulls of a man, a baby gorilla and a male mature gorilla are contrasted, will plainly show. It is not at all surprising, then, that some of the earliest and less specialised apes should resemble man in his cranial characters more closely than do the highly specialised apes of today. Pithecanthropus is one of these fossil forms which does this. There were many more anthropoids in earlier times than at present. Some of these we know resembled man more closely than do the anthropoids of today.

Now if we can discover and learn something about the causes which brought about the changes in the head-forms of the mature anthropoids of today—changes which differentiate them almost as much from their own young as from man—we shall have gone a long way toward explaining those characters in Neanderthal man that make him so ape-like and differentiate him so markedly from the races which preceded and followed him. We get a very good idea of the essential difference between modern man and the men of the Mousterian epoch by a glance at Figure III where Keith has contrasted the manner in which the heads of the two types of humanity are attached to the body.

What is it that constitutes the outstanding difference in the heads of most of the living anthropoids and of man? Is it not the excessive musculature of the former and the comparative absence of this feature in the latter? An examination of the skulls of the young of all the anthropoids makes this quite certain. All those bony protuberances, such as the excessive tori or supraorbital arches, and the upstanding crests or median and occipital ridges of the mature apes, especially of the males, which differentiate them almost as much from their own young as from man, all arise from this cause. The very shape of the head has been altered by this excessive musculature, the mature skulls bearing little resemblance to those of the young undifferentiated forms.

Nehring has shown that the masseter or masticatory muscles do really affect the form of the skull by his investigations upon dogs and apes; and he is of the opinion that the occurrence of a constriction between the orbital and cerebral regions of the skull has direct relation to the strength of the facial musculature and especially of the masseter muscles.

It is a well-known fact that decrease in the size and action of the jaw invariably follows upon primitive man's advance in culture; and the well-known experiments upon certain students at Cambridge have shown that increased mental activity results in increased brain volume. Thus a rise in the culture-status of a primitive people should be followed by three effects—an increase in brain volume, a decrease in facial musculature and a consequent freer expansion of the brain case. Are not these just the features which differentiate the High-terrace men and the Crômagniards from Neanderthal man? Low races, like that of the Mousterian epoch, always have heavy, strong jaws. The muscles which work these jaws arise from the side walls of the skull. In heavy-jawed races these muscles rise higher on the head than in light-jawed races, their limit being marked by the curved line of the temporal crest. Sergi has shown that excessive development of the masseter muscles in the lower races of mankind results in the production of a median ridge like that seen in some of the mature anthropoids. He tells us it is found in Australia, in New Zealand and in many parts of Oceania. The higher these muscles rise the more they tend to compress the skull and modify its shape. Hence the difference in the skulls of the young and the mature apes, and hence the difference in the skulls of Homo neanderthalensis and of the Crômagniards.

The presence of the same features in Neanderthal man as seen in the anthropoids, that is, their excessive musculature, as disclosed by their heavy jaws and prominent tori, makes it quite clear that the men of the Mousterian epoch had followed along the same lines of development, in this respect, as the anthropoids and hence their degenerate and more ape-like appearance. We thus find what we might have expected to find, namely, that as some species or genera of anthropoids, such as Pithecanthropus and others, followed in certain respects the lines of human development, and hence their more human-like appearance, so some species or genera of men, such as Homo neanderthalensis and probably also Homo heidelbergensis, followed in other respects the line of anthropoid development and hence their more ape-like appearance. The same explanation accounts for the appearance of these pithecoid characters in Australian man and the other so-called primitive races. Respecting the excessive bony arches over and around the eyes, Dr. Görke and others have suggested that these are necessary in an animal with a heavy jaw-bone, large molars and a retreating forehead. With such a forehead and a projecting upper-jaw the lines of pressure would enter the skull case at an oblique angle. Thus a development of bone in this region would give the resistance necessary in these circumstances.

Now these characters are not necessarily primitive as we have been in the habit of supposing. Indeed they cannot be those which were possessed by the common ancestor of apes and man, or they would be seen in the young of both branches of the Primates, and this they are not. This is a fact, I submit, which has been too much disregarded in all our inquiries. Time and again the human-like features in the skulls of the young anthropoids, indeed of all the young of the Simiadae, have been remarked upon. It has also been pointed out by some writers tha the skulls of the young Neanderthalers, as exemplified in the Krapina children, are wholly wanting in the pithecoid features characteristic of the adult skulls of Mousterian man; and yet the real significance of this fact seems to have escaped the attention of every investigator. Let us consider a moment what the absence of these features in the young of Neanderthal man and of the anthropoids really signifies. And in order to rightly appreciate the point let us view the skulls of the Krapina children and the skulls of the young anthropoids in the light of that great biogenetic principle, sometimes called Baer's law.

This, briefly expressed, signifies that the ontogeny of the individual recapitulates the phylogeny of the race. In other words, that the embryological development of the individual is an epitome of the evolutionary course taken by the order or class to which it belongs; and further—and this is where this law throws light upon the question we are considering—that the young of any species represents more truly and closely than do the adult members of that species the actual ancestral type from which the species originally sprang. It is true that a wider knowledge of embryological development than von Baer possessed has shown us that this biogenetic law was not so absolute and thorough-going as he conceived it to be; and we can no longer say today that the ontogeny of the individual recapitulates the phylogeny of the race in all its phases. It does recapitulate a great number of very important phases, but it also strangely leaves out a lot which seem equally important, and thus the epitome is not ideally perfect and comprehensive. But taking the law in its general sense and as it applies to the question under consideration, its validity is unassailable and it reveals to us many important truths. Thus we learn, for example, that in the later stages of embryological development the apes and man follow parallel lines which are practically indistinguishable and that during this stage there is a much closer resemblance between the two in the facial and cerebral portions of their heads than appears later in post-natal life. In both we see the same simple generalised head-form, each being equally lacking in any specialised feature. After birth the skulls of the human young retain this generalised form longer than do those of the young of the apes who are seen to more quickly take on the cranial characters of the typical mature human skull as they pass on to the specialised form of their parents, as may be seen from the comparison of skulls in Figure 5.

Now it must follow from Baer's law that the skull-forms of the young of the anthropoids and the young of man must represent very closely the original skull-form of their common progenitor; so that if we were to take a composite photograph of a series of both forms the result would be a type of skull that represents as closely as can be the actual head or skull-form of Homosimius *precursor.*

Are we not, then, forced by the cogency of these facts, to conclude that man has differentiated little in respect to his skull-form, while the anthropoids have differentiated much; and that consequently Pithecanthropus and Neanderthal man do not truly represent in their cranial characters man as he was under his primitive aspects, but rather those anthropoids which have diverged least from the ancestral form; and that in the men of the Mousterian epoch we see the same tendency toward that facial and cranial musculature which is characteristic of the mature anthropoids and which has resulted in giving them their present head-forms?

This view is further supported by the cranial characters of the Anthropoidea as a whole. Any one who has observed the young of monkeys, both of the Old and the New Worlds, will be aware that they show a much closer resemblance to the human type, both in facial and cranial characters, than do their parents. The human aspect of some of them is truly remarkable, and this resemblance grows less and less as they mature and take on the specialised characters of their species, thus confirming the truth of Baer's biogenetic law.

Viewing Mousterian man in this light and as one of the several species or genera into which early man became differentiated we can understand that he may have appeared on the globe at the same time as more highly-developed and less simian-like types did. This view also enables us to see in Homo heidelbergensis a type of man similar to Homo neanderthalensis. We may indeed go farther than this and see in him, if we are led to take that view, an earlier form of the same genus. There is nothing in the character of the Mauer jaw to hinder us from regarding the men of Heidelberg as the direct forerunners of Neanderthal man. The only thing which seems to stand in the way of our establishing this view is the absence of all evidence of the presence of either type during the long interval between the Mousterian epoch and the Mafflian, which latter, Rutot regards as the epoch of Homo heidelbergensis. But this does not mean that none exists or that it will not be found. Remains of either or both may come to light at any time. All we can say is that up to the present we have no direct evidence of the presence of either of these races of man between these two epochs. The human remains now regarded as characteristic of this intervening period are those of the High-terrace men, so called because these remains have been found mainly in the upper 100-foot terraces of several of the rivers of Western Europe. These terraces or ancient river-beds antedate by many millennia the later and lower 50-foot terraces characteristic of the Mousterian culture.

These men are best exemplified in the Galley Hill, the Clichy and the Olmo types. The valleys of the Thames, Somme, Seine and Arno have all revealed this same kind of man, who, in his general cranial characters approximates very closely to the modern type. Keith, after his critical and detailed survey of the human remains known to us now as antedating the Mousterian epoch, comes to the conclusion that all the remains of early man of which we have any knowledge, with the one exception of Heidelberg man, resemble in their cranial characters the skulls of modern man rather than those of Homo neanderthalensis.

From the point of view taken in this paper, this is exactly what we ought to find. If the skulls of the young anthropoids represent in their general characters, as they must, according to von Baer's biogenetic law, the skull-form of the ancestor common to themselves and man, we should find this type of skull more surely the farther back in man's history we go. That this view is sound we are assured by the discovery of Eoanthropus who though very much older than the High-terrace type of man, possessed similar cranial characters.

These skulls of early man, while exhibiting the general contours and cranial capacity of those of modern man, yet possess at the same time certain features that are peculiar to themselves and which tend to prove their antiquity. One of these features—probably that most characteristic of them all—is the great thickness of the cranial vault. The average thickness of a modern skull is about 5 mm.; that of the Galley-Hill man has a thickness more than double this, running from 10 to 12mm. The Clichy skull has even a greater maximum thickness. It runs from 10 to 13 mm. The Olmo skull has an average thickness of 11 mm., while that of Eoanthropus has a maximum thickness of 12 mm. Thickness of skull would thus seem to be one of the characteristics of primitive man; and when in the future we find skulls with this character, under such conditions as surrounded the Galley-Hill, Clichy and Olmo skulls, where the geological evidence of their age is plain and clear, we need not do violence to this evidence and cast doubt upon their antiquity because in other characters they approximate to the modern type of skull.

Admitting, then, with Keith and those who think with him that the Galley Hill, Clichy and Olmo men preceded by many thousands of years Homo neanderthalensis and by their radical difference in type from him, could not have belonged to the same race, we have now to seek the origin and affiliations of these High-terrace men. Were they autochthonous? Did they come into existence in that part of the world where we find their remains? Are they the direct lineal descendants of the Dawn-men, or are they like the Crô-Magnons migrants from the south, earlier representatives of the Mediterranean race?

It is not possible to give decisive answers to these questions one way or the other in the present state of our knowledge. Like the Mediterranean race, they are distinctly dolichocephalic, while Eoanthropus appears to be mesocephalic with a tendency toward dolichocephaly.

Viewing the matter strictly on the merits of the evidence at our disposal, it would seem that we are hardly more justified in regarding the High-terrace men as the direct lineal descendants of the Dawn-men, notwithstanding their common thickness of skull, than as early immigrants from the Mediterranean region. Keith takes the view that Eoanthropus represents a collateral branch of the human family, one of those primitive types or genera that passed out of existence without leaving any posterity to represent them. To others, the evidence seems to point the other way, and marks Eoanthropus as the direct ancestor of the High-terrace men. This is the view held by Elliott Smith, who looks upon Eoanthropus as the direct ancestor of the High-terrace men, and thus possibly of ourselves.

There are difficulties from whichever point of view we may regard the question. But this much at least seems certain, that whether we regard Eoanthropus as the direct ancestor of the thick-skulled High-terrace men, and thus of modern man, or as a distinct race apart which left no posterity, we have in seeking for man's earliest progenitors to look for beings possessing cranial and facial characters similar to those exhibited by him and not by beings like Pithecanthropus. The fact that he possessed strongly-developed canines and had no chin cannot be considered as wholly excluding him from standing in the relation of direct ancestor to the men of the 100-foot terraces. A long interval intervenes between him and them, and in that interval these characters might have become modified. If man and the anthropoids had a common ancestor, as we believe, then the earliest type of man must have possessed just such facial and dental characters as we see in Eoanthropus because these are characteristic of the whole sub-order of the Anthropoidea, and while the anthropoid branch has retained them in an emphasised form the human branch has lost them. The descendants of Eoanthropus may, in course of time, have lost one of these characters and acquired the other and thus might very well have become the direct ancestors of the 100-foot terrace men. There is nothing antecedently impossible in the idea and two facts distinctly favor the notion. Both types of humanity are found in the same region and both possess the same marked thickness of skull, the only doubtful factor in the case being whether the interval between the two periods is sufficient to effect such radical differences. The more we learn of man's past the clearer it becomes that radical changes in typical characters require long ages to bring about. It may, therefore, be better to let the question of the origin and affiliations of the pre-Mousterian men stand in abeyance for the present and await further evidence of a more determinative character. The discovery of Eoanthropus, whatever his relations to the men who are seen to succeed him may be, has had one good result at least—it has restored the 100-foot terrace men to their rightful place in the scale of time. Their high antiquity has been established and they are now seen in their true perspective upon the background of human history.

Regarding man's origin in the light thrown upon it by palaeontologial evidence, that is, seeing him as we do the anthropoids, differentiated into several distinct types, some relatively advanced and some distinctly degenerate, in the Dawn-period of human history, we ought not, in this review of man's past, to overlook entirely the claims to antiquity made by Sergi for the Castenedolo remains.

Notwithstanding the doubt cast upon these by other students and despite the fact that the Castenedolo skull does not possess a single feature which we are accustomed to regard as primitive, not even thickness of bone, Sergi has never faltered in his belief that these remains represent man as he appeared in Italy in the later Pliocene. These skeletal remains were found embedded in Pliocene strata at Castenedolo by Ragazzoni. They represent a man and a woman and also two children, but only the skull of the woman was complete enough for reconstruction. Sergi examined the skeletal remains and the pit from which they were taken by Ragazzoni and was convinced that the bones lay in an undisturbed bed of Pliocene age. We know of only one independent fact that seems to lend support to this view. The Olmo skull was found in the same region about 150 miles to the south of Castenedolo. But while this was taken from a Pleistocene desposit at a depth of 50 feet, the Castenedolo remains taken from the Pliocene bed lay only a few feet from the surface. The Castenedolo skull is the exact counterpart of the Olmo skull in everything but thickness of the vault. The Olmo skull is that of a male, while the other is that of a female. Whether this difference in sex is sufficient of itself to account for the difference in thickness is extremely doubtful. The idea finds no support from the Piltdown skull which, as we have seen, is very thick and yet is probably that of a female also.

If thickness of skull is a *sine quâ non* of ancient human skulls, as the main body of evidence at hand would incline us to think, then its absence in the Castenedolo skull would seem to say that the Castenedolo remains are not as old as the clay beds in which they were found. In other words, their interment was subsequent to the deposition of the bed and may, therefore, represent an intrusive burial of a much later date. This is the view commonly taken. But respect for Sergi's ripe judgment and the knowledge that there are no facts at hand which positively militate against the possibility of men of this type existing in the Pliocene, coupled with the fact that we see more than one type of man on the earth in early Palaeolithic times, should incline us to hold our judgment in supsense and await further discoveries before finally rejecting Sergi's claim for a Pliocene origin for the Castenedolo remains. The fact that a relatively highly-developed race can precede in time one of a lower type is witnessed to by the 100-foot-terrace men with their relatively modern characters. These we now know preceded the low, pithecoid Neanderthal men of the Mousterian epoch. In the face of this evidence it would seem rash to totally deny the claims Sergi makes for the Castenedolo remains or to assert positively that no skull can be truly termed primitive unless it is unusually thick in the vault. Time, too, is wholly on his side, and the future may see his judgment verified as it has the judgment of those who claimed a pre-Mousterian antiquity for the Galley Hill type of man. At any rate, nothing seems more certain than that the antiquity of man will be further augmented rather than diminished as time proceeds and new discoveries are made. As Keith has very pertinently remarked in this connection there is not a single fact known to us which makes the existence of a human form in the Miocene period an impossibility. The latest palaeontological evidence bearing upon the development of the anthropoids and man is wholly in harmony with this view and seems to point to the Middle Miocene as the period when man and the anthropoids first started on their divergent careers.

The type of man we have next to consider is that represented by the Mauer jaw. Homo heidelbergensis precedes in time the High-terrace men as they preceded Homo neanderthalensis. The unique characters of the Mauer mandible, if we disregard for the moment the pronounced canines of Eoanthropus, make it more difficult to relate pre-Mousterian man to Homo heidelbergenesis than to Eoanthropus *dawsoni*. Evidence of affinity between the two races seems to be wholly wanting. The antiquity of the Mauer jaw is unquestionable. The race of men represented by this jaw lived in Europe in the early part of the Pleistocene. All the characters of the jaw suggest a type of man resembling in general facial and cranial features, Homo neanderthalensis. Indeed the Mauer jaw has been fitted into a Neanderthal skull without doing violence to the characters of either.

This type differs so fundamentally from the High-terrace type and also from Eoanthropus that we are practically forced to see in Homo heidelbergensis a race entirely distinct from the other two, a different enus, it may be; and if we may not derive the High-terrace men from Eoanthropus, then there is no escape from the conclusion that there were three distinct types or genera of men in existence in Europe in the earlier part of the Pleistocene.

As we have already seen, the parallel differentiation of the anthropoids into distinct species and genera makes this quite probable; and perhaps to these three types we may yet have to add several others and among them the more advanced type represented by the Castenedolo skull.

With this brief consideration of Homo heidelbergensis, whose chief interest for the present, seems to lie in his absolute isolation—for, like another shadowy character who flashed briefly across the pages of human history, he has neither beginning nor end—we may pass on to a consideration of our last type of man, Eoanthropus *dawsoni*.

The announcement of the discovery of Eoanthropus in 1912 created even greater interest and excitement in anthropological circles than did the discovery in the closing years of the 19th Century of Pithecan hropus *erectus*. The discussions and controversies to which it has since given rise already constitute a considerable body of literature. The discovery of a human skull in a geological horizon of such antiquity as was indicated by the character of the bed containing the Piltdown remains, exhibiting features in some respects so strikingly modern and so remarkably unlike those we had expected to find in a skull of late Pliocene or early Pleistocene age, could not fail to arouse a wide-spread interest and cause not a little embarrassment. Its characters were contrary to all our expectations and the embarrassment was not lessened by the realisation that this well-developed skull, with its marked, modern contours, possessed a chinless jaw which exhibited pronounced canine teeth. Such inharmonious, conflicting characters were hard to reconcile and a number of anthropologists flatly refused to believe the mandible belonged to the skull, though the geological evidence in favor of the relation was as a million to one.

The reception which has been given to the Piltdown discovery affords an admirable illustration of the bias which a dominant and obsessive idea may give to the human mind. Piltdown man is not the kind of creature man's remote ancestor was thought to be. He flew in the face of all our notions in this regard. Hence the mixed reception he met with. Had he been another low-browed, small-brained creature like Pithecanthropus or even had he shown the same degenerate cranial characters as Neanderthal man he would have caused no surprise and the relation of the mandible to the skull would probably never have been called in question. But because he had a brain volume and cranial characters in many respects closely resembling those of modern man and yet possessed at the same time a jaw with marked simian characters and pronounced canine teeth he is a disturbing and disconcerting anomaly and has, as a consequence, divided anthropologists into two conflicting schools of opinion. One school following the lead of G. S. Millar, Jr., an American palaeontologist, is satisfied that the critical examination to which Millar subjected a cast of the Piltdown mandible and the detailed comparison he made of the cast with the jaw of a chimpanzee, proves conclusively that it is not a human jaw at all, but belonged to some chimpanzee-like anthropoid to which Millar has given the name

Pan *vetus*—and refuses to see any relation between the skull and the jaw. The other, following our British authorities, Smith Woodward and Keith, who both hold that the humanity of the mandible is clear and unmistakeable notwithstanding its pronounced canines and chinlessness, is equally satisfied that it rightly belongs to this skull. Millar, in a recent article upon the subject in the *American Journal of Physical Anthropology*,* gives a list of the names of the writers who, up to the time of his writing, had expressed themselves upon this point, a perusal of which makes it clear that anthropologists are about equally divided on the question of the relation of the mandible to the skull.

An impartial consideration, however, of the evidence offered by these opposing schools in substantiation of their views brings out the fact that most of the features upon which they have been obliged to base their opinions are of too general and indeterminate a character to really settle the question one way or another, most of the characters claimed to be peculiarly simian by one school being shown by the other to be equally diagnostic of man; and hence the unsatisfactory and unsettled state of our knowledge up to the present time in respect to this highly-interesting type of humanity

From the outset of the discussion Millar takes, what seems to the present writer to be, a very questionable position. He declares we ought to dissociate the jaw entirely from the skull and judge it independently by the accepted standards of palaeontological evidence as if it had not been found in association with the skull and had no possible relation to it. This method of procedure may be ideally perfect from a purely palaeontological point of view, but it is impossible to regard the mandible wholly in this manner. No matter how anomalous its characters and however much it may be regarded as out of harmony with the skull, the association and contiguity in the same geological bed should have its due weight and must, at least to some extent, inform and direct our judgment. It does not appear to me to be a valid argument to say that if the mandible had been found alone no doubt of its simian origin would have been entertained. It was not found alone and this fact must be taken into consideration and cannot be disregarded in determining its status, the more especially when its characters are said to be equally diagnostic of a man or an ape. The contiguity and the geological conditions must be considered as carrying weight in the circumstances,

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* January—March, 1918

and as helping to determine the genus or species to which it rightly belongs.

Eight features have been put forward by the "humanist" school as diagnostic of the humanity of the mandible. Millar's rebuttal of these is a good example of the character of the discussions and clearly shows how indeterminate are the features upon which we have to base our judgment. He asserts that not one of the eight is a truly diagnostic "human" character; that while it is true that six of the eight features resemble those found in some human jaws it is equally true that exactly the same features occur in jaws of the anthropoids. Indeed, it would appear from the discussion on the teeth that there are no dental peculiarities of sufficient diagnostic value to determine whether a given tooth belongs to the Hominidae or to the Panidae, that is, to a human jaw or to a chimpanzee's; and when the mandible itself is considered we find that the decided human-like characters of the posterior half are about equally balanced by the strong simian-like characters of the anterior. If we take Millar's position in a case like this and wholly disregard the fact that this mandible of mixed human and simian characters was closely associated with a skull admittedly human, the argument is left in the air and we deprive ourselves of valuable corroborative evidence to assist us in determining whether the mandible shall be regarded as simian or human. But if we take the fact of the association into account, as I submit we ought, it gives just that additional evidence we need to form a judgment on the matter; and this evidence, taken in conjunction with the light thrown upon the whole question by von Baer's law, assures us that in the Piltdown remains we are dealing with a single new genus and not with two or possibly three; and thus all the evidence and all the probabilities confirm us in this judgment. For it is wholly improbable, nay, almost impossible, as Smith Woodward has pointed out, that when we find a unique Primate skull in the same geological bed as an absolutely new Primate jaw and in close proximity to a new Primate tooth, we are dealing with the remains of three distinct animals rather than with a single new genus.

One good result, however, has followed from these discussions. We know to-day what we did not clearly know before, that many of the characters we thought were exclusively simian or exclusively human are really neither one nor the other, but equally common to both; and further that we may easily be misled in discussions of this kind if we attempt to generalise too broadly from limited data and insufficient knowledge.

Neither school, strange to say, as far as I have seen, seems to have thought it worth while to approach the question from the point of view of the illuminating biogenetic law of von Baer and Agassiz, or else each has entirely overlooked this source of evidence. The support which the views held by the British anatomical authorities receive when the light of this law is turned upon the question is so considerable and conclusive that the student of open mind need no longer be in doubt as to which view is the more correct one.

If man and the anthropoids had a common progenitor, as no one now doubts, the type and the general characters of that progenitor must be sought in the relatively undifferentiated young of the anthropoids as we find them to-day. Apart from direct palaeontological evidence there is no other source to which we can now go to obtain information on this head. But if the biogenetic law we invoked in this paper to explain the cranial characters of Homo neanderthalensis is valid, and there can be no doubt on that point, then the characters exhibited by the young anthropoids will most closely represent those of Homosimius *precursor*. All we know of the fossil forms of the whole sub-order of the Anthropoidea confirms this. They are chinless animals and generally had well developed canines, but they had, as did also Homosimius *precursor*, that well developed and human-like type of head which characterizes almost all the young of the present-day monkeys and apes. Considering the origin of man and his close affiliation to the anthropoids could the Dawn-men have had much other facial and cranial characters than those seen in Eoanthropus?

Instead of being embarrassed by the mixed characters we find in Eoanthropus, we ought really to have expected them and have felt embarrassed if they had been missing. The Dawn-men, if truly such, must, from their simian affinities, exhibit just such characters in head, face and teeth as those seen in Eoanthropus dawsoni. No doubt exists in our minds as to the humanity of the Mauer jaw, or of the other primitive mandibles, because of their undeveloped chins. Chinlessness is clearly a characteristic of the primitive types of man almost as much as of the anthropoids themselves; and as to the pronounced canines in Eoanthropus the dentition of modern man supplies us with too much evidence of an abnormal development of these particular teeth in man's past to cause any trouble on this point. Any dentist of experience will tell one that cases of abnormal development of the human canines is far from infrequent. The writer numbers among his acquaintances two individuals whose canine teeth are abnormally developed and are much longer and stouter than the adjoining incisors or pre-molars; and it is a well known fact that the milk-teeth of children are more primitive in character and their canines are more pronounced than are the teeth which succeed them; just as the milk-canines of the young of the anthropoids are less developed and less pronounced in character than the permanent ones which follow them. We see, too, the evidence that our remote human and semi-human ancestors possessed more pronounced canines than ourselves in the fact that the roots of the canine teeth start much lower down in the mandible and higher up in the upper-jaw than any other of our teeth, than even those of the molars, and this peculiarity is absolutely without rational explanation unless we see in it the evidence that the canine teeth of our remote ancestors, because of their more pronounced development, required longer and deeper roots than the other teeth to stand the strain they were subjected to by reason of their greater length.

Human dentition has undergone many changes, is indeed still undergoing more important modifications than that entailed by the reduction in size and length of the canines. We are told that the time is not far distant when we shall have lost our third molars, the so-called wisdom teeth, altogether. Already they are taking on rudimentary characters. They are relatively smaller than the other molars and do not appear till we are well advanced in life and are generally the first to decay.

All these facts in respect to the Piltdown mandible would doubtless be admitted by the Millar school of opinion. It is the association of such a lowly, pithecoid jaw with such a relatively well-developed cranium that seems to overshadow and take the force from these significant facts. But their conception of the cranial characters of a Dawn-man is clearly the result of the bias their minds have received from regarding Pithecanthropus and Neanderthal man as the type of beings our earlier human and semi-human progenitors were. When we dismiss from our mind any conceptions of this kind, which we have seen, are wholly unwarranted from the evidence we draw from the skull-forms of the young undifferentiated anthropoids and of the whole Simiadae, the seemingly anomaly and the inharmony between the Piltdown mandible and the Piltdown cranium will no longer exist and we shall see in Eoanthropus a true and typical Dawn-man.

We have been accustomed heretofore to make all our anatomical and morphological comparisons between the skulls of men and the apes with the mature specimens of the latter. Such comparisons are really fruitful only in disclosing to us the differences rather than the similarities between the two types. They do not and cannot show us the phases through which our early ancestors passed in their upward course toward humanity, but rather the degrees of differentiation undergone by the anthropoid apes after their separation from the common parental stem. However much man has changed in his body and limbs from his Simian ancestors, all lines of evidence go to show that he has changed relatively little in respect to his cranial characters; while it is in these aspects in particular that the apes have changed most, and less in the general characters of their bodies and limbs. In other words, the differentiation of man and the anthropoids has followed wholly different lines.

To discover and trace the features they once had in common, we must direct our attention rather to the skulls of the young anthropoids before they have undergone the differentiations characteristic of the skulls of the mature species; and when we do this we learn not only how great are the changes the anthropoids have passed through in the course of ages, but at the same time how very near they once were in respect to their cranial characters to the type we now regard as the human one.

A comparative and critical examination of the skulls of the young anthropoids brings out many striking similarities between them and the typical skulls of man, which are wholly wanting in the more highly-specialised skulls of the mature apes. Keith has called attention, for example, to the fact that a characteristic of anthropoid skulls is the more forward position of the highest point in the vault when compared with the same point in the vault of a typical human skull. This point in the mature anthropoid skulls is at or close to the bregma, the junction of the coronal and sagittal sutures. In the human skull it is about two inches behind the bregma. Thus in Figure 8 where the skulls of the Galley Hill man, La Chapelle man and those of Eoanthropus and Pithecanthropus are compared, it will be seen that in this respect Pithecanthropus was truly ape-like and Eoanthropus truly man-like. In the skulls of the young anthropoids which the writer has had opportunity of examining this point of maximum height would seem to vary with the age of the skull, the younger the skull, the farther back is the maximum point of height. It also varies with the genus of ape, that of the chimpanzee having the highest point farthest back from the bregma. It seems clear from this that the shape and contour of the skulls of the mature anthropoids have been modified by the development of the excessive musculature which characterizes them.

In the mastoid process we see the same influence at work. This process in the skulls of the young anthropoids of all genera is much more human-like than that in the skulls of the mature apes. In the latter the slightly flattened projecting knob of bone has developed into a thick flange-like plate, and forms part of the occipital platform to which are attached the great neck muscles. In the typical human skull this process is a pyramidal-shaped bony boss or projection. In the young of the anthropoids this process is neither wholly human nor wholly simian, but partly one and partly the other; that is to say, it is an intermediate type. In this respect it closely resembles this feature in the skulls of Neanderthal man, being almost identical with the mastoid process as seen in the Gibraltar woman.

Taking the skulls of young anthropoids feature by feature, there are so many points in which they resemble the human skull that we are obliged to postulate a common ancestral form for both to rationally explain these resemblances. There are differences, of course, and some of them marked, for the young anthropoid not only inherits the features of its remote ancestor, but also those acquired in the course of ages by its more recent ancestors. But the cumulative force of the resemblances impresses the investigator very profoundly; and just as in our comparisons of the mature anthropoids and man, in respect to the structure of their limbs and trunk, we find that one genus approximates more closely to man in this particular and another in that, so it is in the comparison of the cranial and facial characters of the young anthropoids. In the head of one we find this feature is more human-like, in another that. Thus the head of the young chimpanzee in its contours and general characters is the most human-like of all. Its vault rises higher than that of the other genera and the frontal aspect is strikingly like that of a mature human skull on a smaller scale. Its prognathism is not more pronounced than that in the Grimaldi boy. The nasal opening of the gorilla, both in its position and in its form, is more human-like than that of the other young anthropoids; its prognathism is also slight. The young chimpanzee and gorilla both show the nascent bony ridge about the eyes so characteristic of the mature ape; while in the young orang this feature is wholly wanting, the orang in this respect being most human-like, while on the other hand its prognathism is much more pronounced than in either the chimpanzee or the gorilla.

No one who has made a comparative study of the characters of the skulls of the young anthropoids and of man can doubt that of all the Primates man has changed least in head form and general cranial characters; and that if we would get the clearest conception of what the skull form and the facial and dental characters of Homo-simius *precursor* were, we can best do this by forming a composite picture of the features which man and the young anthropoids share in common. In this connection I feel convinced that a critical comparison of the skulls of the young Krapina children with those of the young anthropoids would yield valuable results. I believe this has never yet been attempted.

The fortunate discovery of two new fragments of a skull and a human molar by Dawson at Piltdown, in 1914-15, has made it quite clear that in dealing with Eoanthropus *Dawsoni* we are dealing not with a solitary and, therefore, possibly an abnormal, specimen of humanity, but with a true race with distinct generic characters. One of these fragments formed part of the supra-orbital region of a right frontal bone. The other fragment is a part of the occipital bone. Both fragments agree with the type specimen in their mineralised condition and in their unusual thickness of bone, though in the occipital fragment this thickness is not quite so pronounced as in the type specimen.

The tooth is the first lower molar and agrees closely with that in the type mandible. In this connection it is of interest to remark that some of our American authorities, notably, Osborn, following Matthews, have placed the canine tooth found with the original remains in the upper jaw. This association has astonished Keith and other of our British anatomists.

The point at issue is obviously an important one and carries profound significance with it For if the canine rightly belongs to the upper jaw, and the fact is susceptible of conclusive proof, then all the evidence piled up so meticulously by Millar in his effort to prove the mandible to be the jaw of an ape, falls at once to the ground, and the relation of the mandible to the skull is established beyond a shadow of a doubt.

It may be that the evidence of relationship of this canine tooth to the upper or the lower jaw is of that same indeterminate character as the evidence adduced by the two schools of opinion to prove that the mandible was or was not related to the cranium. If this be so, then no definite decision on the point can be reached, and the main question of the relation of the mandible to the skull will remain just where it was before.

And now, in closing this brief review of the evidence bearing upon man's past history, the author would again point out that if the conclusions arrived at in this paper are valid and follow logically, as they seem to him to do, from the evidence at our disposal, then the important fact emerges that neither Pithecanthropus *erectus* nor Neanderthal man can any longer be regarded as standing in the direct line of man's ancestry, or as exhibiting any of the progressive phases through which man passed in his upward course.

All the evidence we have been able to gather suggests, rather, that man's remote ancestor, Homosimius *precursor*, was a creature of quite different character, possessing a relatively-high cranial development accompanied by a somewhat pithecoid mandible and dentition such as are represented in Eoanthropus *Dawsoni*, and in the young of all the present-day anthropoids; and further that in his head form and general cranial characters man has remained practically unchanged from the period when he and the anthropoids first set forth upon their divergent careers; for whereas they have undergone striking and characteristic changes in these respects, developing along lines of excessive facial and cranial musculature, which cramped and restricted their brain development and greatly modified the forms of their heads; man, with the exception of the Neanderthal race, developing along the very opposite lines, has kept and perpetuated the ancestral cranial form and characters and attained a brain expansion which has made him what he is to-day and given him the sovereignty over all other forms of life.

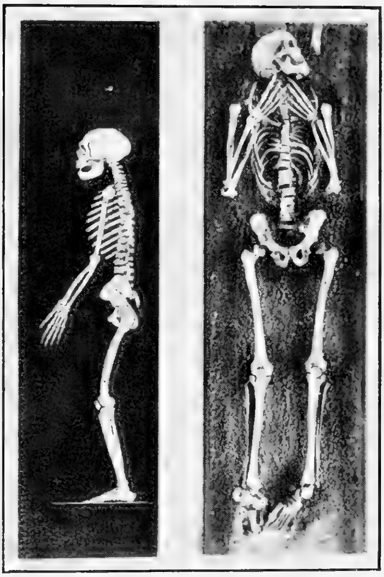


FIG. I.

Comparative view of a Neanderthal skeleton with one of the Crô-Magnon race.

—*after Osborn*

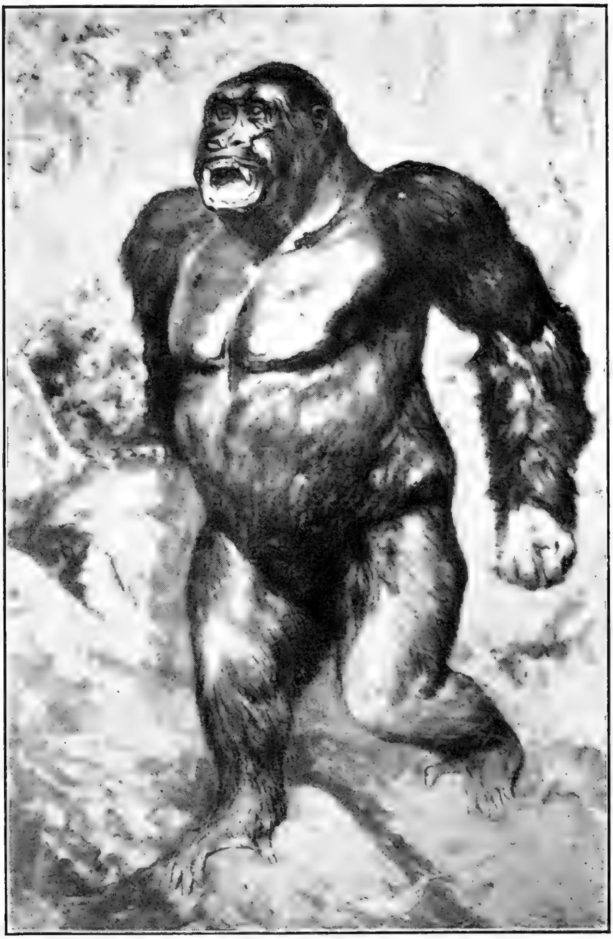


FIG. IV

A mature male gorilla.
Observe the excessive facial and cranial musculature and retreating brow.

(*From "Nature Lover's Library"*)

1 2 3

4 5 6 7 8

FIG. IV.

1. Skull of boy about 8 years old
2. Skull of middle-aged man
3. Skull of aged woman
4. Skull of a child (Indian)
5. Skull of a young gorilla
6. Skull of a young orangoutang
7. Skull of a young chimpanzee
8. Skull of a child (Indian)

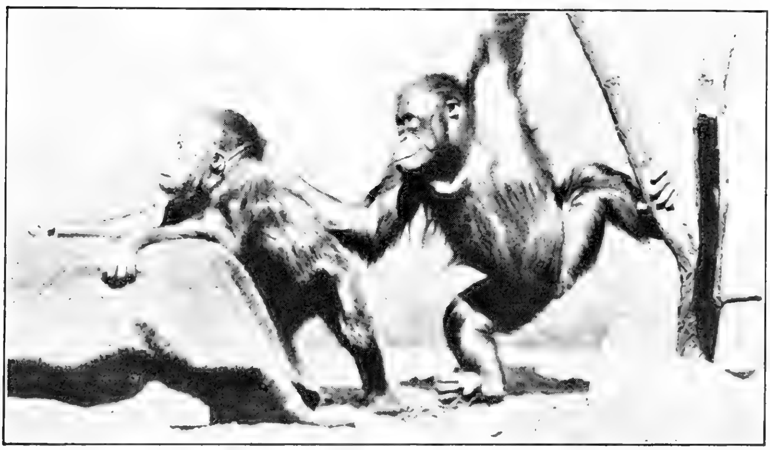


FIG. VI

Two young orangoutangs.
Observe the human-like contours of their crania.
(*From "Nature Lover's Library"*)

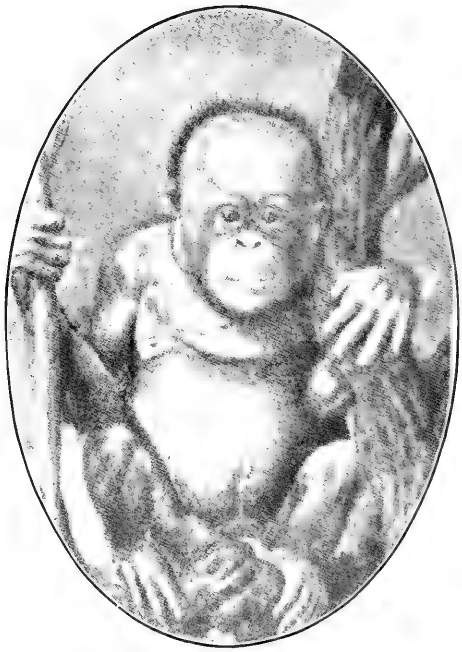


FIG. VII

A baby orangoutang
Observe the well-formed, human-like head.

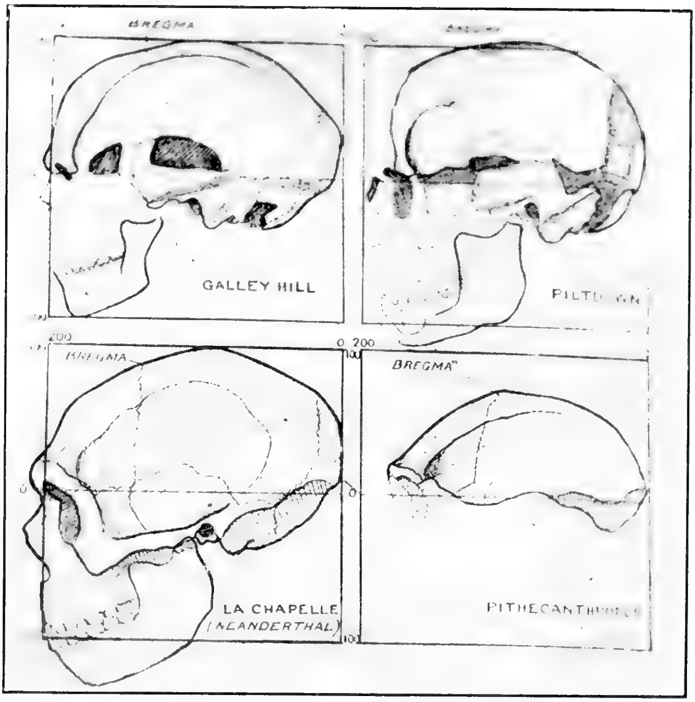


FIG. VIII

Comparison of noted skulls.

—*after Keith*

The Stone Medallion of Lake Utopia

By W. F. GANONG, Ph.D.

(Read May Meeting 1921)

Among the treasures in the museum of the Natural History Society of New Brunswick at St. John is the large stone medallion, carved with the profile of a human head, well represented in the accompanying photograph. It was found in 1863 beside Lake Utopia in the southwestern part of New Brunswick, but its origin remains yet undetermined despite the studies of our local archaeologists. Some new data, however, which I have been able to gather in course of a long interest in the stone, bring us much nearer to a solution of the puzzling problem it presents, as the following discussion, intended to be monographic of the subject, will attest.

DESCRIPTION

The material of the medallion is a fine-grained hard red granite, plentiful in southwestern New Brunswick. Its extreme length is just under 22 inches; its extreme breadth is just over $18\frac{1}{2}$ inches; its thickness varies from $2\frac{5}{8}$ inches to $\frac{3}{4}$ of an inch, though prevailingly much nearer the former figure; and the weight is $51\frac{1}{4}$ pounds. The head is therefore considerably above natural size. The side that is carved was evidently flat in the original slab, but has been worked in the carving to a truer surface. Presumably the back, now so irregular, and tending to flake in a manner suggesting the action of fire, was originally also flat, or nearly, for the high parts show signs of rough working like the face. The stone gives the impression of a flat slab formed naturally by jointing, but improved for his purpose, and of course worked to its oval form, by its proficient unknown carver.

No description is needed for the design on the stone, which in our photograph speaks for itself. The head is cut practically in *intaglio relievato*, that is, with the high parts approximately on the level of the original surface. The sharpness of the profile is skillfully intensified by the polishing of the concave slope thence up to the rim, a notable feature of the work. A diagonal line, faint in the original and barely discernable in the photograph, has been taken to represent a fillet binding the hair, but probably signifies no more than a transition from the smoother face and high forehead to the rougher hair. No doubt this feature, and indeed the entire head, as the sharp profile suggests, was originally much better defined than now, the cause of the change being obvious in the great weathering which the stone has undergone since it was cut. This weathering is particularly marked at the top and bottom of the head, where it has gone so far as well-nigh to obliterate the boundary between head and rim, elsewhere so distinct. At the bottom, especially, there is an aspect of mechanical as well as chemical erosion, as if by running water, or action of waves. This weathering has obliterated also the marks of the engraving tools, which, in view of the hardness of the stone, could hardly have been other than tempered metal.

Discovery

Abundant records of its discovery exist.

The St. John *Morning News* of Wednesday, February 17, 1864, announces its exhibition in the City, with comments on its discovery, appearance, and possible origin. This material is all contained with additional detail in a longer item in the St. John *Morning Freeman* of the next day (February 18), which reads thus:

> A very remarkable stone is now on exhibition at the store of Messrs. Chubb & Co. It is said that it was found near Lake Utopia, in the neighbourhood of Magaguadavic, by a mason who went in search of a hearth stone for a house he was building, and struck by the shape of this stone, removed the moss and turf with which it was covered to the depth of some inches, and took it home. He afterwards gave it to Squire Wetmore, of St. George. Sheriff Harding got it from him and brought it to the city. It is a slab of conglomerate, chiefly granite, and apparently extremely hard and rough grained. It is slightly oval in shape, about 20 inches in length and 3 in thickness, on one side unchiselled, on the other a medallion on which is fairly sculptured a man's face in profile, about the precise character of which there is much question. Some say it is decidedly Indian in its characteristics. This we think is a mistake. The facial lines are not those of the Indians of the present day, and resemble much more the lines of the Assyrian or Egyptian profiles, as represented in ancient sculpture. The nose forms almost a straight line with the forehead. The jaw bone is of extraordinary length, and the chin very small. The hair, too, is cut off square at the back, and confined by a fillet.
>
> The age of this interesting relic must be very great. The rim, which was very deep, is much time-worn, and in every point it bears the marks of great antiquity. Sheriff Harding had the place where this was found marked, and it is to be hoped that next summer the place will be searched. Other remains of the civilized people who once inhabited this continent may probably be found there.

The late Clarence Ward, historian, of St. John, once told me, from his own knowledge, that the stone was a great local wonder when first exhibited, attracting wide attention and discussion.

The *London Illustrated News* for July 16, 1864 (Vol. 45, pp. 78-9) contains an article, illustrated by a fair woodcut of the stone, entitled "Indian Sculpture found near Lake Utopia, Charlotte County, New Brunswick", whereof the essential parts here follow:

We are indebted to Mr. C. C. Ward, of St. John, New Brunswick, for the following account of a curious specimen of Indian sculpture, which is represented by our Engraving. It is a basso-relievo, cut in red granite, of an oval shape, 21 in. long, 18 in. wide, and 1½ in. thick. Although much worn and defaced by time and the weather, it still retains evidence of having been done by a bold and skilful hand. It was found, in the month of November last, at the foot of a precipice of red granite, about a quarter of a mile from the western shore of Lake Utopia, in Charlotte County, New Brunswick. When it was shown to the Indians who frequent the neighbourhood, they at once pronounced it to be the portrait of a chief, and said it was very likely that the chief himself was buried near the spot. They thought it was many hundred years old............... The Indians who have seen it are quite at a loss to account for the fashion and the quantity of the hair represented on the head, since from time immemorial it was customary for the Indians to shave or pluck out all the hair with the exception of the scalp-lock. And although the shape of the head and cast of the features represented on the stone are decidedly Indian, there is an Egyptian character about the whole which suggests some curious ethnological speculations............The tribe of Indians now living at Lake Utopia are the Passamaquoddys, descendants of the old Delaware stock, who for generations have made that locality their favorite haunt. These Passamaquoddys are very skilful in their representations of the beaver and other animals; and we have seen some very beautiful specimens, sculptured in bas-relief, on the bowls of stone pipes. These figures were anatomically correct in drawing, and would do credit to a professional artist...............The sculptured stone is the property of Mr. A. J. Wetmore, treasurer at St. George's, who kindly placed it at Mr. Ward's disposal for the purpose of making a drawing for this Journal.

Mr. C. C. Ward here mentioned was a well known sportsman and artist, brother of Clarence Ward, aforementioned. Lake Utopia and neighbouring parts were favourite hunting grounds of his, as shown by his sporting sketches in *Scribner's Monthly*, 1878-80, in one of which, February, 1878 (reprinted in Mayer's *Sport with Gun and Rod*, New York, 1883, I, 181) he again mentions, with a cut, "a stone medallion having the full-sized head of an Indian sculptured upon it". The final sentence of the above quotation shows that he saw the stone while it was still in Mr. Wetmore's possession, and therefore within a month or two of the time it was found.

Another record published much later belongs in reality almost as early. In the *Annual Report of the Smithsonian Institution for 1881* (published 1883, pp. 665-671) is an article "A sculptured stone found in St. George, New Brunswick", by I. [not J.] Allen Jack, of St. John. It is illustrated by a fair drawing of the stone and an excellent map of Lake Utopia and vicinity marking the place where the stone was found. A synopsis of the article is in *The Canadian Indian*, I, 1891, 265-7, and it is reprinted in full, with unimportant verbal changes, in *Acadiensis*, II, 1902, 267-75, where it is illustrated by an inferior map but by a superior picture from the same photograph as that which accompanies the present paper. Mr. Jack, a well-known late resident and prominent barrister of St. John, much interested in local matters of this kind, states that his article is based on "a tolerable knowledge of the history of Charlotte County and of the province, and an imperfect memory and record of the contents of several letters received from various persons upon the principal subject. . . . The letters which were written to assist me in preparing a paper upon the stone, subsequently read before the Natural History Society of New Brunswick . . . were unfortunately destroyed in the great fire of St. John. The paper itself was preserved, and embodies at least a portion of the contents of the letter[s]." These statements accord with the minutes of the Natural History Society, which read under date 12th February, 1864,—"Mr. Allen Jack then read by request some letters describing the head of an Indian carved in stone found near Lake Utopia Charlotte County"; and again under 11th March, 1864, "Mr. A. Jack then read the Paper of the evening—Subject, the medallion found at Lake Eutopia". The minute then adds,—"On motion resolved . . . That Dr. [C. K.] Fisk be a Committee to procure further information, if possible, on the medallion"; but no sequel to this resolution appears. Thus, although Mr. Jack's paper is of 1881, it is based on information gathered by himself, evidently from those concerned in the discovery of the stone, soon after that event. As to the discovery the paper reads:

In the autumn of 1863 or winter of 1864, a remarkable sculptured stone, representing a human face and head in profile, was discovered in the neighbourhood of St. George, a village in Charlotte County, in the Province of New Brunswick, Canada. This curiosity was found by a man who was searching for stone for building purposes, and was lying about 100 feet from the shore of Lake Utopia, under a bluff of the same formation as the material on which the head is sculptured, which abounds in the neighbourhood. . . . . .The sculpture, shortly after it was discovered, attracted a good deal of attention.

With respect to the obvious possibility that the stone is a modern fabrication, Mr. Jack writes thus:

Opinion, at the time of discovery, was somewhat divided, both in regard to the nationality of the workman by whom the stone was carved and also in respect to the object of the work. . . . . The appearance and position of the stone when discovered, to which I shall presently more particularly refer, convince me that it was not carved for the purpose of deceiving scientific investigators, as might be, and I believe, has been, charged. . . . .

I believe that the finder, who, as I have stated, was searching for stone for building purposes, was attracted by the shape of the stone in question; that it was lying on the surface and covered with moss, and that it was not until the removal of the moss that the true character of the object appeared. An examination of its surface must, I think, convince the observer that the stone has been subjected to the long-continued action of water, and from its situation it seems fairly certain that the water which has produced the wasted appearance was rain, and rain only .... I may refer, but solely for the purpose of expressing my disbelief in any such hypothesis, to the suggestion that art, employed for the purpose of deceiving, and not any force of nature, has produced the worn appearance to which reference has been made. The mossy deposit, and the unfrequented locality in which the curiosity was found, both aid in dispelling this idea............I may further urge that, had the object of the workman been solely to deceive, he would have scarcely selected a stone whereon to carve of a granite character, and especially a piece of granulite, one of the hardest of rocks to work, being not only hard in quality but of crystalline structure.

As to the crucial problem of the origin and meaning of the medallion, Mr. Jack concludes as follows:

............No relic of a similar character to this had been dug up at any Indian burial ground in New Brunswick, and although our Indians produce very well executed full relief figures of the beaver, the muskrat, and the otter, upon soapstone pipes, their skill apparently goes no further in this direction............I think that a careful or even superficial examination of the carving must impress the observer with the idea that it is intended to represent the face of an Indian, and the head, although viewed only laterally, certainly presents many of the peculiarities of the North American type.............By no hypothesis, however, am I able to connect this curiosity with any European custom or idea, and consequently the remainder of my investigation will be devoted to the argument in favor of its Indian origin............

Mr. Jack's argument, elaborated at length, leads to the conclusion that the stone probably represents a monument placed by the Indians at the grave of a chief.

In that most excellent book on the natural history of New Brunswick, *Field and Forest Rambles*, published in 1873 by Dr. A. Leith Adams, a trained scientific observer some years resident in the Province, there occurs (at page 34) an account of the stone, with a crude cut, wherefrom we extract the following sentences:

It is cut on a slab of red granite, and was discovered in a perfectly accidental manner lying among blocks of the same rock on the banks of the beautiful lake of Utopia, at the southern corner of the Province............I spent several days in the locality searching for further relics, and more especially the remains of a temple building said to have existed at one time on a bluff over-looking the lake, of which, however, not a trace was observable............The skill displayed on the medallion clearly indicated a high knowledge of art, never attained by the forefathers of the present Indians; moreover, if it be not the work of a preceding race, it might be one of the trials of skill of some clever Jesuit father in the early days of colonization! Indeed when a drawing of this sculpture was displayed at the Boston Natural History Society, some members pronounced it a very modern imposition, and asserted it to be a likeness of the great Washington! I took pains, however, to satisfy myself on that point, having been assured by my friend Mr. Wetmore, of St. Stephen, to whom it was presented by the workman, that he saw the moss growing on the slab, and was among the first to visit the spot, when he inspected it *in situ*.

No mention of the medallion occurs in records of the meetings of the Boston Society of Natural History, as I am informed by the secretary.

In an article on Lake Utopia in the sportsman's journal *Forest and Stream* in 1892 (reprinted in the St. John *Daily Telegraph*, July 5, 1892) the late Edward Jack, relative of I. Allen Jack, a great observer of natural features of the Province, and a resident of St. George at the time the stone was discovered, speaks of it thus:

Many years since there was a stone mason residing not far from the point where the Magaguadavic......jumps into old ocean [i.e., above St. George]. One day when this mason............was looking over the broken pieces of granite lying on the hillside on the west shore of Eutopia, to obtain some for the uses of his business, his eye fell on an oval piece 21 in. in length by 18 in breadth; when he had turned this over he saw to his amazement sculptured on it in low relief, the head and profile of a man............The mason took his prize to the shore of the lake and rowed home with it. Then he arrived there, he placed his treasure trove in front of his cottage, but his wife refused to allow it to remain, saying that "it glowered at her," good proof of the ancient unknown sculptor's skill. The mason was, I think, Scotch, which may account for the fact that instead of doing as the crafty Arabs did with the Moabite stone, that is to say, break it in pieces, he took it to St. George, and for the consideration of $4, sold it to Mr. A. I. Wetmore, collector of that port.

In an historical article in the *St. Croix Courier*, published at St. Stephen, N.B., January 28, and February 4, 1892, Mr. James Vroom, of whose knowledge we speak below, gives some account of the stone, including the following:

Most people living in the east of this county have either seen or heard of the 'Laney Stone,' a slab of rad granite found at Lake Utopia about twenty-five years ago, on one side of which was carved in relief the representation of a human head. It seems hard to believe that such work could have been done without metal tools; yet the pioneers of Acadia found no metal tools in use among the natives. Unless this unique carving is of comparatively recent date, it is difficult to escape the conclusion that it is a relic either of an extinct people or of a prehistoric settlement of Europeans here; in which case it is strange that no further traces of such a people have been seen.

The name Laney Stone I find applied to it also in a bibliographical note in the *Bulletin of the Natural History Society of New Brunswick*, IV, 1901, 299. James Laney was the name of the mason who discovered the stone. He removed subsequently from St. George, lived for a time at Milltown, N.B., and about 1880 settled in Minneapolis, Minn., where he died in 1915, aged 93 years. Unaware, until the local papers announced his demise, that he was living so lately, I missed the opportunity to secure his own testimony on the discovery of the stone; but his daughter, Mrs. F. S. Welton, to whom I applied for her knowledge of the matter, wrote me, September 29, 1915, such information thereon as she had. She was a very small child when it was found, but had heard it talked of in the family, and her father had spoken of it not long before his death. She adds:

> There is no doubt my father is the real finder of the stone............Father took it to town. While he was there a friend of his got it and took it to the museum ....He took it away from home because my mother did not want to keep it in the house.

For completion of the literature we may add a few references otherwise of slight interest.

In a letter written by the late G. A. Boardman of Calais, Me., to Professor Baird, then Secretary of the Smithsonian Institution (*The Naturalist of the Saint Croix*, Bangor, 1903, 202), under date 29 October, 1868, occurs the sentence, "I have heard more about the stone profile found in the old mound at St. George, but am afraid we cannot get it as it has been sent to St. John; but next summer perhaps you may talk them out of it, or at any rate you can get the loan of it, or perhaps exchange." Fortunately the blandishments of the Secretary, if ever exercised, failed of effect, but possibly he thus obtained the "cast in the United States National Museum" mentioned in the *Report* of that Museum for 1896, 485, where I. Allen Jack's drawing is reprinted, with some comments. There is also a brief account of the stone, with a cut, in a highly interesting and appreciative article on Lake Utopia by E. J. Russell in *Canadian Illustrated News*, VI, November 30, 1872. The brief account of the stone given by C. C. Ward in *Scribner's Monthly* as aforementioned is reprinted with a cut in *The Canadian Antiquarian and Numismatic Journal*, VI, 1878, pp. 166-7, under the title "Stone Medallion found at St. George, N.B." A lost document of the first importance is Mr. Wetmore's own account of the finding of the stone, which Dr. G. F. Matthew tells me was formerly in MS. among the records of the Natural History Society; but a thorough search has failed to reveal it. Other mentions of the stone occur in local literature, but without original data, so far as I know.

Of course I have myself tried to glean additional data from residents of St. George whose memories go back to the event of the discovery, and, needless perhaps to say, I have analysed such testimony in full knowledge of its slight value in comparison with contemporary records. All of any worth that I have found here follows.

Mr. James Vroom of St. Stephen, Charlotte County's foremost scientific and historical scholar, always interested in such matters and a resident of St. George in 1869-72, has told me that he understood Laney to be a poor and shiftless farmer who lived near the Canal (outlet of Lake Utopia) and occasionally worked as a stone mason, that is, a builder of rough stone walls, and that he brought the stone home for use as a hearth stone. Mr. Vroom adds (in a letter of October 30, 1914:

Some of my friends in St. George at the time thought that Mr. Laney himself had fashioned the stone; but the weathered condition of the surface was a convincing argument against that theory. Others thought it might have been made by early French residents; but the design does not favour that assumption.......... The possibility of the carving being of Scandinavian origin occurred to me; but I dismissed it for the very good reason that any Norse stone I had ever heard of bore a runic inscription. It would not be impossible for a Norse visitor to carve a head, but it would have been next thing to impossible for him to have left out the letters that would tell his story to those who came after. I do not believe it is of Indian origin, for an Indian with the top of his head shaved and with long hair at the back cut off so squarely is quite out of the range of my imagination. The Egyption look of the eye and ear, caused by want of perspective, is not of much significance. It merely shows lack of skill in drawing, not convention, in my opinion.

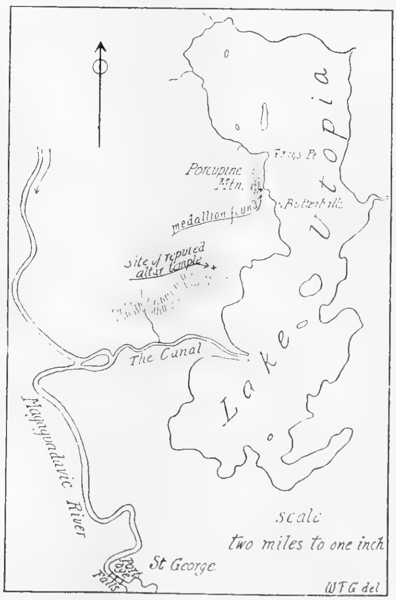
Mr. Thomas A. Sullivan, long resident at Bonney River, near St. George, an observant lumberman and sporting man, has told me that he saw the stone in a boat at St. George when it was first brought there from Utopia by Colonel Wetmore, Mr. Ward, and Sebattis an Indian on their return from a sporting expedition; that it had been found by them at the Lake; and that it had moss upon it, and there was no question raised as to its genuineness. Curiously enough, the same account of the discovery by Colonel Wetmore, Mr. Ward, and the Indian when on a hunting expedition, was given me independently by Mr. Ward's brother, the late Clarence Ward. A memory statement of this kind can have no validity in comparison with the contemporary records which make Laney the finder, but like all traditions it probably has a basis, which I take to be presumably this, that Colonel Wermore's party, when returning from a hunting trip to the Lake, stopped at Laney's house near the Canal, obtained the stone from him, and brought it with them to St. George.

The best traditional information was given me by Mr. Martin McGowan, Police Magistrate of St. George. He told me that he was once a neighbour of Laney, who lived on the north side of the Canal; that Laney found the stone at Lake Utopia; that he had it for some time around the house before he discovered the head upon it; that he told Colonel Wetmore about it and was asked to bring it in, and Colonel Wetmore gave him $5.00 for it; that when Colonel

Wetmore bought it "everybody was going to see it"; and that Colonel Wetmore gave it to Sheriff Harding. Mr. McGowan said there was no question as to its genuineness; Laney was a stone mason, not a stone cutter, and was a shiftless character incapable of working any fraudulent scheme of this kind. He added that the Indians said it was work of the French.

Captain Jesse Milliken, of St. George, recognised locally as having an unsurpassed knowledge of Lake Utopia and its recent history, told me in 1915 that he remembered very clearly the discovery of the stone. It was found by Laney, a stone mason, when seeking good foundation material for a building, for it was customary hereabouts to hunt up pieces naturally jointed with good faces for bedding, and the place where the Laney stone was found offers good fragments of this sort. Laney took it home and kept it before his door for some time, but his wife objecting to its presence because it scowled at her, he sold it to Mr Wetmore, Collector at St. George, for $2.00. Mr. Wetmore later made search of the place for other relics, and even, with others, attempted to dig on a spot close by, pointed out to him by an Indian as the grave of a chief at the head of which the stone had been set.

In the course of our talks, Captain Milliken remarked that he had himself an experience with the finding of the stone in this way, that soon after the discovery he went to the approximate place and there found a line spotted through the woods to the ledge against which it had rested, the moss being wanting where the stone had been, and its outline distinct. The sequel to this remark was inevitable, and I asked Captain Milliken to take me to the place, which he very willingly did. He led me without hesitation to the ledge, though he could not recall, naturally enough, the exact place where the stone had rested. Here follows a synopsis of my notes on this matter:



On the west side of the Lake, about half way from the Canal to its head, is a little point off which lie the two smooth ledges called the Butterballs, and a little farther north is Gray's Point, a very choice camp ground. Between the two, but nearer the former, is a stony cove, from the extreme head whereof it is some 25 to 30 yards straight away from the Lake, through the woods, to a nearly vertical rough ledge, rising several times higher than a man, of red granite much jointed and breaking to many angular fragments. This ledge is a part of precipices which towards the right, rise abruptly, often vertical and sometimes overhanging, to the face of Porcupine Mountain, an abrupt prominent hill, nearly vertical towards the Lake. Turning to the left, the ledge becomes lower and smoother, and finally just before it merges to a wooded slope, is solid and vertical, and somewhere against this face the stone was resting when found. The place has been altered, however, a good deal, Captain Milliken says, by the falling of additional material from above, the ground being covered by a jumble of moss-covered angular masses of granite. The moss is not the slow-growing, or Lichen kind, but the much quicker-growing woods kind.

Genuineness

The foregoing accounts contain discrepancies, but no more than the defective observation, freakish memory, and feeble sense of evidence of most men render inevitable. These apart, the collective testimony seems conclusive that the medallion is a genuine relic, actually discovered by Laney at Lake Utopia in 1863. This deduction from the records is confirmed by the time-worn aspect which the stone has presented from its discovery.

The alternative is of course a fraudulent fabrication, with a motive in practical joking, or profit. As the citations show, this view has been advanced, but only as a guess and never with evidence. On the other hand it is notable that not only have all those who possessed direct knowledge of the discovery of the stone seemed fully convinced of its genuineness, but no suspicion of fraud or mendacity of their part has remained in the minds of others; and this is no small argument in view of the critical attention given the stone, and the habit of men in small communities to constitute themselves vigilant keepers of their neighbours' reputations for veracity.

As to Laney as a possible practical joker, Mr. McGowan and Mr. Vroom agree that he had not the capacity, and was not of a character, to work such a scheme. As to the motive of profit, the smallness of the sum for which he sold the stone in comparison with the labour required to produce it, and likewise the circumstances of its transfer to Colonel Wetmore, seem to negative such an assumption. As I. Allen Jack said, anyone producing such an object, whether as a joke or for sale, could attain his object with a stone far easier to work than this obdurate granite. If the circumstance seems suspicious that Laney was a stone mason, it is to be recalled that his kind of stone masonry was the building of walls, and not stone carving. If, further, the fact seems pertinent that St. George is a seat of a thriving industry in monumental granite and the home of many skilled carvers, sufficient answer is found in the fact that this industry did not originate until 1873, a decade after the stone was found. As to fraud by Colonel Wetmore, Mr. Ward, and Sheriff Harding, who were indeed jovial sportsmen, said to have been fond of practical joking, there seems on the one hand no question that they obtained the stone from Laney who found it, while, on the other there was never any trace of the denouement, and exposure at somebody's expense, which is an indispensible part of the working of a practical joke. Moreover these three men were leading citizens of their communities, and all of high character and ability; and however willing to play temporary jokes on one another or even their communities, they were not the kind who could plot to foist a fraud of this sort permanently on the public. As to the possibility of fabrication by someone unknown, and the "planting" of the stone where Laney found it, there seems no foothold in the records, or reason, for such an origin.

All told, accordingly, the genuineness of the stone as a relic of older times seems abundantly established.

Origin

Its genuineness and antiquity accepted, we ask the origin of the stone, as to which we have no direct knowledge but only a choice of four possibilities,—that it is Indian, extinct race, Norse, or early French.

Indian. Found at a Lake known as a favourite Indian resort, the natural first impulse of those interested in the stone, all unversed in archaeology as they were, was to take it for Indian work, especially as confirmatory suggestion was apparently not wanting from the living Indians of the region. Yet there seems not the least possibility of such an origin. No Indian work approaching it in difficulty, elaboration, or character has ever been found in this part of America, and the gap between this stone and the most elaborate known product of aboriginal workmanship by our Indians is so great as to signify not degree but kind. No relation can be adduced between this stone and the pipes and other objects which our present Indians carve, for these are cut by steel knives from soft stone, and the decoration consists of familiar animals or patterns. To shape and carve so hard a stone as this granite medallion with flint tools, the only ones our aboriginal tribes possessed, and especially to polish the curved slope to the profile, would have been difficult to the point of impossibility, and time-consuming beyond all bounds of aboriginal patience. Further, an Indian would have carved a type familiar to him, but there is nothing in this profile in the least suggestive of Indian features, which in the tribes of this region markedly approximate the Mongolian rather than the Roman type, while the treatment of the hair is as remote as possible from the styles which all early records indicate as prevalent in these parts. Indian affirmations of manufacture by their ancestors can hardly have weight against the testimony of the stone itself, and are neutralized by statements of other Indians, who, according to Mr. McGowan, said the medallion was made by the French. The claim that it stood at the grave of a chief, may however, have some basis, as will soon appear.

Extinct Race. This suggestion, already mentioned, is adduced by no less an authority than W. J. [Sir William] Dawson, the geologist and archaeologist, in explanation of certain "carved stones . . . found in New Brunswick . . . unlike anything executed by the more modern tribes". The plural is evidently intended to cover the medallion, though it is not mentioned, and a conglomerate boulder, crudely carved at one end with a human head, which he describes and pictures (*Acadian Geology*, second edition, 1868, 43-45). This stone, found beside the Kennebecasis River, was, however, later examined critically by G. F. Matthew, also a geologist and archaeologist, whose picture shows a less finished product than Dawson's, and whose description states that "The artist has apparently seized upon a rude semblance of the human face presented (by natural protuberances) and worked out the finer lineaments to correspond," while further details throw doubt upon the complete genuineness of the relic (*Report of the Smithsonian Institution* for 1881, page 672). This stone, formerly in the Museum of the Mechanics Institute at St. John, has disappeared and its fate is unknown. In any case, the descriptions show a work in every way so inferior to the Utopia medallion as not only to place it in a different class, but to bring it within the possibility of fabrication by unskilled workers with the simplest tools. On no better basis that a guess inspired by our ignorance of the real origin of these two stones rests the whole case for an extinct race; and in truth it is not much.

Norse. This origin is also a guess, without supporting evidence. No other traces attributable to Norsemen have been found in this region, the nearest being the very doubtful rune-like markings found on two stones near Yarmouth, Nova Scotia, one of which has been described by Sir Daniel Wilson in these *Transactions* (VIII, 1890, ii, 118, and Plate I; compare also *Collections of the Nova Scotia Historical Society*, XVII, 1913, 51-56). I agree with Mr. Vroom, already cited, that a Norse visitor could have carved the head, but would not have omitted to add the runes to tell its story. In this connection the fact is significant that W. H. Babcock, in his elaborate studies of the Norse Voyages to America (*Smithsonian Miscellaneous Collections*, LIX, 1913, pp. 1-213), wherein he concludes that Passamaquoddy was one of their principal localities, and to whom, therefore, any evidence of their presence there would be especially welcome, has only this to say of the Utopia stone after his consideration of it (p. 52), in light of I. Allen Jack's paper:—

> He believed it to be Indian; but Mr. McIntosh [Curator of the Museum of the Natural History Society at St. John] thinks not. It seems to be something of a mystery, although no one has ascribed it to the Norsemen.

French. Brought to this category primarily by a process of exclusion, we are happily not without evidence, albeit but circumstantial, in its support.

The very marked weathering of the stone subsequent to its cutting would lead us to seek the possible French carver at the earliest possible date. This points to the French colony which spent the winter of 1604-5 on St. Croix Island, now called Dochet Island, which lies 17 miles in a straight line, or 25 miles by the water route, from the place where the stone was found. The history of this colony, which was led by DeMonts and Champlain, is given fully in a Monograph in these *Transactions* (VIII, 1902, ii, 127-231; XII, 1906, ii, 103-6). It was a carefully organized and well equipped expedition of some 75 persons, including noblemen, soldiers, sailors, and various kinds of skilled workmen. They spent a dreary winter in enforced idleness on the Island, enduring such hardships that half of them died; and in the spring the remainder removed to Port Royal (Annapolis), and re-established the settlement, which persisted until 1607 when it was taken back to France and the country temporarily abandoned.

The thought is natural that the stone may have been carved by some member of that colony in the tedium of the winter on the Island. Seeking some test of this possibility, it suddenly occurred to me that although the medallion is composed of stone very like that of the ledge against which it is said to have rested when found, this same band of granite extends across country to Dochet Island, of which it makes up some part, in the same jointed condition as at Utopia. Happening to have in my possession a piece of the Island granite (collected for another purpose), and likewise a piece of the Utopia ledge (secured for comparison with the medallion), and knowing that a formation rarely remains entirely uniform for so great a distance, I thought that an expert comparison of the aforementioned two specimens with the medallion stone might settle whether or not the latter was obtained on the Island or at the Lake. I was able to secure a fragment of the medallion from a partly loose flake on the back, and I sent all three specimens to the Directing Geologist, Mr. (now Dr.) William McInnes, of the Geological Survey of Canada, with a statement of the interest of the problem, and a request for an opinion on the relationship of the specimens from the experts of the Survey. Under date October 30, 1915, Dr. McInnes, to whom I am greatly indebted for this understanding aid, reported as follows:

> In reference to the specimens: 1M, from the back of a stone medallion; 2U, from a ledge at Lake Utopia, and 3D, from Dochet Island; submitted for an opinion regarding the identity of 1M with either of the other two; there are no sufficiently marked differences observable in these specimens to allow their being separated with any certainty.
>
> We have had thin sections made from the specimens and I am glad to be able to send you a memorandum by Dr. W. H. Collins in reference to them.
>
> "Memorandum in reference to thin sections of granites from specimens submitted by Dr. W. F. Ganong, by W. H. Collins.
>
> Thin sections marked 1M, 2U, and 3D.
>
> All three are biotite granites much alike in composition and might easily belong to the same mass.
>
> Section 2U is somewhat fresher than the others and contains notably more biotite and titaniferous magnetite. If a distinction is to be made, I should say that 1M and 3D are probably the same, and different from 2U."

Thus it developes that the medallion granite is nearly if not quite identical with that of both Utopia and Dochet, with a balance in favour of Dochet. This unimpeachable testimony, accordingly, is wholly favourable to the possibility that the original stone slab was obtained on the Island, which fact fits naturally with the supposition that it was carved there. Incidentally, this identity of the medallion granite with that of the Utopia-Dochet belt practically settles any question that the medallion is local work, and not brought from a distance.

The question is now natural whether the St. Croix colony is known to have included any persons of sufficient skill, provided with adequate tools, to carve the stone. This would be probable from the character of the expedition, but is also attested by direct evidence, for Lescarbot, who knew the colony intimately, states that it "had numerous joiners, carpenters, masons (*massons*), stone-cutters (*tailleurs de pierres*), locksmiths," etc., (*Champlain Society's Edition*, II, 318). That these stone-cutters exercised their art not upon buildings alone is shown by a statement of Father Biard, a priest at Port Royal in 1612-3, who writes in his Relation of 1616 (Thwaites' *Jesuit Relations*, IV, 45) that Argal in his expedition against Acadia that year,—

destroyed, everywhere, all monuments and evidences of the dominion of the French; and this they did not forget to do here, even to making use of pick and chisel upon a large and massive stone, on which were cut the names of Sieur de Monts and other Captains, with the fleurs-de-lys.

Again, Haliburton, in his well-known work on Nova Scotia of 1829 (II, 156), describes a stone, found at Port Royal, and known to have been at the time in his possession, as follows:—

In the year 1827 the stone was discovered on which they [the French] had engraved the date of their first cultivation of the soil, in memorial of their formal possession of the country. It is about two feet and a half long, and two feet broad, and of the same kind as that which forms the substratum of Granville Mountain. On the upper part are engraved the square and compass of the Free Mason, and in the center, in large and deep Arabic figures, the date 1606. It does not appear to have been dressed by a Mason, but the inscription has been cut on its natural surface. The stone itself has yielded to the power of the climate, and both the external front and the interior parts of the letters have alike suffered from exposure to the weather; the seams on the back part of it have opened, and from their capacity to hold water, and the operation of frost upon it when thus confined, it is probable in a few years it would have crumbed to pieces. The date is distinctly visible, and although the figure 0 is worn down to one half its original depth, and the upper part of the latter 6 nearly as much, yet no part of them is obliterated—they are plainly discernable to the eye, and easily traced by the finger.

This stone was found by the geologist Jackson, whose account of its discovery is extant and has been published, along with a half-tone cut, from a photograph, of stone and inscription, (Stillson, *History of the Ancient and Honorable Fraternity of Free and Accepted Masons*, 1892, 440; and especially the monographic study by R. V. Harris in *Trans. N. S. Lodge of Research*, I, 1916, 29-39). The stone, which is now embedded and lost in the walls of the building of the Royal Canadian Institute at Toronto, was described by Jackson as a "flat slab of trap rock common in the vicinity."

It is thus manifest that the St. Croix—Port Royal colony of 1604-7 did include someone competent to engrave emblems and figures in stone. Incidentally, there is suggestive resemblance between the stone of 1606 and the Utopia medallion in their size, marked weathering, and engraving upon a natural surface of a flat slab of rock from the immediate vicinity.

It thus appears that the material of the medallion is indigenous to St. Croix Island, on which in the winter of 1604-5 were French colonists competent to carve it. Is any motive for its production evident? Some light on this matter is thrown from another, and the following, source. In 1916 I submitted the photograph accompanying this paper to two of my expert colleagues on the faculty of Smith College, Professor A. V. Churchill, a specialist in the history of Art and Professor S. N. Deane, a specialist in Greek Archaeology, requesting them to give me an opinion upon the status as an art work, and possible origin, of the medallion, and leaving their judgment uninfluenced by any suggestions or theories of my own. Their report, noted at the time, was in substance as follows:—

> Nothing in the photograph suggests the influence of any particular style of art, except that everything about it seems European. There is in fact no particular art about it. Professor Churchill said it seemed to him like the work of some person of abundant leisure with desire to do art work but no knowledge of the method or the technique. It is just the kind of work that children do, or amateurs untrained in representation of such effects,—this shows in the representation of the eye, ear, and mouth. The maker seemed to have some idea or familiar models in mind which he had seen and tried to follow.

This mention of the carving of the stone as a work of abundant leisure recalls the fact that the St. Croix colonists passed on the Island a dreary winter of enforced inactivity, which in turn suggests the idea that the medallion was probably carved primarily as a congenial means of passing the too abundant time by some person competent in stone cutting and imbued with an impulse, unsupported by training, towards art work. Herein we have, I believe, a wholly reasonable motive and setting for the production of the medallion. It is consistent with this idea that the finding on the Island of a natural smooth-faced granite slab would have given the suggestion to utilize the inviting surface for such a purpose.

This origin for the medallion implies a meaning for the head, which, as it bears no resemblance to any of the conventional religious portraits, and shows no trace of insignia of royalty, would seem most naturally to signify a complimentary representation of someone prominent in connection with the expedition. This would presumably be De Monts, official leader, but might be Champlain, nearly as prominent, both of whom spent the winter on the Island. The style of the hair comes perhaps as near as permitted by the exigencies of the carving to the long locks worn by fashionable men of that time. It is possible indeed that there were two of the medallions, for the two leaders, in which case the other may yet be found. The thought that it was meant for someone in the all too well filled burial ground of the Island seems opposed by its shape and the absence of the conventional symbols for memorial stones.

As to how and why the stone, if thus produced, reached Lake Utopia, we can well believe that it was taken there in later, perhaps comparatively recent times, by the Indians, to be used, in imitation of the custom of their white neighbours, as the headstone at the grave of a chief,—their statements to this effect being thus explained. If one thinks the French carver may have made it for this purpose, as a present to the Indians or his own tribute to a friendly chief, it is to be recalled that in such case he would have carved the head of an Indian, which this assurdly is not. There is, however, another possible reason for its presence at Utopia, more consistent with the fact that the place where it was found, amid rocky debris, seems an unlikely situation for a grave,—viz., the place is close to the abrupt cliffs rising into the prominent Porcupine Mountain, a somewhat uncanny repellant and dangerous-looking place, unlike any other around the Lake. It was at such places of uncanny suggestion that the Indians were accustomed to leave votive offerings, as abundant references in our early literature attest. It is therefore possible that this stone, so unlike anything familiar to the Indians, and therefore presumably in their view an especially potent "big medicine," was brought here from the Island, where they found it, as a votive or propitiatory offering to the spirits of this place. Its position, leaning, when found, against the ledge, supports this assumption. Its transportation offers no difficulty, for the canoe route from Island to Lake is all deep still water, except for a short portage at St. George.

Finally, one may well ask how so hard a stone, carved only a little over two and a half centuries before it was found in 1863, could have become weathered so greatly in the interval. This might well occur through exposure to the waves of the sea for a century or two before its removal from the Island. As shown in the afore-cited Monograph, much of the soil of the Island has been washed away since Champlain mapped the place in 1604-5, thus providing a way whereby the stone could have dropped from the upland to the exposed beach. In this connection one cannot but recall the statement of Jackson that the stone of 1606, likewise much weathered, was found "partly covered with sand and lying on the shore." It would seem reasonable that the stone may have been placed over the doorway of one of the larger buildings,—its thinness, oval form, and general character being conformable more to that than any other obvious use. The records show that only a part of the buildings on the Island were removed to Port Royal, the remainder being burnt by some rioting sailors a few years later. It is possible that the stone, deemed too heavy to be worth transport in the deeply-laden pinnaces, was left on a building later burnt, in which case the flaking of the back, already mentioned as suggesting the action of fire, would be explained. A later fall to the beach in the disintegration of the bank, with a long exposure to the waves, would complete a reasonable outline for the stone's experiences.

Summary

The conclusion to be drawn from the foregoing considerations seems accordingly this:—

The Utopia Medallion is a genuine ancient relic, with an honest record. Although direct testimony as to its origin is wanting, many items of circumstantial evidence, all in harmony with contemporaneous probabilities, unite to indicate for it a continuous history consistent with its various peculiarities. This leads back to the French colony on St. Croix Island in 1604-5, where it was probably carved, from a natural slab occuring on the Island, by some member of the expedition who, a competent stone cutter but indifferent artist, made the work an occupation for the too-abundant leisure of a trying winter. In this case the head is probably an attempt at a portrait, possibly of De Monts or Champlain.

Accessory Matters

For the completion of our subject, it is necessary to notice two other matters associated with the medallion,—a reputed altar-temple near by, and a recent fraudulent head suggested by the medallion.

Reputed altar-temple. In local writings occur references, usually or always in association with mention of the medallion, to a stone altar or temple said to have formerly existed on the granite hills near the Canal, not far from where the medallion was found. The following, from that excellent guide-book, Osgood's *Maritime Provinces* (2nd edition, 1880, 32) is typical:—

> Lake Utopia............On a bluff over this lake the earliest pioneers found the remains of an ancient and mysterious temple, all traces of which have now passed away. Here also was found a slab of red granite, bearing a large bas-relief of a human head,............

Mr. I Allen Jack, in his article afore-cited on the medallion, (p. 670) says:—

Upon one occasion, while in conversation with an old resident of St. George, he gave me an account of a somewhat singular monument which, many years before this period, stood on the summit of a hill near the canal, and about one-half mile distant from the place where the carved stone was found. It consisted of a large oval or rounded stone, weighing as my informant roughly estimates, seventy-five hundredweight, lying on three vertical stone columns, from ten inches to one foot in height, and firmly sunk in the ground.. ....My informant stated that the boys and other visitors were in the habit of throwing stones at the columns, and that eventually the monument was tumbled over, by the combined effort of a number of ship carpenters, and fell crashing into the valley.

It is interesting to trace the matter backwards. In 1878, Mr. C. C. Ward, in an article in *Scribner's Monthly* already mentioned, says, along with his mention of the medallion:—

On one of the mountains on Lake Utopia there was at one time, a curious structure resembling an altar, and built with large slabs of granite. Recently some vandals, in order to gratify an idiotic whim, tumbled the largest block down the hill-side, and into the lake.

In 1873 Dr. Leith Adams, with his account of the medallion in his *Field and Forest Rambles*, already cited, adds:—

I spent several days in the locality searching for further relics, and more especially the remains of a temple building said to have existed at one time on a bluff overlooking the lake, of which, however, not a trace was observable.

In the same year E. J. Russell, in the *Canadian Illustrated News*, (VII, 1873, 216) gave an excellent account of the red granite mountains near St. George, whose value was then first achieving recognition. He does not mention temple or altar (nor does he in his article on the Lake in the preceding volume in which he describes the medallion), but in speaking of the cliffs near which the temple-altar is said to have existed, he says:—

Some enormous masses in some parts have detached themselves from the face of the mountain, and lay all ready for shipment, fitted to form the base of a sarcophagus for a President of the United States or a Prime Minister of the Dominion. One piece, which is called "Cleopatra's Needle" contains not less than one hundred tons of stone without a flaw, and rests at an angle of about 45 deg. against the solid sides of its grandfather.

In an accompanying woodcut, he shows this great and very regular columnar rock in its leaning position, presenting indeed, an aspect as though it had been toppled over from the cliff.

Back of 1873 I have not been able to trace any mention of the temple-altar, and it is significant that C. C. Ward, in his excellent account of the finding of the medallion, and his mention of other interesting relics of that region (in the *London Illustrated News* of 1864 already cited), does not refer to it. Mr. Vroom, whose interest and critical judgment in such matters I have already mentioned, heard stories of it "twenty or thirty years" before 1892, but has no belief in its existence. So interesting and striking an object could hardly have failed to attract the notice and investigation of Mr. Ward and Colonel Wetmore at the time they were so interested in the finding of the medallion had the report then been current with any plausible foundation. Thus a fact basis for belief in such a structure is wanting, and it is wholly probable that the story originated simply in speculations centering around the existence of such regularly jointed columns and slabs as occur so frequently in that vicinity, and of which the Cleopatra's Needle of Mr. Russell's description and picture was one example.

Fraudulent Head. In the St. John *Daily Telegraph* of July 5, 1913 (and later, I am told, in *Gun and Rod in Canada*), appeared an account, illustrated with a photograph, of a stone head, roughly carved in the round, said to have been recently discovered at Lake Utopia only a few hundred feet from the place where the medallion had been found. Naturally much interested, I suggested to Mr. Vroom that he go to St. George and investigate the find, but being much occupied, he wrote instead to Captain Charles Johnson, of St. George, a leading citizen and interested observer of all local matters, and manager of one of the granite companies at that place. Mr. Vroom sent me his reply, of which the substance follows:—

> The head is a fraud. Some apprentice boys cut it about twenty years ago. It has been in the camp for years to prop the door back. Last year an enterprising newspaper man was looking for notes, so some of the boys dumped it into the lake, and *found* it, and stuffed him . . . . I must admit I helped the thing along. . . . Fooling a newspaper man and an old friend like you are entirely two different things, so I hasten to set it straight.

The critical reader's first thought may be that the incident of this false head throws doubt on the genuineness of the medallion. I predict, however, that further consideration of the entire matter in light of the laws of logic and evidence will lead to the other conclusion.

THE UTOPIA MEDALLION
One-fifth the true length and breadth

(Photograph from original)

The Ancestry of Archibald Lampman, Poet

By REV. ERNEST VOORHIS, A.M., Ph.D.

Presented by DUNCAN C. SCOTT, LITT. D., F.R.S.C.

(Read May Meeting 1921)

PREFACE

The information contained herein is taken from two larger genealogical records of the Lampman and Gesner families which I have prepared after several years of search and correspondence with various members of both families.

As brother-in-law of the Poet I have had access to unpublished family records.

ERNEST VOORHIS.

Ottawa,
15th April, 1921.

MEMORIES OF THE POET

In sentiment, loyalty and family tradition Archibald Lampman, the poet, is to be reckoned a thorough Canadian. His patriotism and love for his country was not the engrafted product of a few years' sojourn in the land but, on the contrary, the result of a consciousness that his ancestors had helped to lay the foundation of Canada. To him Canada was peculiarly his own land, indeed, he possessed an appreciation of her natural beauty, the rocks, hills, rivers, forests, and flowers, which he could share with but few. He needed no companion on his solitary rambles. Without there were innumerable friends, the trees, fields and flowers, with which as real personalities he communed in silence; while within arose a sequence of thoughts, echoes of nature's voice, which inspired the poet's soul.

Lampman was happiest when exploring new scenes in the forest land of the north, far distant from the sounds and sights of mankind. What is to many the wilderness, to him was the garden of nature. The more profound became the silence, the greater was his enjoyment. Never conscious of loneliness nor of fear, his nature seemed to expand into perfect harmony with the greatness and wildness without. When on a canoeing trip he was always noted for his genuine equanimity, be the weather hot or cold, under clear skies or in storms. Nothing seemed to dampen his lightheartedness. We portaged our burdens through dense forests—once by night; we paddled our birch-bark all day long; sometimes we lost the route, or the rain imprisoned us in the tent; the sun would burn at midday, the ground would be white with frost at dawn; we ran rapids of dangerous violence, and yet in such circumstances, as in all others, Lampman was always the spirit of hope, of joy, of pure delight.

There was never a time when he could not see the humour in every happening. Often as we paddled in silence by the hour, resting his paddle, he would suddenly break into that hearty laugh of his at the recollection of some humourous incident and start the echoes bounding from shore to shore and rousing the solitary loon. Great was his delight when a strange little berry or plant was found. To become acquainted with his new friend was now his serious purpose and until he had discovered its name in Gray's Botany, his constant companion, he could not rest content. Each new find became a personal friend whom he never forgot.

Thus it was that he always seemed to dwell in a plane quite foreign to us of homelier build. While we could merely recognize the beauty of a moss-covered cliff, he would see in it a wealth of colour unperceived by us. As the prospector searches for traces of the coveted vein of gold, so Lampman was a prospector for the treasures of forest and field. Nothing was too humble for his admiration because he recognized friends in nature's community. On one occasion when a companion had differed with his admiration of the common yarrow, great was his indignation, and then he composed the poem of the yarrow:

"It blooms as in the fields of life
Those spirits bloom for ever,
Unnamed, unnoted in the strife,
Among the great and clever."

Lampman's devotion to nature was not without reason, for his ancestors had entered Canada while it was still a wilderness. As pioneers they had penetrated the primeval forests, and lived dependent upon nature's resources and had been taught of her whims and fancies. Deep in their hearts was an inborn love of her fields and forests, a love which has survived in remarkable degree in their descendants.

In the affairs of nations and of men Lampman evinced a keen interest. A deep student of history, delving into chronicles of medieval times and the origins of nations, his knowledge became broad and his appreciation of the hidden philosophy of economics based on antecedent causes was a guide in forming his judgment. Genuine sympathy and love for his fellow man bespoke the largeness of his heart. So acute were his perceptions that no weakness or stain escaped his observation; yet he never revealed in unkindly manner his knowledge of another's faults but, nevertheless, the offender instinctively knew that his secret was revealed. His estimate of the world's doings was enlightened by his keen sense of humour. The ludicrousness of man's littleness and self-deception amused him intensely, because the wider vision of his trained mind enabled him to look beneath the surface and to recognize realities.

Though he thought of other nations thus objectively, his interest in Canadian affairs was subjective in the highest measure. What happened in Canada was to him a personal affair of magnitude and seriousness. His loyalty to the Dominion and his unbounded faith in the future of Canada were an inspiration to his friends. Through him they gathered strength. Patriotism was born in him for his ancestors had fought and died in the defense of Canada, and it is significant that the poet's son with all the eligible young men of the immediate family and others of collateral branches were among the earliest to enlist in the last war. Such a course to them seemed but natural.

Lampman's early training in the classics had developed a profound respect for the thinkers of ages past. They were like living personalities to him and to his last days they contributed in no small measure to his enjoyment of life. In the midst of a busy life already well filled with the duties of his office, the cares of home, and his own writing and reading, he always found time to devote to his Greek. He was well read in Plato, Aeschylus, Sophocles and Homer, and the comedies of Aristophanes furnished him with material for many a delightful discourse while on camping trips. Latin authors did not so strongly appeal to him for he recognized their lack of original imagination and literary inventive genius. It was the polish, refinement and beauty of Greek art that attracted him.

In reading the history of his father's and mother's families one sees that the outstanding characteristics of the poet's mind existed in his ancestors. His remarkable love for nature, his clear perceptions and keenness of vision, his fondness for the classics, his student habit of mind, his literary judgment, his patriotism, are all traceable to his forefathers. Lampman was descended from two United Empire Loyalist families, the Gesners and Lampmans, both of whom had resided in the vicinity of New York sixty-five and thirty-five years respectively before coming to Canada. They were among the earliest of the Loyalists to arrive, the Gesners coming to Nova Scotia in 1778 and the Lampmans to Niagara in 1779. Preferring loyalty to their king rather than a share in the foundation of a new state built upon rebellion, they sacrificed all the advantages acquired by years of residence in the colonies and made their way to Canada in a condition of practical destitution, leaving their property and possessions seized of the Americans.

Though the Gesners were of Swiss origin and the Lampmans of German, it is interesting to note that in the poet no less than six different nationalities were represented, namely, Swiss, French German, Dutch and English. The Gesners were men of literary culture, students of natural history, classical scholars, professors of science and mathematics, theologians; the Lampmans were men of the farm, big and forceful, who loved the open air. It would be difficult to say which of the two families was more distinctly represented in the poet. In general build and personal appearance he resembled the Gesners who were of short stature, dark hair and brown or black eyes. From them in large measure he inherited his literary taste and aptitude, his scholar's mind. Though the Gesners had lived in the country and had scientifically studied the aspects of nature since coming to Canada yet it would seem that the Lampmans bequeathed to him that unique appreciation of the beauty of nature which found expression in the poet's verse.

The Gesner Family

The Gesner family originated in Switzerland, whence some of the branches moved into southern Germany which probably offered them a larger field and better advantages for the pursuit of their favourite studies. One branch, from which the poet was descended, moved into Holland at an early date. During the past four centuries the family has produced many celebrated scholars and scientists whose labours are recorded in history. At the beginning of the 16th century three brothers, Vasa, Paul, and Andreas Gesner resided at Solothurn in Switzerland near the German border whence Andreas and Vasa moved to Zurich. Vasa was the father of the eminent naturalist Conrad von Gesner who was born at Zurich in 1516. He was the most renowned scientist of his age, professor of Greek at Lausanne and at Zurich, and for his achievements was knighted by the Emperor Ferdinand I of Germany. He was not only a Greek scholar and linguist producing such works as a list of all the writers who had ever lived with their works, which he wrote in Hebrew, Greek, and Latin, but he was also a great student of natural history being especially fond of botany. Paul, the second of the brothers mentioned above, was the father of Solomon (1559-1605) divinity professor in the University of Wittenberg. Among the most noted scholars in their day were Andrew Samuel (1690-1761), Jean Albert (1695-1760) amd John Matthew (1691-1761), three brothers. The 18th century records of the Gesners contain names of many celebrated physicians, naturalists, classics, and clergymen.

Johan Hendrick Gesner (1681-1745), the progenitor of the American and Canadian branches, when twenty-nine years old left his home in Holland and with his wife Anne Elizabeth and infant daughter Margaret came to London, whence he sailed by ship "Lyon" arriving in New York June 10th, 1710. This was forty-nine years after the village of New Amsterdam had passed from the control of the New Netherlanders to that of the English, but it was still a mere village and the interior of the colony was a wilderness inhabited by Indians. Many of the original Dutch settlers had moved from New York and had made settlements along the banks of the Hudson river where they long retained their language and customs. One of these settlements was Tappan about thirty miles north of New York and here John Gesner made his home not far from the village of Hackensack where he had acquaintances and friends. Settled upon a comfortable estate of considerable size Gesner devoted himself to the duties of his farm and grist-mill. In contrast to the conditions prevailing in Upper Canada, pioneers in the Hudson valley always had the advantage of a commercial centre at New York whereby communication with Europe was maintained and comforts were accessible.

John Hendrick Gesner resided at Tappan until his death in 1745, a man of pious life, member of the Lutheran church, and respected by his neighbours. A second child, whom he named John, was born to him in 1724. No record has been found of any children born between his daughter Margaret and John. By his will Gesner left all his property to his wife Elizabeth for her lifetime and at her death it passed to his son John. Provision was made for Gerittje (Margaret) in the bequest of "one negro woman", for at that time slavery was the prevailing custom. About 1740 Margaret had married Jacob Valentine of Yonkers and her descendants to-day constitute a well known family in New York. Her first child was named Johannes and her second children were twins whom she called Anna and Margrietje (Margaret). The register of the old Dutch church at Tappan contains the names of many children of the Gesners who were baptized between the years 1744 and 1815.

John Henry Gesner (second) (1724-1811) inherited his father's estate, to which he made considerable additions. He lived continuously at Tappan and in 1811 was buried in the old Gesner burying ground, his grave and that of his wife being marked by tombstones still legible. The site of his house and the family burying ground may still be seen about a mile and a half southeast of Tappan village. In 1744 he married Famitcha Brower, daughter of Adolphus Brower and Jannette Ferdon. The Browers were descended from Adam Brower who emigrated from Cologne, France, to New Amsterdam in 1642. Famitcha's grandfather Jacob Brower, was married in 1682 to Anneke Bogardus granddaughter of the famous Anneke Jans Bogardus who was descended from William of Orange (William the Silent). Jannette Ferdon was descended from Thomas Ferdon who had emigrated to New Amsterdam in 1645. The Ferdons (or more correctly Verdon) were a French Huguenot family who had taken refuge in Holland where they resided for a number of years before coming to America.

Seven sons and two daughters were born to John Henry Gesner (second), the eldest in 1745 and the youngest in 1768. Canadian history is interested in only two of these sons, the twin brothers Henry and Abraham Gesner who settled in Nova Scotia.

The American revolution was fraught with unhappy consequences for the family. The father was fifty-two years old at the outbreak of the war; the eldest son was twenty-seven and the youngest eleven. Several letters of the father and a remarkable diary of his youngest son Nicholas have been preserved. From them we learn that the father, John Henry Gesner (second), endeavoured to maintian a neutral attitude in the war, refusing to sign the Association Articles. Never openly espousing the patriot cause and yet fearing to declare himself a King's man, he passed a miserable existence during the war and was considered a Tory by the Americans. His eldest son John Gesner (third) adopted his father's course, but, being suspected by the Americans, he escaped to New York where he lived, probably as a non-combatant, within the British lines throughout the war. Upon the cessation of hostilities he went to Nova Scotia where he lived for five years. Then returning to Tappan he passed the rest of his life in the nearby village of Nyack, where several of his descendants reside at present.

Nicolas, the youngest of these seven brothers, informs us in his diary that "Father Gesner admonished his sons, Jacob, Isaac, Henry and Abraham to take opportunity to go to New York now in possession of the British. With some others, after their father had admonished them to be good boys, they went off in an open pettiauger belonging to Dennis Sneeden". It is doubtful whether the boys ever saw their father again. Jacob became a captain in the English army and was lost at sea. Of Isaac no further record has been found beyond the fact that he was with the English forces in New York.

Henry and his twin brother Abraham, then eighteen years of age, joined the King's Orange rangers, a loyalist corps raised mainly in Orange county, New York, by Lieut. Bayard. Both boys were with the forces of Sir Henry Clinton in his northern expedition and were present at the storming and taking of Fort Mongtomery. After seeing active service in several engagements the Rangers were ordered to Nova Scotia and embarked for Halifax in October 1778. They remained in garrison duty until 1783 and were then disbanded. In consequence of their loyalist sympathies, Henry and Abraham suffered the loss of all their patrimony, in lieu of which the British Government granted Henry 400 acres in the Cornwallis valley, and Abraham a tract of similar area near Annapolis Royal in the Annapolis valley.

Abraham served in the militia of Nova Scotia for forty years as major. He was one of the first to develop fruit culture in Nova Scotia and devoted himself to his estate which he increased by the purchase of 1,500 additional acres. In 1824 he was appointed to the bench of the Inferior Court of Common Pleas. "His uprightness of character and sincerity of purpose commanded the respect of parliament and people". There are many descendants of Abraham Gesner both in Nova Scotia and in the United States, one of whom lives on the old Gesner place at Belle Isle, Annapolis.

Colonel Henry Gesner, the great-grandfather of the poet Lampman, after receiving his grant of 400 actes of primeval forest, began the life of a pioneer and, before his death, had developed his property to a high state of cultivation. The old residence at Cornwallis still exists in good repair, backed by a great orchard of nearly 7,000 apple trees largely grown from seeds brought from New York by Colonel Gesner. A portion of the old dam forming part of the works of his grist-mill still remains. In this mill the Colonel employed a lad who in after years was the father of one of Canada's celebrated statesmen (Sir Chas. Tupper). The military experience which Henry had acquired during the American revolution proved of great value to the province in later years. In 1818 he held a major's commission in the 16th

Battalion, King's County Militia, and in 1828 he was Lieutenant-Colonel of the 1st Battalion. In 1786 Henry Gesner married Sarah Pineo, daughter of David and Rebecca West Pineo of Cornwallis. He survived his wife eight years, dying in 1850 at the age of 94 years, and both were buried in the churchyard of the English church at Cornwallis. Colonel Gesner and his father and grandfather, the original settler in America, all spoke the language of Holland as well as English. He was a man of great pride and inclined to be autocratic, very proud of his family and reserved with strangers. In personal appearance he was blond with light hair and blue eyes, in contrast to his twin brother who was dark. His sword which he always treasured is now in the keeping of his descendants.

His wife's family, the Pineo, or more correctly Pineau, were French Huguenots, descendants of Jacques Pineau, who came to Bristol, Rhode Island, in 1706. After remaining some years in Connecticut they went to Nova Scotia before the American revolution. Elizabeth Sampson, the grandmother of Henry Gesner's wife, was directly descended from Myles Standish and John Alden.

Twelve children were born to Henry Gesner and his wife Sarah Pineo, all of whom were baptized in St. John's church Cornwallis. This present narrative is concerned with the life and adventures of two of the sons, David Henry Gesner, the grandfather of Archibald Lampman, and Abraham Gesner.

Each of these sons when twenty-seven years of age left their father's home to seek their fortunes. Abraham went to London to study surgery and medicine, returning again to Nova Scotia after taking his degree. A man of scientific tastes he became interested in the geology and mineralogy of Nova Scotia and published various reports and works on the gold fields, geology and mineralogy of the province. In 1838 he was appointed Provincial Geologist of New Brunswick. At the expiration of his office he returned to his father's estate at Cornwallis where he continued the practice of medicine. His scientific experiments resulted in the construction of an electric motor, probably one of the first ever made. Among other achievements was his discovery of a method for the extraction of illuminating oil from coal and petroleum which he patented in the United States under the name Keroselene, afterwards abbreviated to Kerosene.

He was a man of genial and generous disposition, popular with his neighbours, a firm churchman and fond of music. In personal appearance David Henry and Abraham closely resembled each other. They are described as being of medium height, with deep chest and square shoulders, dark complexioned, having black eyes which shone brilliantly, and raven black hair which maintained its colour throughout their lives. The descendants of Abraham Gesner include many noted geologists, clergymen, doctors, chemists and inventors.

David Gesner was born at Cornwallis in 1793. When twenty-seven years old he left Nova Scotia for Montreal, where he taught school for two years. He then studied medicine for two years, but not finding either occupation to his liking and being drawn by a love of adventure and a great fondness for nature, he decided to join the ranks of the pioneers who at that time were beginning to migrate from Lower Canada and the Maritime Provinces to Upper Canada. About the year 1825, in company with other pioneers he arrived at Port Talbot on Lake Erie. Thence he journeyed a few miles westward and took up land in the township of Orford, County of Kent. The Book of Land Grants in the Archives at Toronto records a grant to David Henry Gesner of 200 acres south on Talbot Road on the shore of Lake Erie, 7th June, 1825. At Talbot dwelt Colonel Thomas Talbot, a retired officer of the English army who had secured a grant of 100,000 acres under the condition that he should place a settler upon every 200 acres. "There he dwelt for years, utterly alone, shunning the society of his fellowmen, a picturesque and singular character in the early history of Upper Canada".

The country at that time was an almost unbroken wilderness of primeval forest, peopled principally by Indians and a few settlers who had penetrated west from York as far as London and along the north shore of Lake Erie. Every privation and difficulty which the sturdy pioneer of those days encountered fell to the lot of David Henry and it needed a stout heart and wonderful self reliance to induce a man to leave the comparatively well settled country of Nova Scotia and to brave the unknown wilds of Upper Canada. There he would be deprived of the comforts to which he had been accustomed; communication with his family and friends would be infrequent and subject to the uncertainties of courier post and shipping; whatever he should require for existence must be the fruit of his own labours. Clearing a small space in the forest Gesner erected a comfortable log house in which he dwelt alone for nearly two years. By incessant labour and perseverance he hewed down the forest, cleared his fields, built himself a comfortable home, planted and developed a fruit farm rivalling in some degree his father's estate at Cornwallis. As events turned out, it was not for his own profit alone that he ventured so far from home, for the Government saw in the son of the loyalist Colonel Gesner such qualities as marked him a staunch King's man who could be relied on to hold the country in allegiance to Great Britain. Barely ten years had passed since the battles of the war of 1812 had been fought within a few miles of Gesner's home; the Americans were covetous of the land and there were dissatisfied Canadians ready for an American alliance. Thus it happened that Gesner was appointed Crown Commissioner to strengthen the loyal sentiment. Later he held the offices of Justice of the Peace and King's Counsellor and for many years he was the Government's chief representative in that section.

Companionship was not far distant for at Tyrconnel Gesner met and wooed Sarah Stewart, daughter of Captain John Stewart who with his wife and ten children had moved to Tyrconnel from Digby, Nova Scotia, in 1820. The Stewarts were a Scotch family who had emigrated from County Tyrone, Ulster, in the north of Ireland, to Nova Scotia. Captain Stewart had been educated for the Church of England ministry but had chosen to follow the sea. His wife Sarah was a member of the Culver family who had emigrated from Holland. Gesner was married in 1827 and the young couple taking up their abode in the forest home prepared to face the privations of pioneer life. We shall never know the details of that struggle culminating in final success, but we may infer how lonely and primitive were the conditions of life from the saying of the poet's mother that, when a child, she would often lie awake at night, listening to the howling of the wolves near the house.

Gesner's married life covered a period of fifty-two years. He survived his wife but a few months, dying in 1879 at the age of 86, and both were buried in the churchyard of Trinity church, Morpeth, which Gesner in company with other gentlemen had built and maintained. Eight children were born to them, of whom the last surviving died in 1915.

David Henry Gesner was a man of commanding personality, very domineering and autocratic, a lion-hearted man of iron will and great strength of mind and body. Ruling as the King's Commissioner and as a veritable seigneur in spirit, he was a law unto all in that region and it has been said that his neighbours never ventured on important undertakings without first consulting him and obtaining his approval. He was an unapproachable man who consistently maintained his autocratic attitude both at home and abroad, always intolerant of opposition.

Of his eight children only two married, his eldest son John and his daughter Susannah Charlotte, mother of the poet, for Gesner's autocratic will undoubtedly interfered with the natural development of his children's careers.

The Lampman Family

About the middle of the 18th century three brothers, John, Caspar, and Frederick Lampman left their native town Hanover, Germany, and emigrated with their families to the American colonies coming by way of Holland. The Empire of Germany did not exist at that time. The Duchy of Hanover belonged to the King of England (George II) and it was not until the accession of Queen Victoria (1837) that the Duchy was severed from the English crown. In 1866, about one hundred years after the Lampmans left Hanover, the Dutchy was incorporated with Prussia. Thus the Lampmans in leaving Hanover and coming to America simply transferred themselves from one portion of English territory to another, without change of allegiance to the English Crown.

John, who is thought to have been the eldest, settled in Rennselaerville, and Caspar in Columbia County, New York. The men of these two families remained in the United States after the Revolution, excepting two or three of their sons who, either during or immediately after the war, settled in Lower Canada near Lake Champlain and in northern Vermont. Michael, Stephen, and Henry Lampman are recorded as having settled at Swanton, Vermont, in 1787. The records show that other sons of John and Caspar Lampman settled in the eastern part of the Province of Quebec, but the majority of these two families seem to have sided with the Americans in the revolution and their numerous descendants are to be found in various parts of the United States.

The youngest of these three brothers, Frederick Lampman, the ancestor of Archibald Lampman, was about thirty years old when he arrived in New York in 1750 with his wife Katharine and one or two children. He settled in New Jersey not far from New York and there he lived for thirty-four years. In 1784 when about sixty-five years old he came to Canada and being a U.E. Loyalist was granted 400 acres by the Crown at Stamford, Lincoln County, District of Niagara. Frederick Lampman and all his sons and sons-in-law were strong loyalists. There was no hesitation on their part in siding with the King's adherents. With the exception of a few horses and cattle and some personal effects, which he was able to bring into Canada, all his property was seized by the Americans and he entered the country almost destitute. His family consisted of seven sons and five daughters. The eldest son was 27 years old at the outbreak of the revolution and the youngest seven years of age. All the sons, excepting the youngest Abraham, being of military age were subject to impressment in the American forces and efforts were made to secure them forcibly. The eldest, Peter, escaped from the Americans with great difficulty in 1778 and made his way on foot and alone to Canada. The second son, William, was arrested, accused of being a Tory spy, and, although proven innocent, was mu dered in prison during an altercation with the jailer. During the early period of the war before the British had seized the town of New York, the Loyalists resident in the neighbourhood suffered severely at the hands of the Americans. After the capture of New York many took refuge with the King's forces, leaving their homes in the country which were ransacked by the Americans, while many were driven from their homes in New Jersey and along the Hudson valley, glad to save their lives.

It is greatly to be regretted that many records of the experiences of the Loyalists during that time of changes have been lost, but when it is remembered that they arrived in Canada in the majority of cases utterly destitute and were at once confronted with the problem of making a livelihood in primeval forest land to which they were wholly unaccustomed, the wonder is that any records were left. Frederick Lampman faithfully maintained the chronicle of his children in the Family Bible, and his son Peter continued the record for another generation, and this Bible is carefully treasured to-day by Frederick's great-great-granddaughter, 160 years after he brought it to America. The book is exactly 200 years old. Another interesting relic exists carefully guarded in the Dominion Archives at Ottawa. It is a petition of Peter Lampman dated 11th October, 1796, for additional grant of family lands, witnessed by G. Ridout, and contains a list of his children in a beautiful hand probably written by his wife.

The Peace of Paris was signed in 1783, but it brought no good will to the Loyalists from the Americans. Although the latter insisted that the British forces should leave New York immediately, the Commandant persistently refused to withdraw his troops until the Loyalists had been safely transported to other lands. Under British protection they departed from the colonies where many of their families had lived for half a century and more, some to the West Indies or to England, and others to Canada.

In 1784 a great pilgrimage of the Loyalists to Upper Canada began. They travelled by the old Indian trail west from Albany to the lake country of the Mohawks and Iroquois, where the trail divided, one branch going north to the Indian village of Oswego, whence they sailed across Lake Ontario to Kingston, and the other trail continuing due west to Niagara. The Mohawks and Iroquois whose lands and villages had been devastated by the Americans as the result of their loyalty to the King, joined the Loyalists in seeking new homes in Canada. Among other bands, seven families of Loyalists migrated together to Niagara and took up claims in Stamford township bordering on the Niagara river. They were the Mettlers, Hensels, Lampmans, Bonks, Swayzes, Hoovers, and Seaburns. Among the original settlers in Thorold were the Ostranders, Seaburns, and Uppers, while the Swayzes, Hoovers, and Lampmans settled in Stamford. Four hundred acres were granted to Frederick Lampman. At that time all the territory between the Ottawa river and Detroit river, in which the Loyalists founded homes, was part of the Province of Quebec, but in 1788 Lord Dorchester divided the territory into four districts for settlement to which he gave the names of Lunenburg, Mecklenburg, Nassau, and Hesse. These names in 1792 were changed respectively to Eastern, Midland, Home and Western. Hence the district in which the Lampmans settled was called at first Nassau and later Home.

Twenty-five years ago Colonel E. Ryerson when collecting data of the Loyalists, published a letter which he had received from Mrs, Elizabeth Bowman Spohn, whose grandmother was a daughter of Frederick Lampman. In this letter dated in 1861 Mrs. Spohn described most graphically the sufferings of her grandparents at the hands of the Americans, their rescue by the Indians, their journeying to Canada and the fearful struggle for existence in the primeval wilderness. Of the Lampmans she wrote: "My grandfather married the daughter of a Loyalist from Hudson (North) river, Mr. Frederick Lampman. He was too old to serve in the war, but his four sons and two sons-in-law did. They were greatly harrassed but they hid in the cellars and bushes for three months, the rebels hunting them night and day. At length an opportunity offered, and they made their escape to Long Island, where they joined the British army". Frederick Lampman upon the marriage of his daughter Elizabeth to Peter Bowman in Canada gave her as a wedding present, a cow, bed, six plates, and three knives, which portrays the destitution of the Loyalists.

Only fragmentary accounts are preserved of the struggles and sufferings of the Loyalists during the starvation year of 1785 and for years after. Frederick was sixty-five years old when he arrived in Canada. He did not long survive the sufferings and losses which he had endured in the revolution. In 1789 he died, five years after coming to Canada. In his will which has been preserved, after providing for his wife, he devised the estate to his second son Frederick (second) on certain conditions, and with other bequests, he gave the family Bible to his eldest son Peter. Descendants of his sons Frederick, John, Matthew, and Abraham, and of his five daughters are to be found to-day from Ontario to Vancouver. The war had wrought havoc in his life. His farm which he had carefully developed for thirty-five years together with his personal property was seized by the Americans; his son had been murdered; his two sons Peter and Stephen had escaped to Canada; and finally with his wife, daughters and four younger sons who had survived the war, he journeyed to Canada when sixty-five years of age to begin a life-long struggle in wresting a home from the wilderness. After such experiences the loyalty of the family to the British crown in the war of 1812 causes no surprise.

His son Stephen, who was sixteen years old at the beginning of of the revolution, joined the British forces in New York. At the conclusion of the war he travelled north and settled on Pike river, Stanbridge, Quebec. The town of Bedford, P.Q., owes its inception to Stephen Lampman who was one of the original grantees of the township. The location of his mills on Pike river is shown on old government maps of 1800 and 1815 which are preserved in the Archives at Ottawa. His descendants settled in Vermont and later in the states of Wisconsin and Minnesota.

Peter Lampman, the eldest son of Frederick and great-grandfather of Archibald Lampman was born in Hanover in 1749. He was twenty-seven years old at the beginning of the revolution. In 1777 he married Elizabeth Haines of an English family which after the war settled as U.E. Loyalists in the township of Newark, District of Nassau. Soon after their marriage Peter was compelled to flee from their home to escape impressment with the American forces and the young couple were separated for about five years. His eldest child Catharine was born during her father's flight. If Elizabeth received any news of her husband during those five years, it must have been a most unusual circumstance. Alone and on foot, hunted by the Americans, always in peril of his life, he travelled up the Hudson valley to the city of Quebec, where he arrived in 1779. It is related that at one time, when hard pressed by his pursuers, he hid in a hay mow which the Americans searched with swords and bayonets. At another time he slept in a tree while the searchers passed beneath. After his escape through the American lines, he must have encountered great privation in obtaining food for there were very few settlements and the whole region was held by the Americans. The winter of 1779-1780 he spent at Quebec.

In the spring of 1780 he proceeded west by the St. Lawrence river to the Niagara peninsula where he took up a claim at bend of the Niagara escarpment called St. Anthony's Nose. Newark was the name of the nearest settlement. At this place, the first Parliament of Upper Canada was afterwards held, the name being changed to Grantham, then to Lenox, and finally to Niagara. From the autumn of 1780 to the spring of 1782 Peter Lampman was busily engaged in preparing his new home in the wilderness, cutting down the forest, and building a log house. He was compelled to do the work practically alone for there were very few settlers in that district at the time, the Loyalists not arriving in numbers before 1784 when Peter's family settled nearby at Stamford. In the spring of 1782, having made sufficient preparation, he set out alone for New York to fetch his wife and child. Although peace had been declared in that year, news was slow in travelling, and his return to New York was probably as dangerous as his flight from the town had been. His route this time was by the Mohawk valley through the country of the Five Nations. At some time during the summer of 1782 he found his wife and the little child Catrina then about four years old whom he saw for the first time.

We do not know where they lived for the next nine or ten months, but in the following spring of 1783 Peter returned again to Niagara bringing his wife, Catrina, and an infant son but a few weeks old. It is related that he procured a horse, on which his wife and children rode while he walked by their side. They arrived in Niagara in safety and began life in their forest home where though privations were severe, there was security under the British flag. Peter Lampman's grants were extensive, altogether about 750 acres as recorded in the Land Books of Upper Canada which are preserved in the Archives at Toronto. The estate, which he named Mountain Point, was situated between Thorold and St. Catherine's, and under his care a beautiful fruit farm was developed. Here he lived for fifty-two years. In 1834 he died at the age of eighty-five, having survived his wife fourteen years. They were both interred in the graveyard of the old Lutheran church at Thorold. This historic log church was recently taken down to make room for the new Welland canal.

Ten children were born to Peter Lampman, five boys and five daughters. The eldest daughter Catharine, who had travelled on horseback with her mother to Canada, married in 1797 George Keefer the founder of Thorold, son of George Keefer who had emigrated from Alsace, France, to New York and had lost his life and property as a Loyalist in 1770. The infant boy whom Peter brought to Canada in 1783 and whom he named Jacob seems to have died while young for no further record of him has been found. The second son, Frederick, married the daughter of a Loyalist and moved from Niagara taking up a grant at Palmyra, Talbot Street, in the township of Orford near Lake Erie, a few miles from Clearville, where David Henry Gesner, about the same time 1825, had received a grant. Frederick Lampman was one of the first settlers on Talbot Street and the original grant from the Crown is still preserved by his grandson who occupies the old homestead. All of Peter Lampman's sons served in the Lincoln Militia in the war of 1812 and several of the Lampmans lie buried in Lundy's Lane. His third son, named Peter, the poet's grandfather, was wounded at the battle of Fort George 27th May, 1813. Another son, John, Captain of the 1st Lincoln Militia, was severely wounded at the battle of Lundy's Lane. The Orderly Books of the war of 1812 contain many references to the Lampmans. In the records of marriages made by Peter Lampman's children the names of several well known Loyalist families occur. Captain John Lampman married Mary Secord, sister of Laura Secord, whose brother Abraham Secord married Elizabeth Lampman.

Peter Lampman's third son, who was also named Peter, the grandfather of the poet, inherited the family estate at Mountain Point. He married Agnes Ann McNeal, daughter of Archibald McNeal who had come to Canada from Baltimore. Their family consisted of ten children, of whom seven were sons. The third son, named Archibald, father of the poet, was born in 1822 and died at Ottawa 1895. He was educated at Upper Canada College, graduated Bachelor of Arts from Trinity College, Toronto, 1857, and was ordained in the ministry of the Church of England 1857. He was appointed incumbent of Trinity Church, Morpeth, in 1860 and in May of that year married Susanna Charlotte, daughter of David Henry Gesner. He was remarkably proficient in the classics even for those days when the study of classical authors was considered essential to a liberal education. He was especially devoted to Vergil, Horace, and Cicero, and having the advantage of an excellent memory his store of classical knowledge never faded.

In reading the foregoing sketches of these hardy men, one cannot fail to be impressed with a few facts which seem to distinguish them from men of the present time. Hardships and great labours did not shorten their lives, for they generally attained the age of eighty and even ninety years. Their families were always large, frequently numbering a dozen children of whom very few died in childhood. These men and their wives seemed devoid of fear and their powers of adaptability to new conditions were remarkable. We of to-day can hardly appreciate the difficulties which they conquered, but, built upon such courage, devotion and loyalty as characterized their lives, Canada takes her place among the progressive nations of the world.

Ancestry of Archibald Lampman

Frederick Lampman 1719-1789 and Katrina	John Hendrick Gesner 1681-1745 and Ann Elizabeth
Peter Lampman 1749-1834 Elizabeth Haynes 1757-1820	John Henry Gesner 1724-1811 Famitcha Brower 1723-1788
Peter Lampman 1787-1870 Agnes Ann McNeal 1795-1879	David Henry Gesner 1793-1879 Sarah Stewart 1802-1878
Archibald Lampman 1822-1895 Susanna Charlotte Gesner 1837-1912	Susanna Charlotte Gesner 1837-1912 Archibald Lampman 1822-1895

Archibald Lampman
1861-1899
Maud Emma Playter
1869-1910

Archibald Otto Lampman
1898-
Helen Winifred McKenzie

Mary Natalie Lampman
1921

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Maturin and Diderot

By DR. H. ASHTON

Presented by JUDGE F. W. HOWAY, F.R.S.C.

(Read May Meeting, 1921)

I.

In spite of Professor Saintsbury's statement that "the immense influence of Maturin in France is an old story,"[1] the ordinary reader of English literature has little knowledge of Maturin or of his works. The name will probably recall a chapter in Coleridge's *Biographia literaria*,[2] and if one does not remember that this chapter of invective was written by Coleridge because Maturin's *Bertram* had been accepted in preference to a play of his own,[3] a false impression may remain in the mind.

Coleridge's opinion of the play was not shared by the theatre-going public, nor by such men as Byron and Scott. The latter shows the real situation when he writes to Maturin urging him not to let his reply to Coleridge appear in the preface to *Women*:[4] "Let me entreat you to view Coleridge's violence as a thing to be contemned, not retaliated—the opinion of a British public may surely be set in opposition to that of one disappointed and wayward man. You should also consider, *en bon Chrétien*, that Coleridge has had some room to be spited at the world, and you are, I trust, to continue to be a favourite with the public—so that you should totally neglect and despise criticism, however virulent, which arises out of his bad fortune and your good. . . ."[5]

Maturin and Scott had in common that they were both "slaves to the pen." Curate of St. Peter's Church, Dublin, Maturin kept a "crammer's shop" and was very successful in preparing pupils for the University. His pecuniary difficulties were caused by his rash good-nature, for he became security for a large sum of money at the request of a relative. This person failed in his enterprise, and Maturin

[1]Saintsbury, *A History of the French Novel*. London, 1917. 2 vols. 4⁰. Vol. II, p. 166, Note 3.

[2]Chapter XXIII, Critique on *Bertram*. J. M. Dent. (Everyman's Library.)

[3]*The Fall of Robespierre*.

[4]"A Tale by the Author of *Bertram*." 3 vols. 12⁰. London, 1818.

[5]Lockhart's Scott, Vol. 5. Edinburgh, 1839.

was held responsible for the debt. The "coaching" establishment had to be sold, and for the rest of his life Maturin, like Scott and Balzac, had to write to pay debts.

Needless to say he had already married. At the age of twenty, while still a student, he had persuaded Henrietta Kingsbury, sister of the Dean of Killala, to share his lot. She was a beautiful and talented woman and, in spite of the frequent lack of funds in the household, had never any cause to repent that she had married in haste.

Maturin began his literary career as a novelist and, foreseeing the difficulties that would inevitably arise if he tried to combine the careers of curate and teller of tales, he produced his early work under an assumed name. Later, he turned with some success to the stage, then gave up dramatic work to write his best novels.

His life was one long struggle with poverty, not merely by reason of the debt he had incurred, but also because he spent his money unwisely. Fond of dancing and proud of his skill he gave quadrille parties that were famous in Dublin. His beautiful wife was always well dressed and he also, when not actually in the throes of novel-writing, was careful of his personal appearance.

As a preacher he was popular, and his sermons on the "Errors of Romanism" drew large congregations. His religious convictions influenced his novel *Melmoth*,[6] and his strong nationalism is evident in the *Wild Irish Boy*,[7] and in the *Milesian Chief*.[8]

He appears to have been a wide reader—including Monk Lewis and Mrs. Radcliffe among his favourite authors. Pope, Crabbe, Scott and Moore appealed to him. Byron, though appreciated as a friend, did not find favour as a poet.

After his death all his papers were destroyed by his son William. Dion Boucicault, the elder, while on a visit to Dublin, congratulated the city on having produced two great playwrights—Sheridan and Maturin. The dutiful William did not like to have his father's name connected with the stage, so he proceeded to destroy the evidence—chiefly in the form of unpublished MSS. and correspondence. How the destruction of letters from Balzac and Goethe served any useful purpose is not evident, but the holocaust satisfied William, and left posterity with but meagre knowledge of a charming personality.[9]

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[6]*Melmoth, the Wanderer*. 4 Vols. 12°. Edinburgh and London, 1820.

[7]3 vols. 12°. 1808.

[8]4 vols. 12°. London, 1812.

[9]The author has drawn freely from the biographical material collected for the reprint of *Melmoth*. London (Bentley). 3 vols. 1892.

II.

Melmoth, the Wanderer is the novel that brought Maturin fame at home and abroad. Published in four volumes in 1820, it appeared in Paris the following year, translated by J. Cohen. In 1835 Balzac, in his *Melmoth reconcilié*,[10] continued the story according to his own ideas.

The plot of *Melmoth, the Wanderer*, if plot there be, is a combination of the legends of Faust and the Wandering Jew. Melmoth bargains for a long lease of life; the price is his own soul, with a possibility of escaping payment if he can find someone to relieve him of his bargain on the same terms. The difficulty of handling such a story is obvious, for the hero has to travel to various countries and through several centuries. Maturin adopted the method dear to Mlle. de Scudéry—the tale within a tale—and the result is far from satisfactory.

The story opens in Ireland where John Melmoth discovers a manuscript that gives us the story of Stanton and a story related to him in Spain. A Spaniard, Monçada, arrives at the mansion in Ireland and gives his biography with, as digressions, stories told to him by a Jew. These have to do with Immalee, a girl to whose father a mysterious stranger has told two stories—that of Guzman's family and one announced as The Lovers' Tale. These are duly repeated and then the story of Immalee is resumed and completed. Then Monçada is interrupted and his own story goes no further but the main tale is continued from the time he first began his narrative.

This novel came, curiously enough, when the tale of terror was waning in England. It not only revived interest in this type of work, but actually proved to be the crowning achievement. It stands in the same relationship to this stage in the development of the novel as does Rostand's *Cyrano de Bergerac* to the romantic drama.

The novel of terror appears to have been one of the features of the Romantic Revolt, and the Romantic dramatists never forgot, unfortunately, that an appeal to the nerves is more easily prepared and more effectively made than are more subtle, more elevated, appeals to the mind. Whether this taste was indulged in because readers of the day had peculiar cravings for such excitement, or whether authors were merely possessed with an elfish desire "to shock the bourgeois" is of no consequence. Whatever may have been the incentive none can complain that *Melmoth* failed in its attempt to furnish exactly the type of thrill sought after by the Romanticists.

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[10]*Etudes philosophiques.*

Its importance in the history of the novel in France becomes evident when it is noted that, whereas it came at the end of the vogue in England of the novel of Terror, it was in time for the beginning in France of a similar vogue to which it contributed in no small measure. While the translators were putting the finishing touches to the French edition of *Melmoth* Victor Hugo was feverishly engaged in writing *Han d'Islande*.[11]

Six of its chapters have passages from *Bertram* at the head and this detail is considered sufficiently important to be mentioned in the preface to the first edition: "Tous les chapitres sont précédés d'épigraphes étranges et mystérieuses, qui ajoutent singulièrement à l'intérêt et donnent plus de physionomie à chaque partie de la composition." Something is wanted indeed to add to the interest of *Han d'Islande*, but the *épigraphes* alone are not enough. Perhaps a little less time spent in seeking strange and mysterious passages in Sterne, Shakespeare, Maturin, Lessing and Schiller, and a little more given to the study of real life would have improved the novel. It must be recalled, however, in all fairness, that the author was a mere boy.

Bertram was translated by Charles Nodier, and he is one of the first to record the growing influence of Maturin.[12] Balzac had a wildly exaggerated opinion of the Irish author's place in literature. Gustave Planche saw, in prophetic vision, posterity placing Melmoth between Faust and Manfred.[13] Posterity did not place Melmoth anywhere, but simply lived on day after day, ignoring his very existence. He was forgotten long before Baudelaire referred to him in illustration of his essay, *De l'essence du rire*.[14]

The appeal of Melmoth to the French was not due to its real qualities alone. Some of its faults disappeared in a translation that was very kind to the careless style of the original, others remained and helped instead of injuring, the success of the book. The long feverish descriptions, for example, that occasionally try the patience of the present-day reader, must have been counted by the Romanticist among the beauties of the work. Nature is no more a discreet background, but, together with Gothic buildings, generally in ruins, becomes an actor in the plot. If the mystery of Melmoth, the trusting girl's imminent peril, the horror that one feels lies but a few paces

[11]Written in 1821. First edition 1823.

[12]In *La Quotidienne*, 12 mars 1823, à propos of the recently published *Han d'Islande* by Hugo.

[13]*Portraits littéraires*. Vol. 1. Paris, 1836.

[14]Reprinted in *Curiosités esthétiques*, Paris, Calmann-Lévy, 1889.

ahead, are not enough to cause a thrill, Maturin adds generously a dark night, a rushing river, sobbing winds, eerie trees, beetling crags and a thunder-storm. There is enough correspondence between the moods of humanity and those of nature to satisfy the most faithful disciple of Jean-Jacques'. Subterranean passages, convents, monasteries, castles, manor houses, hidden chambers, walled-up closets with people inside them, dungeons, ruined chapels seen by night, mysterious strangers with corpse-like hands and cold, cold eyes—not a single ingredient of the romantic novel is lacking; and, above all, there is a hero ever driven by fatality, oft in contradiction to his better nature. What Romanticist e'er breathed who did not yearn towards a hero—or towards a villain for that matter—who is evidently urged through life from thrill to thrill by some power greater than mere human volition ?

Maturin fitted exactly into the literary mosaic that was later described as French Romanticism, and while the influence of his plays on early romantic drama, and of his stories on the romantic novel, is now taken for granted, it would be interesting to work out in detail the various points of contact between the works of the Irish clergyman and those of the literary revolutionists in Paris.[15]

III.

We are not concerned here, however, with this particular aspect of the question, but with one that is more curious. While the conception of the novel *Melmoth* was, as has been stated, a combination of two ancient legends, the borrowings of Maturin appear to have been numerous. Had they been from German, English and Spanish, they would have coincided with the reading of the young novelist, Victor Hugo, and would have contributed naturally enough to the foreign influences that helped to bring about the Romantic Revolt in France.

Such was not the case. The main "Spanish" episode in *Melmoth* was borrowed from the French. In an excellent article in the *Times Literary Supplement*,[16] Mr. Bryson writes: "Maturin builds up his efforts with a series of suggestive touches, those instinctive premonitions of something strange in even ordinary affairs; and he certainly describes powerfully and well; his descriptive power is,

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[15]This is being undertaken by a student of the University of British Columbia.

[16]August 27th, 1920. It was this article that drew my attention to Maturin as a fit subject for research. Mr. J. N. Bryson very kindly informed me that the field was clear, as he did not intend to go further in the matter.

indeed, an essential feature of the secret of conveying his supernatural fear. Without quotation of immoderate length it is not possible to illustrate these qualities, but one may point to the interior of the Dominican monastery, in which Monçada is interned—a long description extending through most of the second volume, and making its impression by the culminating effect of vivid flashes of horror. It conveys that feeling of grim monkish mystery inspired by the pictures of Zurbaran."

That is eminently true, but most of the credit is due, not to Maturin, but to Diderot, who had already given a similar interior in his novel, *La Religieuse*.

The Irish clergyman was evidently a fairly wide reader in French, and being at the same time a decided enemy of the Roman Catholic Church, he naturally read Diderot's novel. It is a matter for surprise that, while he frequently supported his statements by references to French sources, he does not think it necessary to indicate *La Religieuse* as a source of inspiration for a very important portion of his own work. Was he of opinion that a novel proved nothing and therefore need not be quoted? Whatever may have been the reasons for his silence he did not succeed in hiding his free use of this "source."

More than a dozen years have passed since the author of this paper first ventured on a study of sources, and, like all experienced workers in this field, he has come to regard with considerable caution all discoveries of similarities between texts. Similarity does not mean plagiarism, parallel passages may prove common sources or parallel inspiration, and nothing more. It is evident that if Diderot truthfully represented a nun who was such against her will, and if Maturin represented a monk who had no wish for monastic life, there must be of necessity points of similarity between the two works. All that can be done in such cases is to marshall the facts, point out similarities, and leave the final decision with the credulous or incredulous reader—though it does no harm to state one's own conclusion in the matter.

Diderot relates the story of a girl who becomes a nun against her will, and who finally escapes from the convent.

Maturin, in the tale of the Spaniard,[17] gives the story of a boy who is forced to become a monk. The two stories diverge when Diderot begins to describe the convent of Sainte-Euterpe, either because Maturin was using Naigeon's edition that suppresses the objectionable picture of the sexual dangers of convent life, or because

[17] *Melmoth* Reprint 1892. Vol. 1, p. 117. All future quotations will be from this edition.

he saw how impossible it would be for him to present such a picture to a British public. One may note, *en passant,* that, elsewhere in his story, he makes a very clear reference to a similar danger in monasteries.[18] The subsequent picture of the Inquisition is either Maturin's own or it has been taken from some work other than Diderot's. With this exception, *Melmoth* follows fairly closely the story as told by Diderot.

The girl in *La Religieuse* is supposed to be illegitimate, and this is the reason for her being forced, against her will, to enter a convent. There comes later a scene in which the mother states clearly that the girl is not the daughter of her supposed father.

In *Melmoth* the illegitimacy of the boy is a mere technicality. He is the son of the parents in whose house he lives, but was born before their marriage. This irregularity is considered sufficient cause to condemn him to a monastic life in spite of his very serious opposition. While the boy does no more than make pitiful scenes in his home the girl actually has the courage to make a public disavowal in the convent.

In each case the mother's confession to her child is the culminating point in the efforts made to force the boy or girl to take the vows.

This step having been taken Maturin darkens the picture. Of this talent he is rather proud for he says: "If I possess any talent it is that of darkening the gloomy and of deepening the sad, of painting life in extremes. . . ." Hence, while Diderot places the girl in happy surroundings, at first, to show how cunningly the work of snaring the future nun is carried on, Maturin has nothing but obvious hypocrisy to paint from the outset. His boasted talent succeeds in diminishing his art and in weakening his thesis.

In each story the victim decides to apply for resiliation of the vows and the obvious difficulty is to procure sufficient paper to draw up the memorandum. There is nothing surprising in the discovery, in each case, that it may be procured by giving as excuse the necessity of writing out a general confession in preparation for an important church festival. Suspicion is naturally aroused by the quantity of paper required and, in one case, the Superior and four nuns, and in the other the Superior and four monks, examine very minutely the cell and the person of the accused and cross-question at some length.

All this may happen in the best regulated religious institutions, and so perforce appear in both novels, but the following passages seem to be too similar to be the result of a mere coincidence.

[18] *Melmoth,* vol. I, p. 177.

The nun is dragged into the underground chamber described below. The Spaniard takes up more time in preliminary pleadings and imaginings (*Melmoth* has to run to four volumes), but finally he also is ushered into his underground chamber which he must needs describe.

"Cependant l'on ouvrit avec de grosses clefs la porte d'un petit lieu souterrain, obscur, où l'on me jeta sur une natte que l'humidité avait à demi pourrie. Là je trouvai *un morceau de pain noir et une cruche d'eau* avec quelques vaisseaux nécessaires et grossiers. *La natte roulée par un bout formait un oreiller; il y avait, sur un bloc de pierre, une tête de mort, avec un crucifix de bois.*"[19]

"I had time to view all the furniture of what I thought my last abode. It was of stone; the roof formed an arch; *a block of stone supported a crucifix, and a death's head with a loaf and a pitcher of water. There was a mat on the floor to lie on; another rolled up at the end of it formed a pillow. . . .*"[20]

The writer confesses absolute ignorance of the "standard" furniture of convent dungeons, and this ignorance leads him to believe that the similarity of the above passages is due to a careful reading of Diderot by Maturin. In describing the scene as a whole the translator is more prolix than the original author and much more careless in composition. The "last abode," and the furniture thereof, are mixed in a way that Diderot's style would not for one moment tolerate.

The length of confinement in the dungeon is three days in the case of the nun, while the monk is liberated on the fourth day.

The persecution continues. Each is excluded from chapel;[21] each is denied food;[22] fellow monks or nuns join in the persecution. When Diderot's nun is met by a sister she is greeted with the cry: "Satan, éloignez-vous de moi,"[23] while Maturin's monk is stood off with: "Apage Satana."[23] For other persecutions the reader of *Melmoth* is invited in a footnote to consult Mosheim's *Ecclesiastical History*.[24]

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[19]*La Religieuse*, p. 85, vol. V, of Diderot, *Oeuvres complètes*, Assézat's edition, Paris (Garnier), 1875. All other references are to this edition.

[20]*Melmoth*, I, p. 242.

[21]*La R.*, p. 71—*Mel.* I, p. 254.

[22]*La R.*, p. 69.—*Mel.* I, p. 255.

[23]*La R.*, p. 71—*Mel.* I, p. 256.

[24]Note to *Mel.* I, p. 266.

Such a life is evidently impossible to prolong and, in each case, relief is offered by the visit of a Bishop. Each is tortured at the last moment, and dragged bound before the visiting Bishop.[25] When asked by the worthy ecclesiastic whether he (or she) abjures Satan, each is made to cry out in physical pain.[26]

The Bishop finds it difficult to put his questions because the Superior continually interrupts,[27] but at length he requires an act of faith,[28] and is much impressed by the result.

There seems to have been an addition made by Maturin to the sly tortures inflicted before the Bishop, to ensure the monk's acting like a person possessed. When the poor wretch is asked to go forward he starts back in evident pain because broken glass has been spread between him and the Bishop.[29] Maturin is not exercising his talent of darkening the gloomy, however, but is simply borrowing an incident that comes in *La Religieuse* after the nun has failed in her application to have her vows annulled.[29] Not only is Maturin skilled in transposing an incident, where necessary, he is equally careful to change an allusion to make it clear to his English readers. When the nun enters the convent at Longchamps the following incident is recorded:

The Superior is speaking— "Mademoiselle, vous savez la musique; vous chantez; nous avons un clavecin: si vous vouliez, nous irions dans notre parloir. . . . Ma mère passa, je la suivis . . . et je chantai, sans y entendre finesse, par habitude, parceque le morceau m'était familier: *Tristes apprêts, pâles flambeaux, jour plus affreux que les ténèbres,* etc.[30] Je ne sais ce que cela produisit mais on ne m'écouta pas longtemps: on m'interrompit par des éloges, que je fus bien surprise d'avoir mérités si promptement et à si peu de frais. . . ."[31]

When the monk enters the monastery the following scene is described: "But you are fond of music doubtless," said the Superior, "you must hear his performance." There was a small organ in the room adjacent to the parlour; my mother was not admitted there, but my father followed to listen. Involuntarily I selected an air from the "Sacrifice of Jeptha." My father was affected and bid me cease. The Superior imagined this was not only a tribute to my

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[25]*La R.*, p. 77—*Mel* I, p. 281. In *La R.* the visit is not made by the Bishop in person but by his *Archidiacre.*

[26]*La R.*, p. 80—*Mel.* I, p. 283.

[27]*La R.*, p. 80—*Mel.* I, p. 283.

[28]*La R.*, p. 82—*Mel.* I, p. 284.

[29]*La R.*, p. 95—*Mel.* I, p. 284.

[30]Telamire's song from *Castor and Pollux,* libretto by Bernard, score by Rameau.

[31]*La R.*, p. 34

talent but an acknowledgement of the power of his party, and he applauded without measure or judgment."[32]

But this is a digression and we must return to our victims whom we left standing before their respective Bishops.

The monk was sent to his cell and promptly knelt down to pray that the Bishop's heart should be touched. We can leave him to describe the result in his own words. As the nun in *La Religieuse* has the same happy inspiration under exactly similar circumstances we can give her version alongside the monk's:

"I knelt and implored the Almighty to touch the Bishop's heart. . . . As I was thus employed I heard steps in the passage. They ceased for a moment and I was silent. It appeared the persons overheard me and paused; and those few words, uttered in solitude, made, I found, a deep impression on them. A few minutes after the Bishop, with some dignified attendants, followed by the Superior, entered my cell. The former all stopped, horrified at its appearance. I have told you, Sir, that my cell now consisted of four bare walls and a bed—it was a scandalous, degrading sight. I was kneeling in the middle of the floor, God knows, without the least idea of producing an effect. The Bishop gazed around him for some time, while the ecclesiastics who attended him testified their horror by looks and attitudes that needed no interpretation. The Bishop, after a pause, turned to the Superior: 'Well, what do you say to this?' The Superior hesitated, and at last said: 'I

"Je priais, lorsque l'archidiacre, ses deux compagnons et la supérieure parurent dans ma cellule.

Je vous ai dit que j'étais sans tapisserie, sans chaise, sans prie-dieu, sans rideaux, sans matelas, sans couverture, sans draps, sans aucun vaisseau, sans porte qui fermât, presque sans vitre entière à mes fenêtres.

Je me levai, et l'archidiacre s'arrêtant tout court et tournant des yeux d'indignation sur la Supérieure lui dit: "Eh bien! madame?"

Elle répondit, "Je l'ignorais."

Vous l'ignoriez? vous mentez! Avez-vous passé un jour sans entrer ici, et n'en descendiez-vous pas quand vous êtes venue? Soeur Suzanne, parlez: madame n'est-elle pas entrée ici d'aujourd' hui?"

[32]*Mel.* I, p. 155.

was ignorant of this.' 'That is a falsehood,' said the Bishop; "and even if it were true, it would be your crimination, not your apology. Your duty binds you to visit the cells every day; how could you be ignorant of the shameful state of this cell, without neglecting your duties?' He took several turns about the cell, followed by the ecclesiastics, shrugging their shoulders and throwing on each other looks of disgust. The Superior stood dismayed. They went out, and I could hear the Bishop say in the passage: 'All this disorder must be rectified before I quit the house,' and to the Superior: 'You are unworthy of the situation you hold; you ought to be deposed.' And he added in severer tones: "Catholics, monks Christians, this is shocking—horrible! tremble for the consequences of my next visit, if the same disorders exist. I promise you it shall be repeated soon." '[33]

Je ne répondis rien: il n'insista pas; mais les jeunes ecclésiastiques laissant tomber leurs bras, la tête baissée et les yeux comme fixés en terre, décelaient assez leur peine et leur surprise.

Ils sortirent tous; et j'entendis l'archidiacre qui disait à la supérieure dans le corridor:

"Vous êtes indigne de vos fonctions; vous mériteriez d'être déposée. J'en porterai mes plaintes à Monseigneur. Que tout ce désordre soit réparé avant que je sois sorti." Et continuant de marcher, et branlant sa tête, il ajoutait: "Cela est horrible. Des chrétiennes! des religieuses! des créatures humaines! cela est horrible![33]

Meanwhile the struggle to have the vows annulled was being continued in each case, and the final result—failure—was the same in each.

The letter bringing the bad news had to be communicated to the Superior before it could be read by the interested person. The girl entered the Superior's cell with eyes cast down: "La Supérieure était avec quelques autres religieuses; je m'en aperçus au bas de leurs robes, car je n'osais pas lever les yeux."[34]

The monk entered also with eyes cast down and he "could only see the hems of many habits, whose wearers were all assembled in the Superior's apartment."[34]

[33]*Mel.* I, pp. 290-292—*La R.*, pp. 85-86.
[34]*La R.*, p. 91—*Mel.* I, p. 294.

The reception, in each case, was such that neither thought it necessary, upon returning to the cell, to read at once the fatal news.

Melmoth, from this point, diverges from *La Religieuse* as has been stated, and while the journey through the underground passages and the various horrors related there call up memories of other sources, these lie outside the province of our present inquiry.

Allowing for similarity of subject, we can conclude, with every semblance of justice, that Maturin had not merely read and recalled the main outline of Diderot's novel, but that he actually consulted it during the composition of this portion of *Melmoth*. If he had followed more closely the sober text of his French predecessor, he would have been more in keeping with our ideas of art,[35] but he would not have been sufficiently "romantic" to have the influence that he certainly exercised upon the French, who no longer read Diderot, and who craved for "something different."

It is one of the little ironies of literary history that the "something different," which caused them such delight was only, as far as this episode is concerned, a tawdry resetting of one of their own literary gems.

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[35]And more in keeping with fact. Any one who has seen a monastery cell will have some difficulty in picturing the scene described above by Maturin (not by Diderot). In a cell in which there are assembled six persons—and a bed—one person takes several turns, followed by three others!

The Second President Lincoln

By RENDELL WILLIAMS

Presented by the Honble. WILLIAM RENWICK RIDDELL, F.R.S.C.

(Read May Meeting, 1921)

An American writer, Emerson Hough (who repeatedly calls himself a "Yankee"), in 1909 published a very interesting book called "The Sowing, a Yankee's View of England's Duty to Herself and to Canada."[1]

On page 36 he says: "Generations hence, England still may be ruling Canada."

If a Canadian had asked Mr. Hough why he thought England was "ruling Canada," no doubt he would have cited The British North America Act, 1867[2]—the so-called "Constitution of Canada"—which, by section 9, provides that "the executive government and authority of Canada is hereby declared to . . . be vested in the" King—by other sections provides for a Governor General appointed by the King to carry on the government in the name of the King, for the appoinment for life of all the Senators and Judges by the Governor General in Council, the members of the Council being chosen and summoned by the Governor General, that any statute of the Dominion can be disallowed and annulled by the King; he would point out that Canada cannot even amend her own Constitution and that the Parliament at Westminster could legally make laws governing Canada. The Canadian would say: "Yes, I guess that's so," and grin.

"But what has that to do with the second President Lincoln?" you say. Read on and see.

Near Atlanta, Georgia, on a small plot of poor land—if such a thing as poor land can be found in the South—lived a coal-black, full-blooded negro. Born in 1867, he was christened Abraham Lincoln, after the idolized and martyred President—we should perhaps say martyred and idolized President, for there was little evidence of idolizing before the martyrdom.[3] Naturally the name was contracted to Ab'm Linkum, but that did not grieve him. It would indeed have taken a great deal to make him downcast—over six feet in height, broad in proportion, the picture of health, shining like a mirror in the sun, he spent his days in joyous abandon interrupted only occasionally by the stern necessity of work to provide food and at least vestiges of clothing for Aunt Mandy and her twelve sable offspring. The eldest was, of course, Ab'm, but for the successors were chosen names taken from the breast-plate of the Hebrew High Priest, for the couple had in their honeymoon been profoundly impressed by the gorgeous succession of names of precious stones read most sonorously if somewhat lacking in orthodox pronunciation by their coloured pastor. And so there were Sardius and Topaz, and Carbuncle (contracted to "Uncle"), and Emerald (who, though a boy, was "Emmy"), and Sapphire ("Fire"), and Diamond, Ligure (generally by a natural association of ideas called "Moonshine"), and Agate ("Aggie"), and Amethyst and Beryl (transmogrified into "Barrel"), and Onyx—her, Aunt Mandy thought well named as she came onexpected. The fruitfulness of the happy couple had not yet got so far as to produce a Jasper, "the only real nigger name in the bunch" as the envious neighbours declared; but hope was not dead.

Thus flourished the happy family in Georgia when the great day came around, the day fixed by the Act of January 23, 1845, the Tuesday after the first Monday of November; and there were chosen by the citizens of each State a certain number of gentlemen, not being Senators, or Representatives, or holding offices of trust or profit under the United States, and not having violated an oath previously taken to support the Constitution of the United States by engaging in insurrection or rebellion against the same or giving aid or comfort to the enemies thereof.

These were the men who were to select the President of the United States for four years, irremovable except by death, resignation or impeachment—and Presidents seldom die and never resign, while no one tries an impeachment since the attempt failed with Andy Johnson. In case of inability to perform the duties of his office, the Vice-President receives the powers of the President, but even partial paralysis cannot disable a President, and that last resort of a patriot, a bullet, could not disable one who had been a College President like Garfield—it had not yet been tried on Wilson but would, if tried, be certain to fail unless it killed.

These men, too, select the Vice-President who may, like Roosevelt, succeed to the Presidency.

The Constitution of the United States was framed by men who feared the wild passions of the mobility—"great importance was attached by the framers of the Constitution to the interposition of he electoral college between the passions and prejudices of the undiscriminating multitude of voters and the high office of President."[4] They feared that if the Legislature should elect a President it would be the work of intrigue, of cabal and of faction, it would be like the election of a Pope by a conclave of Cardinals and that real merit would rarely be the title to the appointment.[5] Election by the people was liable to the most obvious and striking objections; they would be led by a few active and designing men[6] and it would be as unnatural to refer the choice of Chief Magistrate to the people as it would be to refer a trial of colours to a blind man.[7] A popular election would be radically vicious; the ignorance of the people would put it in the power of one set of men dispersed through the Union and acting in concert to delude the people into any appointment.[8]

So the Fathers determined that the appointment of President should be left to Electors. These, of course, would be men of high standing and clear judgment, not filled with party spirit or influenced by regard for any man; they would feel the very great responsibility cast upon them and would anxiously canvass the merits of all natural born citizens of the United States who had attained the age of 35 years and had been for 14 years residents of the United States and they would vote for those best qualified for the high offices of President; he who received the most votes would become President and he who received the next greatest number Vice-President. And thus there would be no intrigue, no cabal, no faction, the people would not be led by a few active and designing men, no one set of men, senators or others, acting in concert could determine the appointment, and real merit would be the sole title to the office.

The selection of these electors being thus of the most serious importance, the citizens of each State examined with the greatest care into the past history, the ability, clearness of vision, soundness of judgment, uprightness and candour of the prominent citizens, to see who should be entrusted with the grave responsibility of acting for them in the selection of their future four year Monarch. An ordinary agent for every day affairs or a lawyer, one might take chances on, but a Presidential Elector! Never, no sir, never.

And so it came about that in at least most of the States a minimum of ten per cent. of the voters knew one, or possibly even two, of those for whom they voted, sometimes indeed only by name but occasionally by sight.

Naturally these splendid specimens of American citizenship were impressed with the tremendous importance of their solemn task; and naturally they communicated with each other most seriously, asking and giving advice and exchanging views.

It early appeared that the great majority were whole heartedly determined that autocracy should end, that there was to be no more one man rule—of course, it was recognized that the President had more power than that old tyrant George III ever pretended to, but while it is excellent to have a giant's strength, it is not the thing to use it like a giant; and so, as it was no longer good form to temper autocracy with assassination, at least in America, they thought it wise not to appoint any one likely to kick over the traces and try to play the strong man. What kind of a man to get?

Believing with Dryden that

"By education most have been misled,"

remembering that Tommy Wilson was a real nice boy before he went to College and Stevie Cleveland was modest, if not meek, before he studied for the Bar, they determined that no highbrow should occupy the White House, not one darned College President or lawyer—these were too sot, too determined to have their own way, too pig-headed to admit of proper steering. This cut out Champ Clark on both counts as well as certain well-known men who, though politicians, are still lawyers. I mean such men as Elihu Root, William Howard Taft, George Wickersham. I am not quite so sure of Selden Spencer, in whom the Spencer perhaps predominates rather than the Selden, or of Henry Cabot Lodge, but then his middle name entitled him in the land of the Bean and the Cod to familiar converse with the Highest, and that had been found fatal by the experience of Germany. What more education does a President want anyway than just to read and write? And while Dogberry may have been a little astray when he thought "to write and read comes by nature," he was infinitely right in his noble precept "for your writing and reading, let that appear when there is no need of such vanity." This type-writing craze, this *cacoethes scribendi epistolarum magnarum doctarum eruditarumque* had to come to an end, especially in the existing scarcity of paper; the ordinary individual should have some chance of getting writing material.

Accordingly a man of limited education was a desideratum, and the more limited the education, within limits of course, the better. No stubborn, stiff-necked, intellectually proud man, but an easy-going man and a pliable, one who would do as he was told by his betters at the other end of the Avenue—that must be the aim.

Having decided the kind of a man to be chosen other considerations arose. That blamed South, which had never forgotten its former ascendency, which could not be weaned from its self-sufficient adhesion to its time-honoured politics, which could not be got to acknowledge the superiority of the North, had to be taught a lesson. The mere election of a Northerner would not be sufficient; Cleveland and Harrison and McKinley and Roosevelt and Taft were from the North, and some other means must be adopted. A brilliant thought struck the mind of Mr. ——, Mr. ——, Mr. ——, whatever is his name? You know, every American knows, the man I mean—the man who got the most votes in Ohio, Mr. ——, but no matter what the name—let us say one of the most illustrious of the Electors and let it go at that. He said: "Let us pick out a Southerner, one of a class which the Southerners despise, and put him over them"—Agreed—but "surely you don't mean a nigger?" "Why not?" "Why not, indeed?" Agreed and agreed.

And then another illustrious Elector—blame my treacherous memory anyway—why can't I remember the name of that remarkable man? Another illustrious Elector said that he had spent the previous winter in Georgia, had noticed the big, indolent, jolly black with the historic name and numerous progeny; that no one respected him but everybody liked him, thereby reversing the situation of the present occupant of the White House, that he was biddable and not uppish, not like—but why continue? What was wanted was a complete change. The South, which had resented Roosevelt seating Booker Washington at his table, would now see a Bookerer than Booker sitting in Washington's chair and learn their place. Moreover, there would be the incidental advantage that Roosevelt's favourite injunction to the American people would be constantly in mind and race suicide would be discredited.

The second Abraham Lincoln came in state to Washington, Aunt Mandy rules the White House with an unskilled and gentle rule, Ab'm Junior is the cock of his school and little Onyx can be seen any fine day sporting her red and yellow stockings on the lawn—stockings the first she had ever possessed but they are gorgeous.

Which things are an allegory—the legally possible is the morally impossible; evils elaborately guarded against are wholly imaginary and non-existent or at the worst negligible, and the prophylactic precautions are full of the very evils they are designed to prevent.

The Electoral College is the only piece of camouflage in the American Constitution. The Constitution of Britain and of Canada is the most elaborate and successful system of camouflage the world ever saw. If one sees anything laid down in the American Constitution it is—except that farcical College—certain to be so; if in the British Constitution it is certain not to be so. The American

Constitution, as a whole, and speaking generally, was framed *uno ictu* by acute and able statesmen as a permanent thing; it was necessarily in writing and *litera scripta manet*; the meaning at one time is the meaning at another, time writes no wrinkles on its austere brow. The British Constitution was not made, it was not even born—like Topsy, it just growed; it is largely unwritten and the very words in which it may be explained change their meaning with the changing times. It is continually grafting new shoots on the old stock, building more stately mansions on the old foundations; clinging fondly to the old names, the old ceremonies, the old forms, it is constantly moulding the old methods to new uses, and adapting the old to the purposes of the new.

Hence it is that the King, nominally King by the Grace of God, is in reality King by grace of an Act of Parliament; head of Army and Navy, he does not appoint an officer, however humble, in either; Defender of the Faith because his predecessor received the title from the Pope for defending the faith against the heretic Martin Luther, though he, George V., must by law be a Protestant; having the right to refuse the royal consent to any Bill passed by Parliament, though that has not been done since the times of William III; and able to select his Ministers from any of the millions of the British subjects to be found wherever the map is coloured red, so long as he selects those whom the House of Commons choose for him—appointing Judges, Ambassadors, Envoys, whom he never saw or heard of—creating Earls, Viscounts, Barons, Baronets, Knights *et hoc genus omne*, but only as the Prime Minister directs,[7] and to cap the climax, King of the United Kingdom of Great Britain and Ireland! United? Ask De Valera (the successor of the Pagan Era and the Christian Era).

So the power exists on paper for Britain to legislate for Canada, which she is as likely to do as the Electoral College to elect the Georgia Negro and no more likely—the Home Administration at Westminster may annul Canadian legislation just as the King can refuse the Royal Assent to a British Bill. The Governor General has, in Canada, substantially the powers of the King in England, but he exercises them in the same way; he must have as Ministers those approved by the House of Commons at Ottawa, the members of which are elected by the people of Canada, and these Ministers must get out and leave room for others if they cannot obtain a majority of the House of Commons. These Ministers in fact appoint Senators, Judges, Commissioners (who are often really Ambassadors) and the Governor General has his appellation on the *lucus a non lucendo*[10] principle because he does not govern.

Canada pays no tribute and owes no obedience to England; she frames her own tariff, and when that tariff conflicts with some old treaty that England had made which in form bound Canada, she insists that it be denounced and denounced it is.

Canada has her own Army and her own Navy commanded by Canadians; she put half a million men under arms in the last war, and sixty thousand of them made the supreme sacrifice—the Mother Country could not call upon her for a man or a dollar except as Glendower could call spirits from the vasty deep. "But will they come?" said the sceptical Hotspur. Canadian soldiers crossed the sea in 1914 and following years until 1918 as Canadians, with Canadian uniforms, Canadian rifles, Canadian horses, Canadian cannon, Canadian ammunition, under Canadian officers paid by the Canadian Government and cared for by Canadian doctors and Canadian nurses. And when Canadians were dying for freedom and democracy their government demanded a part in determining the course of the struggle; Canada's Prime Minister joined the Prime Ministers of the other self-governing Dominions and the Prime Minister of Britain in a War Cabinet on equal terms and with equal authority, and the War Cabinet directed the war on behalf of the British Empire. Canada took part in negotiating the Peace Treaty and signed it as a party after a vain protest against Article X; her representatives joined Australia in refusing to consent to a declaration of Japanese equality and fought England and the United States to a standstill on the question; her Parliament approved the Treaty with the reservation of the right to have it amended; she has taken a prominent part at Geneva and pays no heed to the wishes of England where these conflict with her own interests. Canada is an independent self-governing nation but she will not allow anything to separate her from the rest of the British world. She is British to the last drop of her blood and intends to remain so. England has not for many a day ruled, and never will, rule Canada. She may try it when Ab'm Linkum becomes President of the United States, but assuredly not a minute sooner.

All of which is unintelligible to the lawyer who reads the Statutes only; but is a living truth, the glory and the pride of Canadians. When the lawyer is puzzled beyond all bearing let him contemplate little Onyx with her gay stockings on the White House lawn.[11]

[1]Chicago, London, Toronto, Vanderhoof, Gunn, Co., Ltd., Winnipeg, 1909. Cloth. Cr. 8vo., pp. 222.

[2](1867), 30, 31 Vict., c. 3. (Imp.)

[3]Of which let one Woodrow Wilson take notice and be comforted.

[4]Handbook of American Constitution Law, by Henry Campbell Black, M.A., 3rd edit., St. Paul, 1910, p. 107.

[5]Gouverneur Morris loquendo et arguendo. Journal, pp. 365-368.

[6]So Pinckney of South Carolina.

[7]Mr. Mason's opinion—but then he came from Virginia and knew his people.

[8]Gerry not yet mandering.

[9]When Beaconsfield made his secretary a Peer it was said that he followed the precedent of Caligula, who made his horse, Incitatus, a Consul. It would seem that Incitatus, "Flyer," though he was given a marble stable, an ivory stall, purple trappings and a jewelled collar, failed of the Consulate—at all events Suetonius says: "Consulatum quoque traditur destinasse" and Dio Cassius, "Consulemque se eum creaturum pollicebatur; facturus si diutius vixisset"—it was well that "non diutius vixit."

Canada has put an end to this title business (so far as her citizens are concerned) by resolution of her House of Commons.

When I was a lad my old Scotch tutor taught me that "lucus", a sacred wood or thicket was the same as "lucus," light and that both came from "luceo" (I shine), because the latter did, and the former did not shine. On the same *lucus a non lucendo* principle are "Bellum," war, because it was not bellum, agreeable: "Canis," a dog, because it does not sing, a *non canendo*, etc., so also "Woodrow" because he wouldn't row but insisted on steering, and a stream I knew in my boyhood was "Trout Creek" because there were no trout in it.

[11]For what says the modern Mother Shipton—more up to date than the ancient of Knaresborough?

"When Onyx sports on White House lawn
  And flourishes her gaudy legs,
Then Canada, her freedom gone,
  Will drain of slavery's cup the dregs."

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SECTION III

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The Characteristic K—Radiation from Boron

BY A. LL. HUGHES, Research Professor of Physics, Queen's University, Kingston, Ont.

(Presented by PROFESSOR A. L. CLARK, F.R.S.C.).

(Read May Meeting, 1921)

The wave lengths of the K series of characteristic X radiations have been measured for nearly all elements by Moseley and his successors. The square root of the frequency of the characteristic X-rays is, to a close approximation, a linear function of the atomic number of the element. This relation has not been tested out for elements lighter than sodium as no crystal has been found, or is likely to be found, with a spacing between its planes sufficiently great to measure the comparatively long wave lengths which are to be expected from the light elements. These wave lengths are too long to be measured by a crystal grating and probably too short to be measured by any diffraction grating hitherto made. The method adopted in this investigation is an indirect one involving the use of the quantum relation.

Apparatus.—Electrons of a definite speed from a hot tungsten cathode, T, were allowed to fall on a boron[1] target, B (Fig. 1) and the

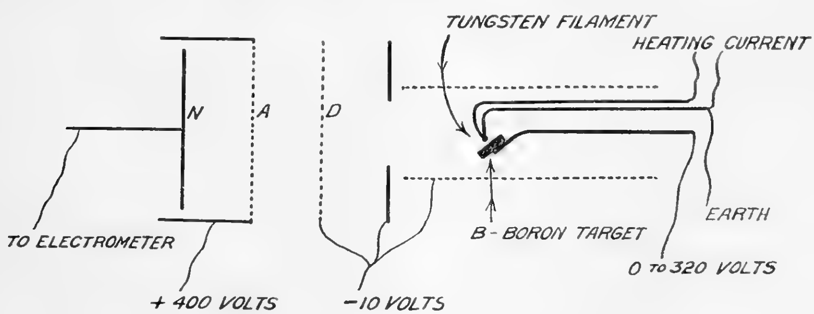

FIG. 1

[1] The writer wishes to thank Dr. W. R. Witney of the General Electric Company for his kindness in supplying the boron.

speed of the electrons was increased by increasing the potential accelerating the electrons between T and B. The boron emitted radiation (which may be regarded as extremely soft X radiation, or as ultra-violet light of extremely short wave length, no distinction can be drawn), part of which fell upon the nickel plate N. The nickel plate emitted photo-electrons under the influence of the radiation, the photo-electric current being measured by an electrometer. As will be seen from the diagram the radiation had to pass through two gauzes. The function of these gauzes was to prevent any electrons or positive ions (if any) from the filament or boron, getting to the nickel plate. The gauze D being at a negative potential with respect to the filament and boron prevented any electrons getting to N, while the gauze A, being at a higher positive potential than either the boron or filament, prevented any positive ions passing to N. Care was taken to secure as high a vacuum as possible by means of a diffusion pump and a liquid air trap. The pressure during the experiments could not be measured on the McLeod gauge and was certainly less than 10^{-6} mm.

Method of Experiment.—The procedure was to measure the photo-electric current from N as the accelerating potential was increased step by step, keeping the electron current constant, and to look for a discontinuity in the curve connecting these two quantities. From the work of Beatty and others on ordinary X-rays, the discontinuity is to be associated with the excitation of the radiation characteristic of the material of the target. Below the critical accelerating potential nothing but "general" radiation is excited, above the critical potential, "characteristic" radiation is emitted in addition. If the accelerating potential necessary to call out the characteristic radiation is V, then the frequency ν, and the wave length λ, of the radiation are given by

$$Ve = h\nu = hc/\lambda$$

where e is the charge on the electron, h is Planck's constant, and c the velocity of light. Expressed in volts and Angstrom units, this is

$$V = 12331/\lambda.$$

Experimental Results.—It was found impossible to get reproducible curves on different days, even though the heat treatment of the apparatus at the beginning of each set of observations and the method of exhausting were always carried out in the way. On some occasions very marked discontinuities in the curves were obtained, on others the discontinuities were definite but not so well marked, while sometimes the curves appear to be almost free from any discontinuity.

The important point, however, is that no matter whether the discontinuity was pronounced or not, it always appeared at the same place. Fig. 2 gives the results obtained on one occasion. It will be seen that on this day a progressive increase in the effect took place. Whether this was due to an increase in the amount of radiation emitted per unit electron current, or whether the nickel plate increased in sensitivity, is not known. However, the discontinuity in the curve always occurred at about 150 volts. The upper curve is the mean of the four runs shown and shows a well-marked discontinuity at 150 volts, which corresponds to a wave length λ82.3.

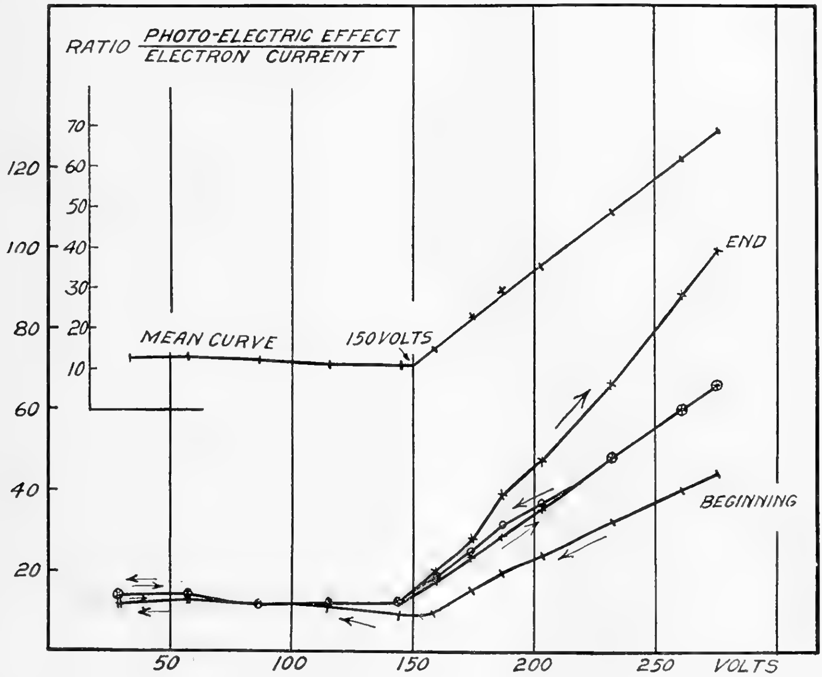

FIG. 2

Discussion.—In Fig. 3 the square roots of the voltages corresponding to the K-critical absorption wave lengths of Mg, Al, P, and S, as determined by the usual crystal grating methods, are plotted against the atomic numbers, giving almost exactly a straight line. This line is produced (assuming the same very slight departure from the linear relation to hold for elements lighter than magnesium as for those heavier) so as to indicate the values to be expected for the lighter elements. The value to be expected for boron is 149 volts which is in good agreement with that obtained in this investigation.

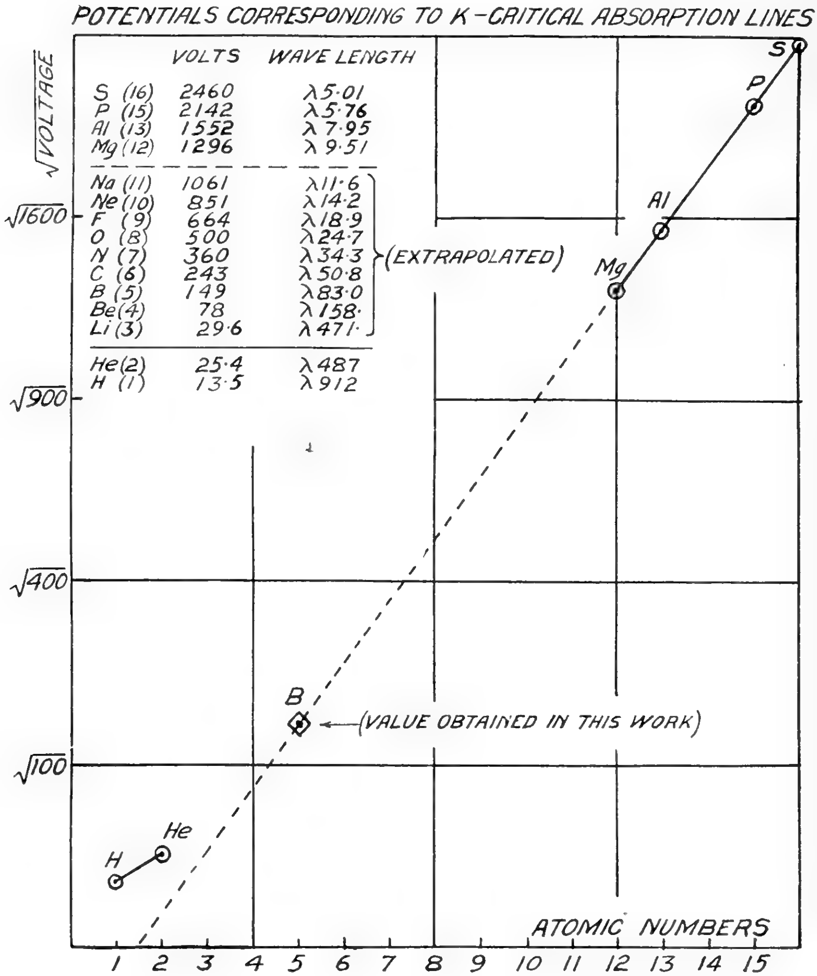

FIG. 3

The K radiation is supposed to be the series of shortest wave length in the spectrum emitted by an element, the Kα line being the first and strongest line in this series, while the critical absorption wave length, in X-ray terminology, is the "limit" of the series. Now Bohr's theory of the hydrogen atom, which is confirmed by experiment, indicates that the series of which λ1216 is the first line, and λ912 is the limit, is the shortest wave length series of hydrogen and is, therefore, to be regarded as the K series for hydrogen. (The corresponding potentials are 10.2 and 13.5 volts, the radiating and ionizing potentials for the hydrogen atoms.) The first line and the limit of the K series for the helium atom may be identified with the radiating potential 21.2 volts and the ionizing potential 25.4 volts of the normal helium atom, which give λ585 (recently identified by Lyman) and λ487 for their wave lengths.

We might have expected the square roots of the potentials corresponding to the K-critical absorption wave lengths for elements of atomic number 3, 4, 5, . . . 11 to lie on a smooth curve (the straight line) joining the values for Mg, Al, etc., on the one hand, and the values for H and He on the other. Our diagram (Fig. 3) shows, however, that the prolongation of the straight line does not pass through the He and H points. Theoretical considerations may indicate a possible cause for the lack of continuity. The K-radiations are associated with the shells of electrons immediately outside the nucleus of the atom. Almost all the elements have one or more shells of electrons external to this one and so these elements are all similar in that the K electrons are shielded, as it were, by one or more external shells. But this is not the case for H and He, for the electrons forming the K shells in these elements (one for H and two for He) are all the electrons they possess. This may possibly account for the experiment values for H and He not lying on the prolongation of the line passing through the experimental values for the heavier elements.

A closer consideration of the problem of X-rays from elements, such as boron, opens up a number of points for investigation. We know from various investigations on He and other gases, that as we increase the potential accelerating the electrons through the gas by small steps, the first line is called out alone by the potential corresponding to it, then, the second line is called out in addition to the first when the potential is raised to a second critical value, and so on, until the potential is raised to the ionizing potential, by which time the complete series of lines appears. But with ordinary X-rays the case is strikingly different. The α, β and γ lines of the K series cannot be called out one by one by potentials corresponding to their frequencies. It is only when the potential accelerating the electrons impinging on the element corresponds to the absorption limit, which is shorter in wave length than any of the emission lines, that the emission lines appear and then they all appear simultaneously. The question then arises as to whether boron and elements near to it behave like the heavier elements or like helium and hydrogen. This problem will possibly be found to be dependent on the situation in the atom of the shell of electrons giving rise to the K series. In most elements the shell giving rise to the K series is surrounded by two or more shells of electrons, a state of affairs very different from that obtaining in hydrogen and helium where the electrons giving rise to the K series are the only electrons outside the nucleus. X-ray phenomena are independent of chemical combination, presumably because the shells of electrons involved in the phenomena are well inside the atom and play no part in chemical combination. For the very light elements it is conceivable that this indifference to chemical state may not occur as the electrons giving rise to the X-rays possibly play some part in chemical combination. It is possible, therefore, that an examination of the nature of this border line radiation between X-rays and ultra violet light may yield results of considerable importance.

Summary.—The curve connecting the radiation from boron, bombarded by electrons, with the energy of the electrons (expressed in volts), shows a discontinuity at about 150 volts. This is taken to be an indication that the K radiation of boron appears at this critical potential, which is about the potential at which one would expect to find it from an extrapolation of Moseley's law.

On the Absorption Spectrum of Liquid and Gaseous Oxygen

BY W. W. SHAVER, M.A.

(Presented by PROFESSOR J. C. MCLENNAN, F.R.S.)

(Read May Meeting, 1921)

I. INTRODUCTION

An investigation was recently undertaken by the author to determine the effect of radiation of various wave lengths on gases, with special reference to hydrogen and nitrogen. During the course of this investigation it was thought some useful information on experimental conditions might be gained by a study of the analogous problem with oxygen, as the effect of radiation on this gas, particularly that in the ultraviolet region, is well-known, having been studied by a number of experimenters.

Accordingly some experiments were performed to obtain the absorption spectrum of oxygen, both in liquid and gaseous form, and in the photographs taken some bands were observed which apparently have not been previously recorded. The absorption spectrum of oxygen has been studied by Liveing and Dewar[1], Olszewski,[2] and others, who found that with a pressure of 85 atmospheres there were a number of bands in the visible region and a general absorption in the ultraviolet beginning about the wave-length $\lambda = 2745$ Å.U., with complete absorption below the wave-length $\lambda = 2665$ Å.U. When the pressure was increased to 140 atmospheres the bands in the visible were intensified while the ultraviolet absorption was complete below the wave length $\lambda = 2704$ Å.U. In the experiments described in this paper seven bands have been observed in the visible region with the addition of four broad bands in the ultraviolet adjacent to the region of complete absorption. In the case of liquid oxygen eight bands were detected in the visible and the same broad ultraviolet absorptions, but the latter were not so sharply defined as with the gaseous oxygen. When these broad absorption bands were closely examined it was found that each one consisted of a set of finer triplet absortpion bands. A brief description of the method of obtaining the photographs and also some further experiments which go to show that these bands were not due either to ozone or to impurity in the gas is given in the following.

[1] Liveing and Dewar, Phil. Mag. 26, p. 387, 1888; Phil. Mag. (5), 34, p. 205, 1892.
[2] Olszewski, Wiedem. Ann., 42, p. 663, 1891.

II. Absorption Spectrum of Liquid Oxygen

In these experiments the light from the spark between aluminium terminals under water, after the manner devised by Henri,[1] was used as the source of radiation. The electrical arrangement for the production of the Henri spark is shown in Fig. 1. (See page 14).

The secondary terminals of an induction coil A B were joined to the spark gap C D and then to two condensers E, F, each of which consisted of two one-gallon Leyden jars joined in parallel, the wires from the secondary terminals being connected to the outside coatings of the two sets of jars as shown in the diagram. The inside coatings of the jars were then joined to a second spark gap consisting of aluminium rods, G, H, about 1 cm. in diameter and conically pointed. These rods were mounted in a vertical plane inclined to each other at an angle of about 45° and held in position by clamps which were provided with threads so that the distance between the sparking points could be readily adjusted. These aluminium terminals were immersed to a depth of about 5 cm. in distilled water in a metal vessel provided with a quartz plate window about 2 cm. in diameter and placed at the proper height so that the spark occurred immediately in front of the window. The light from the spark was focussed by a cylindrical quartz lens on the slit of the spectrograph which was of the large quartz type made by the Adam Hilger Co. Several photographs of the spectrum of this light were taken and it was found to be almost perfectly continuous from the wave length $\lambda = 7000$ Å.U. to the wave-length $\lambda = 2150$ Å.U., as there were only two very slight aluminium reversals throughout this entire range.

The absorption spectrum of liquid oxygen in the visible region was obtained by passing the light from the spark between the aluminium terminals under water through a column of liquid oxygen contained in a cylindrical glass Dewar flask about 5 cm. in internal diameter. The flask was specially prepared for this purpose by being only partly silvered so that there was a clear slit about 1 cm. in width through which the light could pass. A reproduction of the photograph obtained is given in Plate I, Fig. 2 (*b*), in which there can be seen eight well-marked absorption bands. The mean wavelengths of these bands were measured and the results are given in Table I, together with the wave lengths of the absorptions obtained by Liveing and Dewar, and Olszewski.

The absorption spectrum in the ultraviolet region was readily obtained by the use of a small cylindrical Dewar flask, about 1.8 cm.

[1] Henri, Phys. Zeit., No. 12, p. 516, June 15th, 1913.

in diameter, made of clear fused quartz which easily transmitted radiation down to the wave length $\lambda = 2150$ Å.U. This flask was mounted in front of the slit of the spectrograph and filled with liquid oxygen. As before, the light from the spark between aluminium terminals under water was used as the source of radiation and some well-defined broad absorption bands were obtained in the region bordering that of complete absorption. These broad bands were about 30 Å.U. in width, and within each one a fine set of symmetrical triplet bands could be distinguished. The reproduction of the photograph taken, which is given in Plate I, Fig. 3 (*b*), shows the broad absorptions but the sets of triplet bands are not so evident. However, it was found possible to measure the wave lengths of the component bands in three of these sets, and these results, together with the wave-lengths of the broad bands, are given in Table II. The first column contains the limits of the broad bands, the second their mean wave-lengths, and the last gives the mean wave-lengths of the three sets of fine bands.

TABLE I

Absorption by Liquid Oxygen

Author	Liveing and Dewar	Olszewski
Å.U.	Å.U.	Å.U.
6285	6300	6280
5800	5775	5770
5350	5320	5350
4816		4800
4458	4433	
3828		
3631		
3461		

TABLE II

Absorption by Liquid Oxygen

Limits of Broad Bands	Means of Broad Bands	Means of Narrow Bands
Å.U.	Å.U.	Å.U.
2811 2780	2795	
2747 2716	2731	2744 2731 2719
2694 2668	2681	2692 2681 2670
2644 2618	2631	2642 2632 2621

III. ABSORPTION SPECTRUM OF GASEOUS OXYGEN

The absorption chamber for this experiment consisted of a brass tube 35 cm. long and 2.5 cm. in diameter, threaded at each end so that the brass holders which supported the windows could be securely screwed on, making gas-tight joints. The windows were made of plane parallel clear quartz plates, 1.2 cm. in thickness, and were firmly mounted and waxed in the brass holders mentioned above. Oxygen at a pressure of 140 atmospheres was passed into this tube which was then placed so that the light from the Henri spark passed through the absorbing column of oxygen into the slit of the same Hilger quartz spectrograph as was used before. The spectrogram obtained showed seven bands in the visible region which, as other observers have found, corresponded to the absorption bands obtained with liquid oxygen, although they were not so well marked. A reproduction of the photograph is shown in Plate I, Fig. 2(*a*), while the mean wave-lengths of the bands, together with those observed by Liveing and Dewar, are given in Table III.

In the ultraviolet region a broad band absorption, similar to that obtained in the case of liquid oxygen, was found (shown in Fig. 3 (*a*), but with this difference, however, that each band was shifted slightly towards the ultraviolet. The bands were again about 30 Å.U. in width, and as before, each consisted of a fine set of symmetrical triplet bands which, in this case, were much more sharply defined, as the reproduction shows. The wave-lengths of the absorption bands were calculated and the results, given in Table IV, are tabulated in the same manner as those in Table II.

TABLE III

Absorption by Oxygen at 140 Atmospheres Pressure

Author	Liveing and Dewar
Å.U.	Å.U.
6285	6305
5800	5785
5350	5350
4816	4773
3828	4470
3631	
3461	

TABLE IV

Absorption by Oxygen at 140 Atmospheres Pressure

Limits of Broad Bands	Means of Broad Bands	Means of Narrow Bands
Å.U.	Å.U.	Å.U.
2808–2771	2790	
2744–2714	2729	2740, 2727, 2716
2692–2664	2678	2687, 2677, 2666
2642–2616	2629	2640, 2629, 2618

[1] Liveing and Dewar, loc. cit.

The experiment was repeated with the absorption tube filled with oxygen at 107 atmospheres pressure. In this case several of the bands in the visible region disappeared, leaving only the three strong bands with wave-lengths $\lambda=6285$ Å.U., $\lambda=5800$ Å.U., and $\lambda=4816$ Å.U., while the ultraviolet bands remained practically unchanged.

IV. Investigation of the Origin of the Sets of Fine Absorption Bands in the Ultraviolet

(*a*) An experiment was performed to determine whether or not the sets of triplet absorption bands in the ultraviolet were due to some impurity in the gaseous or liquid oxygen used. The oxygen gas was guaranteed by the manufacturer to be 98% pure with nitrogen as the impurity, while liquid nitrogen was the most likely impurity in the liquid oxygen. The absorption of nitrogen was, therefore, tried out by using the apparatus described in Section III and passing nitrogen gas into the absorption tube at a pressure of 140 atmospheres. The experiment was performed in the same manner as when the absorption of oxygen gas was obtained, using the spark between aluminium terminals under water as the source of radiation. A photograph was taken of the absorption spectrum of nitrogen, but there was no trace of any absorption whatever showing that the bands obtained with oxygen as the absorbing medium were not due to the nitrogen impurity present.

(*b*) It was known from the work of W. N. Hartley,[1] and also E. Meyer,[2] that ozone strongly absorbs radiations between the wave-lengths $\lambda=2850$ Å.U., and $\lambda=2330$ Å.U., and it was thought that a small percentage of ozone might be present in the oxygen causing the band absorption which had been observed. This was the more probable on account of the narrow band absorptions obtained by Professors Fowler and Strutt[3] in the region between the wave-lengths $\lambda=3432.2$ Å.U. and $\lambda=3089.5$ Å.U., using less than 1 per cent. of ozone in oxygen, as it was thought that with a smaller percentage of ozone some bands might appear farther down in the ultraviolet which would account for the absorption bands described in this paper. It has been shown by Regener[4] and other observers that light of wave-length $\lambda=1200$ Å.U. to $\lambda=1800$ Å.U. is a powerful

[1] Hartley, Chem. News, p. 268, Nov. 26, 1880.
[2] Meyer, Ann. der Phys., Vol. XII, p. 849, 1903.
[3] Fowler and Strutt, Proc. Roy. Soc. of London, 93, p. 577, 1916-17.
[4] Regener, Ann. der Physik., 20, p. 1033, 1906.

ozonizing agent and that light of wave-length between $\lambda = 2300$ Å.U. and $\lambda = 2900$ Å.U. has an equally effective decomposing effect. It was thought that some weak radiation of wave-length approaching that necessary to produce ozone might be emitted by the spark between the aluminium terminals under water, which would be sufficient to produce a small percentage of ozone in the oxygen whose absorption was being tested.

The apparatus for the experiment described in Section II was again set up, but in this case a glycerine screen, 1 cm. in thickness, was placed in the path of the light from the Henri spark between the lens and the brass absorption tube. This glycerine screen was found to cut off all radiation below the wave-length $\lambda = 2300$ Å.U. so that there was no possibility of any radiation entering the oxygen absorption tube which would transform ozone into oxygen. The tube was filled with oxygen at 140 atmospheres pressure and a photograph of the absorption spectrum taken, a reproduction of which is shown in Fig. 4(*a*). The screen was then removed and the experiment repeated, and the absorption bands shown in Fig. 4(*b*) were obtained. From these photographs it will be seen that the ultraviolet bands were present in both cases, but when the glycerine screen was inserted the intensity of the light was somewhat reduced so that the bands were shown to better advantage than with the screen removed. However, this experiment showed that these absorption bands were not due to the presence of ozone which may have been formed by ultraviolet light falling on the oxygen gas in the absorption tube.

(*c*) To make a more definite test as to whether the ultraviolet bands were due to ozone or not, the absorption spectrum of a mixture consisting of a small percentage of ozone in oxygen was obtained in the following way.

The absorption tube in this case consisted of a glass tube 25 cms. long and 1 cm. in diameter with a small side tube sealed in near each end. The ends of the tube were closed by plane parallel plates of clear quartz securely waxed on so that when mounted in position the radiation from the source, which as before, was the Henri spark, passed along the absorption tube through the quartz windows into the slit of the spectrograph. The absorbing gas was obtained by slowly passing oxygen gas through a Heumann ozonizer and the resulting mixture of ozone and oxygen was led in at one end of the absorption tube through the side tube, passing out through the second side tube at the other end. The gas coming from the tube was allowed to escape into the atmosphere, so that the pressure of the absorbing gas in the tube was approximately one atmosphere. The flow of gas through the ozonizer was started some time before an exposure was made, so as to permit the oncoming gas to sweep out the air from the absorption tube. The percentage of ozone in the mixture in all cases was very small, probably much less than the 1 per cent. mixture used by Professors Fowler and Strutt. The absorption spectrum, when photographed, showed a number of faint symmetrical bands about 7 Å.U. in width in the region extending from the wave-length $\lambda=2704$ Å.U. to the wave-length $\lambda=2455$ Å.U. while below this region there was only partial absorption due to the small percentage of ozone used. A comparison spectrum of the absorption due to oxygen at 140 atmospheres was taken and it was found that the bands did not correspond. This is quite evident from Plate I, Fig. 5, which in reproduction (*a*) gives the oxygen absorption bands, while (*b*) shows the ozone bands, with the mercury arc shown in (*c*) as a wave-length standard. The wave-lengths of the ozone bands were measured and the results are given in Table V, from which it will be seen that they do not correspond to the ultraviolet absorption bands found either with liquid or gaseous oxygen. These experiments conclusively showed that the ultraviolet bands obtained in the absorption spectrum of liquid and gaseous oxygen must have been due to oxygen itself, and not to the nitrogen impurity or small percentage of ozone present.

TABLE V

Absorption by Ozone.
Means of Bands

Å.U.	Å.U.	Å.U.	Å.U.
2701	2623	2556	2491
2678	2605	2539	2478
2658	2587	2523	2458
2640	2571	2504	

V. SUMMARY

(1) The absorption spectrum of oxygen, both liquid and gaseous, between the wave-lengths $\lambda=7000$ A.U. and $\lambda=2150$ A.U. has been examined.

(2) In the visible region eight absorption bands were noted in the case of liquid oxygen and seven with gaseous oxygen.

(3) In the ultraviolet part of the spectrum four broad bands were found both with liquid and also gaseous oxygen, each made up of a set of finer triplet bands. The wave-lengths of these bands were measured and those in the gaseous spectrum were found to be slightly shifted towards the ultraviolet.

(4) Some experiments were performed on the absorption spectra of nitrogen and ozone which were the two most likely impurities present in the oxygen. From the results obtained it was concluded that the bands observed in the absorption spectrum of both liquid and gaseous oxygen were due to oxygen and not to the presence of the impurities mentioned above.

This work was carried out under the direction of Prof. J. C. McLennan to whom the writer wishes to express his most sincere thanks for his advice and many practical suggestions.

The Physical Laboratory,
University of Toronto,
May 15th, 1921.

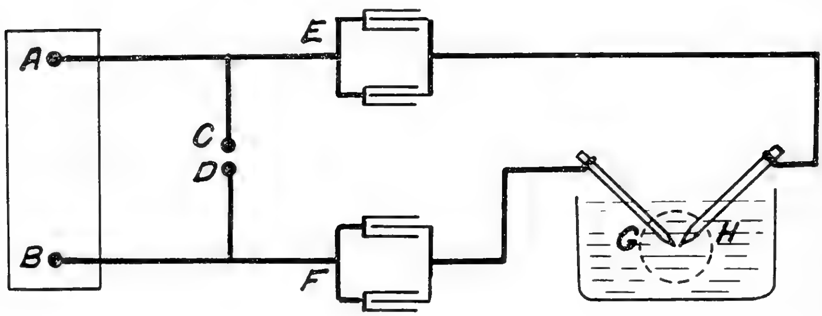

Fig. 1.

Fig. 2.

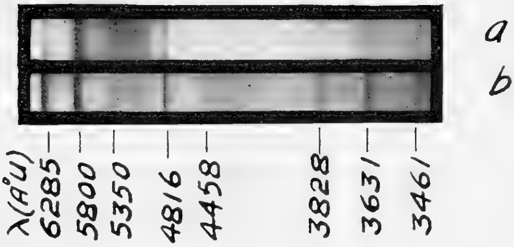

Fig. 3.

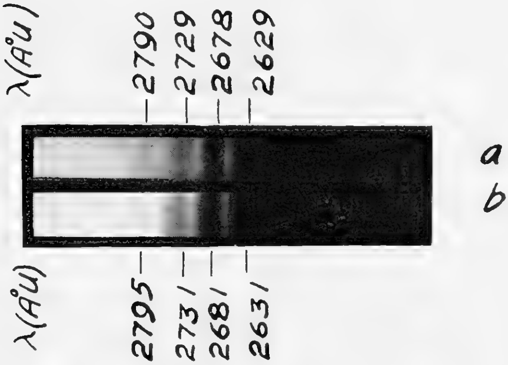

Fig. 4.

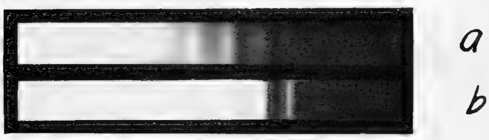

Fig. 5.

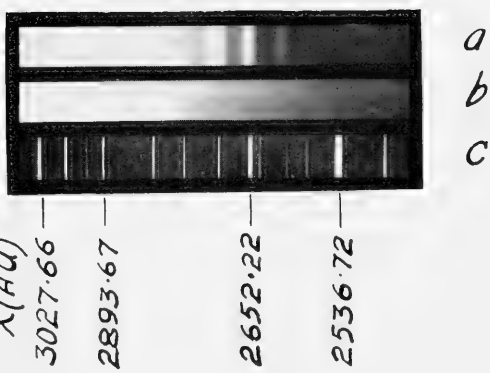

Plate 1.

On the Spectra of Helium, Hydrogen and Carbon in the Extreme Ultraviolet

By PROFESSOR J. C. MCLENNAN, F.R.S., and P. A. PETRIE, B.A.

(Read May Meeting, 1921)

I. INTRODUCTION

In a paper on the extension of the spectrum beyond the Schumann region by Lyman[1] some 27 wave-lengths are recorded by him as coming out strongly on his plates when photographing the spectrum of helium. These wave-lengths covered the spectral region lying between $\lambda = 599$ Å.U. and $\lambda = 1247.9$ Å.U. In discussing these wave-lengths Hicks pointed out that those at $\lambda = 972$, 992, 1026 and 1086 Å.U. fitted the formula for the enhanced spectrum of helium and drew the conclusion that they must belong to that gas. Lyman[2] has, however, dissented from that view and in later communications has stated that in his opinion $\lambda = 992$ Å.U. is attributable to an unknown origin and that $\lambda = 972$ Å.U. and $\lambda = 1026$ Å.U. are due to hydrogen. His opinion, too, is that the wave-lengths which have been recorded by him at $\lambda = 1086$ Å.U. and 1985 Å.U. have their origin in hydrogen or in some other impurity, possibly nitrogen.

In a paper by Millikan[3] also on the extension of the ultraviolet spectrum a comparison is made between the wave-lengths found by Lyman in studying the spectrum of helium and those found by him in photographing the "hot" spark spectrum of carbon. From the values given in his table of wave-lengths it will be seen that some 13 wave-lengths in the spark spectrum of carbon have values very close to those found by Lyman in the spectrum of helium. Regarding this coincidence Millikan has expressed the view that the strong group of wave-lengths which appeared in all of his spectra, and which also appeared in Lyman's work on helium, are to be considered as having their origin in the atoms of carbon.

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[1] Lyman, Ast. Phys. Jl., XLIII, No. 2, p. 89, 1916; Science, XLV, p. 187, Feb. 1917.

[2] Lyman, Nature, CIV, p. 314, 1919, and p. 565, 1920; Phil. Mag., Vol. 41, No. 245, p. 814, 1921.

[3] Millikan, Ast. Phys. Jl., Vol. LII, No. 1, p. 47, 1920; Ast. Phys. Jl., Vol. LIII, No. 2, p. 150, 1921.

In photographing spectra in the extreme ultraviolet region one is compelled to work with vacuum grating spectrographs, and in working with these instruments, even with the best type of design, one is forced to make two, and possibly three, of the joints gas tight by the use of some kind of wax or other substance which contains hydrocarbons as ingredients. For this reason it is practically impossible to make certain in taking photographs of the spectra of helium and hydrogen that these gases are absolutely free from carbon in some form or other. It is, therefore not improbable that the view expressed by Millikan is the correct one.

On the other hand Rutherford[4], in the Bakerian Lecture before the Royal Society of London for 1920, has described a series of experiments on the disintegration of atomic nuclei, the results of which have led him to express the opinion that the nuclei of the atoms of carbon are probably made up of two electrons and four subsidiary nuclei of triprotonic helium. If this view should turn out to be correct it is just possible that in the experiments of Millikan on the spectrum of carbon the atoms of carbon, with the powerful "hot" sparks which he used, were disrupted into their constituent triprotonic helium nuclei, and that the wave-lengths which he observed were due to helium in this form. On this hypothesis it would follow that the wave-lengths in question originated in reality in helium atoms and not in those of carbon. This view Millikan considers untenable since he did not find any trace of helium lines in the spectrum of the "hot sparks" in the region between $\lambda = 2100$ Å.U. and $\lambda = 7000$ Å.U.

In view of the uncertainty which, it will be seen from the above, prevails as to the origin of certain wave-lengths obtained in photographing the spectra of helium and carbon, and possibly, too, of hydrogen, an investigation of the spectra of these elements was undertaken by the writers, and in doing so an attempt was made in carrying out the observations with each element to work with the element in as pure a state as possible and as free from contamination with impurities as it was possible to obtain it. An account of this investigation follows.

II. Experiments

The vacuum grating[5] used in this investigation has already been fully described elsewhere. It will suffice to state here that the grating employed had a radius of 1 metre and a ruling 5.4 cms. wide

[4] Rutherford, Proc. Roy. Soc., Vol. 97, p. 374, 1920.

[5] McLennan, Proc. Roy. Soc., Vol. 98, p. 114, 1920.

and 7.8 cms. long with 6273 lines per centimetre. The photographic plates used were of the Schumann type and were made by The Adam Hilger Co.

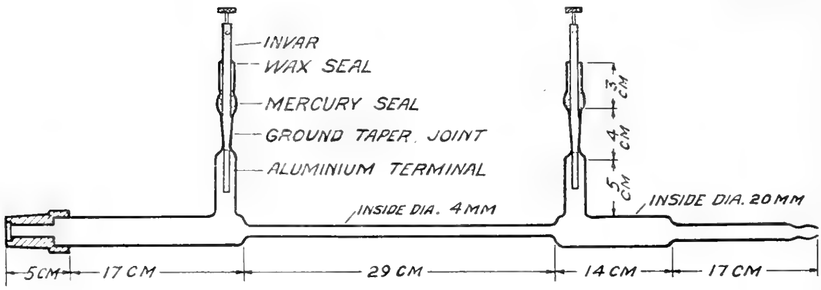
In working with the gases helium and hydrogen the source of light was a fused quartz Geissler tube of the form and dimensions shown in Fig. 1, the electric discharge being obtained from a 15,000 volt ¼ kilowatt Clapp-Eastham Transformer in parallel with a ¼ kilowatt condenser. The discharge in the Geissler tube was backed up by a spark gap in air inserted in the circuit.

The general arrangement of the equipment is that shown in Fig. 2. The vacuum grating, the Geissler tube and two cocoanut charcoal filled tubes which could be cooled with liquid air, were joined in series with a Gaede mercury pump. Between the Geislers tube and the slit of the spectrograph there was inserted a small brass vessel containing a shutter which could be operated with an electromagnet, but which, when either in the closed or in the open position, did not interfere with the passage of gas in the circuit.

In operating with this equipment care was taken to see that all joints were gas tight. The photographic plate was first inserted and then the whole system was repeatedly washed out with hydrogen and thoroughly evacuated with a pair of Trimount pumps backed by a Langmuir diffusion pump, a liquid air-cooled trap being inserted between the latter and the system. The gas to be studied was then admitted and its pressure reduced to the point where the discharge gave the brightest illumination.

In taking the photographs of the spectrum of hydrogen this gas was carefully purified with charcoal cooled with liquid air before it was admitted to the system. The pressure of the gas when the photographs were taken with it was from 5 to 6 cms. of mercury. In the case of helium the gas was also highly purified before being admitted to the apparatus and the exposures were made with the gas at a pressure of 29 cms. of mercury. Prior to taking the photographs the Gaede pump was maintained in operation for upwards of an hour and the gas by means of it made to circulate through the system. During this operation the tubes Q and R were kept surrounded with liquid air and the shutter E was kept in the closed position. The discharge was passed continuously (during this time) in the Geissler tube in order to drive out any gases which might have been occluded in the electrodes.

When it became fairly certain that the gas had been purified as highly as possible by means of the circulation through the charcoal



GEISSLER DISCHARGE TUBE

FIG. 1

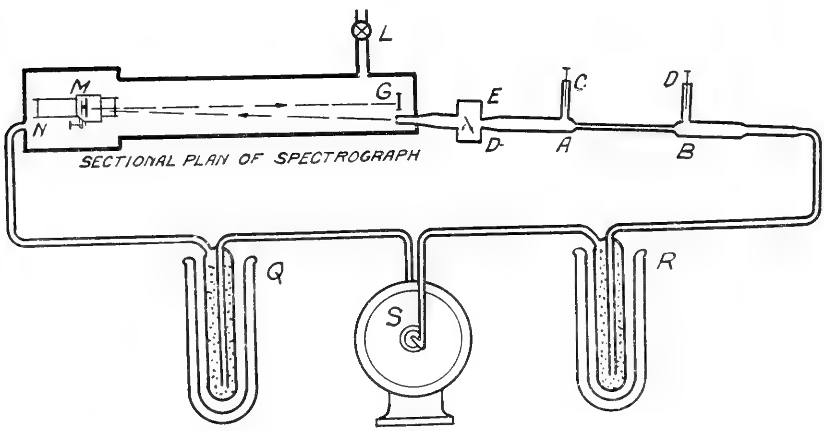


FIG. 2

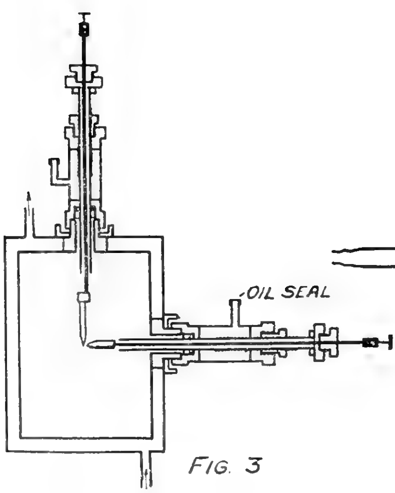


FIG. 3

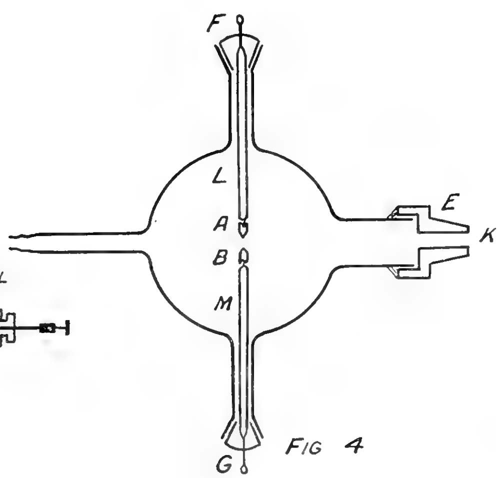


FIG 4

the shutter was opened with the electromagnet and the exposure then made. This was generally of from nine to ten hours' duration. Some photographs were also taken of the vacuum carbon arc, the spectrograph and the lamp, a drawing of which is shown in Fig. 3, being as highly exhausted as possible. A current of 50 amperes was used, the supply being the 110 volt D.C. main. In addition to the above some photographs were taken of the lead spark in helium at atmospheric pressure. The sparking chamber used in this case was made of glass and is shown in Fig. 4. Previous to the taking of the photographs of the spectra of the lead spark the helium was purified by being made to circulate through the charcoal tubes Q and R. While this was being done the spark discharge was made to pass between the electrodes in order to drive out any gaseous impurity which might have been occluded in them. During this preliminary sparking the shutter was, of course, kept in the closed position.

III. Results

The plates were all carefully measured up and the mean wave-lengths obtained from them, together with their relative intensities, are given in Table I. The values given by Lyman[1] for the wave-lengths obtained by him with the spark spectrum of helium, as well as those obtained by Millikan,[2] and by Millikan, Bowen and Sawyer[3] with the spark spectrum of carbon, are also included in the table.

IV. Discussion of Results

A point of interest which arises in considering the results given in the table attaches to the wave-lengths $\lambda = 1931$ Å.U., $\lambda = 1657$ Å.U. and $\lambda = 1561$ Å.U. These wave-lengths all came out strongly in the spectra of helium, carbon and lead. The first and last were absent from the spectrum of hydrogen, but $\lambda = 1657$ Å.U., though of weak intensity, was clearly marked in the spectrum of this gas. These three wave-lengths were strongly recorded in the spark spectrum of carbon obtained by Millikan, and they were also obtained as wave-lengths of strong intensity in the spectra of carbon obtained by McLennan and Lang[4] and by McLennan, Ainslie and Fuller.[5] While working with fluorite or vacuum grating spectrographs several

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[1] Lyman, Ast. Phys. Jl., Vol. XLIII, p. 89, 1916.
[2] Millikan, Ast. Phys. Jl., Vol. LII, No. 1, p. 47, 1920.
[3] Millikan, Bowen and Sawyer, Ast. Phys. Jl., Vol. LIII, No. 2, p. 150, 1921.
[4] McLennan and Lang, Proc. Roy. Soc. 95, p. 272, 1919.
[5] McLennan, Ainslie and Fuller, Proc. Roy. Soc. 95, p. 327, 1919.

observers have recorded, besides, that these wave-lengths are frequently present in the spectra of many of the metals when sparked in hydrogen or helium. It is, however, practically certain that these wave-lengths are due to carbon and to carbon alone. It would follow from this that in spite of all the precautions taken the helium used in the present investigation was not entirely free from carbon in some form. Since the wave-lengths $\lambda = 1931$ Å.U. and $\lambda = 1561$ Å.U. were not recorded in the spark spectrum of hydrogen, and since the wave-length $\lambda = 1657$ Å.U. came out with only weak intensity in that gas it would indicate that the hydrogen was contaminated with carbon to a less degree than the helium.

Interest also attached to the wave-lengths $\lambda = 1640.2$, 1215.1, 1086.1, 1026.0, and 972.7 Å.U. These, as Hicks[6] has pointed out, are the first six members of the series spectrum of the helium ion whose frequencies are given by $\nu = 4\,N\left(\frac{1}{2^2} - \frac{1}{n^2}\right)$. Of these wave-lengths $\lambda = 1640.2$ Å.U. did not appear on any of the plates of the spectrum of helium obtained by us, neither was it obtained by Millikan in the spark spectrum of carbon. It has, however, been observed by Lyman with powerful disruptive discharges in helium. It would appear, therefore, that this wave-length can be emitted by helium provided the gas is subjected to a sufficiently powerful stimulus. Owing to the absence of this wave-length from the spectra of helium obtained by us we are forced to conclude that the excitation used was not sufficiently intense. Possibly its existence was masked by the action of the ionized helium.

Regarding a wave-length at or near $\lambda = 1215$ Å.U. it will be seen that one was obtained by us at $\lambda = 1215.8$ Å.U. with the discharges in helium and hydrogen and with the lead spark in helium. A wave-length at $\lambda = 1215.7$ Å.U. was also found by Millikan on his plates of the spark spectrum of carbon.

From the evidence given above it will be recalled that the hydrogen as used by us was probably only contaminated with carbon to an extremely small degree, if at all. The wave-length $\lambda = 1215.8$ Å.U. obtained by us with hydrogen and with helium came out very strongly with both gases, the intensity being 12. Our conclusion regarding this wave-length is, then, that it is emitted by both helium and hydrogen and that in Millikan's experiments with carbon it may have had its origin in hydrogen occluded in his electrodes or in the walls of his spectrograph, or it may have originated in tri-protonic helium

[6] Hicks, Nature, 104, p. 393, Dec. 18, 1919.

formed by the disruption of carbon atoms. This conclusion fits in with theory for, as is well known, the series for hydrogen atoms whose frequencies are given by $\nu = N\left(1 - \frac{1}{n^2}\right)$ consists of the wave-lengths $\lambda = 1216$ Å.U., $\lambda = 1026$ Å.U., $\lambda = 972$ Å.U., etc. Regarding the wave-length $\lambda = 1086.1$ Å.U. Lyman has expressed the opinion that when he obtained this wave-length in the sprectum of helium it did not originate in helium atoms but in the atoms of some impurity present in the helium used by him. The table shows, however, that this wave-length was obtained by us with fair intensity in the spectrum of helium, but not in the spectrum of hydrogen or in that of the vacuum carbon arc. It was obtained by Millikan also with his "hot" carbon sparks. It seems clear, then, that the wave-length obtained by us at or near $\lambda = 1085.2$ Å.U. and by Millikan at $\lambda = 1085.3$ Å.U. originated in helium atoms. In the case of Millikan's result this conclusion could lead again to the view that the helium had its origin in the disrupted carbon atoms. As to the wave-length $\lambda = 1026$ Å.U., it will be noted that while it was not obtained by Millikan in this spectra of carbon sparks, it was obtained by us in the spectrum of the spark discharge in helium and in that gas only. Lyman states that the wave-length $\lambda = 1026$ Å.U. is usually present on his plates of the spectrum of helium, and that he has also found it in the spectrum of hydrogen. This would go to show that radiation of a wave-length close to $\lambda = 1026$ Å.U. is obtainable from helium as well as from hydrogen atoms. The indications are, however, that it is easier to obtain a photographic record of the wave-length with helium than it is with hydrogen. The conclusion that this wave-length is obtainable with helium, as well as with hydrogen, is in accordance with what would be expected on the basis of the frequency formulae for these two gases given above. It is not clear, however, why Millikan did not obtain a wave-length at or near $\lambda = 1026$ Å.U. in his spectra of the carbon spark, especially when he obtained the wave-lengths $\lambda = 1215.7$ Å.U. and $\lambda = 1085.3$ Å.U. with fair intensities.

As no wave-lengths were obtained by us in the spectra of helium and hydrogen below $\lambda = 1020.9$ Å.U. we have no material available to contribute anything of value concerning the origin of the wave-lengths $\lambda = 992$ Å.U. and $\lambda = 972$ Å.U. Lyman[1] has expressed the opinion that these wavelengths, when obtained in the spectra of helium, were really due to an impurity which, in the case of $\lambda = 972$ Å.U.

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[1] Lyman, Nature, Vol. 104, p. 314, Nov. 20, 1919. Fricke & Lyman, Phil. Mag., Vol. 41, p. 814, 1921. Lyman, Nature, Vol. 104, p. 565, Jan. 29, 1920.

was probably hydrogen. Apart, however, from certain considerations of intensity which he has brought forward there seems to be no conclusive evidence against the probability of these wave-lengths really existing in the radiations capable of being emitted by helium atoms, and in the case of $\lambda = 972$ Å.U. of this wave-length being emitted by hydrogen atoms as well. As the wave-lengths $\lambda = 904.7$ Å.U. and $\lambda = 977.9$ Å.U. were obtained by us with the vacuum carbon arc and not with the spark discharge in helium and hydrogen it would seem that Millikan's view that these wave-lengths belong to the spectrum of carbon is the correct one.

Since the wave-lengths at or near $\lambda = 1037$ Å.U., $\lambda = 1177$ Å.U., $\lambda = 1278$ Å.U. and $\lambda = 1335$ Å.U. were obtained by Millikan with the carbon spark and by us with the spark discharge in helium and with the vacuum carbon arc, but not by us with the spark discharge in hydrogen and since from evidence adduced above there was probably a minute contamination of the helium used by us with carbon in some form, it seems practically certain that the radiation of these wave-lengths had its origin in the atoms of carbon. It may be, however, that the wave-lengths $\lambda = 1278$ Å.U. and $\lambda = 1335$ Å.U. originated in mercury. This would mean, however, that the helium was contaminated with mercury vapour while the hydrogen was not. The radiations having the wave-lengths $\lambda = 1134.7$ Å.U., $\lambda = 1199.7$ Å.U., $\lambda = 1494.4$ Å.U., $\lambda = 1647.2$ Å.U., $\lambda = 1649.9$ Å.U., $\lambda = 1742.6$ Å.U., $\lambda = 1744.9$ Å.U. $\lambda = 1849.3$ Å.U. and $\lambda = 1942.4$ Å.U. it will be seen all come out with strong intensity on our plates of the spectra of the spark discharge in helium, but were not obtained on our plates of the spectra of hydrogen and carbon. Neither were they observed by Millikan in the spark spectrum of carbon. Moreover, wave-lengths $\lambda = 1134.7$ Å.U., $\lambda = 1199.7$ Å.U. and $\lambda = 1494.4$ Å.U. had previously been obtained by McLennan[2] with strong intensities in the spectrum of the helium arc.

In seeking for an explanation of the origin of these wave-lengths one is led again to suspect mercury. A Gaede Mercury pump, it will be recalled, formed part of the circuit of the circulatory system, and it is possible that the liquid air-cooled charcoal traps Q and R did not entirely prevent the mercury vapour from reaching the discharge tube. A confirmation of this view is found in the fact that wave-lengths are recorded for the spark spectrum of mercury by Handke[3] at $\lambda = 1942$ Å.U. and by Lyman[4] at $\lambda = 1849.6$ Å.U., $\lambda = 1745.2$

[2] McLennan, Proc. Roy. Soc. A, Vol. 98, p. 114, 1920.

[3] Handke, Inaugural Dissertation, Berlin, Aug. 1909.

[4] Lyman, The Spectroscopy of the Extreme Ultra-violet, p. 118.

Å.U., λ = 1742.7 Å.U., λ = 1649.8 Å.U., λ = 1647.4 Å.U. and λ = 1495.0 Å.U. Regarding the wave-lengths at λ = 1134.7 Å.U. and λ = 1199.7 Å.U. it is more difficult to decide since the Schumann spectrum of mercury has hitherto been supposed to end at λ = 1188 Å.U. the limit of the series $\nu = (1.5,S) - (m,P)$. If it should turn out that all the above wave-lengths originated in the atoms of mercury it seems strange that they were not obtained in the spectra of hydrogen, since in obtaining the latter, the same discharge tube and the same circulatory system was used as with the helium. On the whole it would seem that the wave-lengths λ = 1199.7 Å.U. and λ = 1134.7 Å.U. should be attributed to helium.

The wave-length which Millikan found at λ = 1402.9 Å.U. in the spark spectrum of carbon, and for which he suggested calcium or silicon as the origin, corresponds approximately to the wave-length λ = 1401.6 Å.U. found by us in the spectrum of helium. This wave-length, too, may have had mercury as its origin for Lyman records a wave-length of strong intensity at λ = 1402.5 Å.U. and Wolff also one at λ = 1402.72 Å.U. in the arc spectrum of mercury. The same origin can be attributed to the wave-lengths λ = 1481 Å.U., λ = 1548.8 Å.U., λ = 1751.4 Å.U. and λ = 1825.9 Å.U. for Lyman has found corresponding wave-lengths at λ = 1481.6 Å.U., λ = 1548.4 Å.U., λ = 1751.5 Å.U. and λ = 1826.2 Å.U. in the spark spectrum of mercury. It may be, however, that these wave-lengths really originated in carbon, if we can assume that the mercury in Lyman's experiments was slightly contaminated with that element in some form. The wave-lengths λ = 1310.4 Å.U., λ = 1463 Å.U., λ = 1577.8 Å.U. and λ = 1624.3 Å.U., found by us in the spectra of helium, do not correspond to any wave-lengths in the list given by Lyman[5] for the mercury spark, and they are probably due to carbon as Millikan suggests. Of the eighteen wave-lengths found by us in the spectrum of helium, which approximated to wave-lengths found by Millikan in the spark spectrum of carbon, all but two, namely, λ = 1085.2 Å.U. and λ = 1215.8 Å.U. can, therefore, be identified by assuming their origin to be one or other of the elements carbon or mercury. As to λ = 1215.8 Å.U., all we can say is that in our experiments its origin might have been hydrogen. Regarding the wave-length λ = 1085.2 Å.U. the origin in our experiments was, no doubt, helium. Its origin in Millikan's experiments is difficult to explain unless we adopt his suggestion and assign it to oxygen or nitrogen. If we take this view it is no longer necessary to

[5] Lyman, The Spectroscopy of the Ultra-violet, p. 118.

call to our aid the theory put forward by Rutherford as to the possibility of disrupting carbon atoms into tri-protonic helium to account for the wave-lengths found by us in the spectrum of helium which closely corresponded to wave-lengths found by Millikan in the spark spectrum of carbon.

From the investigation generally, our conclusion is that Millikan has good warrant for ascribing to carbon the origin of a number of the wave-lengths obtained by Lyman in photographing the spectrum of helium. Our experiments lead us to conclude that it is exceedingly difficult to keep helium when it is used in a vacuum grating spectrograph entirely free from contamination with carbon in some form. It may be that carbon was present in the helium used by Lyman.

The wave-lengths found by us for hydrogen when compared with the values obtained by Lyman for the spectrum of this gas, agree very closely with the latter in the majority of cases. In 27 cases, however, our wave-lengths are also within 2 Å.U. of the values given by him for the spark spectrum of mercury. We consider that this limit, however, is greater than the probable error of our results, and we are inclined to the view that the wave-lengths tabulated by us for hydrogen are correctly attributed to this gas. The wave-lengths $\lambda=1662.6$ Å.U., $\lambda=1672.4$ Å.U., $\lambda=1760.0$ Å.U., $\lambda=1795.7$ Å.U., $\lambda=1806.2$ Å.U. and $\lambda=1832.7$ Å.U. are within 0.5 Å.U. of mercury spark wave-lengths given by Lyman, and it may be that in these cases the radiations should be attributed to mercury. Against this view, however, there is the fact that no trace was obtained on our hydrogen plates of the strong mercury wave-lengths $\lambda=1942.2$ Å.U. and $\lambda=1849.6$ Å.U. which would indicate that the hydrogen used by us was practically uncontaminated with mercury vapour.

V. Conclusions

The conclusions which may be drawn from the present investigation are:

1. That the wave-lengths $\lambda=1931$ Å.U., $\lambda=1657$ Å.U., and $\lambda=1561$ Å.U. frequently obtained in the spectrum of helium, as well as others of less intensity, have their origin in the atoms of carbon.

2. That the series of wave-lengths whose frequencies are given by $\nu=4N\left(\frac{1}{2^2}-\frac{1}{n^2}\right)$ exists for the spectrum of the spark discharge in helium.

3. That in identifying the wave-lengths obtained in vacuum grating spectra of helium, and possibly also of hydrogen, care should be taken to make due allowance for the possibility of wave-lengths being recorded on the plates which have their origin in carbon or mercury introduction into the discharge tube either during the exhaustion of the spectrograph or the purification of the gases.

The Physical Laboratory,
University of Toronto,
June 1st, 1921.

TABLE I

Hydrogen Authors		Helium Authors		Helium Lyman		Carbon Arc Authors		Carbon Spark Millikan		Lead Spark in Helium Authors	
Intensity	Wavelength λ(Å.U.)	Intensity	Wavelength λ(Å.U.)	Intensity	Wavelength λ(Å.U.)	Intensity	Wavelength λ(Å.U.)	Intensity	Wavelength λ(Å.U.)	Intensity	Wavelength λ(Å.U.)
								0	360.5		
								2 No.?	372.1		
								4	384.4		
								4	386.4		
								1	419.8		
								1	450.9		
								6	459.7		
								1	493.7		
								4	499.7		
								1	511.7		
								1	517.6		
								2	530.3		
								2	533.3		
								7	538.4		
								2	543.5		
								2	549.6		
								3	560.5		
								3	564.7		
								6	574.5		
								3	585.7		
								5	595.1		
				1	599.0						
								1.0?	600.2		
								1.0?	609.5		
								3	636.3		
								5	641.8		
				1	643.7						
								6	651.5		
								0	661.5		
								8	687.3		
				2	702.4						
				3	703.5			1	703.0		
								0	711.0		
				5	718.2			1	718.7		
								0	743.6		
								0.0?	749.6		
								1	786.5		
				2	796.8						
								5	799.9		
								6	806.7		
								5	810.0		
				8	833.4						
				7	834.8			5	834.3		
								0	848.4		
								5	858.5		
								1	884.8		
				4	904.6	1	904.7	10	904.1		
				2	916.7						
								1	936.4		
								4	945.6		
								0	954.4		
								0	960.6		
								0	966.6		
				1	972.7						
				2	976.8						
				6	977.6	1	977.9	12	977.1		

Hydrogen Authors		Helium Authors		Helium Lyman		Carbon Arc Authors		Carbon Spark Millikan		Lead Spark in Helium Authors	
Intensity	Wavelength λ(Å.U.)	Intensity	Wavelength λ(Å.U.)	Intensity	Wavelength λ(Å.U.)	Intensity	Wavelength λ(Å.U.)	Intensity	Wavelength λ(Å.U.)	Intensity	Wavelength λ(Å.U.)
				1	990.2						
								2. ON?	991.1		
				3	992.0						
				4	1010.6			10	1010.2		
		1	1020.9								
								1	1022.8		
		2	1026.2	4	1026.0						
		1	1036.8	5	1037.0	1	1037.3	12	1036.7		
								8. Si?	1066.0		
		1	1079.3								
		5	1085.2	2	1084.9			3. ON?	1085.3		
				5	1086.1						
								3	1092.6		
		1	1097.2								
								3 Si, Ca?	1109.6		
								2	1111.3		
		6	1134.7	1	1134.7						
								3	1137.4		
								4	1141.5		
										VF	1158.5
		3	1168.8								
		2	1176.6	8	1175.5	6	1176.8	15	1175.6		
				10	1176.3						
								3	1194.1		
		15	1199.7	5	1199.8					3 He?	1200.0
								5. Ca?	1206.6		
12	1215.8	12	1215.8	10	1216.0			5	1215.7	3 He?	1215.8
								2	1230.2		
				1	1236.0						
		5	1242.9								
1	1246.2			5	1247.9			7	1247.5		
						1	1262.3	5	1262.4		
		1. C?	1278.0			1	1277.7	5	1278.7		
								2. Si?	1294.9		
								2	1296.8		
								3 Si, Ca?	1299.2		
		2	1302.9							1. He?	1303.4
		1	1310.4					1	1310.5	VF He?	1311.0
		2	1319.3								
								2	1322.3		
						1	1324.1	7	1323.7		
		1	1329.0			2	1329,6				
		10. C?	1334.8			10	1335.3	15	1335.0	1. C?	1334.8
										VF	1347.2
								1	1356.2		
								5. Ca?	1362.6		
2	1379.9										
3. D	1386.4										
4. D	1388.7										
								4 Si, Ca?	1393.9		
		1	1401.6								
								4 Si, Ca?	1402.9		
		2	1411.6								
2	1412.9										
								1	1426.9		
								1	1432.2		
										1	1434.0

Hydrogen Authors		Helium Authors		Helium Lyman		Carbon Arc Authors		Carbon Spark Millikan		Lead Spark in Helium Authors	
Intensity	Wavelength λ(Å.U.)	Intensity	Wavelength λ(Å.U.)	Intensity	Wavelength λ(Å.U.)	Intensity	Wavelength λ(Å.U.)	Intensity	Wavelength λ(Å.U.)	Intensity	Wavelength λ(Å.U.)
		1	1463.0					2	1463.7		
4	1474.3										
2	1479.6										
		1	1481.0								
								1	1482.1		
2	1483.6										
		12	1492.3								
2	1492.9										
		10	1494.4								
2	1498.0										
1	1502.4										
2	1505.3										
6 W	1511.0	VF	1511.5								
		VF	1517.5								
4	1518.6										
3	1523.4										
2	1528.9	VF	1528.4								
1	1535.9										
VF	1538.7										
VF	1542.8										
		VF	1544.2								
		VF C?	1548.8					4	1548.8		
								3	1550.9		
										VF	1553.0
		12 C?	1560.8			15	1561.3	5	1561.3	VF	1561.0
1	1569.9										
1	1576.5	1	1577.8					1	1577.6		
4 W	1582.3										
2	1588.8										
1	1593.9										
3	1598.4	2	1598.3								
5 W	1607.2										
3	1614.0										
2	1617.7										
1	1622.1										
		VF	1624.3					1 B?	1624.3		
2	1626.8										
1	1630.9	1	1630.6								
4	1635.3										
1	1642.2										
VF	1646.4										
		2 D	1647.2								
		3 D	1649.9								
1	1655.8										
2 C?	1656.7	12 C?	1656.8			14	1657.5	5	1657.6	2 C?	1656.9
1	1662.6										
2	1667.9										
										2	1670.8
1	1672.4	3	1672.4								
2	1678.7	3	1678.1								
										1	1681.8
1	1687.0										
1	1690.7										
2 D	1694.8										
2 D	1696.5										
2 W	1703.0										
		1	1706.1								

Hydrogen Authors		Helium Authors		Helium Lyman		Carbon Arc Authors		Carbon Spark Millikan		Lead Spark in Helium Authors	
Intensity	Wavelength λ(Å.U.)	Intensity	Wavelength λ(Å.U.)	Intensity	Wavelength λ(Å.U.)	Intensity	Wavelength λ(Å.U.)	Intensity	Wavelength λ(Å.U.)	Intensity	Wavelength λ(Å.U.)
1	1707.9										
VF	1712.6	VF	1712.8								
		1	1724.5								
		2	1730.2								
		12 D	1742.6								
										1 He?	1743.4
		10 D	1744.9								
		1	1751.4					2	1752.3		
1	1754.4										
VF	1760.0										
VF	1765.2										
1	1773.0										
		2	1775.8								
		2	1793.0								
2 W	1795.7										
										2	1796.3
1	1806.2	1	1806.7								
						3	1808.5				
		1	1812.3								
		2	1820.3								
										6	1821.5
		VF	1825.9					1	1827.3		
		VF	1831.0								
8 W	1832.7										
		1	1842.7								
		10	1849.3								
		1	1860.9								
		5	1869.2								
		1	1879.3								
		1	1899.1								
										VF	1899.4
										VF	1904.5
								0	1910.2		
		1	1913.3								
		VF	1919.3								
		15 C?	1930.9			12	1931.6	7	1931.1	6 C?	1930.7
		15	1942.4								
		VF	1951.5								
2	1954.8					2	1955.0				
		6	1973.7								
VF	1981.7										
		4	1987.8								

On the Liquefaction of Hydrogen

By PROFESSOR J. C. McLENNAN, F.R.S.

(Read May Meeting, 1921)

The following paper contains a short account of the method which was adopted in a successful attempt recently made to liquefy hydrogen in the Physical Laboratory of the University of Toronto.

I. HYDROGEN

The hydrogen used in this investigation was obtained in cylinders from the National Electro Products Company, Ltd., of Toronto, and was made by them electrolytically with a new type of cell which they have developed for the production of hydrogen on an industrial scale. Chemical tests, as well as physical ones, made by a Shakspear katharometer, showed the gas as supplied in the cylinders to be of over 99.5% purity.

II. LIQUID AIR

The liquid air used in the investigation was made with a 50 horse-power plant recently installed by the University of Toronto.

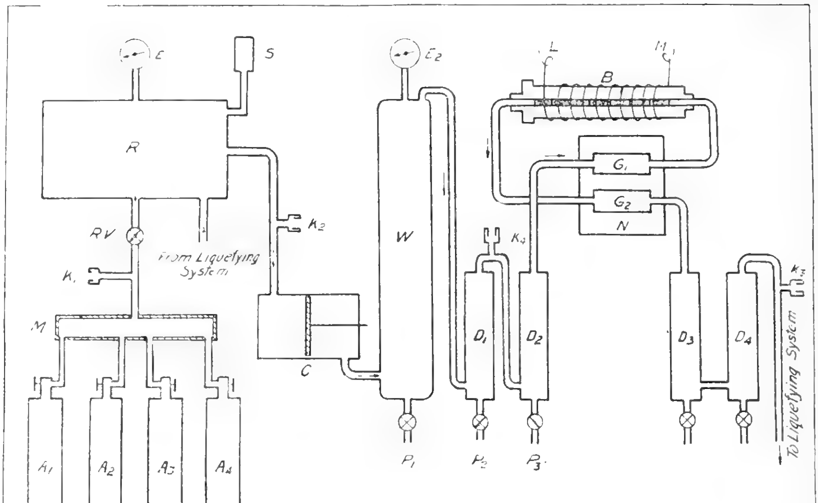
The compressor was of the Norwalk three stage type and the water cooler, the CO_2 purifying columns, and the liquid air machine were obtained from L'Air Liquide Co., Toronto. The Liquid Air Machine was one of the Claude Oxygen-Nitrogen columns so arranged as to produce liquid air or either of the gases mentioned. The machine was also provided with suitable rectifying parts to extract neon and helium from the air if desired.

Repeated tests with this machine showed that with it from 600 to 700 pounds of liquid air could be made in twenty-four hours.

III. ARRANGEMENT OF COMPRESSING AND PURIFYING SYSTEM

The general arrangement for purifying the hydrogen supplied in the cylinders and for compressing it prior to its admission to the liquefier is shown in Plate I.

The hydrogen from the cylinders A_1, A_2, A_3 and A_4 was passed through a reducing valve into a 50 gallon cylinder R, provided with



GENERAL ARRANGEMENT OF THE CYCLE

Plate 1

a blow off S, and a pressure gauge E. The hydrogen in this cylinder was maintained throughout the operation at a pressure of about one pound per square inch above atmospheric pressure. From the cylinder R the hydrogen passed into a Peter Brotherhood 10 horse-power three stage compressor, C, where it was compressed to upwards of 170 atmospheres.

W was a water separator provided with a blow-off P, and D_1 and D_2 were two purifiers filled with caustic potash to dry the gas. From D_2 the compressed gas passed through a cooling bomb G_1 and thence into a heavy walled steel bomb B. This bomb was filled with palladiumized asbestos and was heated by an external electric furnace LM to upwards of 400°C.

The palladiumized asbestos acted as a catalyser and brought about combination between hydrogen and the small fraction of oxygen present in it. From the bomb B the gas passed through a second cooling bomb G_2 and thence through two caustic potash driers, D_3 and D_4, to the liquefier. Outlets at K_1, K_2 and K_3 provided a means of attaching the katharometers with which the gas was tested. As the plate shows, the low pressure cylinder R was provided with a tube for the admission of the pure unused hydrogen which came from the liquefier after the final expansion.

IV. The Liquefier and Subsidiary Heat Exchangers

The arrangement of the liquefier and the subsidiary heat exchangers is shown in Plate II. The coils B, C, D, F, I, were those usually supplied by the British Oxygen Co., Westminster, for the small Hampson Liquid Air machines made by them. The coil A was made up on similar lines, but was about half as long as the others.

The compressed hydrogen was first passed through the coil A, and from there it went in part through the coil B and in part through the coil C, from these two it was passed in turn through the coils D, F and I to the expansion nozzle H. S, a double walled cylinder surrounding the silvered vacuum flask that contained the expansion coil I, acted as a jacket to screen off the admission of heat to the latter.

The cylinder V, surrounding the coil D, was kept filled with liquid air supplied through the valve 2 from the reservoir "a." S was kept filled with liquid air through the valve 3 from "a."

The vessel E, which was a double-walled vacuum flask made up by Messrs. Siebe, Gorman, Westminster, was supplied with liquid air either through the valve 4, the funnel L or directly from the liquid air machine.

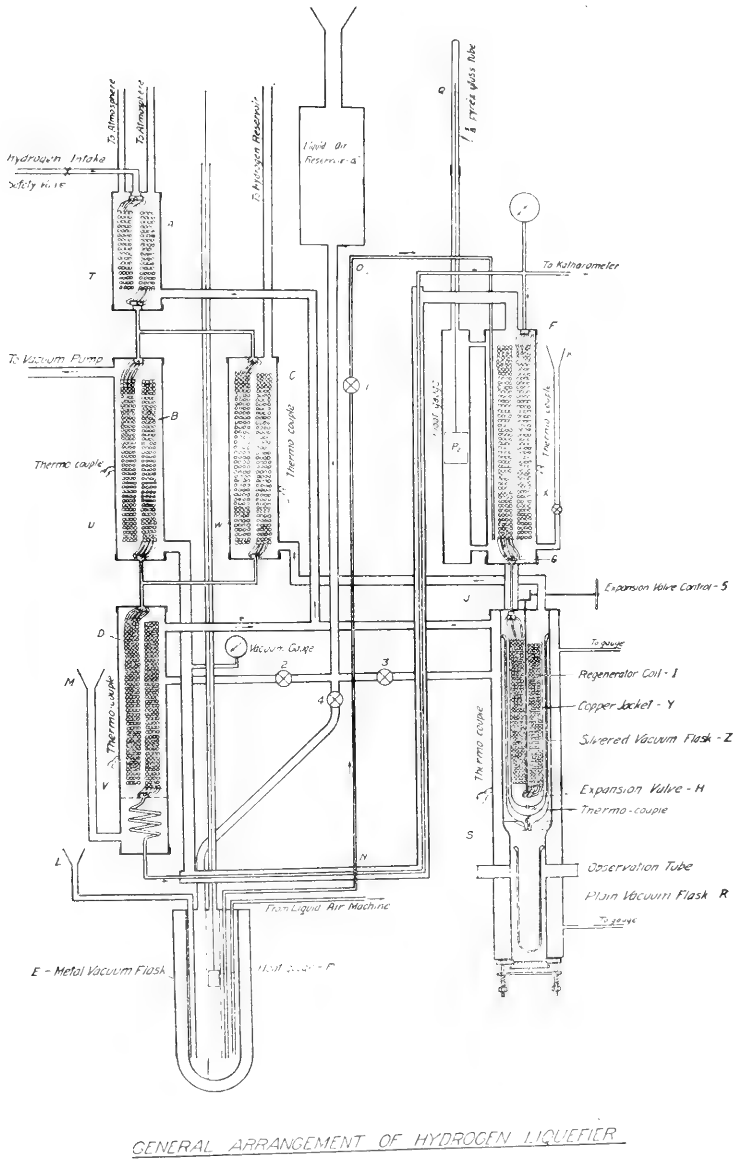
The cylinder X surrounding the coil F was supplied with liquid air from the vessel E or through the funnel K. The float gauges P_1 and P_2 were used to tell the height of the liquid air in the vessels E and X respectively.

The vessel X was connected by means of piping arranged as shown in the plate to an eight horse-power vacuum pump of the Reavell type.

By exhaustion with this pump the liquid air in the vessel X was made to boil under a pressure of a few centimetres of mercury.

As regards the exchange of heat it will be seen from the diagram that the hydrogen in the coil A was cooled by the air which evaporated at atmospheric pressure from the liquid air in the vessels V and S. The hydrogen in the coil B was cooled by the air which came from the liquid air in X boiling under low pressure and that in the coil C by the unused hydrogen which issued from the nozzle H or by that which evaporated from the liquid hydrogen collected in the vacuum vessel R placed within the lower part of the jacket S. The hydrogen in the coils D and F was, of course, cooled directly by the liquid air surrounding them. As the liquid air in X was kept boiling at a very low pressure it followed that the hydrogen which passed from the

Plate II



GENERAL ARRANGEMENT OF HYDROGEN LIQUEFIER coil F into the expansion coil I did so at a temperature near −200°C. The expansion valve was the same as that used in the ordinary Hampson Liquefier and the manner in which the expansion valve was controlled is indicated in the diagram.

The hydrogen which was liquefied was collected at first in the base of a thin copper cylinder surrounding the expansion coil I. From this it flowed into the bottom of the large silvered vacuum flask surrounding the expansion coil and from there it passed into the collecting vacuum flask in the lower part of S. The jacket S was kept airtight at the bottom by means of a heavy circular plate carefully ground to fit into the lower portion of S. This plate was held up by springs which were arranged to give way readily if any sudden large increase of pressure was produced by explosion or otherwise within the jacket S. The collecting vacuum flask was inserted or withdrawn by removing the plate valve entirely.

V. Operations

In operating the liquefier the whole system was first of all cooled down with liquid air in the manner indicated until the thermocouples attached at various points showed that a steady state was reached.

The hydrogen compressed to about 170 atmospheres was then admitted to the system with the expansion nozzle wide open until the thermocouple situated close to the nozzle showed that the gas was issuing from the latter at a temperature below the inversion point.

The nozzle was then throttled down and after this it was found that the expansion coil was rapidly cooled to the temperature of liquefying hydrogen by the expanding gas.

VI. Results

On April 16th the attempt to make liquid hydrogen was successful. In all about half a gallon of it was made. During repeated runs since that time tests were made to see if hydrogen containing as much as one or one and a half per cent. of oxygen could be liquefied by this apparatus. It was invariably found, however, that after a small quantity of the liquid hydrogen had been made the expansion coil choked with solid oxygen and the operations had to cease.

With hydrogen in the cylinders at something over 99.5% purity it was found that the purity attained by means of the palladiumized asbestos was amply sufficient to ensure continuous runs of long enough duration to make liquid hydrogen in comparatively large quantities.

In concluding I wish to express my appreciation of the help given by Mr. G. M. Shrum, M.A., and by those members of the mechanical staff of the Department of Physics who assisted in constructing, assembling, and operating the equipment. I also wish to record my thanks to Professors Dawes and McTaggart, and to Mr. John Patterson, M.A., of the Meteorological Office, Toronto, for the benefit of their advice kindly given in numerous consultations regarding details of the design of the apparatus.

Ionization Potential and the Size of the Atom

BY DR. A. S. EVE, F.R.S.C.

(Read May Meeting, 1921)

It is known that there is for different elements a relation between the ionizing potential and atomic volume, the one increasing as the other diminishes. Hughes, in his book on *Photoelectricity* (p. 51), indicates that the work in removing an electron wholly from an atom might be expected to vary inversely as the radius. In other words the ionizing potential might be inversely proportional to the cube-root of the atomic volume.

Now W. L. Bragg, in the *Philosophical Magazine* (August, 1920), has given the diameters of atoms in Ångstrom units (10^{-8}cm.) on the assumption of close packing in crystal structure. The diameter which he determines is more strictly the distance from centre to centre of contiguous atoms of the same kind. The dimensions which he thus found are far smaller than those deduced from calculations by kinetic theory.

It appears desirable to make a comparison of the ionization potentials, (1) with the diameters as given by W. L. Bragg, and (2) with the cube-roots of the atomic volume.

In the table following the name of the element, the ionization potential and Bragg's diameter ($x10^8$) are set forth in the first three columns. The product of the diameter and ionizing potential appear in the fourth column. The cube-root of the atomic volume is stated in the fifth column and its product with the ionization potential in the sixth column.

GROUP I

I	II	III	IV	V	VI
Element	Ionization Potential	Diameter $x10^8$	II x III	Cube-root of Atomic Volume	II x V
Na	5.11	3.55	18.1	2.87	14.7
K	4.32	4.15	17.9	3.57	15.4
Rb	4.16	4.50	18.7	3.81	15.9
Cs	3.88	4.75	18.4	4.12	16.0
		Mean	18.3	Mean	15.5
		Range	0.8	Range	1.3

GROUP II

I Element	II Ionization Potential	III Diameter $x10^8$	IV II x III	V Cube-root of Atomic Volume	VI II x V
Mg	7.61	2.85	21.7	2.40	18.3
Ca	6.09	3.40	20.8	2.96	18.0
Sr	5.67	3.90	22.2	3.25	18.4
Ba	5.19	4.30	21.8	3.31	17.2
		Mean	21.6	Mean	18.0
		Range	1.4	Range	1.2

GROUP IIB

I Element	II Ionization Potential	III Diameter $x10^8$	IV II x III	V Cube-root of Atomic Volume	VI II x V
Zn	9.35	2.65	24.8	2.09	19.5
Cd	8.95	3.20	28.6	2.35	21.0
Hg	10.38			2.45	25.4

GROUP IIIB

I Element	II Ionization Potential	III Diameter $x10^8$	IV II x III	V Cube-root of Atomic Volume	VI II x V
Tl	7.3	4.50	32.8	2.58	18.8

GROUP IVB

I Element	II Ionization Potential	III Diameter $x10^8$	IV II x III	V Cube-root of Atomic Volume	VI II x V
Pb	7.93	3.80	30.1	2.63	20.8

GROUP VA

I Element	II Ionization Potential	III Diameter $x10^8$	IV II x III	V Cube-root of Atomic Volume	VI II x V
As	11.5	2.52	29.0	2.36 or 2.52	27.2 or 29.0
P	13.3			2.37 or 2.57	31.5 or 34.2

GROUP VI

I Element	II Ionization Potential	III Diameter x10^8	IV II x III	V Cube-root of Atomic Volume	VI II x V
S	8.30	2.05	17.0	2.50	20.8
	or 12.2	2.05	or 25.0	2.50	or 30.4

GROUP VIIA

I Element	II Ionization Potential	III Diameter x10^8	IV II x III	V Cube-root of Atomic Volume	VI II x V
I	10.1	2.80	28.3	2.95	29.8
	or 8.0	2.80	or 22.4	2.95	or 23.6

INERT CASES

I Element	II Ionization Potential	III Diameter x10^8	VI II x III	V Cube-root of Atomic Volume	VI II x V
He	25.4			2.86	73.0
Ne	16	1.30	20.8	2.67	42.8
A	12	2.05	24.6	3.03	36.4

In the first group of the periodic table the products shown in each of the fourth and sixth columns of the above table are fairly concordant so that we may conclude that the work done in the removal of an exterior electron is nearly proportional inversely as the radius.

The same remark applies to four elements of the second group while the members of subgroup B diverge considerably from the values for the A group. According to Urbach (*Phys. Zeit.*, Feb., 1921, p. 116) the B subgroup have a double ring of electrons in the outer zone, while the A subgroup have a single ring. In the case of the inert gases, neon and argon, the diameters estimated by Bragg give products in the fourth column in far better accord with theory than those found from the cube-roots of the atomic volumes set forth in the sixth column.

The values for certain elements in groups 3 to 7 are given in the table for comparison, but our knowledge of ionizing potentials is as yet too fragmentary to permit of any definite conclusions.

The ultimate solution of this problem may involve calculations of the character given by Sir J. Thomson in his recent paper in the *Philosophical Magazine* (March, 1921, p. 526).

I am indebted to Professor A. Ll. Hughes for his assistance in endeavouring to collect the most reliable values for the ionizing potentials.

McGill University.
June 6, 1921.

See also " Nature " 28th July, 1921.

On the Reduction of the Circulants to Polynomial Form

By J. C. GLASHAN, F.R.S.C.

(Read May Meeting, 1921)

Notation.—(i) ω = a primitive root of $x^n - 1 = 0$.

(ii) $\rho_k = \omega^k y_1 + \omega^{2k} y_2 + \omega^{3k} y_3 + \ldots\ldots\ldots\ldots + \omega^{(n-1)k} y_{n-1}$

(iii) $\sigma_l = \frac{1}{l} \rho_1^l + \rho_2^l + \rho_3^l + \ldots\ldots\ldots\ldots + \rho_n^l)$

(iv) $C(n) = (x+\rho_1)\ (x+\rho_2)\ (x+\rho_3) \ldots\ldots\ldots\ldots (x+\rho_n).$
$= x^n + c_2\, x^{n-2} - c_3\, x^{n-3} + \ldots\ldots (-1)^n c_n$

(v) $\epsilon_0 + \epsilon_1 + \epsilon_2 + \ldots\ldots + \epsilon_{n-1} = n$ conditioned by
$\epsilon_1 + 2\epsilon_2 + 3\epsilon_3 + \ldots\ldots + (n-1)\epsilon_{n-1} = 0 \bmod n.$

(vi) $m = n - \epsilon_0.$

(vii) $\epsilon_{1,\mu} + \epsilon_{2,\mu} + \epsilon_{3,\mu} + \ldots\ldots + \epsilon_{n-1,\mu} = m_\mu$ conditioned by
$\epsilon_{1,\mu} + 2\epsilon_{2,\mu} + 3\epsilon_{3,\mu} + \ldots\ldots + (n-1)\epsilon_{n-1,\mu} = 0 \bmod n$
$\mu = 1, 2, 3, \ldots . t$

and $\epsilon_{\lambda,1} + \epsilon_{\lambda,2} + \epsilon_{\lambda,3} + \ldots\ldots + \epsilon_{\lambda,t} = \epsilon_\lambda$
$\lambda = 1, 2, 3, \ldots\ldots n-1$

$\therefore\quad m_1 + m_2 + \qquad\qquad + m_t = m.$

(viii) $$P_\mu = \frac{n(m_\mu - 1)!}{\epsilon_{1,\mu}!\ \epsilon_{2,\mu}! \qquad \epsilon_{n-1,\mu}!}$$

(ix) $|y_1^a y_2^b y_3^c \ldots\ldots y_{n-1}^h|$ = the sum of the non-equivalent products among $y_\lambda^a\, y_{{}^{\backprime}2\lambda^{\prime}}^b\, y_{{}^{\backprime}3\lambda^{\prime}}^c \ldots\ldots y_{{}^{\backprime}(n-1)\lambda^{\prime}}^h$ in which $\lambda = 1, 2, 3, \ldots\ldots n-1$ in succession and '$l\lambda$' = the least positive residue of $l\lambda$ mod n.

Examples. For $n = 7$

$|y_1 y_6| = y_1 y_6 + y_2 y_5 + y_3 y_4$

$|y_1^2 y_5| = y_1^2 y_5 + y_2^2 y_3 + y_3^2 y_1 + y_4^2 y_6 + y_5^2 y_4 + y_6^2 y_2$

$|y_1 y_2 y_4| = y_1 y_2 y_4 + y_3 y_6 y_5$

(x) $[0^{\epsilon_0} 1^{\epsilon_1} 2^{\epsilon_2} \ldots\ldots (n-1)^{\epsilon_{n-1}}] = \Sigma |x^{n-p}\, y_{{}^{\backprime}1-p^{\prime}}^{\epsilon_1}\, y_{{}^{\backprime}2-p^{\prime}}^{\epsilon_2} \ldots\ldots y_{{}^{\backprime}n-1-p^{\prime}}^{\epsilon_{n-1}}|$
in which $p = 0, 1, 2, \ldots\ldots n-1$ and '$a-p$' = the least *positive* residue of $a-p$ mod n.

Examples.—For $\epsilon_0 = 3$, $\epsilon_1 = 2$, $\epsilon_2 = 1$, $\epsilon_3 = 1$, $\epsilon_4 = 0$, $\epsilon_5 = 0$ and $\epsilon_6 = 0$,

$[0^3\, 1^2\, 23] = x^3 |y_1^2 y_2 y_3| + x^2 |y_1 y_2 y_6^3| + x |y_1 y_5^3 y_6^2| + x |y_4^3 y_5^2 y_6|$
$+ |y_3^3 y_4^2 y_5 y_6| + |y_2^3 y_3^2 y_4 y_5| + |y_1^3 y_2^2 y_3 y_4|$

For $\epsilon_0 = 3$, $\epsilon_1 = 3$, $\epsilon_{\_} = 0$, $\epsilon_3 = 2$, $\epsilon_4 = \epsilon_5 = \epsilon_6 = 0$, $\epsilon_7 = 2$, $\epsilon_8 = \epsilon_9 = 0$ and $\epsilon_{10} = 1$ and $j = 10$

$$[0^3 1^3 3^2 7^2 j] = x^3|y_1^3 y_3^2 y_7^2 y_{10}| + x^3|y_2^2 y_6^2 y_9 y^3_{10}| + |y_1^2 y_5^2 y_8 y_9^3 y^3_{10}|$$
$$+ x^2|y_4^2 y_7 y_8^3 y_9^3| + |y_3^2 y_6 y_7^3 y_8^3 y^2_{10}| + |y_2^2 y_5 y_6^3 y_7^3 y_9^2|$$
$$+ |y_1^2 y_4 y_5^3 y_6^3 y_8^2| + x^2|y_3 y_4^3 y_5^3 y_7^2| + |y_2 y_3^3 y_4^3 y_6^2 y^2_{10}|$$
$$+ |y_1 y_2^3 y_3^3 y_5^2 y_9^2| + x|y_1^3 y_2^3 y_4^2 y_8^2|$$

(xi) $(x^{\epsilon_0} 1^{\epsilon_1} 2^{\epsilon_2} \ldots\ldots (n-1)^{\epsilon_{n-1}}) = \Sigma|\, y^{\epsilon_1}_{`1-r'} y^{\epsilon_2}_{`2-r'} \ldots\ldots y^{\epsilon_{n-1}}_{`n-1-\,'}|\, x^{\epsilon_0}$ the summation to include without repetitions only those addends in which $\epsilon_r = \epsilon_0 = n - (\epsilon_1 + \epsilon_2 + \ldots\ldots + \epsilon_{n-1})$.

Examples.—For $n=7$, $\epsilon_0=1$, $\epsilon_1=2$, $\epsilon_2=1$, $\epsilon_3=2$, $\epsilon_4=1$, $\epsilon_5=0$, $\epsilon_6=0$ and $\therefore r=0, 2, 4$

$$(x1^2\ 2\ 3^2\ 4) = \{|y_1^2 y_2 y_3^2 y_4| + |y_1^2 y_2 y_5 y_6^2|\}$$
$$= \{y_1^2 y_2 y_3^2 y_4 + y_2^2 y_4 y_6^2 y_1 + y_3^2 y_6 y_2^2 y_5 + y_4^2 y_1 y_5^2 y_2 + y_5^2 y_3 y y_1^2 y_6 +$$
$$y_6^2 y_5 y_4^2 y_3 + y_1^2 y_2 y_5 y_6^2 + y_2^2 y_4 y_3 y_5^2 + y_3^2 y_6 y_1 y_4^2\} x$$

For $n=7$, $\epsilon_0=1$, $\epsilon_1=2$, $\epsilon_2=2$, $\epsilon_3=1$, $\epsilon_4=0$, $\epsilon_5=1$, $\epsilon_6=0$ and $\therefore r=0, 3, 5$

$$(x1^2\ 2^2\ 3\ 5) = \{|y_1^2 y_2^2 y_3 y_5| + |y_3^2 y_4^2 y_5 y_2|\} x$$
$$= \{y_1^2 y_2^2 y_3 y_5 + y_2^2 y_4^2 u_6 y_3 + y_3^2 y_6^2 y_2 y_1 + y_4^2 y_1^2 y_5 y_6 + y_5^2 y_3^2 y_1 y_4$$
$$+ y_6^2 y_5^2 y_4 y_2 + y_3^2 y_4^2 y_5 y_2 + y_6^2 y_1^2 y_3 y_4 + y_2^2 y_5^2 y_1 y_6\} x.$$

In the former of these examples $|y_3 y_4^2 y_5 y_6^2|$ is omitted, being the same as $|y_1^2 y_2 y_3^2 y_4|$, in the latter example $|y_5^2 y_6^2 y_2 y_4|$ is omitted, being $= |y_1^2 y_2^2 y_3 y_5|$.

For $n=11$, $\epsilon_0=2$, $\epsilon_1=2$, $\epsilon_2=2$, $\epsilon_3=0$, $\epsilon_4=2$, $\epsilon_5=2$, $\epsilon_6=\epsilon_7=\epsilon_8=0$, $\epsilon_9=1$, $\epsilon_{10}=0$, and $\therefore r=0, 1, 2, 4, 5$

$$(x^2\ 1^2\ 2^2\ 4^2\ 5^2\ 9) = \{|y_1^2 y_2^2 y_4^2 y_5^2 y_9| + |y_1^2 y_3^2 y_4^2 y_8 y^2_{10}| + |y_2^2 y_3^2 y_7 y_9^2 y^2_{10}|$$
$$+ |y_1^2 y_5 y_7^2 y_8^2 y^2_{10}| + |y_4 y_6^2 y_7^2 y_9^2 y^2_{10}|\} x^2$$

(xii) Kof (u) = 'the coefficient of u.'

THEOREM I.—By the multinomial theorem

$$\sigma_m = \Sigma \frac{n(m-1)!}{\epsilon_1!\ \epsilon_2!\ \epsilon_3! \ldots\ldots \epsilon_{n-1}!} |y_1^{\epsilon_1} y_2^{\epsilon_2} y_3^{\epsilon_3} \ldots\ldots y_{n-1}^{\epsilon_{n-1}}|$$

in which $m = \epsilon_1 + \epsilon_2 + \epsilon_3 + \ldots\ldots + \epsilon_{n-1}$.

THEOREM II.—By Waring's theorem

$$c_m = \Sigma \left\{ (-1)^\tau \frac{\sigma_r^a\ \sigma_s^b\ \sigma_t^c \ldots\ldots}{a!\ b!\ c! \ldots\ldots} \right\}$$

in which $\tau = a + b + c + \ldots\ldots$

and $ar + bs + ct + \ldots\ldots = m$.

THEOREM III.—Hence, in c_m

Kof $|y_1^{\epsilon_1} y_2^{\epsilon_2} \ldots\ldots y_{u-1}^{\epsilon_{u-1}}|$ is $\Sigma\{(-1)^q P_1 P_2 \ldots\ldots P_q\}$

in which q is to take all possible values.

Examples.—For $n=7$, $\epsilon_1=2$, $\epsilon_6=2$ and $\therefore m=4=2^2$

$$\text{Kof } |y_1^2y_6^2| = -\frac{7(3!)}{2!\ 2!} + \frac{7^2(1!)^2}{2!} = 7\left(-\frac{3}{2}+\frac{7}{2}\right) = 7\times 2$$

If $n=7$, $\epsilon_1=\epsilon_2=\epsilon_3=\epsilon_4=\epsilon_5=\epsilon_6=1$ and $\therefore m=6=4+2=3+3=2+2+2$

$$\text{Kof } |y_1y_2y_3y_4y_5y_6| = -7(5!)+7^2\{3(3!1!)+(2!2!)\}-7^3(1!1!1!) = -7\times 15$$

If $n=11$, $\epsilon_1=2$, $\epsilon_2=1$, $\epsilon_3=\epsilon_4=\ldots\ldots=\epsilon_8=0$, $\epsilon_9=1$, $\epsilon_{10}=2$ and $\therefore m=6=4+2=(2\times 2)+2=3+3=2+2+2$.

$$\text{Kof } |y_1^2y_2y_9y_{10}^2| = -\frac{11(5!)}{2!2!} + 11^2\left\{3!\,1!+\frac{3!\,1!}{2!2!}+\frac{2!\,2!}{2!\,2!}\right\} - \frac{11^3(1!)^2(1!)}{2!}$$
$$= 11(-30+66+16\tfrac{1}{2}+11-60\tfrac{1}{2}) = 11\times 3.$$

If $n=11$, $\epsilon_1=\epsilon_2=\epsilon_3=\ldots\ldots=\epsilon_{10}=1$,
and $\therefore m=10=8+2=7+3=6+4=5+5$
$=6+2+2=5+3+2=4+4+2=4+3+3=4+2+2$
$=3+3+2+2=2+2+2+2+2.$

$$\begin{aligned}\text{Kof } |y_1y_2y_3y_4y_5y_6y_7y_8y_9y_{10}| &= -11(9!)+11^2\{5(7!1!)+10(6!2!)\\&+20(5!3!)+11(4!4!)\}-11^3\{10(5!1!1!)+20(4!2!1!)\\&+20(3!3!1!)+15(3!2!2!)\}+11_4\{10(3!1!1!1!)+5(2!2!1!1!)\}\\&-11^5(1!1!1!1!1!) = 11\times 615.\end{aligned}$$

THEOREM IV.—By the cyclosymmetry of the circulant $C(n)$

$$\text{Kof } |x^{\epsilon_0}y_1^{\epsilon_1}y_2^{\epsilon_2}\ldots\ldots y_{n-1}^{\epsilon_{u-1}}| = \text{Kof } |x^{\epsilon_{n-1}}y_1^{\epsilon_0}y_2^{\epsilon_1}\ldots\ldots y_{n-1}^{\epsilon_{n-2}}|$$

Hence

$$\text{Kof } [0^{\epsilon_0}1^{\epsilon_1}2^{\epsilon_2}\ldots\ldots(n-1)^{\epsilon_{n-1}}] = \text{Kof } |y_1^{\epsilon_1}y_2^{\epsilon_2}y_3^{\epsilon_3}\ldots\ldots y_{n-1}^{\epsilon_{n-1}}|$$

Examples

$$\begin{aligned}C(7) &= [0^7]-7\{[0^516]-[0^41^25]-2[0^4124]+[0^31^34]+[0^31^223]-2[0^31^26^2]\\&-[0^31256]+[0^21^23^26]+2[0^21^2246]-5[0^21^2345]+15[0123456]\}\end{aligned}$$

Arranged according to powers of x this becomes

$$\begin{aligned}C(7) &= x^7-7\{(x^516)-(x^41^25)-2(x^4124)+(x^31^34)+3(x^31^223)\\&-2(x^31^26^2)-(x^31256)-(x^21^43)-2(x^21^32^2)-3(x^21^356)\\&+(x^21^23^26)+2(x^21^2246)-5(x^21^2345)+(x1^52)-(x1^45^2)\\&-2(x1^446)+(x1^36^3)+3(x1^33^25)-(x1^3236)+2(x1^22^235)\\&-5(x1^23^224)+(x1^22^24^2)+15(x123456)+(1^536)-(1^42^26)\\&-2(1^4235)+(1^32^35)+3(1^32^234)-2(1^33^26^2)-(1^33456)+(1^22^36^23)\\&+2(1^23^2256)-5(1^22^2456)\}+(1^7).\end{aligned}$$

$$\begin{aligned}C(11) &= [0^{11}]-11\{[0^91j]-[0^81^29]-2[0^8128]+[0^71^38]+3[0^71^227+0^71^236\\&+0^71^245]-4[0^71^2j^2]+6[0^71235]-5[0^7129j+0^7138j]\\&-]0^61^47]-2[0^61^34^2]-4[0^61^326+0^61^335]+7[0^61^39j]\end{aligned}$$

$-6[0^{6}1^{2}2^{2}5+0^{6}1^{2}7^{2}6]+5[0^{6}1^{2}5^{2}j]-12[0^{6}1^{2}234+0^{6}1^{2}578]$
$+10[0^{6}1^{2}28j+0^{6}1^{2}37j+0^{6}1^{2}46j]-[0^{6}1^{2}389+0^{6}1^{2}479+0^{6}1^{2}569]$
$-2[0^{6}123610+0^{6}124510]+[0^{5}1^{5}6]+5[0^{5}1^{4}25+0^{5}1^{4}34]$
$-6[0^{5}1^{4}810]-3[0^{5}1^{4}9^{2}]+10[0^{5}1^{3}2^{2}4+0^{5}1^{3}6^{2}7+0^{5}1^{3}7^{2}5]$
$-[0^{5}1^{3}5^{2}9+0^{5}1^{3}8^{2}3]+7[0^{5}1^{3}j^{3}-13[0^{5}1^{3}27j+0^{5}1^{3}36j$
$+0^{5}1^{3}45j+0^{5}289]-2[0^{5}1^{3}379+0^{5}1^{3}469]$
$+9[0^{5}478+0^{5}568]-7[0^{5}1^{2}2^{2}8^{2}]-14[0^{5}1^{2}2^{2}79]$
$-3[0^{5}1^{2}2^{2}6j+0^{5}1^{2}3^{2}4j+0^{5}1^{2}3^{2}68+0^{5}1^{2}7^{2}24]$
$+19[0^{5}1^{2}3^{2}59+0^{5}1^{2}7^{2}89]+8[0^{5}1^{3}5^{2}28+0^{5}1^{2}5^{2}37]$
$-25[0^{5}1^{2}5^{2}46]-3[0^{5}1^{2}j^{2}29]+8[0^{5}1^{2}j^{2}38+0^{5}1^{2}j^{2}47+0^{5}1^{2}j^{2}56]$
$-6[0^{5}1^{2}235j]+5[0^{5}1^{2}2369+0^{5}1^{2}2459]$
$+27[0^{5}1^{2}2567+0^{5}1^{2}3458]-17[0^{5}1^{2}2378+0^{5}3467]$
$+16[0^{5}1^{2}2468]+10[0^{5}1^{2}2468]-[0^{5}12389j]$
$+43[0^{5}1247910]-15[0^{4}1^{4}2^{2}3]+7[0^{4}1^{4}4^{2}j]$
$-4[0^{4}1^{4}5^{2}8]-5[0^{4}1^{4}6^{3}]+2[0^{4}1^{3}3^{3}j]+13[0^{4}1^{3}5^{3}4]-9[0^{4}1^{3}7^{3}9]$
$-8[0^{4}1^{3}5^{2}j^{2}]+3[0^{4}1^{3}6^{2}9^{2}]-19[0^{4}1^{3}7^{2}8^{2}]+6[0^{4}1^{3}2^{2}5j+0^{4}1^{3}3^{2}67$
$+0^{4}1^{3}6^{2}34+0^{4}1^{3}7^{2}23+0^{4}1^{3}7^{2}6j+0^{4}1^{3}9^{2}54]+17[0^{4}1^{3}2^{2}69$
$+0^{4}1^{3}2^{2}78+0^{4}1^{3}5^{2}36+0^{4}1^{3}6^{2}8j+0^{4}1^{3}9^{2}48]-27[0^{4}1^{3}3^{2}49$
$+0^{4}1^{3}4^{2}38+0^{4}1^{3}5^{2}27]-5[0^{4}1^{3}3^{2}58+0^{4}1^{3}4^{2}29+0^{4}1^{3}8^{2}59$
$+0^{4}1^{3}9^{2}2j+0^{4}1^{3}j^{2}28]+28[0^{4}1^{3}4^{2}56+0^{4}1^{3}8^{2}4j]$
$-16[0^{4}1^{3}6^{2}25+0^{4}1^{3}j^{2}37+0^{4}1^{3}j^{2}46]+12[0^{4}1^{3}234j+0^{4}1^{3}2368]$
$-10[0^{4}1^{3}2359+0^{4}1^{3}2467+0^{4}1^{3}3457]-32[0^{4}1^{3}2458$
$+0^{4}1^{3}6789]+[0^{4}1^{3}389j+0^{4}1^{3}479j+0^{4}1^{3}569j]$
$+34[0^{4}1^{3}6789]+24[0^{4}1^{2}2^{2}3^{2}j+0^{4}1^{2}2^{2}4^{2}8+0^{4}1^{2}3^{2}5^{2}4]$
$+9[0^{4}1^{2}2^{2}5^{2}6+0^{4}1^{2}3^{2}4^{2}6]-2[0^{4}1^{2}2^{2}j^{2}7+0^{4}1^{2}3^{2}8^{2}9+0^{4}1^{2}3^{2}j^{2}5]$
$-15[0^{4}1^{2}2^{2}349+0^{4}1^{2}2^{2}367+0^{4}1^{2}3^{2}257+0^{4}1^{2}5^{2}489+0^{4}1^{2}7^{2}359$
$+0^{4}1^{2}7^{2}458]+18[0^{4}1^{2}2^{2}358+0^{4}1^{2}2^{2}457+0^{4}1^{2}3^{2}248$
$+0^{4}1^{2}5^{2}678+0^{4}1^{2}7^{2}25j+0^{4}1^{2}7^{2}269]+7[0^{4}1^{2}2^{2}89j]$
$+51[0^{4}1^{2}3^{2}69j+0^{4}1^{2}7^{2}368]-26[0^{4}1^{2}3^{2}78j+0^{4}1^{2}7^{2}34j]$
$-37[0^{4}1^{2}5^{2}29j+0^{4}1^{2}5^{2}38j]+29[0^{4}1^{2}5^{2}47j]$
$+36[0^{4}1^{2}23456+0^{4}1^{2}25789+0^{4}1^{2}3459j]+58[0^{4}1^{2}2379j]$
$-8[0^{4}1^{2}2469j+0^{4}1^{2}2478j+0^{4}1^{2}3468j]-74[0^{4}1^{2}2568j]$
$-19[0^{4}1^{2}34789+0^{4}1^{2}45679]-38[0^{4}12358j]+4[0^{3}1^{3}3^{3}5^{2}]$
$+30[0^{3}1^{3}2^{3}3j]-14[0^{3}1^{3}2^{3}49+0^{3}1^{3}3^{3}28]-3[0^{3}1^{3}2^{3}58$
$+0^{3}1^{3}2^{3}67+0^{3}1^{3}3^{3}46]+34[0^{3}1^{3}2^{2}3^{2}9+0^{3}1^{3}5^{2}7^{2}6]$
$-21[0^{3}1^{3}2^{2}4^{2}7+0^{3}1^{3}3^{2}9^{2}6]+23[0^{3}1^{3}2^{2}8^{2}j+0^{3}1^{3}3^{2}7^{2}j]$
$-32[0^{3}1^{3}2^{2}j^{2}6+0^{3}1^{3}5^{2}6^{2}8]-45[0^{3}1^{3}3^{2}4^{2}5]+[0^{3}1^{3}4^{2}6^{2}j]$
$+12[0^{3}4^{2}7^{2}8]-32[0^{3}1^{3}5^{2}6^{2}8]+13[0^{3}1^{3}2^{2}348+0^{3}1^{3}4^{2}589$
$+0^{3}1^{3}5^{2}46j]+46[0^{3}1^{3}2^{2}357+0^{3}1^{3}3^{2}789+0^{3}1^{3}5^{2}389]$
$-9[0^{3}1^{3}2^{2}456+0^{3}1^{3}4^{2}57j+0^{3}1^{3}6^{2}279]-20[0^{3}1^{3}2^{2}79j$
$+0^{3}1^{3}3^{2}256+0^{3}1^{3}5^{2}37j+0^{3}1^{3}6^{2}378]-53[0^{3}1^{3}3^{2}247$

$$+0^3 1^3 3^2 59j]+2[0^3 1^3 3^2 68j+0^3 1^3 4^2 679+0^3 1^3 5^2 234]$$
$$-31[0^3 1^3 4^2 236+0^3 1^3 5^2 479]+35[0^3 1^3 4^2 39j+0^3 1^3 5^2 28j]$$
$$-73[0^3 1^3 2369j]+15[0^3 1^3 2378j]-18[0^3 1^3 2468j]$$
$$-29[0^3 1^3 24789]+37[0^3 1^3 2567j]+81[0^3 1^3 25689]$$
$$+70[0^3 1^3 34689]-7[0^3 1^3 45678]-15[0^3 1^2 2^2 3^2 5^2]$$
$$-4[0^3 1^2 2^2 9^2 10^2]+7[0^3 1^2 3^2 8^2 j^2]+36[0^3 1^2 2^2 3^2 46+0^3 1^2 2^2 7^2 58]$$
$$+3[0^3 1^2 2^2 4^2 35]+69[0^3 1^2 2^2 4^2 9j]-30]0^3 1^2 2^2 5^2 89+0^3 1^2 2^2 j^2 34]$$
$$-8[0^3 1^2 2^2 5^2 7j+0^3 1^2 3^2 5^2 69+0^3 1^2 3^2 j^2 79]-52[0^3 1^2 2^2 7^2 3j]$$
$$+58[0^3 1^2 2^2 7^2 49+0^3 1^2 3^2 8^2 27]-19[0^3 1^2 2^2 9^2 36+0^3 1^2 3^2 4^2 7j]$$
$$+14[0^3 1^2 2^2 8^2 47+0^3 1^2 2^2 8^2 56+0^3 1^2 2^2 9^2 45+0^3 1^2 3^2 5^2 78]$$
$$+25[0^3 1^2 3^2 4^2 89]+47[0^3 1^2 5^2 7^2 34]-41[0^3 1^2 5^2 7^2 8j+0^3 1^2 3^2 8^2 45]$$
$$+6[0^3 1^2 2^2 359j]+28[0^3 1^2 2^2 368j]-38[0^3 1^2 2^2 4689]$$
$$-16[0^3 1^2 2^2 3789+0^3 1^2 3^2 456j+0^3 1^2 5^2 679j+0^3 1^2 7^2 468j]$$
$$+61[0^3 1^2 2^2 458j+0^3 1^2 3^2 4579+0^3 1^2 j^2 2578]+94[0^3 1^2 2^2 5679]$$
$$+83[0^3 1^2 2^2 467j+0^3 1^2 5^2 2478]+39[0^3 1^2 3^2 259j]+116[0^3 1^2 3^2 258j]$$
$$-5[0^3 1^2 3^2 267j+0^3 1^2 5^2 2469+0^3 1^2 7^2 2348+0^3 1^2 7^2 5689]$$
$$+17[0^3 1^2 3^2 2689+0^3 1^2 5^2 236j+0^3 1^2 5^2 2379+0^3 1^2 7^2 459j+0^3 1^2 j^2 3568]$$
$$-71[0^3 1^2 3^2 4678+0^3 1^2 7^2 369j+0^3 1^2 j^2 2389]+50[0^3 1^2 5^2 3468]$$
$$-60[0^3 1^2 7^2 2456]-126[0^3 1^2 j^2 2479]-27[0^3 1^2 j^2 2569]$$
$$+72[0^3 1^2 j^2 3478+0^3 1^2 j^2 4567]-98[0^3 1^2 23457j]$$
$$-109[0^3 1^2 234589]+45[0^3 1^2 234679]-65[0^3 1^2 235678]$$
$$+100[0^3 1^2 26789j]+12[0^3 1^2 35789j]+78[0^3 1^2 45689j]$$
$$+57[0^3 1234789j]-23[0^3 1^2 2^2 3^2 6^2 9]-56[0^2 1^2 2^2 4^2 5^2 9]$$
$$+87[0^2 1^2 2^2 4^2 7^2 5]+141[0^2 1^2 2^2 3^2 47j]+9[0^2 1^2 2^2 3^2 489$$
$$+0^2 1^2 2^2 4^2 36j]-112[0^2 1^2 2^2 3^2 579]+31[0^2 1^2 2^2 3^2 678]$$
$$-79[0^2 1^2 2^2 4^2 379+0^2 1^2 2^2 5^2 368]-2[0^2 1^2 2^2 4^2 568]$$
$$+75[0^2 1^2 2^2 5^2 34j]+64[0^2 1^2 2^2 5^2 467]-57[0^2 1^2 3^2 4^2 25j]$$
$$-35[0^2 1^2 2^2 4^2 269]-13[0^2 1^2 3^2 4^2 278]+29[0^2 1^2 2^2 34569]$$
$$-59[0^2 1^2 2^2 34578+0^2 1^2 3^2 4679j]-70[0^2 1^2 3^2 24568]$$
$$-136[0^2 1^2 3^2 2789j]+106[0^2 1^2 3^2 4589j]-26[0^2 1^2 3^2 5678j]$$
$$+190[0^2 1^2 234689j]-96[0^2 1^2 235679j]+80[0^2 1^2 245678j]$$
$$-63[0^2 1^2 3456789]-615[0123456789j]\}.$$

The importance of the circulants lies in the fact that the question of the solution by radicals (or circular functions) of the equation $C(n)=0$ is reducible to the problem of determining y_1^n, $y_2^n \dots y_{n-1}^n$ explicitly in terms of $c_2, c_3, \dots c_n$, *i.e.*, the solution by radicals of $Q(n)=x^n+q_2 x^{n-2}+q_3 x^{n-3} \dots q_n=0$ is the inverse of the problem considered in this paper. This was proved by Abel and his demonstration that the general equation of degree higher than four is not resolvable in terms of radicals alone, rests on his identification of $Q(n)$ and $C(n)$.

Tartaglia's solution of the cubic Q(3) = 0, as published by Cardan, is simply the reduction of Q(3) to C(3). In like manner Euler's solution of the quartic Q(4) = 0 rests on the explicit determination of y_1^4, y_2^4, y_3^4 in terms of q_2, q_3, q_4 given Q(4) = C(4).

Abel gave the radical *forms* which appear in y_1, y_2, y_3, y_4 in the solution of the quintic but did not express the quantities under the radical signs in terms of q_2, q_3, q_4, q_5. He added that he had determined similar forms for the equations of the 7th, 11th, 13th, etc., degrees. (*Crelle*, V, 336; *Nouv. An.*, IV, 536; *Memorial Volume*, "Correspondence," 21-2.)

The present writer has, in the case of the quintic, expressed y_1, y_2, y_3, y_4 explicitly in terms of q_2, q_3, q_4, q_5 and the rational root of the dioristic sextic (*Am. Jour. of Math.*, XIII, 49-56). He has also determined $y_1, y_2, \ldots\ldots y_3$ in terms of $q_2, q_3, \ldots\ldots q_7$ and the common root of the triple diacrinic system for the isodyadic septimics. These form the widest class of septimics that hitherto have been solved, including, as they do, the Gaussian cyclotomic septimics as special cases.

Nitrophthalic Anhydrides and Acetylamine-phthalic Anhydrides with Toluene and Aluminium Chloride

By W. A. LAWRANCE, M.A.

Presented by PROFESSOR F. B. ALLAN, F.R.S.C.

In a recent article in the *Journal of the American Chemical Society* Lawrance has published the results of a study of the reaction of these derivatives of phthalic anhydride with benzene and aluminium chloride. A similar study, using toluene instead of benzene, has given eleven new derivatives of orthobenzoyl-benzoic acid. In every case the reaction with toluene takes place in the position para to the methyl group.

Bromphthalic Anhydrides with Benzene and Aluminium Chloride

By H. N. STEPHENS, B.A.

Presented by PROFESSOR F. B. ALLAN, F.R.S.C.

Improved methods of preparing bromphthalic anhydrides were worked out and the reaction with benzene and aluminium chloride gave good yields in each case but 3-bromphthalic anhydride gave only one acid product. When acetic anhydride was added in this reaction the 4-bromphthalic anhydride gave two diphenyl-bromphthalides but the 3-bromphthalic anhydride gave only a trace of one diphenyl-bromphthalide.

The Effect of Certain Chemicals on the Rate of Reproduction of Yeast

By N. A. CLARK, B.S.A.

Presented by PROFESSOR W. LASH MILLER, F.R.S.C.

Measurements have been made of the rate of reproduction of yeast in malt wort to which had been added varying amounts of alcohol, acetone, phenol, methyl-green, ammonium fluoride, sodium bicarbonate, acetic acid, or hydrochloric acid. In each series the concentration of the substance added was increased until reproduction ceased entirely. The effect of adding malt infusion in varying amounts to artificial media was also studied.

The Behaviour of Yeast with Methyl-Green

By W. B. LEAF, B.Sc.

Presented by PROFESSOR W. LASH MILLER, F.R.S.C.

If yeast be planted in wort containing methyl-green it may or may not reproduce, depending on the amount of yeast used and on the concentration of the green. If seeded to a count of 100 (100 × 250,000 cells per c.c.) in wort containing 0.167% methyl-green no reproduction takes place; if left in the solution for more than 100 hours the cells will still form colonies on wort-agar, but will not form colonies on wort-agar containing 0.005% methyl-green—a medium on which untreated yeast grows freely. The relation between the duration of "sickening" in the 0.167% green, and the time required to cause active fermentation in pure wort, has been studied; also the behaviour of the "sickened" yeast with phenol, the acclimatization of yeast to methyl-green, and its reversion when grown in pure wort.

The Scattering of Light; Note on Wolski's Paper on Optically Empty Liquids

By PROFESSOR F. B. KENRICK, F.R.S.C.

In *Kolloidchemische Beihefte, 13*, 137 (1920) P. Wolski describes experiments in which he filters water and other liquids through collodion filters and thus obtains liquids which show no bright specks under the ultramicroscope. In expressing these results, however, he uses language which is capable of a very different interpretation from that which is justified by his experiments. He says that "the water had become completely optically empty" and (in his final conclusions) "therefore the light specks and scattering phenomena observed up to the present time result from the presence of a foreign substance." In view of these statements it seems necessary once more to make clear that, as found by Martin (1913), the motes in a liquid may be removed by several different methods: distillation without ebullition, cataphoresis, envelopment, and no doubt, also by filtration through collodion, but that there still remains a light-scattering which is constant in intensity irrespective of the method of purification.

The following experiments are, I think, conclusive. Water, freed from motes by distillation without ebullition, was passed through a flattened capillary under the ultra-microcsope. From the dimensions of the field of view, the depth of focus and the speed of the motes, it was easy to determine roughly the number of motes per cubic centimetre. Ordinary distilled water showed about 20,000. Wolski found 29,000, so it is evident that he and I are looking at the same thing. The light scattering of this water was 0.7 (benzene = 1). After two distillations the number of motes was about 1,000 and the scattering 0.12; after eight distillations no particles were seen and the scattering was 0.07. These results show that distillation removes the ultra-microscopic particles just as Wolski's filter does, but that the liquid still scatters light as was shown in 1913.

The Pressure-Volume Relations of Superheated Liquids

By K. L. Wismer

Presented by Professor F. B. Kenrick, F.R.S.C.

Unusual conditions were imposed on these experiments by the fact that under extreme superheating liquids can be kept for only a few seconds before explosion takes place. Bulbs of the liquid were first heated to about 170° at a pressure of 30 atmospheres (a treatment which favoured subsequent superheating) and were then transferred to another thermostat at the temperature to be investigated, say 130°. The pressure was then suddenly lowered and in the brief interval of time before explosion took place the pressure and the position of a mercury meniscus outside the thermostat were noted. Manipulation of the bulb was made possible by the use of a long flexible capillary glass tube to connect it with the manometer and pressure machine.

The pressure-volume relations were determined for liquid ether at 121°, 128° and 134° for pressures from above 30 atmospheres to as low as 1 atmosphere. Similar measurements were made with ethyl chloride at 99°, 110° and 117°. In both cases the p-v curve is almost a straight line and shows no sign of more rapid curving as the limit of superheating is reached although in both cases the temperatures reached at atmospheric pressure are much above the maximum temperatures possible, calculated from van der Waals' equation.

The Scattering of Light by Dust-free Liquids, II

By W. H. Martin, M.A.

Presented by Professor F. B. Kenrick, F.R.S.C.

The accuracy of the measurements of intensity and polarization of the light scattered by various liquids has been increased by the use of cross-shaped containers with sealed-in, flat, glass end-plates. Measurements of light scattered by two-component liquid solutions show that the relative intensity of the scattered light is always somewhat greater than that calculated on the assumption that the light is an additive property for the two liquids. Liquids which polarize the scattered light very far from completely show, on dilution, much more nearly complete polarization.

Measurements of the ratio of the intensity of incident light to that of scattered light have been made for liquids. The results show that liquids scatter from about one-tenth to one-fifth as much light as do the same weights of the liquids in the gaseous state.

Redetermination of the Melting-point of Sodium Chloride

By Professor J. B. Ferguson

Presented by Professor W. Lash Miller, F.R.S.C.

In connection with the calibration of a platinum, platinum-rhodium thermocouple the melting-points of zinc, antimony, silver-copper eutectic, sodium chloride, silver, and copper were determined. All were found in good agreement with the accepted values except sodium chloride. Samples of the pure salt from various sources gave melting and freezing points within a few microvolts of each other; a White potentiometer with eliminating switch was used, the position of the junction in the melt was varied, and all the usual precautions were taken. There seems little room for doubt that the accepted value $801° \pm 1°$ is at least one degree too low.

The Passage of Hydrogen and Helium through Silica Tubes

By PROFESSOR J. B. FERGUSON and G. A. WILLIAMS, B.S.

Presented by PROFESSOR W. LASH MILLER, F.R.S.C.

The rate at which hydrogen passes through transparent (not devitrified) silica-glass tubes at 440°C is 1.5×10^{-4} c.c. (0°,760mm.) per hour per sq. cm., the external pressure being one atmosphere and the internal pressure a few hundredths of a mm. At 628°C, 5×10^{-4} c.c., and at 727°C, 8×10^{-4} c.c. For external pressures of 0.5 to one atmosphere the rate is proportional to the pressure difference; for 0.25 atm. the rate is somewhat greater than this relation would lead one to expect. Pyrex glass and (German) combustion tubing were impermeable; the pyrex blackened. Helium at 632°C diffused through the silica-glass at least five times as rapidly as hydrogen. Air does not pass at temperatures up to 800°C and pressures up to one atmosphere.

Researches Carried out in the Chemical Laboratory of the University of Toronto during the Session 1920-1921

Presented by PROFESSOR W. LASH MILLER, F.R.S.C.

(1) *The Intermediate Compounds in the Reaction between Phthalic Anhydride, Benzene and Aluminium Chloride and their Use in the Synthesis of Mixed Phthalides.*

By T. C. MCMULLEN, B.A.

One of these intermediate compounds has been isolated and analyzed. It is almost impossible to get this intermediate compound pure and it is very easily hydrolysed but the analyses approximate to the formula: $C_{14}H_9O_3Al_2Cl_5$ after prolonged drying in the vacuum oven.

This intermediate compound may be used either for the preparation of benzoyl-benzoic acid or for the preparation of diphenylphthalide and if a different hydrocarbon is used with the intermediate compound a mixed phthalide is formed as, for example, phenyl tolylphthalide. Several of these mixed phthalides have already been obtained. (Under direction of PROFESSOR F. B. ALLAN)

(2) *The Reaction of Naphthalic Anhydride with Benzene and Aluminium Chloride*

By F. Lorriman

Naphthalic acid was prepared by the oxidation of acenaphthene. It was found that the anhydride is much more easily obtained by the sublimation of the acid than by any of the methods described in the literature. The product of the reaction of the anhydride with benzene and aluminium chloride is hard to free from aluminium compounds. It has been purified although its formula has not yet been determined.

(Under direction of Professor F. B. Allan)

(3) *Carbmethoxy-benzoyl Chlorides with Aluminium Chloride and Various Aromatic Hydrocarbons*

By M. E. Smith, B.A.

Isophthalic acid and terephthalic acid have been prepared in some quantity from commercial xylene and separated by the different solubilities of the barium salts. The acids were further purified by the preparation of their esters. The three carbmethoxy-benzoyl chlorides were prepared from the monomethyl esters of the three phthalic acids.

These Friedel and Crafts' reactions have given better methods of preparing m-benzoyl-benzoic acid, p-benzoyl-benzoic acid, p-toluyl-p-benzoic acid and 2, 4-dimethyl-benozoyl-o-benzoic acid. The following new compounds have been obtained: p-toluyl-m-benzoic acid, 2, 4-dimethyl-benzoyl-m-benzoic acid, 2, 4-dimethyl-benzoyl-p-benzoic acid and several of their derivatives.

(Under direction of Professor F. B. Allan)

(4) *The Action of Ammonium Fluoride on Yeast in Presence of Agar-agar*

By Miss I. L. Roberts, B.A.

Addition of agar in quantities insufficient to cause "setting" has little influence on the behaviour of yeast in solutions of ammonium fluoride in wort; concentrations of ammonium fluoride, however, which, if dissolved in wort, would have very little effect on yeast, will completely prevent reproduction if contained in the wort-agar plate.

Under direction of Professor W. Lash Miller

(5) *The Effect of Various Substances on the "Bunching" of Yeast*

By F. I. Eldon

Many substances when added to wort cause the yeast to grow in clumps or bunches instead of single cells or chains of two or three. Among these are: ammonium chloride, ammonium nitrate, ammonium fluoride, ammonia, methyl-green, methyl-ethyl ketone 1%, ethyl ether $\frac{1}{3}$%, carbon tetrachloride 0.5%, isoamyl alcohol 1%, normal butyl alcohol 1%, carbon bisulphide 1%. By means of the last two bunches of 50-200 cells may be obtained in from 24 to 48 hours. The stock yeast used averaged about 2.5 cells per chain; addition of 1% or 3% acetone reduced this to 1.9 or 1.7 respectively, with more than 5% acetone the bunching was above normal. Phenol behaves like acetone, but the effect is not so marked.

(Under direction of Professor W. Lash Miller)

(6) *The Effect on the Growth of Yeast of an Unknown Constituent of Malt*

By G. H. W. Lucas

Yeast grows much more readily in malt infusion than in the best of the "artificial" media made up of sugar, salts and water; addition of even one per cent. of the malt infusion to the artificial medium is readily noticeable. It has been found possible to concentrate this unknown constituent by removing the accompanying substances, and it is hoped that it may shortly be isolated.

(Under direction of Professor W. Lash Miller)

(7) *A Study of the Extent to which Liquids may be Superheated and of the Conditions under which Superheating is Possible*

By C. S. Gilbert, B.S.

The highest temperatures to which various liquids have been superheated at atmospheric pressure in open capillary tubes are given below, with the vapour pressures corresponding to these temperatures, the boiling points and association-coefficients:

Liquid	Highest temp.	Vapour pressure	Boiling point	Association coefficient
Ethyl ether	143	11,500 mm.	35°	1
Ethyl alcohol	201	22,700	78	2.7
Methyl alcohol	180	20,100	66	3.4
Chloroform	173	11,000	61	1
Acetone	174	14,400	56	1.3
Carbon bisulphide	168	11,700	46	1
Water	270	41,200	100	2.3 to 3.8
Sulphur dioxide	50	6,300	10	1
Benzene	203	11,200	79	1
Chlorobenzene	250	8,300	132	
Bromobenzene	261	6,100	156	
Aniline	262		183	
m-Xylene	235		137	

A calculation of the amount of vapour in a bubble whose pressure caused by surface tension would balance the above vapour pressures leads to quantities about a hundred times greater than correspond to the ordinarily accepted molecular dimensions. It is noteworthy that liquids which can be heated to temperatures corresponding to abnormally high vapour pressures are those which are abnormal in having high association coefficients.

Many rather indefinite results were also obtained which point to the presence of nuclei both in the walls of the tubes and also in the liquids themselves which initiate ebullition.

(Under direction of PROFESSOR F. B. KENRICK)

(8) *Solubility of Crystal Faces; an Investigation of the Equilibrium Between Various Crystal Faces and Solution, with Special Reference to Cubic and Octahedral Sodium Chloride.*

By E. G. HAAS, B.S. and J. W. RUSSELL

Practically all evidence for difference in solubility of different crystal forms of the same substance is based on determinations of the rate of solution. In the present research an attempt is being made to obtain direct evidence of difference in solubility which is independent of rate measurements. Three ways are being tried to settle whether a crystal is growing or dissolving: (1) Observation of concentration streams, indicated by movement of suspended particles seen through a microscope, (2) attaching floats to a crystal so as to adjust its weight to that of the displaced liquid, and observing whether it goes up or down; (3) direct weighing of the crystal. The vessels are kept airtight, the stirrers passing through mercury seals. Up to the present, with one exception, only ambiguous results have been obtained. The following is definite but requires confirmation; a solution of sodium chloride was obtained at 28.15° in which in 52 hours a cube gained 0.0046 g and an octahedron alongside it lost 0.0014 g.

(Under direction of PROFESSOR F. B. KENRICK)

(9) *The Dehydration of Spencerite, a Basic Phosphate of Zinc*

By J. W. REBBECK, B.A.Sc.

Attempts were made to measure the vapour tension of Spencerite, $Zn_3(PO_4)_3.Zn(OH)_2.3H_2O$, at temperatures between 75° and 200°C. Equilibrium if attained was attained very slowly; calcium chloride acts as a catalyser; at 125°C the vapour tension is at least 126 cm. Microscopic examination by Professor T. L. Walker identified two dehydration products, viz: $Zn_3(PO_4)_2.Zn(OH)_2$ and $Zn_3(PO_4)_2.ZnO$, the first of which has the composition but not the optical properties of Tarbuttite. The vapour tension quoted above is that of a mixture of Spencerite and the pseudo-Tarbuttite.

(Under direction of PROFESSOR J. B. FERGUSON)

(10) *The Equilibrium between Hydrogen, Steam, and the Oxides of Iron*

By D. M. FINDLAY, R. M. ROBERTSON and H. G. NOBLE

Experiments in which gases of known composition were passed over iron and its oxides in a silica-glass tube heated electrically to 750°C. The composition of the gas in equilibrium with ferrous oxide is approximately that given by Chaudron. The existence of solid solutions between FeO and the magnetic oxide has been established, and the existence of solid solutions for a limited range in the neighbourhood of pure iron seems probable. There are, however, no solid solutions approaching FeO in composition on the iron side.

(Under direction of PROFESSOR J. B. FERGUSON)

(11) *Quantitative Study of the Electrolysis of Sodium Sulphide and Sodium Hydrogen Sulphide solutions*

By W. R. Fetzer, M.A.

An analtyical method was devised for determining the various sulphur salts that may occur in solution together with sodium sulphide. When the current density is not too high, considering the concentration of the solution and the amount of stirring, polysulphide alone is formed at the anode in sodium sulphide solutions, 16.0 g of sulphur being liberated per faraday; at higher current densities sulphates are formed and the amount of polysulphide falls off. When the acid sulphide is electrolysed hydrogen sulphide and polysulphide are formed: their amounts under various conditions were determined.

(Under direction of Professor W. Lash Miller)

(12) *Study of Automatic Current Regulation in Electric Furnaces*

By J. Kelleher and E. R. Westman

Continuation of the work published by J. K. in *Trans. Am. Electrochem. Soc.*

(13) *Recovery of Precious Metals from the Anode Slimes in Nickel Refining*

By H. W. Powell

Anode slimes, from which most of the nickel and copper had been removed by treatment with sulphuric acid, were roasted in oxygen at 650°C and then in hydrogen at the same temperature in a small rotary electric tube furnace with continuous feed (about 4 oz. per hour). All copper, nickel, silver, and palladium could be dissolved from the roast by leaching at 70°C with a solution containing one vol. nitric acid, one vol. sulphuric acid, and 12 vols. water.

(Under direction of Professor J. T. Burt-Gerrans)

(14) *The Alkali Treatment of Storage Battery Separators*

By J. H. Ratcliffe

The separators (sheets of wood, $6 \times 6 \times 5/32$ inches) were boiled for 27 hours in a 2.5% solution of caustic soda and samples removed every hour. The maximum permeability of the wood to salt solutions was reached on boiling for 3 to 4 hours, after which it decreased. The loss of weight of the wood, and the loss of caustic from the solution reached a maximum on boiling for 5 to 7 hours, after which it remained constant. The following is the order of permeability, after treatment, of the woods tested; the numbers are proportional to the diffusion constants: Basswood 63, B.C. cypress 45, poplar 35, elm 33, southern cypress 29, B.C. cedar 24, Port Orford cedar 24. Elm is much the strongest mechanically of the woods examined.

(Under direction of Professor J. T. Burt-Gerrans)

(15) *The Use of Glycerine in Making up Battery Plates*

By W. D. Stalker

Negatives.—A dry mixture of litharge with one per cent. lamp black (graphitized carbon is not so good) was worked to a paste with a solution containing water 66%, sulphuric acid 17%, glycerine 17%, by volume; about 11 c.c. liquid to 70 g powder. This was pasted on automobile grids of the lattice type, $4.75 \times 2.5 \times 0.125$ inches, and dried at room temperature for five days between wooden boards under pressure. The plates were then formed for 24 hours with 0.25 amp., which sulphated them badly; this was followed by 39 hours at 0.5 amp. The negatives so formed showed complete conversion (voltage against cadmium); their current efficiency—viz., the ratio of ampere-hours output (8 hours to fall from 2.1 to 1.8 volts measured on open circuit) to input (under the same conditions)—was 76%; and their weight was 91.5 g. per ampere hour. When they were made in the same way without glycerine the efficiency was 82% but the weight was 233 g. per ampere hour.

Positives.—A mixture of red lead 75%, litharge 25%, and lamp-black 0.3% was pasted with the same glycerine acid solution (about 12 c.c. liquid to 65 g. dry mixture). The plates were dried in air for 17 days, but no change in weight occurred after the fifth day. They were formed for 24 hours with 0.25 amp. (badly sulphated) followed by higher currents (mostly one ampere) for 36 hours. Their efficiency was 80% and weight 293 g. per ampere hour. Without glycerine the efficiency was 76% and weight 521 g.

(Under direction of PROFESSOR J. T. BURT-GERRANS)

(16) *The Preparation of Boron Carbide from Boric Acid and Carbon in the Electric Furnace*

By J. M. LOGAN

Boric acid was mixed in different proportions with graphite, charcoal, or electrode carbon and heated to different temperatures (measured with the pyrometer) from 800°C to 1,800°C, in closed carbon tubes or plumbago crucibles, by means of a granular carbon resistor electric furnace; some runs were made in the Moissan arc furnace. In the product boron was determined as loss when heated with chlorine in a combustion tube, carbon by burning the residue in oxygen, ash as the final residue; iron was determined in a separate sample. The best results were obtained by two hours heating at temperatures exceeding 1,800°C in crucibles turned from 4 inch carbon electrodes covered with a lid of the same material threaded on and luted with a mixture of powdered coke and sodium silicate. Crystals of the same form were obtained whether carbon or boric acid was present to an excess of 25%.

(Under direction of PROFESSOR J. T. BURT-GERRANS)

(17) *A Method for the Rapid and Accurate Estimation of Copper in White Alloys and Babbit Metals*

By E. W. MCHENRY

High grade babbits (low in lead) are dissolved in 10 c.c. conc. hydrochloric acid (for one gram metal) with addition on 25 c.c. tartaric acid solution (30 g. to 100 c.c.) and as little nitric acid as is needed to effect solution. The solution is diluted to 55 c.c., cooled, and after addition of 30 c.c. ammonia (0.880) cooled again, and titrated very slowly (about four minutes) with standard potassium cyanide solution (about 5 g. per litre.) The potassium cyanide solution must be standardized by means of a babbit whose content of copper has been determined gravimetrically. With low grade babbits use a larger sample and filter off the lead chloride before adding the ammonia.

(Under direction of PROFESSOR L. J. ROGERS)

(18) *A Rapid Method for Determining Nitrate in Chili Nitre*

By MISS J. I. LANE

In the technical analysis of Chili nitre, insoluble matter, moisture, and chlorides are determined directly, and the nitrates by difference. Devarda's direct method for nitrates is based on reduction to ammonia by a special alloy; though accurate, this method is slow, it involves the use of special apparatus and a comparatively small sample. In the new method 2.5 g. of the Chili nitre is heated to 110°C in an electric oven with 50 c.c. of twice normal sulphuric acid; the loss of acidity gives nitrates and chlorides, the latter of which is determined directly.

(Under direction of PROFESSOR L. J. ROGERS)

(19) *The Rapid Determination of Arsenic in Mispickel and Smaltites*

By PROFESSOR L. J. ROGERS and J. E. CLARKE, B.A.Sc.

Dissolve a sample containing about 0.2 g. arsenic in a mixture of 10 c.c. conc. nitric acid and 10 c.c. conc. hydrochloric acid; dilute to 100 c.c., add 2 g. tartaric acid dissolved in water, and then 5 c.c. saturated solution of microcosmic salt. Then add magnesia mixture and ammonia in excess, in the usual manner; this precipitates both arsenic and phosphorus. Allow to stand two hours, filter, wash with dilute ammonia and once with water. Add precipitate and paper to 70 c.c. hydrochloric acid (1:1), cool, add 3 g. potassium iodide (dissolved in water to 6 c.c.) swirl one minute, add 70 c.c. distilled water and titrate at once with thiosulphate. Standardize the thio by pure arsenious acid, using the same method.

The Vertical Movement of "Alkali" under Irrigation in Heavy Clay Soils

By FRANK T. SHUTT, D.Sc., and ALICE H. BURWASH, B.A.

(Read May Meeting, 1921)

In the examination of the soils of Southern Alberta—a work undertaken to obtain the chemical and physical data necessary to a satisfactory classification of the areas involved into irrigable and non-irrigable tracts —several important problems have arisen, the solution of which would have a distinct and direct bearing on the decision respecting the advisability of releasing the land for cultivation under irrigation.

One of the most urgent of these problems as affecting the possibility of rise of alkali under irrigation is the determination, upon the application of water, of the movement, its direction and rate, of alkali in a heavy clay subsoil, the surface soil to a depth of say 15″ to 18″ being essentially free from soluble saline matter. An opportunity to study this question and collate useful data thereon was offered by the soil conditions existing over certain large areas on the C.P.R. Demonstration Farm at Tilley, Sec. 24, Tp. 17, Rge. 13, West of the 4th Meridian, Alberta. Speaking broadly, the conditions referred to are a heavy, stiff, almost impervious, clay loam, free from all save traces of saline matter, of good quality but difficult to work and drain. The surface soil overlies a subsoil of an extremely heavy and impervious character which carries a notable saline content. In the zone 0′.5 to 1′.5 the alkali reaches a notable but not excessive concentration and materially increases to a depth of 5 feet, marking the lowest point at which samples were taken.

The "alkali" found is essentially sodium sulphate, with small percentages of magnesium sulphate, the whole being associated with comparatively large amounts of calcium sulphate. Chlorides and carbonates of the alkalies are practically absent.

For the purpose of this study soil groups consisting of four members each, viz., A−0′.0−0′.5, B−0′.5−1′.5, C−1′.5−3′.0 and D.−3′.0−5′.0 were taken by means of a soil auger. Groups were collected in two plots, under various croppings, the first series being taken in 1916, irrigation water having been applied for the first time in 1915. Successive group samples from the two points selected were obtained in 1917, 1918, 1919 and 1920 and their saline content determined. The analyses of 1920 (Group 1585) indicate, therefore, the position and nature of the saline content of the area to a depth of five feet after six seasons' irrigation of approximately 1½ acre feet annually. Analyses of the water-soluble saline content of the soils from Plot I and Plot II are detailed in the following tables; the results obviously indicate the movement of the alkali from year to year.

PLOT I.—WATER-SOLUBLE SALINE CONTENT EXPRESSED IN PERCENTAGES ON AIR-DRIED SOIL.

Crops.—1916, Wheat: 1917 and 1918, Western Rye Grass, Timothy and Brome: 1919, White Clover: 1920, Mixed Grasses and Clover.

Group No.		Total Solids after ignition	CaO	MgO	Na_2O	SO_3	CO_2
1209	A	.200	.034	.001	.107	.058	.032
	B	.520	.052	.051	.162	.235	.048
(1916)	C	4.840	1.156	.387	.454	2.855	.030
	D	4.048	.942	.266	.453	2.301	.028
1611	A	.160	.020	....	.079	.016	.044
	B	.160	.022	....	.104	.027	.074
(1917)	C	4.672	1.393	.220	.358	2.655	.042
	D	2.400	.501	.159	.350	1.399	.037
1652	A	.200	.040	.023	.070	.033	.044
	B	.184	.060	.029	.068	.028	.065
(1918)	C	.300	.069	.036	.087	.092	.039
	D	1.736	.365	.100	.235	.972	.035
1678	A	.146	.071	.013	.072	.060	.028
	B	.270	.037	.013	.118	.117	.047
(1919)	C	.902	.151	.068	.214	.548	.033
	D	2.036	.384	.141	.340	1.282	.035
1585	A	.130	.013	....	.053	.027	.047
	B	.176	.028	....	.056	.015	.044
(1920)	C	2.800	.728	.197	.276	1.448	.035
	D	4.052	.708	.403	.576	2.127	.032

Plot I.—Briefly considered, the data of this plot indicate that during the five years of the investigation the soil to a depth of 1′.5 (A and B) improved slightly but markedly as regards its saline content. Under the conditions of the experiment irrigation had lowered rather than raised the saline matter of the chief root feeding zone.

With respect to the zones "C" and "D" (1'.5 – 5'.0) the results are somewhat erratic, showing considerable fluctuation from year to year. No marked diminution occurred in "C" (1'.5 – 3'.0) in 1917 but in "D" (3'.0 – 5'.0) there was a reduction of 2% in the total saline matter. In 1918 the saline content of both "C" and "D" was very materially lower. In 1919, and to a still greater degree in 1920, the results indicate an increase in the concentration of saline matter in both "C" and "D", though in "C" it did not reach the percentage present in 1916. It is very doubtful if these movements are to be attributed to irrigation, for field notes made on an examination immediately following an irrigation indicate that the water had not penetrated below 1'.5.

PLOT II.—WATER-SOLUBLE SALINE CONTENT EXPRESSED IN PERCENTAGES ON AIR-DRIED SOIL.

Crops.—1916, Clover: 1917, Alfalfa: 1918, Wheat and Alfalfa: 1919, Pasture: 1920, Barley, Clover and Alfalfa.

Group No.		Total Solids after Ignition	CaO	MgO	Na_2O	SO_3	CO_2
1210	A	.160	.031	.014	.087	.033	.039
	B	.152	.034	.013	.087	.023	.053
(1916)	C	3.420	.811	.222	.326	1.916	.032
	D	3.676	.918	.252	.423	2.060	.032
1612	A	.300	.049	.025	.095	.119	.065
	B	2.140	.492	.167	.191	1.243	.037
(1917)	C	2.948	.643	.232	.390	1.696	.030
	D	2.920	.665	.217	.358	1.683	.030
1651	A	.152	.025	.015	.082	.025	.039
	B	.208	.031	.032	.103	.026	.079
(1918)	C	4.668	1.277	.391	.349	2.562	.039
	D	2.072	.374	.177	.349	1.168	.026
1679	A	.166	.061	.017	.058	.054	.032
	B	.140	.042	.038	.053	.044	.044
(1919)	C	.904	.305	.058	.089	.519	.034
	D	3.206	1.049	.145	.182	1.837	.032
1586	A	.184	.031	.018	.096	.029	.029
	B	.208	.100	.018	.109	.072	.053
(1920)	C	4.038	1.411	.137	.226	2.289	.029
	D	1.944	.462	.137	.337	1.036	.025

Plot II.—The saline content of the zone 0′.0 – 1′.5 (A and B) is fairly constant throughout the period of investigation with the exception of that for the season 1917. The evidence at the conclusion of five years' irrigation is quite favourable indicating as in Plot I that there has been no appreciable increase of alkali in the soil to a depth of 1′.5. The reason for the comparatively high alkali content of 1917 is not apparent; it may be the result of a rise of alkali following irrigation but more probably may be explained by a slight error in locating the point of collection.

The alkali content of the zones "C" and "D" varies considerably from season to season; there is no general trend. It is impossible to advance any satisfactory reason to account for these results; they may be due to a number of factors. Our impression is that the several determinations represent original impregnations and that the apparent fluctuations are not the result of the movement of soil moisture.

As publication in the proceedings of the Society this year necessitates the presentation of material in the briefest form possible the detailed field notes are omitted. It may, however, be stated that each plot received three irrigations during the season and that at no time during the whole five years of the investigation was there any surface indications of alkali.

Throughout the whole period of observation the crops on both plots were fair to good, with the exception of that on Plot II in 1917 which showed signs of distress evidently from alkali. At the conclusion of this work, and after six years' irrigation, the crops of the season 1920 were found to be excellent, with no signs of injury from alkali. These observations confirm what has been shown by the analytical work, that irrigation, under the conditions of the experiment, had not caused any appreciable rise of alkali. Notwithstanding a close almost impervious subsoil strongly impregnated with alkali, it would seem possible that an area of heavy clay may be safely irrigated for a number of years, provided that at the outset the surface soil is free from alkali and that provision is made for the removal of surplus water by surface drains and ditches.

Notes on the Nature of Burn-outs

By FRANK T. SHUTT, D.Sc., and ALICE H. BURWASH, B.A.

(Read May Meeting, 1921)

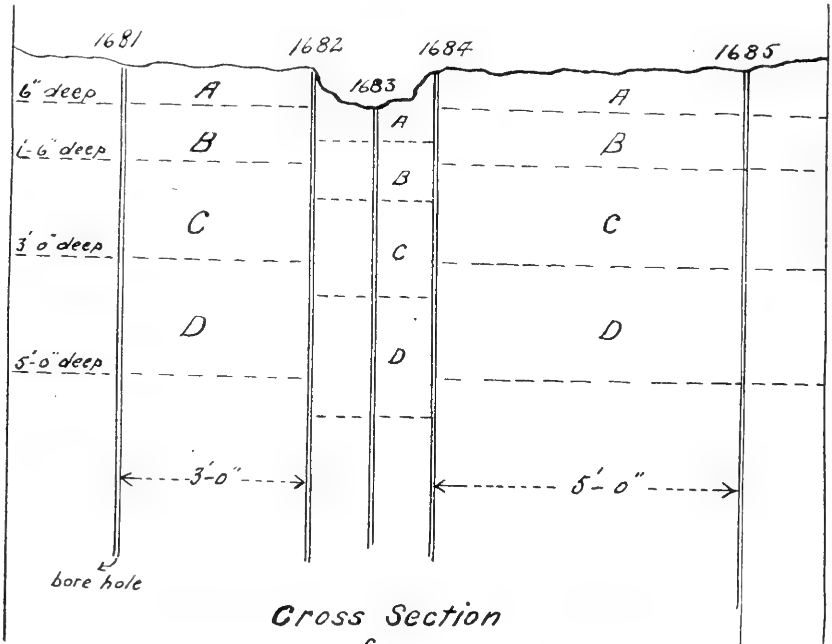
The prairie surface of certain areas in the western provinces, and more particularly in Southern Alberta and South-Western Saskatchewan, is characterized by irregular but roughly circular depressions or eroded spots varying from 3 to 6 inches in depth and from a few inches to several or many feet in diameter. These depressions, pockets or eroded spots are commonly known as "burn-outs". They may be few or many in a given area; in the latter case the prairie takes on a peculiar pitted or pock-marked appearance. When these burn-outs are numerous or large they may leave—presuming they are eroded areas—but a small percentage of the original unaffected virgin surface soil and the question then arises, how will such an area, when put under cultivation, compare in respect to fertility with land broken from similar prairie but free from burn-outs? [1] From their occurrence and appearance there seems little doubt but that burn-outs are spots that have lost, from one reason or another, the fertile surface soil, and this assumption is borne out by the fact that they carry no vegetation save cacti, in districts in which the surrounding prairie is well grassed. The soil of a burn-out for the first few inches is usually extremely hard and so impervious that after water has been standing on the spot for several days the soil beneath the first few inches is still hard and dry. After breaking for cultivation this burn-out soil apparently becomes as pervious as the soil or subsoil of the adjacent area.

To settle this question as to the nature of burn-outs is a matter of some considerable agricultural importance. While it is true that the marked difference prevailing in humid districts between surface soil and subsoil, in respect to nature and fertility, is not as apparent in soils under semi-arid conditions, yet it is obvious that if an area has lost, say 50 per cent of its surface soils rich in humus and nitrogen —the distinguishing features of a fertile loam—it must, for some years after "breaking," be inferior as compared with an adjacent area free from burn-outs.

The burn-out selected for this investigation, and which may be considered typical, is situated a few hundred feet north of the Govern-

[1]It has been estimated that in Southern Saskatchewan alone there are 652,800 acres so affected. ("Problems of the Burn-out District of Southern Saskatchewan.") J. Stanfield, Trans. Roy. Soc. of Canada, 1919. Field engineers who have made surveys in both provinces state that the affected area of Southern Alberta is very much larger than that of Southern Saskatchewan.

ment Demonstration Farm, Brooks, Alberta. Five groups of soil samples were collected, each group consisting of four members, as follows: A—0′.0—0′.5, B—0′.5—1′.5, C—1′.5—3′.0, and D—3′.0—5′.0. The location of the groups in respect to the burn-out is shown in the accompanying diagram, all the points of collection being in the one straight line.



Cross Section
of
Burn-out and adjacent land.

"A".—The surface soil in groups 1681 and 1682 is a dark grey-brown loam, containing much medium and fine sand but with clay characteristics predominating; fairly well supplied with semi-decomposed vegetable organic matter. In groups 1684 and 1685, on the opposite side of the burn-out, the proportion of clay to sand is much the same as in groups 1681 and 1682 but is characterized by a much higher organic content.

This member ("A") of the group 1683, taken in the centre of the burn-out, offered several points of contrast when compared with "A" of the unaffected adjacent area, but chiefly differed in its much lower organic content, giving it the quality and appearance of a subsoil.

"B," the soil representing a depth between 0′.5 and 1′.5, for 1681 and 1682 is a light grey clay with a considerable proportion of fine and medium sand; fairly porous, indicating possibilities of good drainage. It has an appreciable organic content, as is generally found in subsoils in semi-arid districts.

In 1684 and 1685 "B," as regards its mineral constituents and physical properties, is similar to the corresponding member in 1681 and 1682 but is slightly higher in organic matter following the richer surface soil "A."

In the burn-out group 1683 "B" does not differ markedly in physical characters from "A" in the same group, a mixture of clay and fine sand with the former predominating.

"C" and "D" throughout the whole five groups are quite uniform in character. They are silty clay, with a larger proportion of silt in D than in C. Both possess a small amount of fine or medium sand.

A partial analysis was made of the air-dried soils, obtaining the results given in the following table.

PARTIAL ANALYSIS OF AIR-DRIED SOILS.

Group No.		Moisture	Loss on Ignition	Nitrogen	Mineral Matter	
					Soluble in Acid	Insoluble in Acid
1681	A	1.380	6.320	.2884	6.195	86.105
	B	2.905	3.405	.1363	9.690	84.000
	C	1.410	5.080	.0871	17.980	75.530
	D	1.825	3.745	.0871	19.530	74.900
1682	A	1.030	5.930	.2564	6.210	86.830
	B	1.965	3.220	.1329	6.725	88.090
	C	2.650	5.075	.0977	12.085	80.190
	D	2.655	5.175	.0871	14.595	77.675
1683	A	3.530	4.800	.1931	6.570	85.100
	B	4.305	3.605	.0977	8.580	83.510
	C	3.000	7.695	.0835	15.240	74.065
	D	2.095	6.615	.0743	11.345	79.945
1684	A	2.660	10.750	4.095	7.070	79.520
	B	2.845	5.120	.1825	6.445	85.590
	C	2.070	3.590	.1120	5.460	88.880
	D	3.175	6.900	.0693	13.140	76.780
1685	A	4.800	13.090	.5247	5.785	76.325
	B	1.705	5.400	.1999	5.150	87.745
	C	2.485	3.235	.1155	4.730	89.550
	D	2.390	4.510	.0871	2.700	90.400

The chief differences from the chemical point of view between surface soil and its subsoil are the higher percentages of nitrogen and organic matter in the former; this well-established fact may be legitimately used as a diagnostic factor in the consideration of the present problem.

An inspection of the data of the foregoing table shows that the nitrogen content of 1683 "A" is decidedly less than that of "A" in any of the other groups; it is but little higher than that of "B" of 1681 and 1682 and almost identical with that of "B" of 1684 and 1685. The evidence, in our opinion, is satisfactory as indicating that the burn-out represents an area from which the surface soil has been removed.

The surface soil of the area represented by Groups 1684 and 1685 is somewhat richer in organic matter and its concomitant nitrogen than that represented by Groups 1681 and 1682, and we consequently find that "B" and "C" of the former groups (1684 and 1685) possess higher percentages of these constituents than 1681 and 1682. In "D" throughout the whole five groups the nitrogen content approaches the same figure.

In accordance with our practice in the examination of soils from irrigable areas the water-soluble content of these samples was determined. Groups 1683, 1684 and 1685 were found entirely free from alkali. Group 1682 is free to a depth of 3 feet; in D (3′.0–5′.0) a small percentage of soluble matter which proved to be calcium sulphate was observed. As in the other groups, "A" of 1681 contains no saline matter, "B," "C" and "D" of this Group, however, show a notable but not serious impregnation, which is chiefly sulphate of soda. In "D" there is a marked percentage of calcium sulphate, a characteristic feature of certain subsoils in Southern Alberta.

When these burn-outs are large, say several feet in diameter, it is noticed that, for a few years after breaking, the crops upon them are lighter than those on the surrounding unaffected soil. This disparity tends to disappear with a few years' tillage, a fact which is in accord with our observation that the subsoils of semi-arid areas are rich in available plant food and, as compared with those of humid districts, are more or less readily brought into a condition of economic productiveness.

The Oiliness or Lubricating Properties of the Various Series of Hydrocarbons

Preliminary Report by W. F. SEYER

Presented by PROFESSOR E. H. ARCHIBALD,

(Read May Meeting, 1921)

It has long been a matter of speculation as to which series of hydrocarbons possesses the property of lubrication or oiliness to the greatest degree. It has been maintained by some authorities that these properties are due to unsaturation. This view is to a certain extent supported by the fact that the paraffin hydrocarbon C_nH_{2n+2} series do not make good lubricating oils. The chief constituents of lubricating oils belong to the series C_nH_{2n}, C_nH_{2n-2} and C_nH_{2n-4}. It is obvious that these series may represent either the saturated naphthene or oelfin hydrocarbons. The majority of lubricating oils contain both series, as their iodine number indicates. It was with a view to decide which of these series of hydrocarbons possesses the property of oiliness or lubrication to the greatest degree that the following work was done.

As a preliminary investigation it seemed well to first determine the difference that existed in regard to this property between the saturated and unsaturated constituents of a mineral lubricating oil. For this purpose a sample of lubricating oil was obtained from the B.C. Refining Co. This had been distilled from a California crude asphaltic base petroleum. Approximately 400 c.c. of this oil, in a separatory funnel, was treated repeatedly with 50 c.c. of liquid sulphur dioxide. At a temperature of −10°C two layers formed, the lower one consisting of a solution of the unsaturated hydrocarbons in the liquid sulphur dioxide. This treatment was continued until the lower or sulphur dioxide layer had only a slight colour after shaking. After the separation of the saturated and unsaturated constituents in this way the sulphur dioxide was removed by blowing carbon dioxide through the oil. To insure complete removal the oil fractions were washed several times with an alkaline solution, then with water, and finally dried.

The coefficient of friction of the two oils was then determined by means of an Olsen friction machine. The following readings taken over a period of one hour will show the general agreement of the results for the individual oil and the extent to which the two oils differ, as indicated by the reading on the weighing arm of the machine.

TABLE I

Readings on Weighing Arm of Friction Machine at Five Minute Intervals

Saturated Oil	Unsaturated Oil
10.0	6.8
9.5	6.5
10.0	6.50
10.0	6.50
10.05	6.55
10.03	6.52
10.05	6.55
10.05	6.70
10.00	6.50
10.05	6.50
10.01	6.60

Load......................................700 lbs.
Temperature..............................33-34°C
Revolutions per minute....................400
Time......................................1 hr.

The averages obtained for a large number of such runs were as follows:

AVERAGE OF READINGS ON WEIGHING	UNSATURATED	SATURATED
Arm..............................	6.5 lbs.	10.0 lbs.
Coefficient..........................	.009	.014
Specific viscosity at 35°.............	3	2.8

It was thus seen that with this particular oil the unsaturated constituent possesses the greatest lubricating property. However, as the friction varies directly with the viscosity and as the viscosity of the unsaturated portion is greater than the saturated, the real difference is still greater. This difference can be calculated from the usual formula $X = \frac{V}{P}\frac{K}{Y} = \frac{F}{P}$

Where X = coefficient of friction
F = force to *move the bearing*
P = *Load on the bearing*
V = velocity
K = coefficient of viscosity
Y = thickness of the oil film.

Thus the coefficient of friction of an unsaturated oil having the same viscosity as the saturated would be $\frac{X_1}{X_2} = \frac{K_2}{K_1}$ or 0.0076, which is almost twice that of the other.

It was noticed that the unsaturated oil, after having gone through the machine once, had become turbid and upon standing a considerable sediment of carbon was obtained. The saturated oil, on the other hand, showed no deposit of carbon. The decomposition of the former must have been due entirely to the pressure as the temperature never rose above 35°C.

The above results indicate that the coefficient of friction is not independent of the chemical nature of the oil. Ubbelohe,[1] on the other hand, has shown experimentally that under the same mechanical conditions, oils with the same specific viscosity have the same coefficient of friction. His results are probably due to the fact that the oils which he used were similar in chemical composition, for it is obvious that one may have many liquids with the same viscosity as lubricating oils yet have a very high coefficient of friction.

In the derivation of the above formula, $X = \frac{V}{P}\frac{K^*}{Y}$ two assumptions are made, one that V varies directly as K. This has been shown by Lacsher to be correct between certain limits. The second is that Y, the thickness of the film, is always constant and that, therefore, there is always a perfect oil film formed. The results obtained in this experiment would seem to show that oils differ in their film forming properties, the unsaturated oil forming a better one than the saturated, thereby reducing the friction. Another fact which proves that the oil film is never perfect is that journals and bearings do wear out. Thus to make the above formula agree more closely with the facts some correcting factor should be introduced expressing the film forming properties or chemical nature of the oil. In the hopes of determining the nature of this factor the investigation of the relative film forming or lubricating properties of the various series of hydrocarbons is being undertaken.

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[1]Petrol, 7, 773, 882, 938. (1912.)

* Where V, P, and Y are constant.

The Thermal Evolution of Gases Absorbed by Charcoals and Carbonized Lignites

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Early experiments on the absorption of gases by charcoal showed that the phenomenon obeyed the following equation:

$$X_t = A . P_t^{\frac{1}{n}}$$

where X_t is the amount of gas absorbed per gram of charcoal at temperature t, P_t is the pressure of the surrounding gas when equilibrium is attained at temperature t, and A and n are constants for a given temperature but are functions of the temperature.

The above expression agrees very approximately with experimental results over the range of ordinary pressures.

If the pressure is kept constant and the temperature varied the adsorption is represented according to Titoff[1] by the equation

$$\log X_t = \log X_o - (a - b \log P) . t.$$

where X_t and X_o are values of X at temperatures t and $0°C$,

a equals $\frac{d}{dt}(\log A)$ and b equals $\frac{d}{dt}\left(\frac{1}{n}\right)$.

Several theories have been put forward to account for the process of adsorption:

(1) *Chemical Combination.*—In order to explain the production of the large amount of heat during adsorption it was suggested that chemical combination takes place, with the consequent production of carbon monoxide and dioxide.

(2) *Solid Solution.*—This theory which contemplates the actual penetration of the gas into the charcoal, the concentration being constant throughout the whole mass of the charcoal, was accepted by Miss Homfray[2] as being most consistent with her results.

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[1] Titoff: Zs. f. phys. Chem. 74, 1910, p. 641.
[2] Miss Homfray: Zs. f. phys. Chem. 74, 1910, p. 641.

(3) *Surface Condensation.*—The third theory is that the gas is condensed upon the surface of the charcoal. Early experiments showed that under similar conditions those gases that are more easily liquefied were adsorbed to a greater extent. Thus the investigators were led to consider the adsorbed gas as having been condensed by the charcoal. This theory accounts for the large amount of gas adsorbed in a small quantity of charcoal better than the two given above.

There are two other theories which have been put forward which are only modifications of the above theories. The first was proposed by McBain[3] in 1909. His experiments on the adsorption of hydrogen by charcoal showed that two processes take place. The gas is first condensed on the surface of the charcoal. This takes a very short time for its completion; at the most, two or three minutes. He termed this process "adsorption." At the same time the gas is diffusing into the interior of the charcoal forming a solid solution. This requires a much longer time for its completion, about twenty-four hours or more. He called this process "absorption," and proposed the term "sorption" to be used when considering the two processes together.

A recent theory suggested by Langmuir is in many respects an elaboration of two of the theories given above. According to Langmuir, a molecule of gas approaching the surface of a solid comes into the field of force of those atoms near it, and, in general, these gas molecules condense on the surface, no matter what the temperature may be. At the same time evaporation comes into play, the amount of evaporation being dependent on the temperature.

Adsorption is the direct consequence of the time lag between the condensation and the subsequent evaporation of the molecules. The adsorbed layer, according to Langmuir, does not exceed one molecule in thickness, or at the most, a few molecules. In order to account for the large amount of gas adsorbed by charcoal and other solids he assumes that such porous bodies present a much larger surface to the gas than is apparent.

Heat of Absorption

Saussure, in 1814, was the first to observe that heat is evolved during the process of adsorption of gases by charcoal. Quantitative measurements have been made by Chappuis, Dewar and Titoff.

[3] McBain: Phil. Mag. 18, 1909, p. 916.

Dewar's work was performed with the charcoal at the temperature of liquid air and Titoff's at 0°C.

Chappuis and Titoff observed that the first portion of the gas to be adsorbed always evolved more heat than subsequent additions. Applying the second law of thermodynamics Titoff found that

$$\frac{d}{dt}(\log P) = \frac{Q}{1.985\,T^2}(\log X)$$

where P is the pressure of the gas in equilibrium with a certain adsorbed quantity X, T, the temperature, and Q, the quantity of heat evolved if a gram molecule of the gas were adsorbed at the pressure P. Therefore if Q were constant and if log P were plotted against log X at different temperatures, the curves so obtained for two different temperatures should be equidistant from one another for all values of X or P. But if Q is not constant, but greater for lower than for higher values of X, as is usually the case, then the curves ought to be further apart for lower values of X than for higher. Titoff found this to be the case.

The object of the experiments to be described below was to measure the heat developed when a number of gases were adsorbed by different samples of charcoals and carbonized lignites and to account for it.

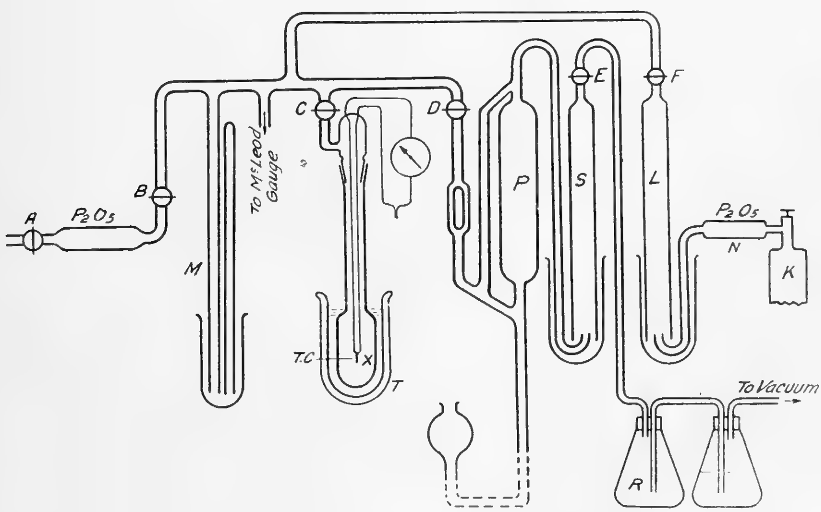


Fig 1

A diagram of the apparatus is shown in Fig. 1. The sample of charcoal or lignite was placed in tube *X*. Around this was placed a large silvered thermos vessel *T* containing a known quantity of water, which was used as a calorimeter. The gas used was taken from *K* which is a gas cylinder or other gas reservoir. It was carefully dried by phosphorous pentoxide at *N* and admitted to the apparatus at *L*. The manometer *M* registers the pressure and indicates the progress of the adsorption. In all those experiments the equilibrium pressure was the atmospheric pressure. The heat effect was always completed thirty minutes after the experiment was started and each experiment was allowed that time for the adsorption to take place. At the completion of the adsorption the gas was pumped out of the apparatus by means of the Töpler pump *P* into the graduated tube *S* to be measured. If required it could then be collected over water in the bottle *R* for subsequent analysis.

The heat developed during the experiment was measured by the rise in temperature of the water in the calorimeter. The water equivalent of the calorimeter was found by inserting a small electrical resistance coil and comparing the heat measured electrically with that measured by the calorimeter.

After the adsorption was completed the calorimeter was left in the same position surrounding the sample tube. As the gas is pumped out of the charcoal it passes through the reverse process to that when the adsorption was taking place. A corresponding cooling of the sample tube is then observed which would be a measure of the heat due to the compression of the gas in the tube *X* and its condensation on the surface of the sample contained in it.

But in the case of air and oxygen chemical action will probably take place. In order to obtain a measure of the heat due to this source the gas pumped out was collected in bottles over water. It was then made to bubble slowly through a solution of caustic potash to take out any carbon dioxide that it might contain. The amount of carbon dioxide was obtained by finding the increase in weight of the solution after the gas had passed through it.

The remaining gas was then passed through a tube containing iodic anhydride at about 100 C°. Here any carbon monoxide that it might contain is oxidized according to the reaction:

$$I_2 0_5 + 5CO = I_2 + 5CO_2 .$$

The iodine is absorbed by a solution of silver nitrate. The carbon dioxide thus formed is subsequently absorbed as before and the amount measured will give the amount of carbon monoxide that has been formed.

Now, knowing the heat of formation of carbon dioxide and of carbon monoxide, the heat due to their formation may be determined. This, then, would complete the analysis of the heat of adsorption.

The following samples have been tested:

No.1.—Carbonized Lignite (26.4059 gms.) obtained from the Department of Mines, Ottawa.
No. 2.—Cocoanut Charcoal (26.6947 gms.).
No. 3.—Commercial Wood Charcoal (13.8772 gms.).
No. 4.—Activated Charcoal (24.1542 gms.). This charcoal is made by exposing the raw material to high pressure steam at about 1000°C. It was obtained from the National Lamp Works, Cleveland, Ohio.
No. 5.—Lignite Carbonized at 350°C. (14.9400 gms.).
No. 6.—Lignite Carbonized at 450°C. (15.7534 gms.).
No. 7.—Lignite Carbonized at 550°C. (14.9581 gms.).
No. 8.—Cocoanut Charcoal (28.6883 gms.).

The gases used were air, oxygen, nitrogen and carbon dioxide.

In the following experiments T is the approximate rise in temperature of the sample when the gas is first admitted to the apparatus, X is the amount of gas adsorbed by the sample in c.c.'s $N.T.P.$ Tests for CO and CO_2 were not made in the early experiments. Temperatures were read correctly to a tenth of a degree. In all the experiments the samples of absorbent were allowed to become saturated with gas, then the gas was pumped off, and the process repeated time and time again.

EXPERIMENT 1. Sample No. 1. Carbonized Lignite (26.4 gms.). Gas used: Air.

	t	Gas adsorbed	Total Heat	Heat per gram sample	Heat per c.c. gas adsorbed
	°C	c.c. N.P.T.	Calories	Calories	Calories
1	6.0	201.9	180.1	6.8	0.88
2	6.0	166.1	124.7	4.8	0.75
3	6.0	163.1	160.7	6.1	0.98

EXPERIMENT 2. Sample No. 1. Gas used: Nitrogen.

	T	Gas adsorbed	Total Heat	Heat per gram sample	Heat per c.c. gas adsorbed
	°C	c.c. N.P.T.	Calories	Calories	Calories
1	1.2	195.5	41.6	1.6	0.21
2	2.2	198.5	41.6	1.6	0.21

EXPERIMENT 3. Sample No. 1. Gas used: Oxygen

In each of these experiments the gas was pumped off in two stages: the first with the sample at room temperature and the second after the sample had been heated to a certain temperature. Care was taken to keep this temperature the same for all experiments. The gas collected in the two stages was separately examined for CO. Sample No. 1 was heated to 475°C.

	T	Gas adsorbed	Heat per gas sample	Heat per c. c.gas	Total Heat	1st test for CO_2	2nd test for CO_2	Heat due to CO_2	Difference from total
	°C	c.c. N.P.T.	Calories	Calories	Calories	c.c. N.P.T.	c.c. N.P.T.	Calories	Calories
1	168.0	479.7	121.7	6.7	3199.4	......	......	......	......
2	196.0	532.5	127.4	6.3	3351.8	......	......	......	......
3	168.0	451.9	121.2	7.1	3188.3	188.0	......	822.2	2366.1
4	216.0	327.3	87.5	7.1	2338.1	25.9	28.6	235.1	2103.0
5	231.0	334.0	84.5	6.7	2256.3	31.9	54.9	379.3	1877.0

EXPERIMRNT 4. Sample No. 1. Gas used: Carbon dioxide

	T	Gas adsorbed	Total Heat	Heat per gram sam ple	Heat per c.c. gas adsorbed	Latent Heat of Vap. of gas adsorbed
	°C	c.c. N.P.T.	Calories	Calories	Calories	Calories
1	18.5	565.9	415.8	15.8	0.73	34.0
2	16.8	447.1	327.0	12.4	0.73	26.8
3	19.5	468.5	326.9	12.4	0.69	28.1
4	19.0	474.2	318.6	12.1	0.67	28.5

EXPERIMENT 5. Sample No. 2. Cocoanut Charcoal (26.7 gms.). Gas used: Air. Sample heated to 475°C.

	T	Gas adsorbed	Heat per gm. sample	Heat per c.c. gas	Total Heat	1st test for CO_2	2nd test for CO_2	Heat due to CO_2	Heat of adsorption	Heat of accounted for	Heat not accounted for
	°C	c.c. N.P.T.	Calories	Calories	Calories	c.c. N.P.T.	c.c. N.P.T.	Calories	Calories	Calories	Calories
1	8.0	200.3	5.2	0.69	139.0	4.6	0.0	20.4	46.3	66.7	72.3
2	8.0	218.0	5.6	0.69	150.5	2.6	0.0	11.1	46.3	57.4	93.1

EXPERIMENT 6. Sample No. 2. Gas used: Oxygen.

	T	Gas adsorbed	Heat per gm. sample	Heat per c.c. gas	Total Heat	Heat of adsorption	Test for CO_2	Heat due to CO_2	Test for CO	Heat due to CO	Heat accounted for	Heat not accounted for
	°C	c.c. N.P.T.	Calories	Calories	Calories	Calories	c.c. N.P.	Calories	c.c. N.P.T.	Calories	Calories	Calories
1	11.2	306.9	14.5	1.2	387.8	....	16.2	71.2	....	....	71.2	....
2	11.2	291.8	12.4	1.1	332.4	....	9.9	43.6	....	....	43.6	....
3	6.0	190.4	6.9	0.97	185.3	46.3	4.7	20.6	....	....	66.9	118.4
4	6.0	163.1	5.9	0.96	158.2	22.6	1.4	6.2	....	....	28.8	129.4
5	6.0	160.1	5.1	0.84	135.6	45.2	5.8	25.7	....	....	70.9	64.7
6	8.0	162.4	4.2	0.69	113.0	55.5	13.1	57.3	....	....	112.8	0.2
7	4.5	178.4	4.7	0.69	124.3	32.9	14.0	61.5	....	....	94.4	29.9
8	4.5	185.7	4.7	0.66	124.3	45.2	13.2	57.5	....	....	102.7	21.6
9	2.5	164.7	6.3	1.03	169.5	45.2	8.4	36.7	....	....	81.9	87.6
10	4.5	169.4	5.1	0.80	135.6	22.6	3.1	13.7	2.8	3.7	40.0	95.6
11	2.5	165.3	3.4	0.55	90.4	45.2	1.1	4.9	2.0	2.6	52.7	37.7
12	2.5	154.0	3.8	0.66	101.7	49.7	0.6	2.4	1.0	1.9	54.0	47.7
13	2.5	153.3	3.8	0.66	101.7	32.9	0.0	0.0	2.2	2.8	35.7	66.0
14	3.5	156.2	2.5	0.43	67.8	45.2	7.8	34.3	1.1	1.4	80.9	—13.1
15	2.2	150.1	3.4	0.60	90.4	45.2	9.6	41.4	3.7	4.8	91.4	— 1.0
16	2.5	159.5	2.6	0.43	67.8	55.5	7.9	34.5	7.9	10.3	101.3	—33.5
17	2.5	157.4	2.9	0.50	79.1	45.2	1.9	8.4	1.7	2.3	55.9	23.2
18	2.2	147.6	2.9	0.54	79.1	22.6	11.3	49.5	3.7	4.8	76.9	2.2

The above readings were taken over a period of fifteen weeks. They show that the amount of gas adsorbed by the sample is large at first but it steadily diminishes as the experiment is repeated and becomes constant. This is also true of the amount of heat developed per gram of charcoal.

EXPERIMENT 7. Sample No. 3. Wood Charcoal (13.9 gms.). Gas used: Oxygen. Sample heated to 475°C.

	T	Gas adsorbed	Heat per gm. sample	Heat per c.c. gas	Total Heat	Heat of adsorption	Test for CO_2	Heat due to CO_2	Test for CO	Heat due to CO	Heat accounted for	Heat not accounted for
	°C	c.c. N.P.T.	Calories	Calories	Calories	Calories	c.c. N.P.T.	Calories	c.c. N.P.T.	Calories	Calories	Calories
1	23.0	147.1	10.8	1.02	150.5	22.9	12.1	53.1	....	....	76.0	74.5
2	23.0	131.5	13.2	1.39	183.4	22.9	17.1	74.7	....	...	97.6	85.8
3	26.0	108.0	14.0	1.80	194.9	22.9	17.3	75.6	....	...	98.5	96.4
4	19.0	90.4	11.7	1.79	162.0	0.0	12.5	54.8	....	...	54.8	107.2
5	14.0	97.0	9.0	1.30	126.1	11.5	9.0	40.0	....	...	51.5	74.6
6	12.0	96.3	9.0	1.31	126.1	11.5	7.4	32.5	....	...	44.0	82.1
7	14.0	73.8	7.4	1.39	103.2	22.9	5.0	21.9	....	...	44.8	58.4
8	8.5	89.1	7.7	1.21	107.8	22.9	4.3	19.0	....	...	41.9	65.9
9	11.0	89.8	7.4	1.15	103.2	11.5	0.0	0.0	1.9	2.6	14.1	89.1
10	12.0	80.1	7.4	1.29	103.2	22.9	6.1	26.5	3.4	4.5	53.9	49.3
11	6.5	80.3	7.4	1.28	103.2	22.9	6.8	29.9	1.1	1.5	54.3	48.9

EXPERIMENT 8. Sample No. 4. Activated Charcoal (24.2 gms.). Gas used: Oxygen. Sample heated to 475°C.

	T	Gas adsorbed	Heat per gm. sample	Heat per c.c. gas	Total Heat	Heat of adsorption	Test for CO_2	Heat due to CO_2	Test for CO	Heat due to CO	Heat accounted for	Heat not accounted for
	°C	c.c. N.P.T.	Calories	Calories	Calories	Calories	c.c. N.P.T.	Calories	c.c. N.P.T.	Calories	Calories	Calories
1	2.0	188.8	1.9	0.24	45.9	34.4	4.7	20.7	2.7	3.5	58.6	12.7
2	2.0	198.7	2.4	0.29	57.3	22.9	6.3	27.4	3.1	3.9	54.3	3.0
3	2.0	187.8	1.9	0.24	45.9	45.9	3.3	14.6	1.1	1.4	61.9	—16.0
4	2.0	192.4	1.9	0.24	45.9	45.9	....	....	....	....	45.9	0.0

EXPERIMENT 9. Sample No. 5. Lignite carbonized at 350°C. Gas used: Air. Sample heated to 350°C.

	Gas adsorbed	Heat per gm. sample	Heat per c.c. gas	Total Heat	Heat of adsorption	Test for CO_2	Heat due to CO_2	Test for CO	Heat due to CO	Heat accounted for	Heat not accounted for
	c.c. N.P.T.	Calories	Calories	Calories	Calories	c.c. N.P.T.	Calories	c.c. N.P.T.	Calories	Calories	Calories
1	21.1	0.7	0.54	11.5	11.5	3.5	15.5	0.4	0.4	27.4	—15.9
2	19.2	3.1	2.6	50.4	0.0	0.3	1.1	0.7	0.9	2.0	48.4
3	27.7	2.9	1.7	45.8	11.5	2.6	11.3	1.3	1.6	24.4	21.4

EXPERIMENT 10. Sample No. 5. Gas used: Oxygen.

	Gas adsorbed	Heat per gm. sample	Heat per c.c. gas	Total Heat	Heat of adsorption	Testfor CO_2	Heat due to CO_2	Test for CO	Heat due to CO	Heat accounted for	Heat not accounted for
	c.c. N.P.T.	Calories	Calories	Calories	Calories	c.c. N.P.T.	Calories	c.c. N.P.T.	Calories	calories	Calories
1	17.4	8.6	7.9	137.4	11.5	0.0	0.0	2.5	3.3	14.8	122.6
2	18.9	8.6	7.3	137.4	11.5	4.8	20.8	4.6	5.9	38.2	99.2
3	21.9	7.9	5.7	126.0	11.5	3.2	13.9	0.9	1.1	26.5	99.5
4	23.0	7.2	4.9	114.5	0.0	1.9	8.2	0.0	0.0	8.2	106.3

EXPERIMENT 11. Sample No. 5. Gas used: Carbon dioxide.

	Gas adsorbed	Heat per gm. sample	Heat per c.c. gas	Total Heat	Heat of adsorption	Latent Heat	Heat accounted for	Heat not accounted for
	c.c. N.P.T.	Calorie	Calories	Calories	Calories	Calories	Calories	Calories
1	127.7	6.5	0.81	103.1	57.3	8.0	57.3	45.8
2	135.4	6.5	0.76	103.1	80.2	8.1	80.2	22.9
3	157.3	5.7	0.56	91.6	68.7	9.4	68.7	22.9

EXPERIMENT 12. Sample No. 6. Lignite carbonized at 450°C. Gas used: Air. Sample heated to 450°C.

	Gas adsorbed	Heat per gm. sample	Heat per c.c. gas	Total Heat	Heat of adsorption	Test for CO_2	Heat due to CO_2	Test for CO	Heat due to CO	Heat accounted for	Heat not accounted for
	c.c. N.P.T.	Calories	Calories	Calories	Calories	c.c. N.P.T.	Calories	c.c. N.P.T.	Calories	Calories	Calories
1	35.9	2.2	0.96	34.5	11.3	4.8	21.2	1.2	1.5	34.0	0.5
2	40.1	4.3	1.70	67.8	22.6	3.4	15.0	0.0	0.0	37.6	30.2

EXPERIMENT 13. Sample No. 6. Gas used: Oxygen.

	Gas adsorbed	Heat per gm. sample	Heat per c.c. gas	Total Heat	Heat of adsorption	Test for CO_2	Heat due to CO_2	Test for CO	Heat due to CO	Heat accounted for	Heat not accounted for
	c.c. N.P.T.	Colaries	Colaries	Colaries	Colaries	c.c. N.P.T.	Calories	c.c. N.P.T.	Calories	Calories	Calories
1	49.4	16.5	5.3	259.9	22.6	12.2	53.3	0.0	0.0	75.9	184.0
2	44.3	18.6	6.6	293.8	22.6	7.3	31.8	6.8	8.8	63.2	230.6
3	46.0	15.0	5.2	237.3	11.3	10.7	46.7	2.3	2.8	60.8	176.5
4	44.2	15.0	5.4	237.3	11.3	5.5	24.3	6.4	8.3	43.9	193.4

EXPERIMENT 14. Sample No. 6. Gas used: Carbon dioxide.

	Gas adsorbed	Heat per gm. sample	Heat per c.c. gas	Total Heat	Heat of adsorption	Latent heat of gas adsorbed	Heat accounted for	Heat not accounted for
	c.c. N.P.T.	Calories	Calories	Calories	Calories	Calories	Calories	Calories
1	143.4	10.1	1.1	158.2	158.2	8.6	158.2	0.0
2	250.1	8.6	0.54	135.6	135.6	15.0	135.6	0.0
3	256.4	8.8	0.55	140.1	140.1	15.4	140.1	0.0

EXPERIMENT 15. Sample No. 7. Lignite carbonized at 550°C. Gas used: Air. Sample heated to 550°C.

	Gas adsorbed	Heat per gm. sample	Heat per c.c. gas	Total Heat	Heat of adsorption	Test for CO_2	Heat due to CO_2	Test for CO	Heat due to CO	Heat accounted for	Heat not accounted for
	c.c. N.P.T.	Calories	Calories	Calories	Calories	c.c. N.P.T.	Calories	c.c. N.P.T.	Calories	Calories	Calories
1	82.0	6.7	1.2	101.7	22.6	33.3	145.5	0.5	0.6	168.7	—67.0
2	65.5	6.0	1.4	90.4	9.0	33.9	148.6	0.5	0.6	158.2	—67.8

EXPERIMENT 16. Sample No. 7. Gas used: Oxygen.

	Gas adsorbed	Heat per gm. sample	Heat per c.c. gas	Total Heat	Heat of adsorption	Test for CO_2	Heat due to CO_2	Test for CO	Heat due to CO	Heat accounted for	Heat not accounted for
	c.c. N.P.T.	Calories	Calories	Calories	Calories	c.c. N.P.T.	Calories	c.c. N.P.T.	Calories	Calories	Calories
1	66.2	22.4	5.1	339.0	22.6	33.1	144.6	7.0	9.0	176.2	162.8
2	80.6	14.3	2.6	214.7	22.6	44.7	195.7	6.0	7.8	226.1	— 11.4
3	72.4	15.1	3.1	226.0	22.6	26.3	115.0	6.0	7.8	145.4	80.6

EXPERIMENT 17. Sample No. 7. Gas used: Carbon dioxide.

	T	Gas adsorbed	Heat per gm. sample	Heat per c.c. gas	Total Heat	Heat of adsorption	Latent Heat	Heat accounted for	Heat not accounted for
	°C	c.c. N.P.T.	Calories	Calories	Calories	Calories	Calories	Calories	Calories
1	20	168.8	12.1	1.1	180.8	90.4	10.1	90.4	90.4
2	20	300.9	12.1	0.6	180.8	100.7	18.0	100.7	80.1
3	20	265.9	10.5	0.6	158.2	158.2	16.0	158.2	0.0

EXPERIMENT 18. Sample No. 8 Cocoanut Charcoal (28.7 gms.). Gas used: Air. Sample heated to 475°C.

	T	Gas adsorbed	Heat per gm. sample	Heat per c.c. gas	Total Heat	Heat of adsorption	Test fo CO_2	Heat due to CO_2	Test for CO	Heat due to CO	Heat accounted for	Heat not accounted for
	°C	c.c. N.P.T.	Calories	Calories	Calories	Calories	c.c. N.P.T.	Calories	c.c. N.P.T.	Calories	Calories	Calories
1	2.0	200.6	2.4	0.3	68.7	45.8	21.1	92.4	0.0	0.0	138.2	—69.5
2	2.0	195.1	1.9	0.3	57.3	45.8	23.4	102.6	0.7	0.8	149.2	—91.9

EXPERIMENT 19. Sample No. 8. Gas used: Oxygen.

	T	Gas adsorbed	Heat per gm. sample	Heat per c.c. gas	Total Heat	Heat of adsorption	Test for CO_2	Heat due to CO_2	Test for CO	Heat due to CO	Heat accounted for	Heat not accounted for
	°C	c.c. N.P.T.	Calories	Calories	Calories	Calories	c.c. N.P.T.	Calories	c.c. N.P.T.	Calories	Calories	Calories
1	6.0	206.2	1.9	0.3	57.3	57.3	43.3	190.4	0.4	0.5	248.2	—190.9
2	6.0	222.0	1.6	0.2	45.8	45.8	35.5	154.5	3.2	4.0	204.3	—158.51
3	6.0	200.3	1.9	0.3	45.8	45.8	20.3	109.2	1.0	1.4	156.4	— 99.1

EXPERIMENT 20. Sample No. 8. Gas used: Carbon dioxide.

	T	Gas adsorbed	Heat per gm. sample	Heat per c.c. gas	Total Heat	Heat of adsorption	Latent Heat	Heat accounted for	Heat not accounted for
	°C	c.c. N.P.T.	Calories	Calories	Calories	Calories	Calories	Calories	Calories
1	23.0	836.1	11.6	0.4	332.1	332.1	50.2	332.1	0.0
2	23.0	950.7	11.6	0.3	332.1	286.3	57.0	286.3	45.8
3	23.0	781.9	11.7	0.4	355.7	330.6	46.9	330.6	25.1

Summary

1. Of the four gases investigated oxygen develops the largest amount of heat for each cc of gas adsorbed. The above tables show that this is due to the chemical action that takes place between the gas and the adsorbent. Both carbon dioxide and carbon monoxide are formed.

The largest amount of heat evolved per gram of adsorbent takes place when carbon dioxide is used. Since the boiling point of this gas is higher than the others it is more readily adsorbed.

The heat effect for air is much smaller than that for oxygen. Both carbon dioxide and carbon monoxide are formed but to a smaller extent.

These are a contradiction to some of the results given by Miss Homfray. She found only a trace of CO_2 and no CO formed when oxygen is adsorbed by cocoanut charcoal. This must have been due to the fact that she analysed only the last portions of the gas pumped off instead of all the gas as was done in these experiments.

2. In the case of the adsorption of oxygen the amount of gas adsorbed diminishes and becomes constant as the experiment is repeated. This is also true of the heat developed per gram of adsorbent.

3. In the experiments with carbon dioxide the heat developed is not accounted for by the latent heat of vaporization of the amount of gas adsorbed, showing that some other process than condensation is taking place.

4. The coarser kinds of charcoal form carbon dioxide when oxygen is adsorbed more readily than others. They also adsorb more oxygen than the other kinds of charcoal.

The above work was carried out under the direction of Professor E. F. Burton, to whom my thanks are due. I also desire to thank Dr. Stansfield of the Department of Mines, Ottawa, and Dr. Goss of the National Lamp Works, Cleveland, for gifts of material.

A New Vibration Experiment—Cylinders and Rods Balanced on Cylinders

By JOHN SATTERLY, F.R.S.C.

(Read May Meeting, 1921)

At the close of the conference held in the Department of Physics of the University of Toronto in January last, a distinguished chemist and physicist, after looking over the mechanics section of the laboratory and examining the different experiments on vibration, suggested the following experiment as an interesting exercise for the higher students.

I have, therefore, set it up and the following note gives the work that has been done upon it.

The experiment consists in balancing a cylinder at right angles across another cylinder, setting it in up-and-down vibration like a see-saw and finding its time of swing. By using different cylinders a study may be made of the conditions of stability and the factors upon which the time of swing depends.

The figure gives an elevation of the two cylinders looked at in the direction of the axis of the fixed cylinder. MN shows a portion of the balanced cylinder in its horizontal position and M_1N_1 shows it when the cylinder is tilted.

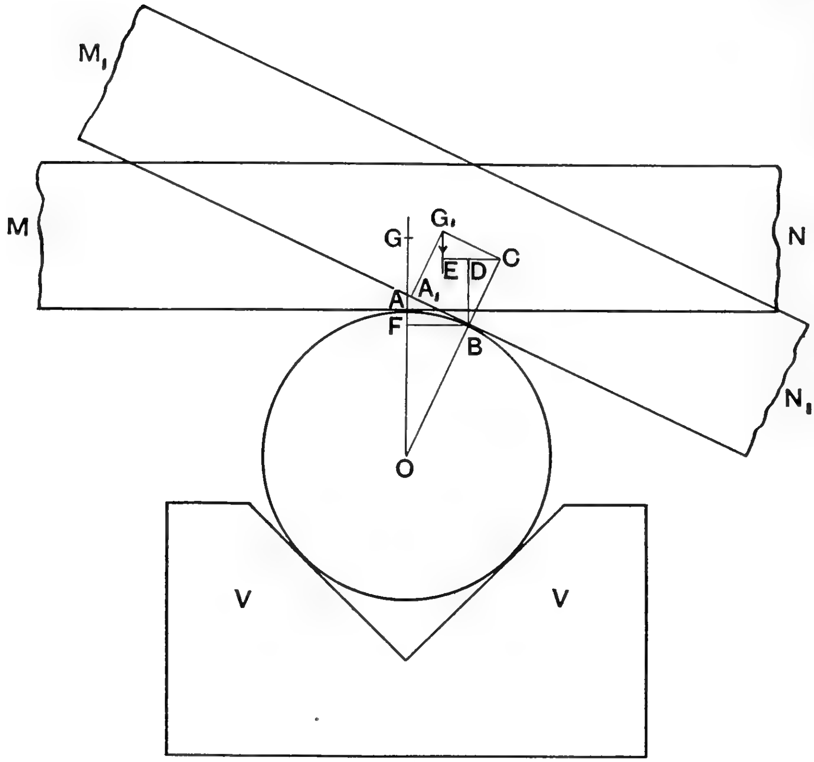
Let O be the centre of the cross-section of the fixed cylinder, G the position of the centre of gravity of the balanced cylinder when in the horizontal position, G_1 the position of the centre of gravity when the balanced cylinder is depressed on one side to make a small angle θ with the horizontal.

To get the position of G_1 let A and B be the points of contact between the cylinders in the two positions. Measure off BA_1 equal to the arc BA and draw A_1G_1 at right angles to and meeting the axis of the cylinder in G_1.

Join OAG. Draw OB to meet the axis of the balancing cylinder in C. Join CG_1. Draw a vertical line BD through B, a vertical line G_1E through G_1, and a horizontal line CDE to cut these verticals in D and E respectively. Draw BF at right angles to OA.

Let a = radius of cross-section of fixed cylinder.

Let m, l, b = mass, length and radius of balancing cylinder.



Let I = moment of inertia of balancing cylinder about an axis through its centre of gravity at right angles to the plane of vibration.

Let I_1 = moment of inertia of balancing cylinder about an axis at right angles to the plane of vibration passing through the point of contact of the two cylinders. I_1 will vary in value as vibration occurs.

Let θ = angle of inclination of balancing cylinder to the horizontal. θ is always small.

Condition of Stability

When the cylinder moves from the horizontal position to the inclined position the point on the balancing cylinder which was in contact with the fixed cylinder at A moves to A_1.

$$\therefore G_1C = A_1B = \text{arc } AB = a\theta.$$

The equilibrium will be stable if the vertical through G_1 lies between A and B. Therefore for stability CE must be greater than CD, *i.e.*, $a\theta \cos\theta$ must be greater than $b \sin\theta$.

$$i.e., \quad \frac{a\theta \cos\theta}{b \sin\theta} \text{ must be } > 1$$

$$\text{or} \quad \frac{a}{b} \text{ must be } > \frac{\tan\theta}{\theta}$$

When θ is very small $\dfrac{\tan\theta}{\theta} = 1$ very nearly. As θ increases $\tan\theta$ increases at a greater rate than θ. For an angle as large as 5°

$$\frac{\tan\theta}{\theta} = \frac{.0875}{.0873} = 1.002.$$

For 10° $$\frac{\tan\theta}{\theta} = \frac{.1763}{.1745} = 1.01$$

so that for all angles that are likely to occur in the experiment $\dfrac{a}{b}$ must be greater than unity or the arrangement will be unstable.

Calculation of the Period of Vibration by the "Force and Moment" Method

The moment of the weight of the balancing cylinder about B $= mg \times DE = mg\ (CE - CD) = mg\ (a\theta \cos\theta - b \sin\theta)$.

Also $I_1 = I + m\ G_1B^2 = I + m\ (b^2 + a^2\ \theta^2)$.

By the ordinary formula in mechanics

$$I_1 \frac{d^2\theta}{dt^2} + mg\ (a\theta \cos\theta - b \sin\theta) = 0$$

whence if the angle θ is so small that squares and higher powers of θ may be neglected we get

$$(I + mb^2) \frac{d^2\theta}{dt^2} + mg\ (a - b)\ \theta = 0$$

whence we see that the motion is simple harmonic and of period

$$T = 2\pi \sqrt{\frac{I + mb^2}{mg\ (a-b)}}. \qquad (1)$$

Calculation of the Period of Vibration by the "Energy" Method

The height of G above $O = a + b$.

Let α = angle of extreme tilt of balancing cylinder. The height of the centre of gravity of balancing cylinder above O is now $OF + BD + EG_1$,

$$i.e., \; a \cos \alpha + b \cos \alpha + a\alpha \sin \alpha,$$

$$\text{or } (a+b) \cos \alpha + a\alpha \sin \alpha.$$

The decrease in potential energy when the tilt has decreased to θ

$$= mg\{(a+b)(\cos \alpha - \cos \theta) + a(\alpha \sin \alpha - \theta \sin \theta)\}.$$

This must be equal to the gain of kinetic energy of the cylinder

i.e. to $$\tfrac{1}{2} I_1 \left(\frac{d\theta}{dt}\right)^2.$$

$$\tfrac{1}{2} I_1 \left(\frac{d\theta}{dt}\right)^2 = mg\{(a+b)(\cos \alpha - \cos \theta) + a(\alpha \sin \alpha - \theta \sin \theta)\}.$$

Differentiating both sides with respect to the time and substituting we get, by neglecting θ^2 and higher powers of θ, and also $\theta \left(\frac{d\theta}{dt}\right)^2$,

$$(I + mb^2) \frac{d^2\theta}{dt^2} + mg(a-b)\theta = 0,$$

whence as before

$$T = 2\pi \sqrt{\frac{I + mb^2}{mg(a-b)}}.$$

Application of the Formula

For a solid cylinder

$$T = 2\pi \sqrt{\frac{\frac{l^2}{12} + \frac{5}{4} b^2}{g(a-b)}}. \tag{2}$$

If a rod of rectangular cross-section is used as a vibrator instead of a cylinder and b is its half depth

$$T = 2\pi \sqrt{\frac{\frac{l^2}{12} + \frac{4}{3} b^2}{g(a-b)}} \tag{3}$$

If b is small in comparison with l the equation reduces in both cases to

$$T = 2\pi \sqrt{\frac{l^2}{12\, g(a-b)}} = 2\pi \sqrt{\frac{l^2}{6\, g(A-B)}} \tag{4}$$

where A and B are the diameters of the cylinders (B = thickness in case of rod), and we see that the period now depends only on the difference between A and B and not on their absolute values.

The same formulæ can be used for tubes having the same l and b as long as b is small in comparison with l.

Deductions

(*1*) For balancing cylinders and rods of the same length $(A-B)T^2$ is a constant.

(*2*) For balancing cylinders and rods having the same B and resting on the same fixed cylinder the period is proportional to the length.

Error Produced by Neglecting the Radius Term in the Numerator of the Formula for the Period

For the cylinder

$$T=2\pi\sqrt{\frac{\frac{l^2}{12}\left(1+\frac{15b^2}{l^2}\right)}{g(a-b)}}$$

$$=2\pi\sqrt{\frac{\frac{l^2}{12}}{g\,(a-b)}}\cdot\left(1+\frac{15b^2}{2l^2}\right) \text{ approximately.}$$

So that if $b \not> \frac{1}{27}\, l$ the error will not exceed one per cent.

Experiment

The experiment has been tried with cylinders of glass, brass and steel and with brass rods. Two brass saddles (see Figure) about 4 cms. high with a V-notch about 1½ cms. wide were made and screwed to the table about 3 to 4 inches apart to receive the fixed cylinder.

The balancing cylinders were then placed in position, set in gentle vibration and timed with a stopwatch. Usually five or ten vibrations were timed and the observations were repeated several times to get a good mean. Individual readings are apt to vary considerably due to roughness at the points of contact. This was very noticeable with the brass cylinders vibrating on a brass cylinder. The steel cylinders were found to be troublesome to keep on the balance, perhaps because they are so smooth.

The diameter of the balancing cylinder must always be less than that of the fixed cylinder in order to get stability.

Results.—(These were taken with about the same degree of precaution that an ordinary student would take in class.)

I.—Glass Rods and Tubes

(A) A set of six inch rods and tubes were first tried.

Diameter of Fixed glass cylinder 1.29 cms.

Balancing Cylinder		$A-B$	Period T	$T^2\ (A-B)$
Length	Diameter			
cms.	cms.	cms.	seconds	
15.25	.47	.82	1.36	1.52
15.25	.65	.64	1.48	1.40
15.25	.80	.49	1.76	1.51
15.25	.85	.44	1.84	1.50
15.25	.97	.32	2.09	1.40
				Mean 1.47

(B) Next a set of three inch glass rods and tubes was tried.

Diameter of Fixed Glass Cylinder 1.29 cms. (Same cylinder as before).

Balancing Cylinder		$A-B$	Period T	$T^2\ (A-B)$
Length	Diameter			
cms.	cms.	cms.	seconds	
7.63	.47	.82	.70	.40
7.65	.61	.68	.72	.35
7.63	.75	.54	.84	.38
7.63	.82	.47	.92	.40
7.63	.98	.31	1.06	.35
				Mean .38

Note

Since $$T=2\pi\sqrt{\frac{\frac{l^2}{6}}{g(A-B)}}$$

$$T^2\ (A-B)=\frac{4\pi^2 l^2}{6g}$$

Therefore $T^2\ (A-B)$ is proportional to l^2.

The long cylinders quoted in A are twice as long as the short cylinders quoted in B and one quarter of 1.47 is nearly .38.

The moments of inertia of the glass cylinders could not be quickly calculated as some were rods and others tubes of different wall thicknesses.

II.—Solid brass cylinders were tried next. They were balanced on a fixed glass cylinder. The results were as follows:

II.—Solid Brass Cylinders

Diameter of Fixed Glass Cylinder 2.51 cms.

Balancing Cylinders		$A-B$	T	$T^2(A-B)$
Length	Diameter			
cms.	cms.	cms.	seconds	
15.3	.47	2.04	.87	1.65
15.3	.63	1.88	.93	1.63
15.3	.79	1.72	.98	1.66
15.3	.95	1.56	1.02	1.66
15.3	1.15	1.36	1.09	1.62
15.3	1.27	1.24	1.16	1.66
				Mean 1.65

Check by calculation for No. 6 of the above table. Substituting in Equation (2) we get

$$T=2\pi\sqrt{\frac{\frac{15.3^2}{12}+\frac{5}{4}(.63)^2}{g\times .62}}=2\pi\sqrt{\frac{9.5+.5}{g\times .62}}=1.13 \text{ sec.}$$

For No. 1 above

$$T=2\pi\sqrt{\frac{\frac{15.3^2}{12}+\frac{5}{4}(.23)^2}{g\times 1.02}}=2\pi\sqrt{\frac{19.5+.06}{g\times 1.02}}=.87 \text{ sec.}$$

Neglecting the $\frac{5b^2}{4}$ correction for the thick cylinder would lower the calculated period about 1 per cent., with the thin cylinder the error is negligible.

III.—Brass Rods were now tried. Breadth of Rods = 1.94 cms. Fixed Glass Cylinder of diameter 2.51 cms. used.

Balancing Rods		$A-B$	T	$T^2 (A-B)$
Length	Thickness B			
cms.	cms.	cms.	seconds	
15.25	.64	1.87	.92	1.58
7.62	.64	1.87	.46	.40

One quarter of 1.58 = .40 nearly.

The experiment is interesting inasmuch as it gives the student an example of a vibrating body with a movable point of support. Its likeness to a see-saw will give it familiarity, and he can now go on to study the effect of loading up the ends and so improving the likeness.

Note added October, 1921,

Just about two months ago the author saw an experiment similar to the above in use in the classes of Dr. G. F. C. Searle at the Cavendish Laboratory, University of Cambridge. Dr. Searle works on a larger scale using a rod about one metre long and one centimetre thick resting on a vertical wheel of diameter about twenty centimetres. The value of g is deduced from the readings. An account of this experiment is given in Searle's "Experimental Harmonic Motion". The author was not aware of Dr. Searle's work when he wrote the above paper. Using the readings for the longer brass rod of the above table in Eq. 4. the value obtained for g is 970 cms. per sec. per sec.

Automatic Mercury Pump

By D. F. STEDMAN

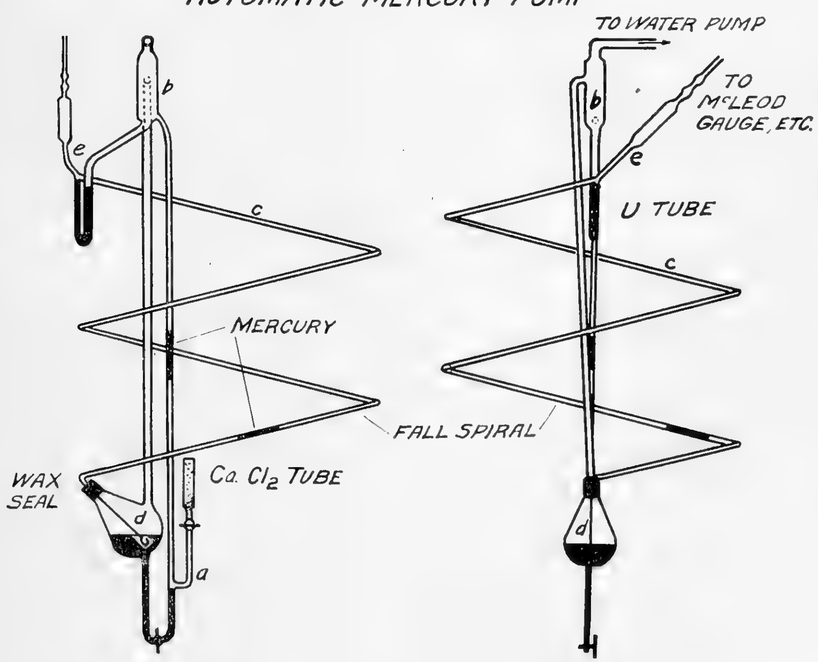
Presented by PROFESSOR E. H. ARCHIBALD, F.R.S.C.

(Read May Meeting, 1921)

This pump was designed primarily to use as small an amount of mercury as possible, and thus have none of the troublesome 76 cm. connections except in the gauge.

The whole pump is operated by an ordinary water pump which should produce a vacuum of at least 1.5–2 cms. of mercury. When a little air enters through "*a*" it breaks the column of mercury here, raises the section to "*b*," and drops it into one side of a U-tube. This displaces mercury on the other side which runs down the spiral fall tube "*c*," pushing the air in front of it through the mercury pool in bulb "*d*." As soon as the mercury is out of the top of tube "*a*" the diminished pressure allows the mercury to rise in tube to level in "*d*" and the process is repeated.

AUTOMATIC MERCURY PUMP



As at present developed several points must be noticed in the construction. The spiral "*c*" should be as smooth as possible, and free from joints, or the mercury will break and let air pass, which will also happen if tube is much steeper than 1:5 (11−½°), or of greater internal diameter than 3 mm. (slope must be rather accurately adjusted as at 10° it may stop, and at 13° it will break at the slightest kink). In constructing the top of fall tube care should be taken to have a rather sharp smooth bend, with connecting tube "*e*" very slightly below highest point. This is necessary as under a vacuum the mercury has a great tendency to break into drops. The drawing represents conditions about as they should be. The capillary "*d*" should be about .5 mm. internal diameter, and should be made by first thickening the fall tube, heating a rather short part of the thickened tube till quite soft, and not drawing out too quickly (to shorten constricting portion and strengthen capillary). The first side of the U-tube should be wide enough to prevent air bubbles being carried over. The length of mercury column carried up in "*a*" does not need to be longer than 4−4.5 cm., using 3 mm. tube; if much longer the shock at the bottom of the spiral will be considerable. There should be a slight constriction at "*a*" (to ½ internal diameter); this makes a slightly greater pressure below it than that represented by the column of mercury being lifted, permitting length of column being regulated by tap at bottom. The bulbs between pump and gauge, etc., prevent mercury being carried over on stopping pump (which should be done by clamping rubber connection to water pump and allowing air to enter slowly through "*a*"). The bottom of fall tube should taper a little before the bend and be quite thin where it enters the wax seal. This construction makes a sudden jet of mercury through capillary which will effectually carry quite a small bubble of air through. (Wax seal is used to permit capillary to be perfectly straight and smooth, which would be difficult if a glass seal were used.)

This pump (spiral 27 cms. high, 18 cm. diameter), when tested with only a McLeod gauge attached (total volume to be evacuated app. 50 c.c.), took ½ hour to reach .001 mm. of mercury and with a 250 c.c. flask attached reached .0008 mm. in 2½ hours, and then stopped pumping, but the flask was connected to the pump with sealing wax, which may have leaked a very little.

I desire to acknowledge my indebtedness to Dr. W. F. Seyer for many helpful suggestions regarding the construction of this pump.

Chemical Laboratory,
University of British Columbia,
Vancouver, B.C.

The Effect of Thermo-luminescence on Electrical Conductivity

By C. A. MACKAY, M.A.

Presented by PROFESSOR H. L. BRONSON, F.R.S.C.

(Read May Meeting, 1921)

Our present knowledge of the physical changes which occur during photo- and thermo-luminescence of solids is very incomplete. In order to arrive at any satisfactory theory as to the nature of this type of luminescence, it is essential that as much data as possible be obtained concerning the variation in the properties of solids when emitting light of this sort.

On the basis of the commonly accepted theories as to the mechanism of photo-luminescence it might be expected that the electrical conductivity of matter is greater during the emission of light than in its normal state. However, it has been shown by Nichols and Merritt[1] that the conductivity of eosin is unchanged when this substance emits fluorescent light, under the action of ultra-violet light.

It was suggested that the writer investigate the electrical conductivity of various substances, which, under suitable conditions, are thermo-luminescent. Three crystals, calcite, fluorite and feldspar, were examined. All showed thermo-luminescence when gently heated over a Bunsen burner.

APPARATUS AND METHOD OF MEASUREMENT

The crystals, after being carefully cleaned with pure alcohol, were mounted as shown in Figure 1. The brass electrodes were cemented to the parallel faces of the crystal by means of a metallic preparation named "Smooth-On."

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[1] Publication 152, Washington Carnegie Institution.

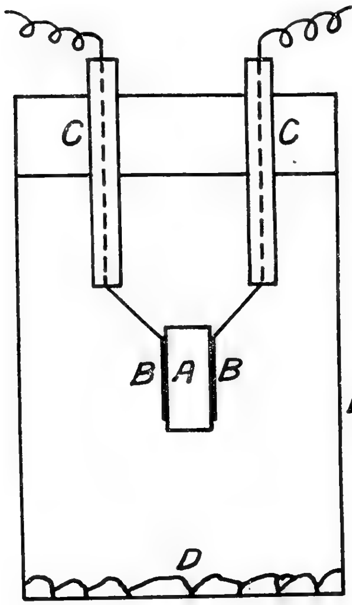


Fig. 1.

A.—Crystal of calcite.
B.—Brass electrodes.
C.—Glass tubes filled with sulphur.
D.—Calcium Chloride.
E.—Tin container.

The currents through the crystals, which varied from 5×10^{-14} to 2.5×10^{-9} amperes, were measured by a Dolazalek electrometer with a subdivided mica condenser in parallel with a pair of quadrants.

To produce luminescence the calcite was cooled to −80°C and then placed in a thermostat at 22°C. In other experiments the change of temperature was from 22°C to 100°C.

Effect of Time and Temperature on Conductivity

During certain preliminary measurements it was noticed that the current gradually decreased after the potential was first applied to the crystal. Table 1 shows a characteristic set of readings.

TABLE 1

Time	No. of secs. per 100 scale divisions T	Current = Const. $\times \frac{1}{T}$
0	74 secs.	.0135 K
6	111 secs.	.0090 K
12	131 secs.	.0076 K
31	147 secs.	.0068 K
61	152 secs.	.0066 K

It is seen that the above effect resembled polarization, but took much longer to reach a maximum. To make sure that this factor was eliminated the potential was applied at least 4 hours before any readings were taken.

Table 2 shows a typical set of readings to show the effect of temperature on the conductivity. The calcite was maintained at each temperature for at least 1½ hours so that any possible effect of thermo-luminescence might disappear.

TABLE 2

Temperature	Current = Const. $\times \frac{1}{T}$
22.8°C	.0061 K
27.5°C	.0110 K
34.7°C	.0210 K
37.5°C	.0284 K
45.4°C	.0680 K

EFFECT OF THERMO-LUMINESCENCE

Table 3 shows the effect of thermo-luminescence on the conductivity of the calcite when it was suddenly heated from −80°C to 22°C.

TABLE 3

Time	No. of secs. per 100 scale division T	Current = Const. $\times \frac{1}{T}$
1	22.0 secs.	.045 K
4	....	....
15	....	....
19	3.0 "	.333 K
31	15.4 "	.065 K
36	18.6 "	.054 K
42	21.0 "	.048 K
55	31.8 "	.031 K
57	32.8 "	.031 K

Values for the second and third readings are not given since T was too small to measure. This data is plotted in Figure 2, curve A. The conductivity increased rapidly to a maximum followed by a gradual decrease until the normal value of the current at 22°C was reached. This variation in current cannot be attributed solely to the temperature effect. Table 3 shows that the magnitude of the increase in the current above the normal value is over 1,000 per cent.

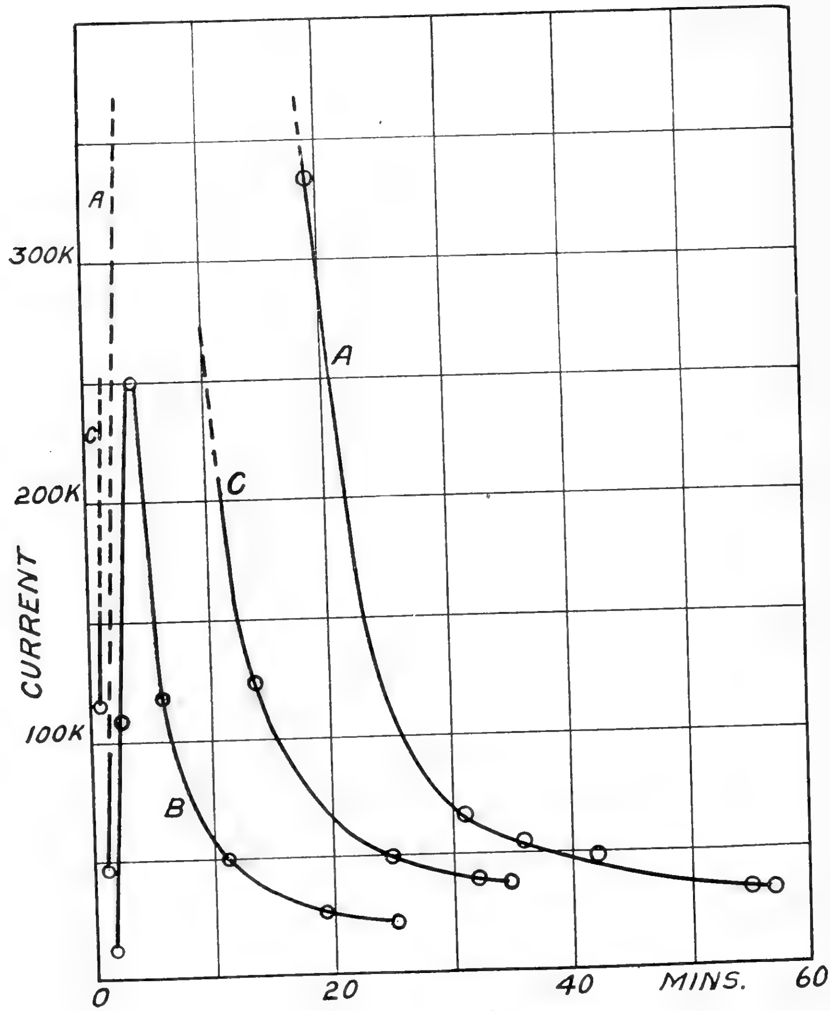


FIG 2

When the whole process was repeated the change in the current was smaller. A third repetition gave a still smaller effect, for which the data is plotted in Curve B, Fig. 2. Since the change in conductivity depends on the thermo-luminescence, the latter effect must also have decreased.

The same procedure was used for the higher range of temperature 22°C to 100°C. Suitable precautions were taken to keep the crystal and insulation dry. The results were similar to those obtained previously, but it was noticed that successive excitations decreased the thermo-luminescence more quickly at the higher temperatures than at the lower.

Effect of X-rays

It is known that exposure to X-rays will restore the property of luminescence.[1] A preliminary trial of the effect of X-rays was made on a small piece of calcite. It was heated over a Bunsen burner until no luminescence could be detected by the eye in a dark room. It was then exposed to X-rays from a coolidge tube and again heated. The luminescence, though not as intense as originally, was partially restored.

When the original crystal of calcite was exposed to X-rays it was found that the conductivity was increased, but the effect lasted not more than 1 hour. The exposure to the X-rays was 50 milliampere minutes at 60 kilovolts through 8 inches of air. After an interval of 2 hours the crystal was excited to luminescence using the temperature range −80°C to 22°C. The results plotted in Curve C, Fig. 2, show that the calcite was partially restored to its original condition by the X-rays. At the higher range of temperature the restoration was not so complete.

Two other substances, fluorite and feldspar, were also examined. The data shown in Tables 4 and 5 is very similar to that obtained for calcite.

Table 4—Fluorite

Time	Current
7 mins.	.185 K
11 "	.048 K
15 "	.021 K
33 "	.021 K
56 "	.006 K
63 "	.004 K

[1] Wiedemann and Schmidt, Wied. Ann. 56 p., 177, 1895.

TABLE 5—FELDSPAR

Time	Current
1 min.	.217 K
3 "	.800 K
6 "	.007 K
9 "	.003 K
15 "	.003 K

Both substances gave a smaller effect when excited a second time.

This investigation yielded three results.

1. Thermo-luminescence of calcite, fluorite and feldspar caused an increase in the electrical conductivity of these substances.

2. When calcite was excited to thermo-luminescence more than once, successive excitations produced smaller increases in the electrical conductivity.

3. Exposure to X-rays partially restored the crystal of calcite to its original condition, so that the electrical effect of thermo-luminescence was nearly as great as initially.

For their valuable suggestions the writer thanks Drs. Bronson and Johnstone.

On the Variation of the "Emanating Power" of Certain Uranium Minerals with Temperature and a New Secondary Radium Emanation Standard[1]

By J. H. L. JOHNSTONE, M.B.E., Ph.D.

Presented by PROFESSOR H. L. BRONSON, F.R.S.C.

(Read May Meeting, 1921)

INTRODUCTION

The usual method for the determination of small quantities of radium depends upon the separation and collection of the radium emanation which is in equilibrium with the radium present in the material under examination. The activity of this emanation is determined in a suitable electroscope or other testing device and is compared with the activity of the emanation in equilibrium with a known quantity of radium. A similar method is used for determining the radioactivity of natural waters.

In the type of measurement referred to, the amounts of radium which can be conveniently estimated are of the order of 10^{-9} gram. The preparation of a suitable "standard" radium solution is attended with considerable difficulty since the accurate measurement of a quantity of radium less than 10^{-4} gram by means of the gamma radiation is practically impossible.[2] Amounts of radium of the order of 10^{-3} gram must, therefore, be used and the solution must be diluted to a considerable volume in order to attain the strength necessary for this purpose. Another difficulty in the case of dilute radium solutions is the belief expressed in many quarters that such solutions are not permanent but tend, on standing, to deposit a portion of the contained radium.[3] Moreover, when a standard solution is used for the calibration of the electroscope, the process of boiling off the emanation, collecting it, drying the gas, and introducing it into the electroscope is necessarily a somewhat complicated and troublesome

[1] The experimental work which is reported in this paper was carried out in the Sloane Physical Laboratory of Yale University in 1916. The chief reason for the delay in publication was the author's entry into active service with H. M. forces. The author expresses his thanks to Prof. B. B. Boltwood of Yale University for suggesting this problem and for his kind advice and interest.

[2] W. Bothe, Phys. Zeit. 2, P. 33, 1915

[3] Professor Boltwood has found that the addition of hydrochloric acid to the radium solution prevents this deposition.

operation. In some laboratories[4] the emanation from the standard solution is introduced by drawing into the electroscope a current of air which is allowed to bubble through the solution. This method has certain disadvantages which need not be considered here. Another method of calibrating an electroscope in terms of radium has been suggested [5] which consists in collecting the total amount of radium emanation in equilibrium with the radium contained in a known weight of suitable uranium mineral whose uranium content is known. This may be accomplished in two ways. Either the mineral is dissolved under suitable conditions and the emanation set free is collected, or[6] a solution of the mineral is prepared, sealed up, and allowed to stand until the equilibrium amount of emanation has accumulated. In the former case it is only necessary to determine the proportion of emanation[7] which spontaneously escapes from the powdered mineral used as a specimen, thus involving two determinations, with the consequent possibility of considerable error. The second method is open to objection since there is usually a lack of assurance that the radium salts *remain* in solution, an essential requirement if the results are to be trustworthy. Either of these methods is inconvenient and somewhat troublesome, especially in the hands of those who are not particularly experienced.

In any series of experiments involving the frequent determination of radium it is important to calibrate the electroscope from time to time as its sensibility is subject to occasional and unavoidable variations. For calibration the use of a specimen of primary uranium mineral in which the proportion of uranium present is determined by analysis has the additional drawback that the accurate quantitative determination of uranium is, from the analytical standpoint, a somewhat difficult operation. The use of such a mineral involves also, as has already been mentioned, the determination of the "emanating power" of the mineral and the assumption that this emanating power is a constant under the general conditions of experiment. It has been observed [8] by a number of experimenters that solid substances con-

[4] This method is used in the laboratory of Madame Curie.

[5] Boltwood, B. B., Am. Jour. Sc. 18, 381, 1904; Phil. Mag. 9, 599, 1905.

[6] Heimann und Marckwald, Phys. Zeit. 14, 303, 1913.

[7] Boltwood, B. B., Phil. Mag. 9, 599, 1905.

[8] Boltwood, B. B., Am. Jour. Sc. XXV, 294, Ap. 1908, also Phil. Mag. 9, 599, '05.
Dorn, Abh. der Naturforsch, Ges. fur Halle -a-s, 1900.
Rutherford, Phys. Zeit. 2, 249, 1901.
P. Curie, Theses presentee a la Faculte des Sciences de Paris, 1903, p. 129.
Strutt, Proc. Roy, Soc. LXXIII, 191, 1904.
Kolowrat, Le Radium, 4, 317, 1907; 6. 321, 1909; 7, 266, 1910.

taining thorium and radium compounds show a marked variation in the proportions of emanation which escape from them, and that these variations are influenced by changes in temperature and the amount of moisture present. It will be shown in the course of this paper that the emanating power of powdered uranium minerals is subject to similar variations from the same causes.

For calibration purposes the use of some solid material containing radium having an emanating power, which would not be appreciably affected by the changes in temperature and atmospheric humidity under the usual conditions of experiment, would obviously possess a great advantage over other methods now in use. This material could be sealed up in a glass tube and the radium emanation allowed to collect for a definite, known period and would furnish a convenient source from which, as desired, a definite quantity of radium emanation could be obtained. After having once been calibrated by comparison with a standard radium solution or standard uranium mineral it would thereafter be available for the convenient calibration of an electroscope. On account of the variation in the emanating power of a uranium mineral, such minerals in their natural state are not suitable for the purpose which has just been considered. However, it is known that by heating a uranium mineral to a comparatively high temperature, its emanating is greatly reduced. It was thought possible that simultaneously with the reduction of the emanating power other changes might take place in the heated mineral which would cause the rate of escape of emanation to be less susceptible to variations in temperature and humidity of the air coming in contact with the material. In the course of the work described in this paper evidence has been obtained that the anticipated changes in the properties of the mineral actually do occur so far as the temperature effect is concerned, and if the humidity of the air coming in contact with the mineral be kept constant it will be shown that the heated uranium mineral furnishes a sufficiently constant source of radium emanation to satisfy the requirements which have been already outlined.

Apparatus and Method

The measurement of the ionization currents were made in an air-tight, emanation electroscope,[1] which had a capacity of about 3 liters. The ionization chamber was fitted with two side tubes which could be opened or closed by means of stopcocks. The charged electrode

[1]Previously designed and used by Professor Boltwood.

was a brass rod 3 mm. in diameter and 20 cm. long. The rod passed through a plug of sealing wax, and carried on its upper end a strip of brass on which was fastened a gold-leaf five centimeters long. The sealing wax was surrounded by a guard ring and both were fastened in a threaded ebonite plug which completely closed the ionization chamber. The gold-leaf was protected by a felt-covered metal case, which contained two small mica windows, through which the movement of the leaf was observed. The electrode was charged by touching the back of the brass strip carrying the gold-leaf with a wire which passed through a glass tube in the case. The charging wire and the guard ring (the latter permanently) were connected to the negative pole of a battery of 480 volts. The positive pole of the battery and the ionization chamber were permanently earthed. The movement of the gold-leaf was observed through a fixed telemicroscope with a scale in the eye-piece.

To calibrate the electroscope the emanation was separated by the Boltwood method [2] from a weighed amount of a standard specimen of uraninite, which had a uranium content of 73 per cent. and possessed an emanating power at 18°C of 11 per cent. It was immediately transferred through a calcium chloride drying tube to the electroscope and the rate of movement of the gold-leaf in divisions per minute measured at the end of three hours. Taking the value of the ratio of radium to uranium in primary uranium minerals as 3.35×10^{-7},[3] a movement of one division per minute of the gold-leaf was found to correspond to the presence in the ionization chamber of the emanation in equilibrium with 2.84×10^{-10}g. radium.

As the heating of a uranium mineral greatly reduces the emanating power it was desirable that the material used for the experiments to be described should have a high uranium content and, what is more important, a large emanating power, otherwise the weight of mineral which would have to be taken for a practical standard would be inconveniently large. A specimen of carnotite and one of uraninite were selected for the purpose, and both, when finely powdered, satisfied the requirements mentioned. The carnotite, obtained from Colorado, had a uranium content of 7.6 per cent. It was quite porous in structure and was easily ground to a powder. The emanating power, measured at 18°C, was 16.2 per cent. The uraninite used was a specimen of primary uraninite, supposed to have come from

[2]Am. Jour. Sc. 18, 379, 1904; Phil. Mag. 9, 599, 1905.

[3]Boltwood's value (Am. Jour. Sc. 25, 296, 1908) in terms of the International Standard.

India. It had a uranium content of 67.5 per cent. and possessed an emanating power of 8.4 per cent. at 18°C.

In order to collect the emanation which was evolved from a definite weight of the powdered mineral under the particular conditions of experiment the following method was used: One end of a piece of glass tubing (bore 0.75 cm. and length 15 cm.) was tapered to a point and sealed off in a flame. A small plug of cotton wadding was then stuffed through the tube into the sealed-off end. A weighed amount of mineral (2 gms.) was placed in the tube and on top of this another plug of wadding. The remaining end of the tube was then tapered out and sealed. To maintain the tubes at definite temperatures for any given time, they were placed in a self-regulating, gas thermostat in which temperatures twenty degrees above room temperatures were obtainable. For temperatures higher than this an electrically heated oven was utilized. To transfer the collected emanation from the tube to the electroscope the latter was first exhausted by a water pump. Both stopcocks were then closed. The emanation tube was attached to the upper exit tube of the electroscope by a short piece of thick-walled rubber tubing. The stopcock was opened and closed again, then the tip of the emanation tube was broken off inside the rubber tubing. The stopcock was opened slowly and again closed. The other tip of the emanation tube was then broken off, the stopcock opened gradually and air was drawn into the electroscope through the emanation tube for about five minutes when the stopcock was closed. The pressure of the air within the electroscope was still considerably below that of the outside air, and thus, if there were any tendency to leakage, it would be from the outside to the inside. At the end of three hours the inside pressure was raised to that of the outside air by allowing air to enter the electroscope from the exterior and then closing the stopcocks. The time taken for the gold-leaf to pass over a definite interval of the scale was measured with a stopwatch. Both stopcocks were finally opened and air was drawn through the electroscope for a half hour. In this way the emanation was completely removed from the electroscope, and when the active deposit had decayed and the natural leak was determined, the instrument was ready for a new series of measurements.

A number of preliminary experiments were made which demonstrated that by increasing the humidity of the air in the sealed tubes the emanating power of the mineral was increased. In order to eliminate any variations due to changes in the content of moisture in the air a large tube was prepared which contained a considerable quantity of ammonium nitrate crystals held between plugs of cotton wool. Preparatory to sealing up the tubes containing the minerals air was drawn through the ammonium nitrate tube and then through the tube containing the mineral. A fairly constant humidity of the air in contact with the mineral could, therefore, be assured.

The emanation tubes were sealed and kept at definite temperatures for times varying from one to thirty days. Having partially exhausted the electroscope the emanation tube was connected with it, the tips broken and air was sucked through carrying with it into the electroscope the emanation, which had accumulated in a known time under the particular conditions. At the end of three hours the activity of the emanation was determined. The activity determined in this manner is a measure of the emanation which has accumulated during the time and under the given conditions. Assuming that the emanation continues to be evolved at the same rate for a prolonged period then the maximum or equilibrium value which would be ultimately attained is given by the expression

$$I_0 = \frac{I_t}{1 - e^{-\lambda t}}$$

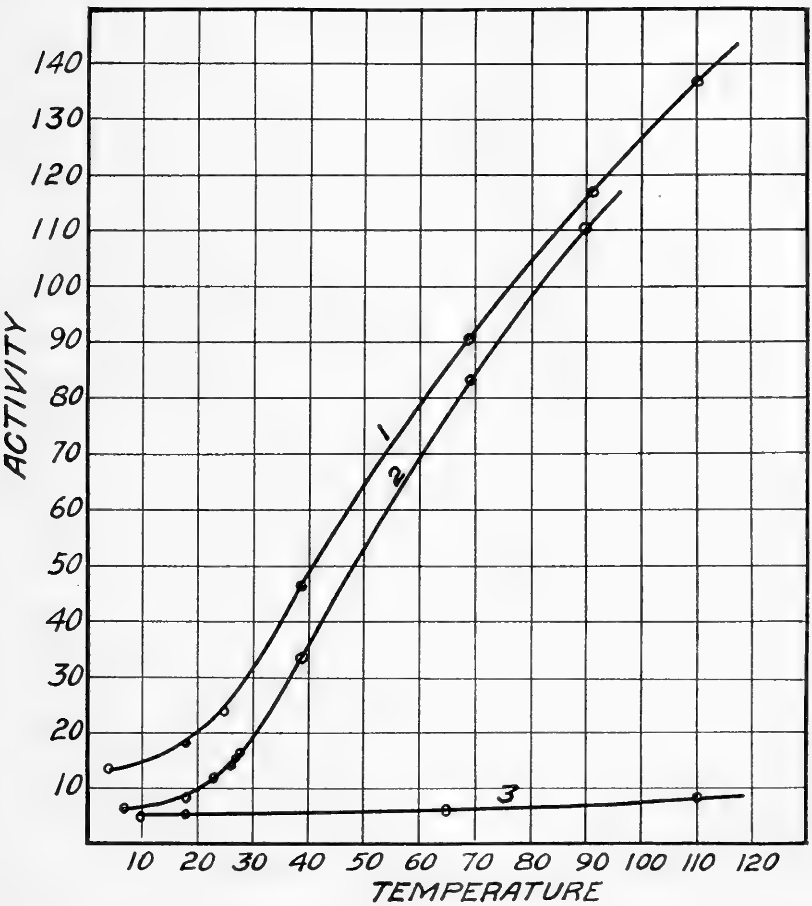
where I_0 is the equilibrium value and I_t is the value of the activity measured.

Results

The value of the equilibrium quantity of emanation evolved from the carnotite at different temperatures is shown graphically by curve 1, the abscissae representing temperatures centigrade and the ordinates divisions per minute movement of the gold-leaf. In this case *different* tubes[4] were maintained at the *definite* temperatures for periods of approximately twenty hours, and from the values of the activity measured, the equilibrium quantity was calculated. It was found that when the tubes were heated for more than twenty hours, at the higher temperatures especially, the value of the equilibrium quantity of emanation as calculated by the above expression was smaller the longer the tube was heated. This means that the emanation is evolved at a rate which depends on the time the tube has been heated. The amount of emanation evolved was found to depend on the previous history of the mineral as Kolowrat[5] found to be the case. If the tube was heated to a fairly high temperature and the emanation

[4]The activities of the different tubes of carnotit maintained at the same temperature for the same length of time did not vary by more than 2 per cent. at the most, which indicates that the material was quite homogeneous.

evolved measured, a subsequent heating at the same temperature produced a value which was smaller, the higher the temperature of the first heating.



It should be noted here that the emanating powers were calculated on the assumption that the emanation escaped at the same rate for thirty days as it did for the first 20 hours of heating. But, as was pointed out, the rate of escape rapidly decreases with the time of heating and, therefore, the values calculated have only a relative significance.

The uraninite tubes were examined in the same way and similar results found, which are plotted in curve 2. In the calculation of the

[5] Loc. cit.

numbers plotted the uraninite was reduced to the same uranium basis as the carnotite.

The fact that the temperature coefficient of the emanating power was so much decreased by a previous heating of the mineral was suggestive. It was thought possible that by a more drastic treatment of this sort a product might be produced whose emanating power would have a very small and permanent temperature coefficient. Two grams of the carnotite were heated to a temperature of approximately 400°C in a crucible for half an hour and the material was sealed up as described. The emanating power at 18°C was reduced by this treatment from 16.2 per cent. to 5.4 per cent. Curve 3 graphically indicates the result of a series of measurements made for this tube and shows that the temperature coefficient has been reduced to a very small value. To find how the emanating power of this tube was affected by increasing the humidity of the air contained in it, a tube filled with cotton wool was attached to one end of the emanation tube and air was sucked over the wet wool through the emanation tube for about five minutes. The latter was then sealed and measurements of the activity of the evolved emanation, made at the end of a few days, showed that the emanating power was increased by 15 per cent. However, if the air which enters the emanation tube is always passed through the ammonium nitrate tube, any variations in the emanating power due to the moisture effect were found to be eliminated. The following determinations of the equilibrium amount of emanation evolved by eight grams of this material which has been strongly heated indicate its constancy over considerable ranges of laboratory temperature.

Temperature	Time sealed	Equilibrium activity (arbitrary units)
15	3 da. 0 hr.	26.5
21	1 " 22½ "	26.6
20	2 " 0 "	26.6

By treating the uraninite in the same manner, similar results were obtained. This shows that by heating the minerals for a short time to a temperature above 400°C the temperature coefficient of the emanating power is reduced to such a small value that for ordinary ranges of laboratory temperature it may be neglected. Therefore if the equilibrium amount of emanation evolved from a tube of carnotite, treated in the manner described in this paper is once measured in terms of some standard of radium, it may thereafter be used as a standard of radium emanation. The value of the activity of the equilibrium amount of emanation evolved will be practically independent of the usual variations in laboratory temperature and it will remain practically constant, provided the humidity of the air contained in and passing through the tube is always maintained at the value it possessed when it was standardized.

Summary

1. The variation with the temperature of the emanating power of certain specimens of carnotite and uraninite has been determined.

2. By heating the minerals to a high temperature, the temperature coefficient of the emanating power is greatly decreased so that for ordinary ranges of laboratory temperature it may be assumed to be negligible.

3. A secondary emanation standard has been suggested which can be easily and simply prepared, which is not subject to appreciable variations under ordinary conditions and which is more convenient to use, particularly in the field, than either the customary standard radium solution or a uranium mineral of known composition.

Destructive Distillation Yields from British Columbia Fir and Alder Wood

By WILLIAM AGEE HARDY, B.Sc.

Presented by E. H. ARCHIBALD

Although British Columbia is one of the most important lumbering districts in the world it is not an appreciable factor in the wood distillation industry at the present time. Several attempts have been made to establish commercial plants both in this Province and in the States of Washington and Oregon, but none of these is now in operation. Pit burning for charcoal, however, has been found profitable to a limited extent during the last few years.

In this Province the wood distillation industry has the choice of two main sources of raw material: first, the waste from the saw mills, and second, a cut of alder or other second growth wood. There are several places in British Columbia, especially in the Fraser River valley, where large quantities of alder are easily obtained near the banks of navigable water. The yields of acetic acid, methyl alcohol, turpentine and tar which may be expected from Douglas Fir mill waste have been determined by Benson and Darrin (*Jour. Ind. and Eng. Chem.*7, 916, 1915) on a semi-commercial scale. As to the second source no data is available as to the yields which may be expected from the alder wood of the Pacific Slope. With the mild winters and heavy rainfall it is to be expected that the yields will be somewhat different from those obtained from Eastern woods. It was with a view of obtaining information on this subject that the following investigation was undertaken.

SELECTION OF SAMPLES

(*Alder Wood*)

Alder wood trees from six to eight inches in diameter were selected from several localities within a few miles of the University. In all cases an average sample of the trunk was obtained by cutting sections at different heights. No branches or limbs were used.

Samples 1 and 2 are different trees cut in September, 1920, from a tract in South Vancouver, allowed to lie outside in the weather until April and then distilled without additional drying.

Samples 3 and 4 are different trees cut sometime in the Autumn, allowed to lie outside in the weather until April and then cut to size and dried at a temperature of from 20 to 30 deg. centigrade for three weeks and then distilled. Sample number 4 contained a portion of slightly rotten wood. Difficulty in settling out the tar and a low yield of acetic acid was noticed in this case.

Samples 5, 6, 7 and 8 are from trees cut in the Point Grey district, weathered outside for five months, and then cut to size and dried at a temperature of from 20 to 30 deg. C. for five or six days. Samples 5, 6 and 7 are from separate trees and number 8 is a mixture of the three.

(Fir Mill Waste)

Samples 9 and 10 are Douglas Fir taken from a pile of slabs purchased by the University in August, 1920, and piled outside until April. The wood selected represents, as nearly as possible, an average sample of this lot of five cords. However, neither bark nor pitchy pieces were selected. Sample 9 was distilled as it came from the uncovered pile while sample 10 was thoroughly dried at a temperature of from 20 to 30 deg. C. for ten days.

Samples 11 and 12 are from a two cord lot of mill waste sold in Vancouver after it had been well seasoned in a wood yard. These two samples represent well-seasoned fir mill waste and not water-soaked slabs. Pitchy pieces and bark were avoided in preparing the samples.

EXPERIMENTAL WOOD DISTILLATION RETORT

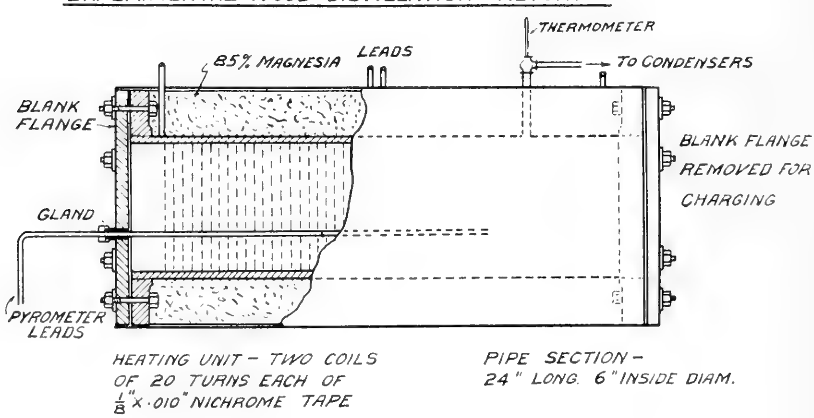


FIG. 1

Apparatus and Methods

A retort (Fig. 1) was constructed of a 24-inch length of 6-inch steel pipe fitted with standard flanges on the ends and a one-half inch delivery pipe in the top and a gland in the end for the pyrometer element. This retort was heated by two coils of twenty turns each $\frac{1}{8}$ x .010 Nichrome tape on a 110volt circuit. The retort was horizontal and blank flanges were fitted at the ends with asbestos gaskets. The whole was well insulated by 85 per cent. magnesia lagging and sheet asbestos wrappings. The distillate was condensed by two large Liebig condensers in series with a trap between. The gases were not measured. A study of the yield and composition of the gases from Douglas fir has been made by Tremper (*Jour. Ind. and Eng. Chem.* 7, 926, 1915).

Distillation

The retort was charged with wood cut to the size of kindling in eleven inch lengths. The distillation usually required from six to eight hours and a final temperature around 700°F. was reached. The rate of heating and the temperature varied somewhat with the amount of moisture in the various samples.

Treatment of Distillate

The entire distillate was allowed to stand for several days in a large graduate until most of the tar had settled. A 400 c.c. sample of the clear liquid was distilled until a boiling point of 130°C. was reached. The volumes of the distillate and residue were measured. A sample of the distillate was titrated with half-normal sodium hydroxide and a second larger sample (250 c.c.) was neutralized with lime and fractionally distilled. The gravity of this second distillate was obtained by means of a Westphal balance.

Notes on Methods of Calculation

The weights of wood and charcoal were obtained by direct weighing and need no explanation.

The volume of tar reported is the sum of the tar which separated on first standing and the tar as obtained by a redistillation of the clear liquid.

The grams of acetic acid are calculated from the titration of the distillate after the removal of the tar and before neutralization for the removal of the methyl alcohol. By this method all volatile acids with a boiling point under 130°C. are calculated as acetic acid. The extent of the error due to this cause was not determined.

The methyl alcohol was determined by observing the gravity of the distillate after neutralization and a careful fractionation with a good distilling column. By this method the acetone is estimated as methyl alcohol as their gravities are similar. It has been shown by Benson and Darrin (*loc. cit.*) that the acetone may be as high as twenty per cent. in the case of Douglas fir.

Experimental Data

Run No.	Wood	Weight grams	Charcoal grams	Distillate c.c.	Acetic Acid grams.	Methyl Alcohol grams.	Tar c.c.
1	Alder	2600	700	1700	108	9	....
2	"	2800	800	1600	130	17	....
3	"	2200	900	850	93	9	140
4	"	1600	650	650	76	19	....
5	"	2200	700	1150	108	27	130
6	"	2200	700	1150	108	29	125
7	"	2200	720	1050	102	30	140
8	"	2200	780	1040	109	27	140
Avg.	"	**2250**	**744**	**1149**	**104**	**21**	**135**
9	Fir	3600	1100	1100	61	9	180
10	"	2800	1200	850	50	7	150
11	"	2600	1000	1200	39	12	180
12	"	2700	1100	1100	45	12	250
Avg.	"	**2925**	**1100**	**1237**	**49**	**10**	**190**

Results Calculated to a Cord Basis

	Alder wood	Douglas fir
Pounds of acetate of lime per cord....................	181.	69.
Gallons (Imperial) of 85% methyl alcohol per cord.....	4.0	1.5
Gallons of tar per cord............................	17.	19.
Pounds of Charcoal..................................	992.	1200.

Results

The accompanying table shows the detailed results of the different runs with the additional table giving the results as calculated for a cord of 3,000 pounds in the case of alder and 3,200 pounds in the case of Douglas fir. This is approximately correct for fir, but the assumed 3,000 pound weight for a cord of dry alder is somewhat in doubt.

The turpentine and rosin in the distillate from the fir were not determined as the quantity was small with the wood used. No investigation of the tar and light oils was made as it is expected that these will be examined in detail at a future date. The possibility of influencing the composition of the tar, especially the fir by very low distillation temperatures is apparent and suggests an interesting research.

The runs on fir were made primarily to give a comparison of the yields as obtained from the experimental retort and from the larger half-cord retort used by Benson and Darrin (*loc. cit.*). It is seen that the results for acetate of lime agree very closely while the methyl alcohol yield is lower in the smaller retort. It is to be expected that there would be a difference due to the use of different samples, but, on the whole, the results check as closely as could be expected.

In considering the distillation of alder on a co nmercial scale, the high percentage of moisture in the green wood and the difficulty which would be experienced in seasoning it in this damp climate should be given careful thought. As the wood will not retort properly when green and will not season when exposed to the winter rain without rotting to some extent, drying under cover or artificial drying must be resorted to.

Conclusions

1. Existing data as to the yields from the destructive distillation of Douglas fir have been checked.

2. Pacific Coast alder was found to yield about 990 pounds of charcoal, about 181 pounds of acetate of lime, and 4 Imperial gallons of 85 per cent. methyl alcohol per cord.

3. It is considered that this low yield of methyl alcohol is due to the moist yet warm winters which this part of the Pacific Slope experiences.

4. The alder charcoal is even grained and appears to be of high quality.

Chemical Laboratory,
University of British Columbia.

The Coefficient of Viscosity of a Gas. An Elementary Laboratory Experiment

By JOHN SATTERLY, M.A., D.Sc., A.R.C.Sc., F.R.S.C.

(Read May Meeting, 1920)

The volume of a liquid which flows per second through a horizontal uniform capillary tube is given by the formula

$$V = \frac{p_1 - p_2}{l} \cdot \frac{\pi a^4}{8\eta} \qquad \text{(1)}$$

where p_1 = the pressure at the inlet end of the tube.
p_2 = the pressure at the outlet end.
a = the radius of the bore of the tube.
l = the length of the tube.
η = the coefficient of viscosity of the liquid.

This statement is known as Poiseuille's Law.

If instead of a liquid a gas is flowing through the tube (the conditions being isothermal and the gas one that obeys Boyle's Law) the formula is

$$p_1 V_1 = p_2 V_2 = \frac{p_1^2 - p_2^2}{2l} \cdot \frac{\pi a^4}{8\eta} \qquad \text{(2)}$$

where p_1, p_2, a, l, η have the meanings described above and V_1 is the volume of gas (at pressure p_1) entering the tube and V_2 is the volume of gas (at pressure p_2) leaving the tube. If p_1 is only slightly greater than p_2, say $p_2 = p_1 - p$ where p is small, we may write

$$p_1 V_1 = (p_1 - p)\, V_2 = \frac{(p_1 + p_2)\ (p_1 - p_2)}{2l}\ \frac{\pi a^4}{8\eta}$$

from which

$$V_1 = p\pi a^4 / 8l\eta \qquad \text{(3)}$$

$$\text{or } \eta = p\pi a^4 / 8lV \qquad \text{(4)}$$

the same formula that was used in the case of liquids. Hence we see that in order that Poiseuille's formula may be applied to the flow of gases through a capillary tube the difference of the pressures must be small in comparison with either the inlet or outlet pressures. The volume may then be measured indifferently at either of these pressures.

If for example we have p_1 = atmospheric pressure =, say, 1,030 cms. of water and p_2 = say, 1,025 cms. of water, we make an error of only $2\frac{1}{2}$ in 1,030, which is negligible in an elementary experiment.

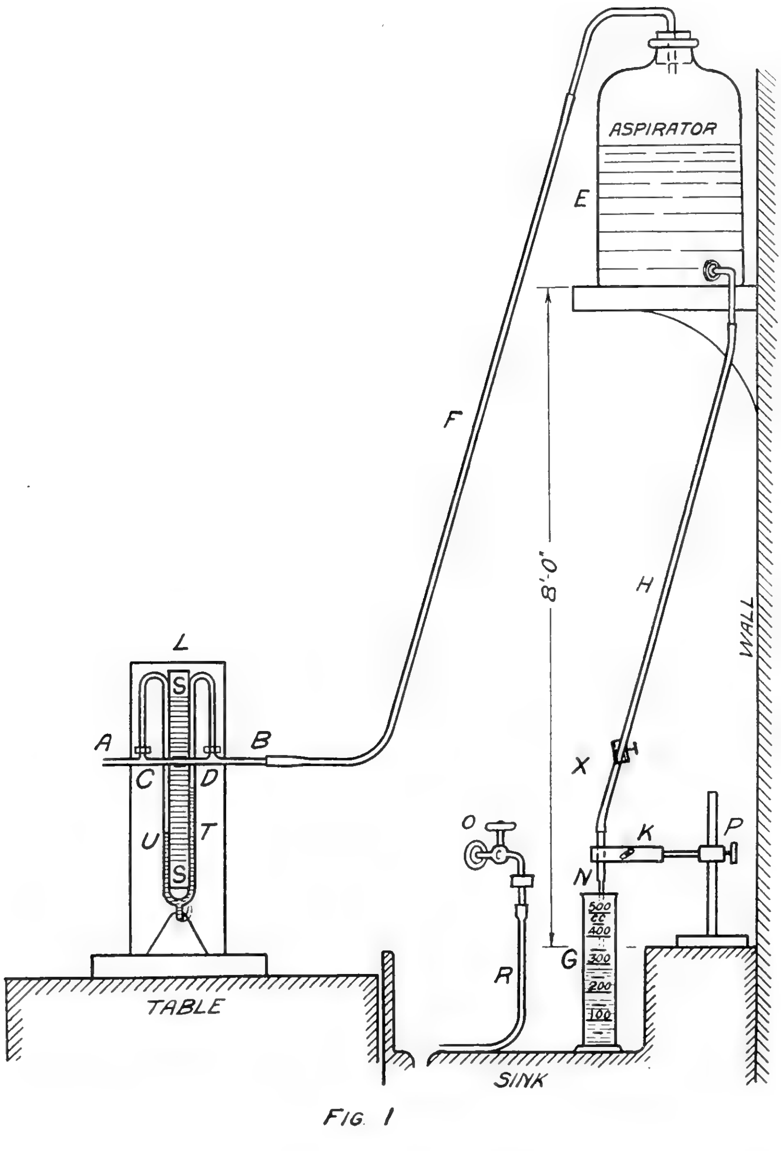

ASPIRATOR
E
F
8'0"
H
WALL
L
S
A
B
C
D
U
T
S
X
O
K
P
N
500
CC
400
300
200
100
G
R
TABLE
SINK

FIG. 1

In the apparatus used for some years in my elementary laboratory in Toronto to find the coefficient of viscosity of air a uniform capillary tube AB (Fig. 1) about 30 cms. long and $1\frac{1}{2}$ mm. in bore is selected and two short tubes of about the same bore are carefully sealed on at right angles at two points C, D, about 6 cms. from the ends, and to these are sealed a length UT of three-eighths inch glass tubing bent as shown in the diagram. This tube serves as a pressure gauge and the arms just enclose a wooden millimetre scale SS graduated alike on the two edges. The tube is mounted by brass clips on a wooden stand L, a strip of white paper being placed as a backing to the tube. In some forms a tube runs from the bottom of the U-tube back under the upturned V notch in the stand and communicates by a rubber tube to a funnel supported in a bracket at the back. This tube may be clipped tight with a screw clamp.

By means of the funnel and tube water is supplied to the manometer. Sometimes by accident a large current of air is sent through the viscosity tube and the water in the gauge is blown out. It is not an easy matter to replace the water without some device as mentioned above.

The complete apparatus for the experiment is arranged as shown in Fig. 1, which is self-explanatory.

For a given position of the screw clamp X the water flow soon gets steady and consequently the position of the water in the gauge UT. When this stage has been reached the water from N is collected in a 500 c.c. graduated cylinder. The time of collection of 500 c.c. is noted and the gauge readings. The volume per second is obtained by dividing 500 c.c. by this time. If two students work at this experiment the times are noted by an ordinary watch, and the experiment repeated until constant results are obtained. If only one student works at it a stopwatch is supplied.

By tightening up the screw clamp to various degrees a set of corresponding values of pressures and volumes is obtained. When the bottle has run out a piece of tubing R connected to a cold water tap O serves to fill the bottle again and meanwhile it is safer to disconnect the tube F from the viscosity tube. The experiments can then be repeated.

To get the radius of the bore of the tube an accurate travelling microscope may be used. In Toronto we use instruments with verniers reading to one-hundredths of a millimetre. The microscopes are sighted straight at the end of the tube and the cross wire carried from one tangential position to the bore to the opposite position. This is done for horizontal and vertical diameters at both ends of the tube and the average taken as the average radius in the portion of the tube *CD*. The length *CD* is measured to the nearest millimetre from junction to junction, making a careful estimate of the position where the effective length of the capillary tube begins and ends.

The readings for three tubes *A*, *B*, *C*, in use in my laboratory and made up without any special selection of the tubing are shown in Table I. The readings were taken by the author with a stopwatch and were not duplicated.

TABLE I

Tube	Difference in readings on two sides of gauge	Time for 500 c.c. of water to flow through	Volume per second
	pressure in cms. of water	secs.	c.cs. per sec.
	1.8	50.6	9.9
	3.0	30.6	16.3
	3.6	26.0	19.2
A	4.0	23.6	21.2
	5.8	17.2	29.1
	7.3	13.8	36.3
	9.3	12.1	41.3
	1.3	66.2	7.6
	2.9	30.0	16.7
	3.5	23.6	21.2
	4.5	19.0	26.3
	5.5	16.0	31.3
B	5.9	14.8	33.8
	6.9	13.4	37.3
	7.2	12.8	39.1
	8.0	12.5	40.0
	10.2	11.8	42.4
	12.7	10.4	48.1
	1.0	76.0	6.5
	1.5	52.6	9.5
	2.8	27.5	18.2
	3.8	20.0	25.0
C	5.1	15.6	32.1
	5.3	15.4	32.5
	6.5	13.2	37.9
	7.1	12.5	40.0
	10.0	10.4	48.0
	10.6	10.2	49.0

The dimensions of the tubes (taken by the author without duplication) are as given in Table II.

TABLE II

Tube	Length cm.	Diameter				Average
		Left end		Right end		
		Horizontal	Vertical	Horizontal	Vertical	
		cm.	cm.	cm.	cm.	cm.
A	14.1	.164	.150	.151	.158	.156
B	15.1	.155	.161	.165	.167	.162
C	15.4	.172	.163	.171	.174	.170

The best way of getting the average from the flow results is to plot a graph between the pressure head (in cms. of water) and the volume of air passing per second. The graphs for the three tubes are shown in Fig. 2. It is noticed that at the lower end of the graphs the curves are straight showing the direct proportionality between p and V, but at the higher end the graphs turn towards the axis of pressure showing that an increase in pressure at this stage does not send through a proportional volume of air.

Therefore to get the coefficient of viscosity the best straight line is drawn through the first part of the graph and the slope of this line obtained.

From Fig. 2 we see that for a tube A

$$p/V = .190 \text{ in appropriate units.}$$

Substituting in equation (4) we get

$$\eta = \frac{\pi}{8} \times (.190 \times 980) \times \frac{(.078)^4}{14.1} = 00019 \text{ C.G.S. units.}$$

For tubes b and c we get in the same way

Tube (B) $p/V = .173$
and $\eta = .00019$ C.G.S. units
Tube (C) $p/V = .158$
and $\eta = .00020$ C.G.S. units.

The results are in close agreement and with the correct value of η given in books of tables. This value is about .00018+at 20°C.

Osborne Reynolds[1] showed that the formula quoted above in equation (1) was true as long as the motion was "stream-line" motion but that once a critical velocity was exceeded eddies were set up and a more than proportionate increase of pressure was required to send through a given volume of fluid. He and others have shown

[1]Osborne Reynolds, Phil. Trans. 1883, Poynting and Thomson, Properties of Matter, ch. XVIII.

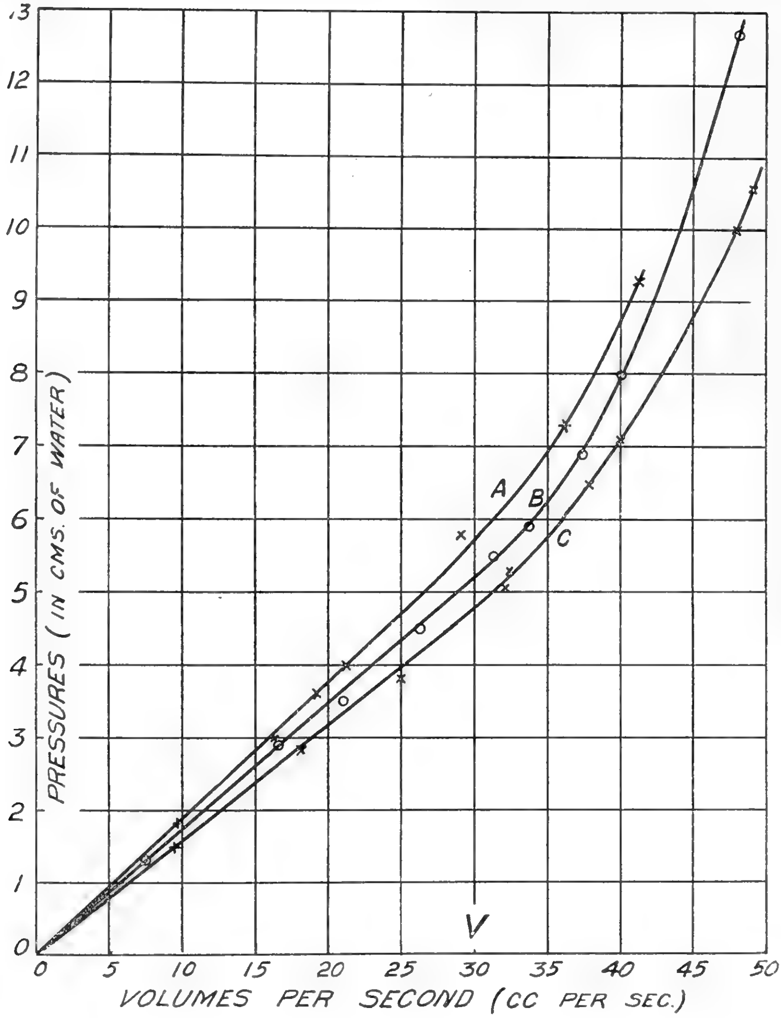


FIG. 2

that for liquids and gases this critical velocity is about

$$\frac{1000\eta}{\rho a} \text{ cms. per second,}$$

where ρ is the density of the fluid (liquid or air) and the other letters have the meanings given above, all being expressed in C.G.S. units. For tube (A) this velocity is for air about

$$\frac{1000 \times .00018}{.00125 \times .078}$$

or 1800 cms. per second,

which corresponds to a flow of about 35 c.cs. per second. Reference to curve (*a*) in Fig. 2 will show that at the point corresponding to this flow the graph changes from the straight line to the curve. In this way the student is able to verify an interesting fact.

Objections to this method of getting the viscosity of air are:

(1) The volume of air drawn through the tube *CD* is not quite the same as the volume of water which runs out at the nozzle *N*.

(2) The mean radius of the effective portion from the tube viz., *CD*, is got from measurements at the ends *A* and *B*. This may introduce a considerable error, especially as in the calculation the radius is raised to the fourth power.

Advantages of the method are:

(1) Simplicity.

(2) It serves to show the student how the viscosity of air may be used in the design of a meter to measure the flow of a stream of air.

From 1908 to 1910[2] the author used such a meter when collecting the radium emanation from the air by passing an air stream through coco-nut charcoal tubes where the emanation is absorbed. In that instance the capillary tube was a narrow copper tube and connections to the pressure gauge were made by soldered joints and india-rubber tubing. A detailed study of such meters has been made by A. H. Benton, of the Gas Mask Research Bureau of U.S.A.[3], and there is no doubt that gas-flow meters designed on the basis of viscosity resistance will prove of great value in many experiments where the flow is too small to allow of the use of any other cheap form of meter.

Another and easier way of performing the experiment is to use a gas meter instead of aspirator and graduated cylinder. It would be poor teaching, however, to use an expensive gas meter in an experiment designed with a view to simplicity of apparatus. In some experiments with a gas meter reading to thousandths of a cubic foot, measurements were taken when compressed air at a steady pressure passed firstly through the gas meter and then the viscosity gauge and secondly when meter and gauge were interchanged. For tube *B* the two graphs coincided up to a pressure difference of about six cms. of water and then separated, going along two practically

[2]Satterly, Phil. Mag., Oct., 1908, and July, 1910.

[3]Benton, Journal of Industrial and Engineering Chemistry, July, 1919.

parallel lines, the line for "meter before gauge" lying above the line for "gauge before meter." The difference is perhaps due to the fact that the gas meter registers correctly only when its outlet pipe is open to the air. More work may be done on this point, using a capillary tube without the projecting ends AC, DB, so that the whole of the pressure fall may lie in the capillary tube CD under test.

University of Toronto, 1920.

A Reversible Pendulum

By H. F. DAWES, M.A., Ph.D., Professor of Physics, McMaster University, Toronto

(Presented by John Patterson, F.R.S.C.)

(Read May Meeting, 1921)

1. In the accurate determination of "g" by means of a Reversible Pendulum there must be taken into account the following physical properties of the motion requiring corrections or compensation which vary with the design of the pendulum.

(*a*) *Temperature.*

(*b*) *Buoyancy of Air.* This force acts through the Centre of the Geometrical Figure of the pendulum so that its moments about the axes of rotation will be unequal unless the external form is symmetrical about a Centre of Figure and, of course, all cavities are air tight. In the Kater form the pendulum is not symmetrical so that observations must be corrected for this effect or the error eliminated by using the pendulum in a vacuum. In Repsold's pendulum the figure is symmetrical.

(*c*) *Flow of Air.* The net effect of the flow of air past the moving pendulum is to increase its equivalent mass and Moment of Inertia as shown by Stokes, Du Buat, Bessel. For a symmetrical pendulum this increase is the same for both axes.

(*d*) *Viscous Resistance of Air.* For a pendulum of symmetrical figure the viscosity of the air will produce equal damping for the two axes. When, therefore, the actual damped periods are equal the undamped periods will also be equal and it will be necessary to make only a single correction for damping, viz., the equality period from which "g" is to be calculated.

(*e*) *Determination of Equality Period.* Kater's method consisted in making successive trials until very exact equality of the periods about the two knife edges was attained. Bessel showed that approximate equality only is required, the common period being calculated from observed periods which are nearly equal.

Several methods may be used to vary the period of the pendulum: (1) By altering the positions of the knife edges, (2) By changing the moment of inertia about the axes by means of movable weights. In order to determine the *Equality Period* one may make a series of determinations of the period corresponding to variations in either of these adjustments and then plot curves, one for each knife edge, showing relation between the period and the varied item. The point of intersection of these curves corresponds to the position of the variable for equal periods and the value of the common period may be read off from the curve or obtained from the observed values by the calculation corresponding to the determination of the said point of intersection. Unless the periods are nearly equal these curves are usually not rectilinear so that the calculation is complicated or a large number of observations are necessary in order to obtain an accurately drawn curve.

2. In the pendulum to be described an attempt is made to combine a number of the desiderata indicated in the foregoing discussion. The pendulum is symmetrical in figure as required for considerations (*b*) and (*c*). Its construction is shown diagramatically in Figure 1

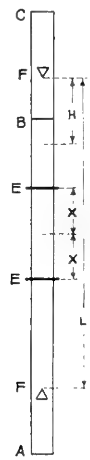


FIGURE #1

and its dimensions are given in the following table. *CB* is solid brass rod and *AB* is aluminium tubing of the same external diameter as the rod. In order to avoid correction for expansion by change of temperature I should prefer that the whole be constructed of an Invar of which the coefficient of expansion is a minimum at the temperatures of ordinary use; the dimensions of the solid rod and the thickness of the tubing could easily be chosen to fit into the further requirements indicated below.

The knife edges are inserted rigidly at *F*, *F*. The ends are closed and the joints made air tight. Each end carries platinum tips to make electrical contact in order to use a coincidence method of evaluating the period. The bar carries two sliding weights *E*, *E*, by which the period may be altered. These weights are accurately equal in dimensions and weight and are intended to be used at equal distances from the centre thereby maintaining the symmetry of figure. *By this construction the Centre of Gravity of the pendulum remains unaltered as the weights are moved since the Centre of Gravity of the two weights is always the fixed point midway between the Centres of Gravity of the individual weights.* On account of this property of the construction the relation between the *squares of the periods* about either knife edge and the *squares of the corresponding distances between the centres of the weights* is rectilinear, as will be shown below (Section 4). The determination of the equality period from two pairs of observations is therefore a simple one.

3. DIMENSIONS OF PENDULUM.

Aluminium Tubing	Length	124.5	cm.
	Walls	.127	cm. (9. B. & S.)
	Mass	307.5	gm.
Brass Rod	Length	38.8	cm.
	Mass	1477	gm.
Diameter of Bar		1.90	cm.
Movable Weights (each)	Mass	104	gm.
	Diameter	4	cm.
	Thickness	1.275	cm.
Distance between Knife Edges		99.295	cm. at 19° C.

The dimensions were chosen so as to give a distance of 40 cm. between centres of adjustable weights for equality of period. On account, however, of the uncertain values of the weights of the knife edges and their mountings, end caps, and cuttings in the making it was not possible to calculate the exact position very accurately in the designing stage. It turns out to be about 34 cm. as will be seen from the records given below.

4. THEORY.

m is the mass of each sliding weight, mk^2 its moment of inertia about axis through its centre of gravity parallel to the knife edges. If x is the distance from the C. G. of the weight to the Centre of Symmetry of the pendulum, $m(k^2+x^2)$ is its moment of inertia about parallel axis through the C. S. and $2m(k^2+x^2)$ the moment of inertia of the two sliding weights about this axis.

Since the C. S. of the pendulum is also the C. G. of the pair of weights and this point is distant $L/2$ from either knife edge (L being the distance between the knife edges), it follows that the moment of inertia of the pair of weights about either knife edge is $2m(k^2+x^2+L^2/4)$.

I, I', are the moments of inertia of the remaining parts of the pendulum about the respective knife edges. M is the mass of the whole pendulum and h, $L-h$ the distances of the knife edges from the centre of gravity of the whole. I, I', and h are thus independent of the position of the sliding weights and therefore of x.

The periods for any setting of the adjustable weights are therefore:

$$T=2\pi\sqrt{\{I+2m(k^2+x^2+L^2/4)\}/Mgh}$$

$$\text{and } T'=2\pi\sqrt{\{I'+2m(k^2+x^2+L^2/4)\}/Mg(L-h)}$$

and hence the curves T^2 against x^2, T'^2 against x^2 are rectilinear. The equality period may therefore be found from four observations of period, two with the sliding weights at a position x_1 and two at a position x_2, either by setting out the points on coordinate paper, joining the corresponding pairs of points by straight lines and finding the period corresponding to the point of intersection, or by direct calculation. If T_1, T_1', are the periods for the position x_1, and T_2, T_2', for the position x_2, it may be readily shown that the formula for calculating the required period is

$$T_0^2=\{T_1^2T'^2_2-T_2^2T'^2_1\} \,/\, \{(T'^2_2-T'^2_1)-(T_2^2-T_1^2)\}$$

5. Reduction Factors.

In order to obtain the value of any T^2 from the observed value the square of the period, P, the value of P^2 must be multiplied by the following factors:—

$\left(1-\frac{\alpha^2}{16}\right)^2$, on account of the finite amplitude, α, of the angle of swing,

$\left(1-\frac{\lambda^2}{\pi^2}\right)$, to correct for damping for which λ is the logarithmic decrement,

$\left(1-\frac{i}{I}\right)$, where i/I is the moment of inertia of the hydrodynamic mass of the air set in motion by the pendulum compared with the moment of inertia of the pendulum itself,

$\left(1-\frac{mL}{2Mh}\right)$, on account of the buoyancy of the mass m of air displaced.

The product of P^2 into these factors is equal to $(P^2 - A)$ to small quantities of a second order where

$$A = \left(\frac{\alpha^2}{8} + \frac{\lambda^2}{\pi^2} + \frac{i}{I} + \frac{mL}{2Mh}\right)T_0^2$$

The T^2, x^2, curve is therefore parallel to the P^2, x^2, curve and below it at a distance A.

For oscillations about the second knife edge the T'^2, x^2, curve is similarly parallel to the P'^2, x^2, curve and below it at the distance

$$A' = \left(\frac{\alpha^2}{8} + \frac{\lambda^2}{\pi^2} + \frac{i}{I} + \frac{mL}{2M(L-h)}\right)T_0^2$$

Solving the equations of the T^2, T'^2 curves for the value of T_0^2 and taking account of the fact that h/L for this particular design of pendulum is small or nearly unity according to the knife-edge from which h is measured, the value of T_0^2 is shown to be less than P_0^2 by $\left(\frac{\alpha^2}{8} + \frac{\lambda^2}{\pi^2} + \frac{i}{I}\right)T_0^2$ *the correction for the buoyancy of the air disappearing.*

6. Set of Values.

The following is a set of values (C. G. S. Units)

x_1	33.664	x_1^2	1133.3	x_2	2.262	x_2^2	5.117
T_1	2.016	T_1^2	4.064	T_2	1.994	T_2^2	3.976
T'_1	2.060	T'^2_1	4.244	T'_2	1.978	T'^2_2	3.912

These values give the curves of Figure 2. The (Period)^2 coordinate of the point of intersection is $P_0^2 = 3.999$.

In making these observations the amplitude of swing at no time exceeded 1/100 and scarcely fell to half value in one thousand oscillations so that the values of the first two terms of the reduction factor, $\alpha^2/8$ and λ^2/π^2, were extremely small.

Taking the value of the added mass on account of the motion of the air surrounding the pendulum as one half the mass of air equal to the pendulum in volume $i/I = .00015$.

The value of T_0^2 is therefore $3.999 \times (1 - .00015)$ and the value of "g" calculated therefrom is 980.41 as compared with the accepted value at Toronto, viz. 980.46.

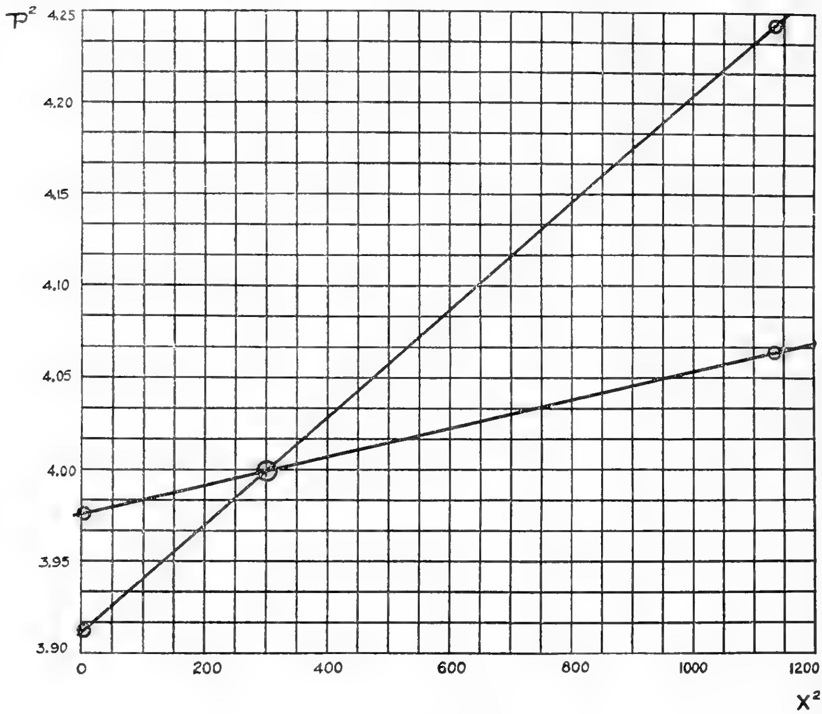


FIGURE #2.

Selected Radiations Emitted by Specially Excited Mercury Atoms

By H. J. C. IRETON, M.A.

(Read May Meeting, 1921)*

I. INTRODUCTION

Investigation of the relationships among the frequencies of the spectra of the elements has shown that the members of a spectral series are given by an equation of the form

$$\nu = (X, S) - (Y, P)$$

and the form of this equation suggests, in the light of the quantum theory, that the frequencies of the members of the series are proportional to differences in the energy possessed by the entity which is radiating the wave lengths in question.

If we suppose that those radiations emitted by an atom which constitute spectral series arise from the displacement of electrons in atoms, it would follow from the form of the equation given above that (X, S) and (Y, P) may be taken to be proportional to the energy possessed by the atom with the electron in the two positions or states between which the displacement takes place. We have then in the series frequency formulae for the atoms of any element, values for the energy which correspond to the various states in which those electrons in the atoms may be which contribute by their displacement to the radiation emitted. The values of (X, S) and (Y, P) taken from the frequency formulae of the spectrum of an element can be arranged in order of magnitude, and in this way be used to throw some light on the question of the configuration of the extra nuclear electrons of an atom emitting radiation.

This method has been suggested by Birge and has been applied by Foote and Meggers[1] to the Caesium atom. An application of the method to the atom of mercury, involving the use of data from known spectral series for this element, is shown in Fig. 1. According to this diagram, it will be seen that the wavelength $\lambda = 1849.6$ Å.U. may arise from electrons passing from the position of $(2, P)$ energy to that of $(1.5, S)$ energy. The second member of this principal single line series may be represented by electrons passing from the $(3, P)$ position to the $(1.5, S)$ one. The series $(2, P) - (m, S)$ where

* Communicated by Professor J. C. McLennan, F.R.S.

[1] Scientific Papers No. 386. Bureau of Standards.

$m = 2.5$, 3.5, etc., having the wavelength $\lambda = 10140$ Å.U. as its first member, may be represented by electrons passing from the (m, S) positions into the $(2, P)$ position. The lines of the second subordinate series of triplets are represented by electrons passing from the (m, s) positions into the $(2, p_1)$, $(2, p_2)$ and $(2, p_3)$ positions; the lines of

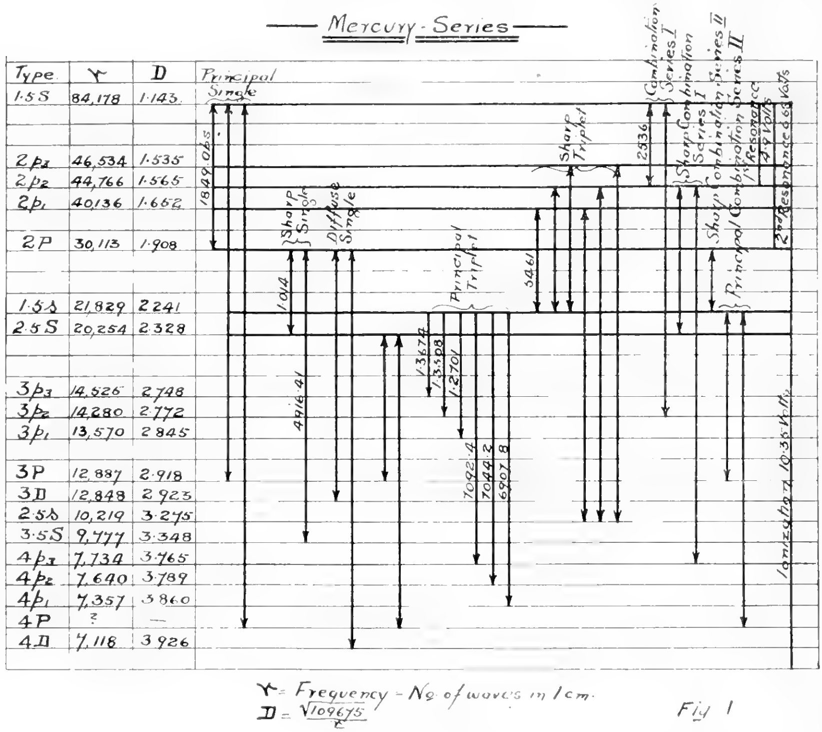
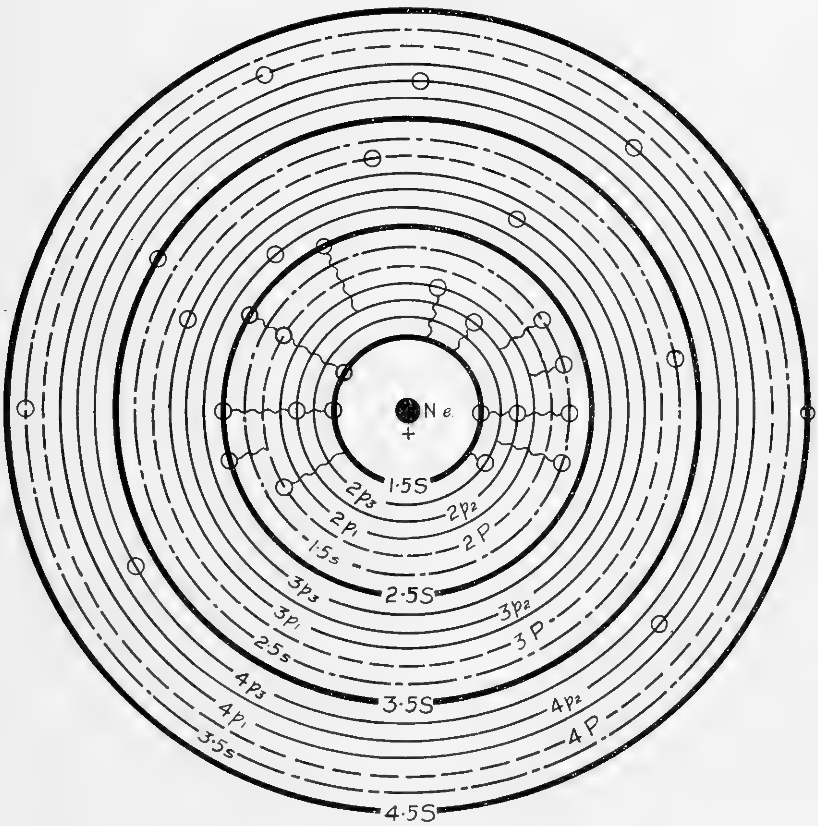


Fig 1

the $(1.5, S)-(m, p_2)$ series, a combination series, by electrons passing from the (m, p_2) position into the $(1.5, S)$ position. By this diagrammatic representation of series frequencies, one can see at a glance, not only how the various members of principal and subordinate series arise, but also how the members of the various combination series may be obtained.

On the basis of the Bohr atomic theory, we have a central nucleus surrounded by ring orbits in which electrons revolve. As long as an electron remains in the same orbit there is no radiation. According to Bohr, radiation is due to the loss of atomic energy caused by the passing of electrons from an outer to an inner orbit, this loss occurring in integral multiples of the quantum of the monochromatic radiation concerned.

In Fig. 2 this process of radiation has been illustrated diagrammatically for certain series lines. The circles represent stationary orbits for the revolving electrons, that is, when an electron is revolving in one or other of these orbits it is supposed not to radiate. Radiation is emitted according to the theory when an electron passes from an outer orbit to an inner one and when radiation is absorbed an electron is lifted from an inner to an outer orbit. For example, the wave lengths $\lambda = 5460.97$ Å.U., $\lambda = 4358.66$ Å.U., and $\lambda = 4046.78$ Å.U. may be represented by electrons passing from the (1.5, s) orbit to the (2, p_1), (2, p_2), and (2, p_3) orbits; the wave length $\lambda = 2536.72$ Å.U. by an electron passing from the (2, p_2) orbit to the (1.5, S) orbit, the wavelength $\lambda = 10141$ Å.U. by an electron passing from the (2.5, S) orbit to the (2, P) orbit.



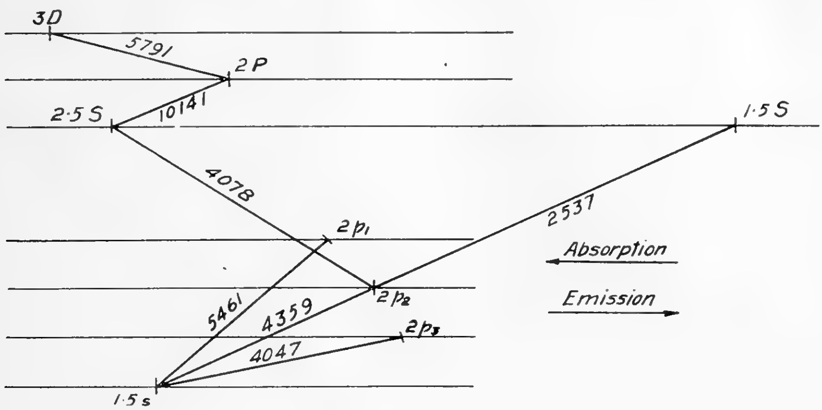
ELECTRONIC ORBITS - MERCURY ATOM
FIG. 2.

From an examination of the diagram it will be seen that before electrons are in a position to emit by their return to stable orbits radiation corresponding to certain wave lengths, they must be lifted out to definite orbits by the absorption of radiant energy or by colliding electrons of proper velocity. The electron may now return to its original orbit emitting radiation of wave length equivalent to the energy absorbed. If the temporary orbit in which a displaced electron may be situated is more than one orbit removed from the stable one, the return of the electron may possibly take place by intermediate stages. Again, if the electron has been lifted from its stable position to an outer orbit by the absorption of energy, it is then in a position to absorb more energy, suitably quantized, so as to be lifted to a more distant orbit. From this one it may be possible for it to return to its original position by a variety of transitions. For example, where an atom of mercury absorbs light of the wave length $\lambda = 1849.6$ Å.U. the electron is lifted to the $(2, P)$ orbit. If, when it is in the $(2, P)$ orbit, it absorbs energy of the wave length $\lambda = 10141$ Å.U. it is still further lifted to the $(2.5, S)$ orbit. According to the diagram this electron is now in a position to return to the stable orbit in at least two ways. It may return along the same path emitting the wave lengths $\lambda = 10141$ Å.U. and $\lambda = 1849.6$ Å.U. or it may pass from the $(2.5, S)$ orbit to the $(2, p_2)$ orbit emitting the wave length $\lambda = 4078.05$ Å.U. and from the $(2, p_2)$ orbit to the stable orbit $(1.5, S)$ emitting the wave length $\lambda = 2536.72$ Å.U.

On this basis it will be seen that when mercury atoms absorb light of the wave length $\lambda = 2536.72$ Å.U. electrons are lifted to the $(2, p_2)$ orbit. These atoms are then in a condition to absorb the light of all wave lengths for which the orbit $(2, p_2)$ is the initial orbit of an absorption process, that is, they are able to absorb light of the wave length $\lambda = 4358.66$ Å.U.—$[\nu = (2, p_2) - (1.5\ s)]$—or of the wave length $\lambda = 4078.05$ Å.U.—$[\nu = (2, p_2) - (2.5, S)]$. On the return to the stable orbit $(1.5, S)$ the electron may pass into one of the $(2, p)$ orbits giving rise to the emission of the wave lengths $\lambda = 5460.97$ Å.U. $\lambda = 4358.66$ Å.U. or $\lambda = 4046.78$ Å.U. On the other hand on the absorption of the wave length $\lambda = 4078.05$ Å.U. the electron is lifted to the $(2.5, S)$ orbit. Now it may return to the $(2, P)$ orbit giving rise to the emission of $\lambda = 10141$ Å.U.—$[\nu = (2, P) - (2.5\ S)]$, etc. Fig. 3 is an alternative method of illustrating the same process.

If the wave lengths corresponding to the return to the $(1.5, S)$ orbit from one of the $(2, p)$ or the $(2, P)$ orbits are not all known, it may perhaps be explained by the fact that they have been too faint to be recorded photographically.

Some experiments have been made by the writer to test out experimentally the ideas set forth above. In particular an attempt was made to see whether it was possible for mercury atoms to emit radiation of the wave lengths λ=5460.97 Å.U. and λ=4046.78 Å.U.



ORIGIN OF MERCURY RESONANCE SPECTRA.

FIG 3.

when they had previously been made to absorb successively light of the wave lengths λ=2536.72 Å.U. and λ=4358.66 Å.U. Experimental results were obtained which lend support to the idea. Some experiments were also made in which it was found that mercury atoms which had absorbed radiation of the wave length λ=2536.72 Å.U. were in the condition to absorb and subsequently re-emit the wave length λ=4358.66 Å.U. while ordinary unstimulated atoms of mercury were not.

An account of the investigation follows.

II. Apparatus and Experiments.

A specially constructed mercury arc lamp, as shown in Fig. 4 was used. It consisted of a pyrex tube of about 4.5 cms. bore, closed at the ends by plugs cemented into the tube. Supported inside this were two small tubes, one of glass, the other of quartz of about 8 mm. bore and having walls of equal thickness. These tubes were permanently closed at the left hand end. At the right hand their open ends passed through and projected equal distances beyond the end of the lamp. A quartz plate was cemented on to close the open ends of these inner tubes. These were placed as symmetrically as possible within the lamp, so as to receive equal illumination. Short side arms allowed the two inner tubes to be connected by a U tube arrangement, so that when mercury was placed in them, the vapour pressure would be the same in both. Various currents from 6 to 20 amperes at 220 volts were used in operating the arc.

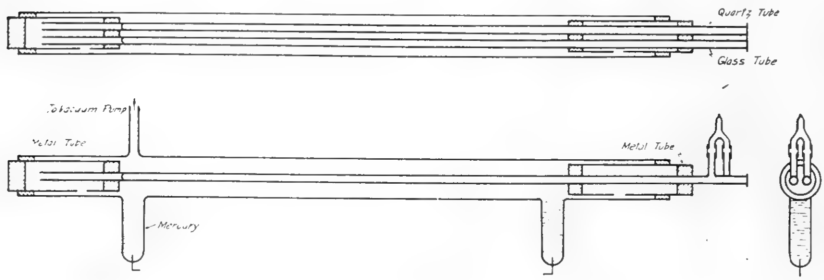
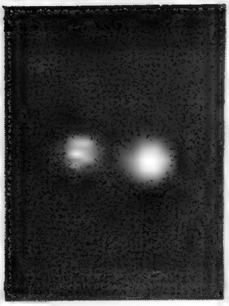


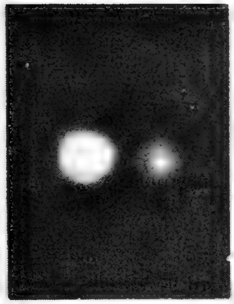
FIG 4

Close up to the window, which covered the projecting end of the inner tubes, a monochromatic filter and an automatically timed shutter and plate holder were placed. By the use of this arrangement photographic comparisons could be made of the intensities of light of the same wave length issuing from the two tubes. With a few minutes' exposure, results illustrated in Plate I (*a*) were obtained, when the inner tubes contained no mercury and were open to the air. In one set of experiments a filter was used that allowed light of wave length $\lambda = 5460.97$ Å.U. only to pass out. It will be seen that the spot from the glass tube is the stronger. Numerous photographs were taken and this result was invariably obtained. Equal quantities of mercury were introduced into the tubes so as to make as certain as possible that in the two the density of the mercury vapour was the same. This was also ensured by the connection between the two tubes referred to already. The tubes were then thoroughly exhausted and sealed off. The lamp was set in operation and photographs were again taken of the radiation of wave length $\lambda = 5460.97$ Å.U. issuing from the two tubes under these circumstances. It was invariably found that the light of the wave length $\lambda = 5460.97$ Å.U. issuing from the inner tube of quartz was stronger than the radiation of the same wave length issuing from the glass one. An illustration obtained from one of a number of photographs taken in this way is shown in Plate I (*b*).

Some photographs were also taken of the radiation of wave length $\lambda = 4358.66$ Å.U. issuing from both tubes when they were



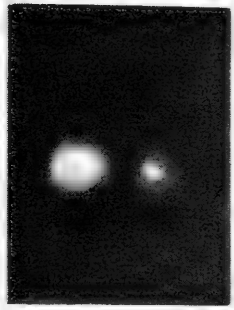
Spots obtained with
$\lambda = 5460{\cdot}97$ ÅU.



Without vapour in tubes
(a)

With vapour in tubes
(b)

Spots obtained with
$\lambda = 4358{\cdot}66$ ÅU.



Without vapour in tubes
(c)

With vapour in tubes
(d)

Note — In each illustration the left hand spot was produced by light issuing from the quartz tube. —the right hand spot by light issuing from the glass tube.

Plate I.

empty and when filled with mercury vapour in the manner just described. In this case also it was invariably found that with the empty tubes the radiation of wave length $\lambda=4358.66$ Å.U. issuing from the glass tube was stronger than the radiation of the same wave length issuing from the quartz one. When, however, the tubes were filled with the mercury vapour it was always found that the radiation of wave length $\lambda=4358.66$ Å.U. which issued from the quartz tube was of stronger intensity than that which issued from the glass one.

Photographs illustrating the results obtained with radiation of this wave length are shown in Plate 1 (*c*) and (*d*).

In this case the radiation of wave length $\lambda=4358.66$ Å.U. was isolated by a combination of numbers 45, 36, 50 and 48 Wratten Light filters.

Attempts were also made to apply this method to obtain a comparison of the intensities of the radiation of wave length $\lambda=4046.78$ Å.U. issuing from the tubes when empty and when filled with mercury vapour. It was found, however, impossible to isolate satisfactorily the radiation of this wave length, either by the use of filters or by other means, and consequently no information was obtained about the emission of this radiation by mercury atoms stimulated by the successive absorption of light of wave length $\lambda=2536.72$ Å.U. and $\lambda=4358.66$ Å.U.

III. Discussion of Results.

With the arrangements adopted in the experiments described above, it will be seen that when the inner tubes were empty, the radiation of wave lengths $\lambda=5460.97$ Å.U. and $\lambda=4358.66$ Å.U., which issued from the tubes, came after entering the tubes either directly to the windows or was reflected to the windows from the inner surfaces of the tubes.

When the tubes contained the mercury vapour, the radiation of the wave lengths mentioned which issued from the windows came

I. in part direct from the arc or by reflection from the walls of the tubes

II. in part after being scattered by the mercury vapour and

III. in part from those mercury atoms which had received the special and specific stimulation, corresponding to the successive absorptions of the radiations $\lambda=2536.72$ Å.U. and $\lambda=4358.66$ Å.U.

As every precaution was taken to maintain uniform conditions throughout the experiments, it seems reasonable to suppose that in so far as I and II are concerned the ratio of the intensity of the radiation of wave lengths $\lambda=5460.97$ Å.U. and $\lambda=4358.66$ Å.U. that issued from the quartz tube to the intensity of the radiation of these wave lengths issuing from the glass tube was the same when both tubes contained mercury vapour as when they were empty. It seems fair then to draw the inference that the increase invariably observed in the intensity of the radiation of wave lengths $\lambda=5460.97$ Å.U. and $\lambda=4358.66$ Å.U. issuing from the quartz tube when the tubes contained mercury vapour was due to some cause other than those referred to in I and II. As glass is opaque to all radiations shorter than $\lambda=3000$ Å.U. while quartz is transparent to radiations with wave lengths as short as $\lambda=1800$ Å.U. one is forced to the conclusion that the observed increase in the intensity of the wave lengths $\lambda=5460.97$ Å.U. and $\lambda=4358.66$ Å.U. was due in some way to wave lengths shorter than $\lambda=3000$ Å.U.

It is known that mercury vapour strongly absorbs radiations of wave lengths at or near $\lambda=2536.72$ Å.U. and at or near $\lambda=1849.6$ Å.U. On this account one would naturally seek to associate the observed increased emission of the radiations in question with the absorption by the mercury vapour in the quartz tube of radiations of the wave lengths $\lambda=2536.72$ Å.U. and $\lambda=1849.6$ Å.U. From the work of R. W. Wood[1], Steubing[2] and others, it is known that mercury vapour exhibits strong fluorescence when light of the wave lengths $\lambda=2536.72$ Å.U. and $\lambda=1849.6$ Å.U. is allowed to fall on it and that the fluorescence spectrum produced under these circumstances includes a symmetrical structureless band extending from the red down to the wave length $\lambda=3700$ Å.U. with its maximum at 4850 Å.U.

It was therefore thought at first that the observed increased intensity of the radiation of wave lengths $\lambda=5460.97$ Å.U. and $\lambda=4358.66$ Å.U. might have been due to the fluorescence of the mercury vapour produced by either or both of the wave lengths $\lambda=2536.72$ Å.U. and $\lambda=1849.6$ Å.U. Numerous trials showed however, that in order to obtain distinct photographs of the $\lambda=4850$ Å.U. fluorescent band from mercury vapour, which was made to fluoresce as strongly as possible, exposures of long duration extending from 3 to 5 hours were required when the fluorescent light was focussed directly on the slit of the spectrograph and when no absorption screen was inserted in the path of the light. Even with such exposures

1 R. W. Wood, Physik. Zeit. X. 425 u. 466, 1909.

2 Steubing, Physik. Zeit. X. p. 787, 1909.

the fluorescent band obtained was not at all comparable in intensity with the photographs of the spots obtained from the light, issuing from the tubes, which, as mentioned above, passed through absorption screens to isolate the waves concerned. To obtain the fluorescent band with intensities comparable to those of the spots, exposures would have been required of from 7 to 10 hours duration.

It should be stated that in the case of the wave length $\lambda = 5460.97$ Å.U. the filter used cut down the intensity of the light approximately by 30%, while in the case of the wave length $\lambda = 4358.66$ Å.U. the combination of filters used allowed only about 50% of the light issuing from the tubes to pass through.

When the light issuing from the tubes was examined with a quartz spectrograph the spectrograms of the light issuing from the quartz tube showed no trace of the fluorescent band for exposures even much longer than those made in the experiments in which the spots shown in Plate I were obtained.

In view of the above results it seems correct to attribute the increase in intensity of the light issuing from the quartz tube as being due to some other phenomenon than that of fluorescence of the mercury vapour produced by the wave length $\lambda = 2536.72$ Å.U. and $\lambda = 1849.6$ Å.U. From the series relationships which hold among the wave lengths in the spectrum of mercury it does not seem possible that the absorption by the mercury vapour of radiation of the wave length $\lambda = 1849.6$ Å.U. could to any appreciable extent contribute to an emission by the mercury vapour of wave lengths $\lambda = 5460.97$ Å.U. and $\lambda = 4358.66$ Å.U. One is forced, therefore, to the conclusion that the increased emission of the wave lengths $\lambda = 5460.97$ Å.U. and $\lambda = 4358.66$ Å.U. originated in the absorption by the mercury vapour in the quartz tube of the radiation of wave length $\lambda = 2536.72$ Å.U. From the diagrams given it is easily seen that mercury atoms which absorbed this radiation were in the condition to absorb and therefore re-emit the radiation of wave length $\lambda = 4358.66$ Å.U. Such atoms must have been present in the mercury vapour in the quartz tube but there could be none in this condition in the vapour in the glass tube as radiation of wave length $\lambda = 2536.72$ Å.U. could not enter it to produce the necessary change in the atoms. This would explain therefore the increased emission from the vapour in the quartz tube observed with the wave length $\lambda = 4358.66$ Å.U.

As regards the increased emission of the wave length $\lambda = 5460.97$ Å.U. it is clear, as already stated, that atoms which absorbed radiation of wave length $\lambda = 2536.72$ Å.U. would be in the condition to absorb radiation of wave length $\lambda = 4358.66$ Å.U. The successive absorption of these two radiations would result in electrons being lifted from their stable orbit to the (1.5, *s*) orbit. They would therefore be in the condition to return to their stable orbits either by emission of radiation of wave lengths $\lambda=5460.97$ Å.U. and $\lambda=4046.78$ Å.U. followed by the emission of radiations where frequencies are given by $\nu=(1.5, S)-(2, p)$, and $\nu=(1.5, S)-(2, p_3)$. This would seem to account satisfactorily from the observed increased emission of the radiation of the wave length $\lambda=5460.97$ Å.U. from the quartz tube.

It would have been of interest to see whether there was also an increased emission of radiation of the wave length $\lambda=4046.78$ Å.U. from the quartz tube, but as indicated above, this was not found to be practicable.

During the course of the investigation the attention of the writer was drawn to a paper by Fuchtbauer[3] dealing with the same subject. In Fuchtbauer's experiments a tube of quartz containing mercury vapour was exposed to the light issuing from a quartz mercury vapour arc lamp of special design. It was so arranged that by cooling when desired, one end of the tube with ether and carbon dioxide snow, all the mercury vapour could be taken from the part of the tube exposed to the light from the lamp. With this arrangement it was found that when the tube was filled with mercury vapour the radiation of wavelengths $\lambda=4046.18$ Å.U., $\lambda=4358.66$ Å.U. and $\lambda=5460.97$ Å.U. which issued from the free end of the tube was very much greater than when the exposed part of the tube was deprived of mercury vapour. These experiments, it will be seen, confirm the results obtained in the present investigation but in them the part played by the ordinary scattering of light by atoms was not eliminated as it was in the present investigation by the use of the two tubes.

It should be pointed out, however, that in Fuchtbauer's experiments wavelengths which belonged to the enhanced series did not exhibit the strengthening shewn in the case of the arc lines $\lambda = 5460.97$ Å.U. and $\lambda = 4358.66$ Å.U.

In conclusion the writer wishes to express his indebtedness to Professor J. C. McLennan, F.R.S., for suggesting the problem and for continuous assistance during the investigation.

The Physical Laboratory,
University of Toronto.
May 1, 1921.

[3] Fuchtbauer, Physik. Zeitschr XXI. P. 635, 1920.

The Radial Velocities of 594 Stars

BY J. S. PLASKETT, W. E. HARPER, R. K. YOUNG, H. H. PLASKETT

This work, which will appear as Vol. II No. 1, Publication of the Dominion Astrophysical Observatory, has been the main work of the observatory since actual observing commenced in May, 1918.

The stars were selected, in co-operation with the Mt. Wilson Observatory, from those in Boss's Preliminary General Catalogue north of the equator, which had not been previously observed for radial velocity. The programme, as prepared for this observatory, consisted of 770 stars in the alternate (even) minutes of right ascension. Of these 770 stars 50 around the eighth photographic magnitude or fainter were postponed for lower dispersion, leaving 720 stars to be observed. As 183 of these 720 stars proved to be spectroscopic binaries or otherwise unsuitable, there were left 537 constant velocity stars, of which 3,287 plates were obtained and measured, for the main list. In addition a list of the "gamma" velocities of 22 spectroscopic binaries, whose orbits have been determined here from 544 plates, and a table of the estimated velocities of 35 binaries from 206 plates are given, making a total of 594 stars.

The observations were all made with single prism dispersion, 34 A to the millimetre at Hγ until Aug. 12, 1919, and 29 A after that date when a larger angle prism was substituted. All the stars whose spectral type is F0 or later, provided the lines are sharp, were measured on the spectro-comparator, and the earlier type spectra on micrometer engines. Inter-comparison of computed and measured values of the standards on the spectro-comparator gives confidence that the resulting velocities, with this instrument, are free from appreciable systematic error, which has been confirmed by the agreement of the velocities of some stars obtained in common here and at other observatories. For the micrometer measures, the wave-lengths of the lines used have been obtained from the best known values and, as the same wave-lengths have been used throughout, any future change in wave-length can readily be applied to the velocities.

As the average number of spectra obtained and measured per star is 6.1, and as the accordance in these well defined stellar spectra is generally excellent, the mean velocities should be reliable. Some measure of the accuracy is given by the probable errors as determined in the usual way from the residuals, from the mean velocity, of the individual plates. An idea of their general magnitude may best be obtained by dividing the stars into three main groups according to the method of measurement and the number and quality of the spectral lines. All the stars of type F0 to M, with the exception of a few fuzzy lined F's, have been measured on the spectro-comparator and form the first group with probable errors of the mean ranging between ±0.1 and about ±1.0 and of a single plate between ±0.2 and ±2.5 km. per second, with average errors of ±0.5 and ±1.2 respectively. The second group includes the A and B type stars with fairly sharp and numerous lines, measured on micrometer engines, the probable errors ranging from about ±0.5 to ±1.5 for the mean velocity and from ±1.2 to ±3.5 for the single plate. The third group includes those stars, mostly of the A type in which the few lines present are broad, diffuse and frequently lacking in contrast. In many of these only broad $H\gamma$ and $H\delta$ were measurable and the accidental errors are high, ranging from about ±1.0 to ±4.0 for the mean and ±2.5 to ±10.0 for the single plate. To compensate partly for the unavoidably high accidental error of this group, a larger number of plates, up to 8 or 10, were made of many of these stars. For single prism dispersion the accuracy of these velocities may be considered quite satisfactory and the number of plates obtained increases the confidence in the reliability of the results.

The complete publication will contain, besides descriptive matter, tables of the individual velocities of 3,493 plates of 572 stars. These velocities are summarized in tables of the mean velocities of 537 constant velocity stars and of the estimated velocities of the centre of mass of 35 spectroscopic binaries. In addition a table of the "gamma" velocities of 22 spectroscopic binaries, whose orbits have been determined here, is given.

1. *On Some New Formulae for the Direct Numerical Calculation of the Coefficient of Mutual Induction of Coaxial Circles*

By LOUIS V. KING, D.Sc., F.R.S.C.

A formula based on the computation of arithmetico-geometrical means by calculating machine was discussed by the writer some years ago in a former paper. The present paper deals with a new property of the arithmetico-geometrical scale which leads to an extremely convergent expression for the inductance of coaxial circles lying close to one another.

2. *On a New High Frequency Vibration Galvanometer*

By LOUIS V. KING, D.Sc., F.R.S.C.

By means of a mechanical device, the vibrations of the reed of a Brown telephone receiver are optically magnified to such an extent that 1,000-cycle alternating currents of a few micro-amperes may be easily measured. In combination with vacuum amplifiers, currents several thousand times smaller may also be measured.

3. *On the Photographic Recording and Measurement of Radio-telegraph Signals*

By LOUIS V. KING, D.Sc., F.R.S.C.

In modern methods of heterodyne reception, the incoming radio-frequency current in the aerial is caused to "beat" with the oscillations of a local circuit, the frequency of the resulting musical note being adjustable by the tuning condenser. The high frequency vibration galvanometer above referred to will give visible signals which are just audible in the telephone receiver. Owing to the sharpness of resonance of the vibration galvanometer, visual or photographic reception by this means is remarkably free from static interference. Various applications to practical wireless problems are discussed.

4. *On a New Lecture Room Illustration of Atomic Models*

By Louis V. King, D.Sc., F.R.S.C.

The essential feature of this form of atomic model is the use of a powerful alternating field, in which steel spheres or needles repel one another with forces which are remarkably uniform. Attraction to some fixed centre can easily be arranged for in a number of ways. Under this system of forces the spheres or needles arrange themselves in concentric rings, resembling some of the atomic models which have been proposed.

The Transmission of Heat Through Thin Boundary Films of Air or of Water at the Surface of Glass.

By A. Norman Shaw, D.Sc., and L. A. Smith, B.A.

Presented by A. S. Eve, F.R.S.C.

The following points were discussed in the paper:

1. The immediate need and the practical application for further physical data of this type.

2. The experimental determination of normal surface conductivities.

3. The results obtained by the writers for the equivalent thermal conductivities of thin films of water or of air at the surface of glass.

4. Comparisons of the thermal conductivities and also of the temperature gradients for the different parts of a double window.

5. Observations on single-frame double windows.

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[1]N.B.—As part of this work has been reported in the Journal of the American Society of Heating and Ventilating Engineers for December, 1920, and as a full account is to be published later, this paper was not submitted for further publication here.

Transactions of The Royal Society of Canada
SECTION IV

SERIES III | MAY, 1921 | VOL. XV

Camsellite, a New Borate Mineral from British Columbia, Canada

By H. V. ELLSWORTH and E. POITEVIN
(Published by permission of the Deputy Minister of Mines)

Presented by R. A. A. JOHNSTON, F.R.S.C.

(Read May Meeting, 1921)

Early this year (1921) Mr. W. Thomlinson, Collector in British Columbia for the Department of Mines, sent in some specimens of a fibrous vein material, asbestos-like in appearance, but characterized by an almost pure white colour unusual in chrysotile. The specimens were obtained from a serpentine mass near Douglas Lake in the Nicola Mining Division, where the mineral is said to occur in considerable abundance filling shear zones in the serpentine. In heating the white mineral before the blowpipe R. A. A. Johnston detected the boron flame colour and further chemical examination confirmed the presence of large amounts of B_2O_3.

The samples so far examined are fragments of vein-like material varying from one quarter inch to three inches in width and consist of an intimate mixture of the new mineral with yellowish to greenish chrysotile and white dolomite. There are no fibres crossing from wall to wall as is commonly characteristic of chrysotile veins. The trend of the fibrous structure is in a plane parallel to the extension of the vein, though the fibres run in all directions within this plane, giving the impression that many shearing movements have occurred in various directions parallel to the veins. The vein material as a whole, is also more or less crumpled and wavy and the whole effect is suggestive of severe deformation.

While the three minerals are all very intimately associated so that it has been impossible so far to obtain them individually pure there are, nevertheless, layers varying from a quarter of an inch in thickness to paper thinness, in which one or other of the minerals predominates. By selecting a layer of the white material which showed apparently the greatest freedom from the associated minerals and carefully scratching away the fibres with a steel point, one could feel and avoid the harder, gritty dolomitic portions. The areas showing a yellowish or greenish colour due to chrysotile were also rejected. In this way the sample for Analysis I (Borate) was obtained.

The purest layer of dolomite in the specimen from which the borate sample I was obtained was broken out, crushed, and as much as possible of the fibrous material removed under the binocular. It was then crushed fine and sifted on a 200 mesh sieve. Most of the remaining fibrous material was left on the sieve and the dolomite powder which passed through was used as the material for Analysis II.

The sample of chrysotile analyzed (III) was obtained from a layer in the same specimen from which the borate and dolomite were taken. It was carefully worked over under the binocular and appeared to be quite free from borate, but contained a little dolomite.

The three samples were carefully analyzed in duplicate, direct determinations being employed for all constituents, with the following results:

I

Borate	%
SiO_2	7.65
Fe_2O_3	0.86
FeO	0.95
MnO	0.85
Al_2O_3	0.26
CaO	3.69
MgO	41.72
B_2O_3	29.07
Na_2O, K_2O	0.03
NiO	trace
Cr_2O_3, SrO, BaO, P_2O_5, ZnO	Not detected
$H_2O+110°$	9.88
$H_3O-110°$	0.52
CO_2	5.64
	100.12

II

Dolomite	%
CaO	29.05
MgO	20.98
FeO	0.29
MnO	0.66
Al_2O_3	0.09
CO_2	46.10
$H_2O+110°$	0.69
$H_2O-110°$	0.03
SiO_2	1.15
MgO	1.01
B_2O_3	trace
	100.05

III

Chrysotile	%
SiO_2	39.95
MgO	41.43
Fe_2O_3	1.44
FeO	0.13
Al_2O_3	0.32
MnO	0.06
CaO	0.75
Cr_2O_3	0.01
CO_2	1.15
$H_2O+110°$	13.04
$H_2O-110°$	1.80
NiO, K_2O, Na_2O, B_2O_3	traces
	100.08

1 A

		Molecule Ratios		
MgO	45.24	1.1220	$\frac{1.1633}{2}$	$=0.5816-1.998$ or 2
Fe_2O_3	0.85	0.0053		
FeO	1.28	0.0178		
MnO	1.09	0.0154		
Al_2O_3	0.29	0.0028		
B_2O_3	40.40	0.5788	$\frac{0.5788}{1}$	$=0.5788-0.994$ or 1
$H_2O+110°$	10.55	0.5858	$\frac{0.5858}{1}$	$=0.5858-1.006$ or 1
			Average	0.5821
$H_2O-110°$	0.26			
K_2O, Na_2O	0.04			
	100.00			

Theoretical Composition of Camsellite ... $2MgO.B_2O_3.H_2O$...

MgO	47.87
B_2O_3	41.44
H_2O	10.69
	100.00

2 A

CaO	29.77
MgO	21.50
FeO	0.30
MnO	0.68
Al_2O_3	0.09
C_2O	47.25
H_2O	0.41
	100.00

3 A

SiO_2	40.80
MgO	41.90
Fe_2O_3	1.48
FeO	0.13
Al_2O_3	0.33
MnO	0.06
Cr_2O_3	0.01
$H_2O+110°$	13.35
$H_2O-110°$	1.84
	100.00

Considering first the dolomite analysis II we may deduct SiO_2, MgO and H_2O to form chrysotile, assuming the true percentage of water in chrysotile to be 14.84, as shown in III, and neglecting the minor constituents of the latter (Fe_2O_3, FeO, Al_2O_3, MnO) which would in no case contribute more than 0.01% to the results. In making the analysis the dolomite was dissolved in the smallest possible amount of dilute hydrochloric acid added in small portions till action ceased. The chrysotile thus set free was filtered off and treated separately for magnesia and silica with results indicated in the analysis.

Evidently the chrysotile was only slightly, if at all, affected by the treatment.

The result of the recalculation for the dolomite after making these deductions is shown in Table IIA.

In the case of the chrysotile (III) we may deduct all the CaO and CO_2 and the necessary amount of MgO to form dolomite. After recalculation this gives results as in Table IIIA indicating the presence of about 2.41% of dolomite in the chrysotile sample as prepared for analysis.

We are now in a position to correct the borate analysis I for the dolomite and chrysotile present. If we deduct all the CaO and CO_2 along with the necessary MgO, H_2O and minor constituents using the CaO and CO_2 as the bases of calculation we obtain for the dolomite present in the borate mixture approximately 11.95% as indicated below:

CaO	3.69
MgO	2.45
MnO	0.08
FeO	0.04
CO_2	5.64
H_2O	0.05
	11.95

From the calculation the ratio of MgO: CaO in the dolomite mixed with the borate is as 1:1.5 while in the dolomite sample II it was 1:1.385. The slight excess of lime in this case, if not due to analytical error, may indicate that a little of the CaO replaces some MgO of the borate.

Deducting in a similar way the SiO_2, MgO and H_2O and small amounts of the minor constituents to form chrysotile we obtain for the chrysotile present with the borate approximately 18.69% as below:

SiO_2	7.65
MgO	7.84
Fe_2O_3	0.27
FeO	0.02
Al_2O_3	0.06
MnO	0.01
H_2O 110°	2.50
H_2O-110°	0.34
	18.69

Deducting the dolomite and chrysotile from the borate mixture and recalculating we obtain the results given in IA.

The formula indicated for the mineral is, therefore, $2MgO.B_2O_3.H_2O$ with ferrous and ferric oxide, manganous oxide and alumina in small amounts apparently replacing MgO. It is comparable to Sussexite, which has the same general formula, but in which manganous oxide is much in excess of magnesia.

Sussexite (Penfield, *Am. Jour. Sci.*, 36, 323, 1888.)

MnO	38.08
MgO	15.92
ZnO	3.24
B_2O_3	33.31
H_2O	9.43
	99.98

The water present is certainly chemically combined since only relatively small amounts are lost below a red heat. A one gram sample was heated in a platinum crucible at various temperatures with results as indicated below:

Time	Temperature	Loss in %
3 days	110°C	0.52
3 "	140	0.02
2 "	180° ±10°	0.07
6 hours	300 "	0.08
6 "	350 "	0.15
6 "	400 "	0.12
6 "	450 "	0.05
9 "	500 "	0.43
9 "	550 "	1.51
Total loss up to 550°		2.95
Total water		10.40

It thus appears to be a mineral of sufficient stability to admit of its having been produced at the range of temperature commonly ascribed to pneumatolytic action.

Pyrognostics, etc.

Before the blowpipe the mineral, though mixed with some chrysotile serpentine and dolomite fuses readily with little or no intumescence or exfoliation, imparting a green colour to the flame. The fused material is brownish black and opaque. It is soluble in HCl, H_2SO_4 and HNO_3. The hardness is less than 3. It is readily distinguishable from sussexite by the smaller manganese content.

Preparation of Thin Sections

Owing to the softness of the borate and the crumbly character of the whole mixture it was quite impossible to prepare sections in the ordinary way. An account of the procedure by which excellent sections were prepared, therefore, may be of interest.

The masses of borate mixture were sawn into pieces about two inches square, which were immersed in a not too concentrated solution of Canada Balsam in benzol. The Canada Balsam previous to solution in benzol had been heated to drive off the more volatile constituents until on cooling it had the correct degree of hardness for grinding. The beaker containing the squares immersed in the solution was then placed in a strong glass vessel and subjected to vacuum. There was for two or three hours abundant evolution of air from the squares, and when this finally ceased, normal atmospheric pressure was restored. The solution was then allowed to evaporate overnight until it had reached a syrupy consistency, when the squares were removed and placed in an electric oven at 50°C. After about 24 hours the squares were dry and could be worked in the usual way by sawing and grinding.

The heating in the oven, an undesirable feature which was adopted merely to save time, caused oxidation of the iron and manganese of the borate, which became darker in colour, no doubt accentuating the absorption observed in sections in polarized light.

It is likely that an ether solution of balsam would be better than the benzol solution for the preliminary soaking process owing to its lower boiling point.

Optical Properties

The sample prepared for analysis when examined under the microscope was seen to consist chiefly of minute fibres of camsellite showing parallel extinction and high birefringence. There were minor amounts of dolomite and chrysotile present, the former readily distinguishable by its characteristic cleavages, the latter by its low birefringence. The fibres of camsellite are always flattened parallel to the axial plane. The extinction is parallel and suggests that the mineral is orthorhombic. Its elongation is negative while that of chrysotile is positive. The habit of the mineral does not allow the emergence of an optic axis and for that reason β could not be determined. No attempt was made to measure 2V, but this angle is probably very large. α and γ were determined by the oil immersion method.

Camsellite	Chrysotile Serpentine
Elongation..........Negative	Elongation..........Positive
$\alpha = 1.575 \pm 0.005$	$\beta = 1.544 \pm 0.003$
$\gamma = 1.649 \pm 0.005$	
Birefringence very strong	
$(\gamma - \alpha) = 0.074$	$(\gamma - \alpha) = 0.013$
Pleochroism weak.	

Paragenesis and Geological Relationships

According to the description of Wm. McNeill of Merritt, B.C., on whose claim the mineral occurs, it is located in an area of serpentine ½ mile wide by a mile long, about 30 miles east on a waggon road Nicola station, which would bring it near the eastern end of Douglas Lake in an area mapped by G. M. Dawson (*Ann. Rep., G.S.C.*, 1894, vol. VII) as Lower Cache Creek formation of carboniferous age. Map 556 (B.C. Sheet No. 12, Kamloops Sheet) shows a mass of plutonic rock, probably granite, about four miles in diameter occupying the centre of this Cache Creek area, north of Douglas Lake, and probably not more than a mile or two from the camsellite occurrence. Dawson states that the rocks mapped as plutonic are chiefly granites and syenites with some associated gabbro in places and are always intrusive, being chiefly of late Triassic age, while according to others they are Jurassic. The Cache Creek formation, according to Dawson, is made up of limestone or marble as the upper members, with argillites, cherty quartzites and contemporaneous volcanics in great variety, as the lower part. Beds of nearly pure serpentine are associated with the volcanics. Dawson further states that "the rocks of this formation are almost invariably shattered and dislocated in an extreme degree." This fact is well evidenced in the camsellite, which shows the effect of extreme shearing and crumpling actions which must have taken place during or following its formation. The camsellite and also the dolomite are so intimately associated with the chrysotile that they appear to be but little later in order of formation and probably are contemporaneous, geologically speaking. It may be noted, however, that MnO is low in chrysotile, higher in the dolomite and still higher in the borate apparently indicating that the borate was the latest. This conclusion is supported by the evidence of structures observed in thin sections which leave little doubt that the order of deposition is as indicated, chrysotile first followed by dolomite and finally borate. The camsellite was, no doubt, formed by replacement of the silicic acid of the serpentine by boric acid. The boric acid may have come either from volcanic action or from the granite intrusion. Geological evidence would appear to rule out the Miocene volcanics as the source of the boric acid of camsellite, and we must ascribe its origin either to contemporaneous volcanic action during the Cache Creek period, to the volcanics of the Nicola formation or to pneumatolytic action from the granite intrusion.

At the suggestion of R. A. A. Johnston the mineral has been named in honour of Chas. Camsell of the Geological Survey in recognition of his valuable contributions to our knowledge of the geology of British Columbia.

Fig. I.

18 diameters. Thin section across vein showing Camsellite as dark, wavy material interbanded with and penetrating lighter chrysotile. There are two cracks in the section which are pure white.

FIG. II.

18 diameters. Thin section of Camsellite as dark fibrous material with prominent band of chrysotile (light) and broken off band of rough fibrous dolomite (gray) at right. Fracturing and deformation is very evident in lower right hand corner.

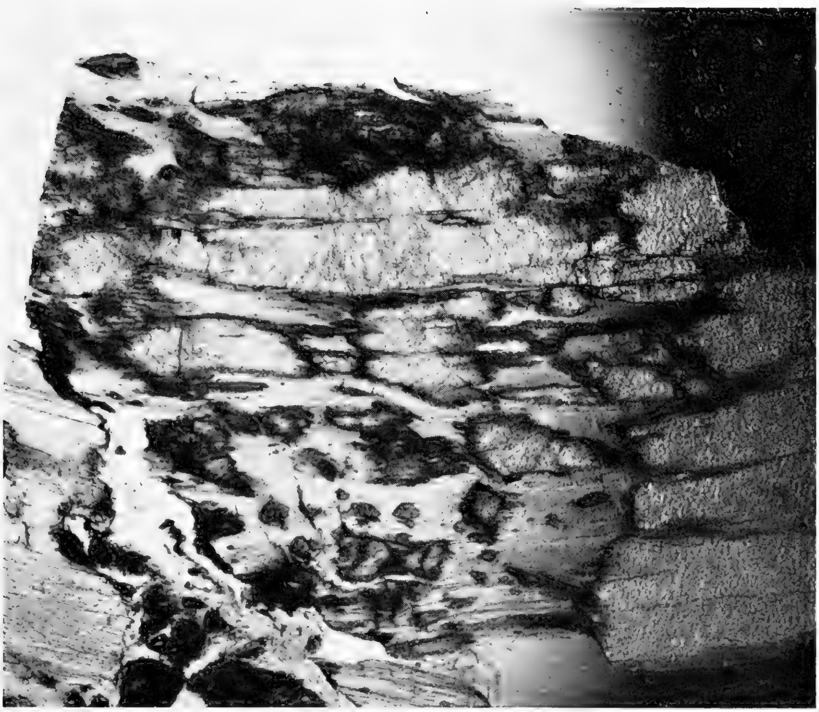

Fig. III.

18 diameters. Section parallel to banding of vein, showing fibrous Camsellite penetrating dolomite (with rough surface).

Pleistocene Oscillations of Sea-level in the Vancouver Region, British Columbia

By W. A. JOHNSTON, M.A., B.Sc.

Presented by R. A. A. JOHNSTON, F.R.S.C.

(Read May Meeting, 1921)

INTRODUCTION

The occurrence in the Vancouver region, British Columbia, of two Pleistocene boulder clays, separated by stratified sands and clays, has long been known and has been described by several geologists. It was referred to by G. M. Dawson, who stated[2] that it was doubtful whether the two boulder clays corresponded to the two periods of glaciation, evidences of which he had found in the interior of British Columbia, but that there may have been several climatic oscillations during the Pleistocene. O. E. LeRoy, who examined the area in 1907, describes briefly[3] the Pleistocene deposits and states that the stratified deposits overlain by till were formed by sub-glacial streams and also by streams issuing from the front of the glacier at a period of recession, but failed to find sufficient evidence to indicate an interglacial period. This view is apparently also held by R. A. Daly[4], who examined the area along the International boundary and by C. Camsell.[5] In a report[6] published in 1918 E. M. J. Burwash describes somewhat fully the Pleistocene deposits of the area and gives evidence to show that during the Pleistocene there was at least one interglacial period of long duration. There is, therefore, a difference of opinion as to whether extensive retreats of the ice-sheet took place in this region during Pleistocene time, but there is no doubt that at least one retreat and readvance of the ice-sheet occurred, the only point in dispute being the extent of the retreat and its significance as indicating an interglacial period. This question is not here, considered but attention

[1] Published by permission of the Director, Geol. Surv. Can.

[2] Geol. Surv. Canada, Ann. Rep. Vol. VII, 1894, p. 253B.

[3] Geol. Surv. Canada, Publication 996, 1908, p. 27. Preliminary Report on a portion of the main coast of British Columbia and adjacent islands, included in the New Westminster and Nanaimo Districts.

[4] Geol. Surv. Canada, Memoir No. 38, Part 2, p. 596.

[5] Geol. Surv. Canada, Guide Book No. 18, Part 11, 1913, p. 272.

[6] The Geology of Vancouver and Vicinity, The Univ. of Chicago Press, 1918.

is directed to the character and extent of the oscillations of sea-level relatively to the land, which took place during the Pleistocene, and to whether they were associated with the advances and retreats of the ice-sheet. The Vancouver region is one of the few known areas where conditions are favourable for determining this question, for in this region the stratified deposits interbedded with till are in part marine and hence should furnish some evidence regarding the position of sea-level during the times of formation of the sediments. The character and magnitude of Pleistocene and post-Pleistocene changes in level of the coast of British Columbia and adjacent regions were first described by G. M. Dawson in a paper published in the Canadian Naturalist in 1878. The well-known post-glacial uplift of the coast region of British Columbia has been referred to by several writers. The Pleistocene and post-Pleistocene changes of level in the Vancouver region have been described by Burwash in his report on the area and in the Puget Sound region to the south by J. H. Bretz.[7] Field work by the writer during parts of 1919 and 1920 in the Vancouver region and in the lower part of the Fraser delta showed that a previously unknown marine horizon occurs in the Pleistocene deposits of the region. The marine deposits appear to indicate that a third but probably local advance of the ice-sheet occurred and furnished some definite evidence regarding the position of sea-level relatively to the land, during a period of retreat of the ice, previously to the last advance.

Topography

The Vancouver region includes a part of the Fraser delta, which is bounded on the north by the Coast Range, on the east by the Cascades and has its southern limits in the State of Washington. The delta is composite in structure and was built up at different times. The oldest part is Eocene in age, is consolidated and forms the bed-rock of the greater part of the area. The bed-rock is overlain and very largely concealed by Pleistocene and Recent deposits having a maximum thickness as shown by borings of about 1,000 feet.

The topography of the delta region is in the main low but here and there island-like hills rise to various heights up to 1,000 feet above the sea. The lowest part of the area is occupied by the Recent or modern delta of the Fraser, which is nearly all below the level of high tide and is dyked to exclude the flood-tidal and freshet waters. It extends inland for 19 miles from the Strait of Georgia to the City

[7] Glaciation of the Puget Sound region; Washington Geological Survey, Bulletin No. 8, 1913.

of New Westminster and across its seaward front is 14 miles wide. The Recent delta is bounded on the north by an upland area extending east to New Westminster and north for 5 miles to Burrard Inlet, at the seaward entrance of which the city of Vancouver is situated. The inlet extends east for 14 miles and is bounded on the north by the Coast Range and on the south by an escarpment in the Eocene rocks, which at one place near the eastern end of the inlet rises to 1,125 feet above the sea. The upland area between Burrard inlet and the recent delta of the Fraser has a general elevation of 200 to 300 feet above the sea and consists in the southern part largely of drift deposits and in the northern part of rock ridges veneered with drift. At New Westminster the Fraser flows in a comparatively narrow valley 1½ miles wide between two upland drift areas. The area south of the river has a general elevation of 200 to 300 feet above the sea and extends for 7 miles southeast to the Nicomekl-Serpentine valley. This valley is continuous through to the Fraser river at Fort Langlely, 15 miles above New Westminster, and represents a post-glacial outlet channel of the Fraser which was abandoned during the period of post-glacial uplift when the land was about 50 feet lower than it is at present. Since that time the Fraser has occupied its present main channel past New Westminster. South of the Nicomeckl-Serpentine valley and extending to the International Boundary is another upland drift area 200 to 400 feet above the sea. In the seaward part of the Recent delta, at the International Boundary the highland area of Point Roberts has been joined to the mainland by the construction of the delta. It has a fairly even upper surface and a general elevation of about 200 feet above the sea. This upland area, as well as parts of those extending south from New Westminster to the International Boundary, were considered by Daly and LeRoy as remnants of the late Pleistocene Fraser delta which was dissected by the present stream as the result of post-glacial elevation. Burwash, however, holds that the flat-topped upland areas are composed largely of stratified deposits, which are interglacial in age and which were much eroded previous to the deposition of the till sheet overlying them.

The Pleistocene and Recent Deposits

The Pleistocene deposits of the region are remarkably thick and complex in character. The succession of deposits, as pointed out by Burwash,[1] is in the main similar to that in the Puget Sound region

[1] Ibid., p. 80.

as described by Willis and Bretz. Two till sheets have been recognized in both regions—the lower till known as the Admiralty till and the upper as the Vashon till. Separating the two tills are thick deposits of stratified sand and gravel, silts and clays, known as the Admiralty sediments. Stratified silts, which are probably of Pleistocene age, occur in places below the lower till but no evidence of till older than the silts has been found. Stratigraphically above the upper till, but covering it only in places, are the outwash and delta sands and gravels and stratified clays deposited during the final retreat of the ice-sheet and the Recent delta and alluvial deposits.

Although the Admiralty sediments are probably in part at least marine because of their position near sea-level and on the coast, and because they consist in part of stratified clays, upwards of 100 feet of which are exposed in the sea cliffs near the International Boundary, they have yielded no marine fossils in the Fraser delta region. A single occurrence of fossil marine shells in the drift deposits near Central Park, between Vancouver and New Westminster, was reported by Burwash,[2] who thought that the fossils were from the Admiralty sediments but investigation by the writer of the occurrence appeared to show that they were in till, or at least that the mode of occurrence was doubtful, for the shells were found in an excavation for a well in which no good section was exposed. Fossil marine shells in the Pleistocene deposits were, however, found by the writer at a number of widely separated localities in the Fraser delta region. The marine horizon appears to be younger than the Admiralty sediments and older than the latest glacial deposits.

The fossil marine shells occur at a definite horizon in the drift deposits exposed in the sea cliff extending along the coast for several miles west of White Rock, near the International Boundary. The marine horizon was found at several places in these sections for a distance of about two miles along the coast. It lies at a nearly uniform height in the sections of about 100 feet above sea-level. The shells occur in stony, unstratified clay in a zone a few feet thick near the middle of what appears to be a single till sheet 40 to 50 feet thick. The shelly zone, however, is more clayey and less stony than the till in general; many of the shells are well preserved, and barnacles and worm-shells occur attached to the stones. It is, therefore, probable that it represents an old sea-bottom ploughed by the advancing ice, which deposited the till. It is not impossible, however, that the shelly till was transported some distance and hence

[2] Ibid., p. 87.

does not represent the actual position of the old sea-bottom. The till below the marine zone overlies stratified sands, silts and clays varying from a few feet to nearly 100 feet in thickness which are again underlain by till. These stratified deposits and lower till are evidently to be referred to the Admiralty sediments and Admiralty till and, therefore, the marine horizon is probably later than a till which overlies these deposits.

An excavation 26 feet deep for a sewer along 16th Avenue West in Kitsilano, Vancouver, exposed near the base of the cutting, a shell bed which was continuous in the section for a distance of nearly 1,000 feet. The shells occur in the upper 1 or 2 feet of blue stony unstratified clay, 6 to 8 feet of which are exposed at the base of the section, and in a sandy layer, a few inches thick overlying the clay. The shell beds are overlain by 3 to 6 feet of sand without definite stratification and stony in places. The sand is overlain by 12 to 16 feet of faintly stratified silt and clay, barren of fossils and containing numerous large glaciated boulders. The shell bed occurs at this locality at a height of 50 feet above the sea. No true till overlies the shell bed but the presence of glaciated boulders in the overlying clays and the unfossiliferous character of the clays shows that glacial conditions followed the formation of the shell beds. The till exposed at the bottom of the section probably overlies the stratified (Admiralty) sediments but this relation was not directly observed.

Fossil marine shells were also found in a section exposed by the construction of the Pacific highway along the side of the hill on the south side of Fraser river 1½ miles above New Westminster. The hill rises somewhat steeply from the level of the river up to about 200 feet. At the base of the section in the road cutting which rises gradually along the side of the hill blue stony till is exposed. The shells occur in the upper 1 to 3 feet of the stony clay and in a sandy bed a few inches thick overlying the clay. The shell beds are overlain directly by 6 to 10 feet of stratified sand and clay barren of fossils, and immediately to the east the till and the fossiliferous beds pass beneath a thick deposit of stratified sand and gravel in which a large excavation for a gravel pit has been made. The gravels are at least 50 feet thick and occur in the form of a ridge or dome with marked stratification dipping down on either side in the form of an anticline. They are, therefore, probably fluvio-glacial in origin and show that glacial conditions followed the deposition of the shell beds. The shell beds at this locality are 40 to 50 feet above the sea. The occurrence of the marine beds at this locality on the north slope of the hill and only 40 to 50 feet above the level of the river shows that the valley between the drift ridges at New Westminster, now occupied by the Fraser river existed at the time of the marine incursion. It is probable, therefore, that considerable erosion of the drift deposits had taken place prior to the deposition of the shell beds.

The fossil shells, as determined by E. J. Whittaker of the Canadian Geological Survey, are of 20 species. He states: "The fauna is quite comparable with the inshore fauna of the British Columbia coast at the present time. Most of the species range from Behring Sea to Puget Sound. The assemblage represents a typical mixture of intertidal and shallow water forms." At the two localities mentioned—Kitsilano and near New Westminster—numerous well preserved molluscan shells occur. Several specimens with both valves attached and closed and filled with sand were dug out of the stony clay. This mode of occurrence and the fact that they occur only in the upper part of the clayey till and not scattered through it shows that they have not been transported but lived nearly in the position in which they are found. They show that at the time of their deposition the sea stood 50 to 100 feet higher than it does at present.

Fossil shells have been found also in wells in the drift near Central Park and as far up the Fraser valley as Murrayville, 2 miles east of Langley Prairie. At these places the surface material is till and the shells are reported at various depths, from 15 to 30 feet and at various heights up to 350 feet above sea-level. It is not certain in what material the shells occur and it is possible that at these localities the shells are not in place.

Although it is not possible to trace the marine horizon definitely throughout the district it is probable, because of the general similarity of the mode of occurrence of the fossils, that the horizon is a single one and extends over a considerable area in the Fraser valley. The marine deposits show that some time during the Pleistocene period the sea entered the Fraser valley following a retreat of the ice-sheet, and the till which overlies the marine beds shows that a readvance of the ice-sheet took place. The position of the marine horizon in the upper part of the Pleistocene series, the fact that in places the marine beds are overlain not by till but by stratified deposits only, and the evidence that the valley in the drift deposits above New Westminster existed at the time of the marine invasion, appear to show that the readvance of the ice-sheet occurred late in the Pleistocene and was more or less local in character.

The occurrence is a remarkable one when it is considered in connection with the character in general of the Pleistocene deposits in the region. It is the only marine horizon known in the Pleistocene of the Fraser valley. It is underlain in places by 50 to 100 feet of stratified silts and clays (part of the Admiralty sediments) which, because of their position near the coast and in the wide open part of the valley, are probably marine, yet so far as is known they contain no marine fossils. The shell beds are overlain in places by an observed thickness of 15 to 20 feet of stratified silt and clay and, stratigraphically, by the post-glacial clays, 100 feet or more in thickness, which are also probably marine, but contain no marine fossils nor have marine fossils been found in even the lowest of the raised beaches of the district. The apparent absence of marine life in the waters occupying the Fraser valley during the time of deposition of the Admiralty clays and later during the deposition of the post-glacial clays was probably due to the low salinity of the water occasioned by the great inflow of fresh water from the melting ice-sheets. During a part of late Pleistocene time, however, marine life was, as has been shown, abundant in the waters occupying the valley.

The Oscillations of Sea-level

The pre-glacial position of sea-level relatively to the land in the Vancouver region is not definitely known and is not easily determined because it is difficult to estimate the amounts of glacial over-deepening of the mountain valleys and fiords and to distinguish between valleys formed by normal stream erosion and those of structural origin. It is generally held that, during the Pliocene, the land in this general region stood much higher relatively to sea-level than it does at present, and the absence of marine Pliocene on this part of the coast bears this out. A boring made at Steveston, near the mouth of Fraser river, showed that the Pleistocene and Recent deposits have a thickness of about 860 feet below sea-level. This part of the Fraser valley is so wide that ice erosion could scarcely have had much effect in over-deepening the valley. It is possible, therefore, that, preglacially, the land stood about 900 feet higher than it does at present—as was held by G. M. Dawson.[1] On the other hand it is possible that the lower part of the Fraser valley is mainly structural in origin and the relationships of the small valleys tributary to the main valley and those tributary to Barrard Inlet suggest that the position of sea-level was not greatly different from what it is at present, but it was probably somewhat lower.

During the deposition of the Admiralty sediments the land was probably lower relatively to sea-level than it is at present for, as

[1] Trans. Roy. Soc. Canada, 1890, Vol. VIII, Sect. IV, p. 17.

pointed out by Burwash,[1] there is a transition upwards from the till to the stratified clays which overlie it, and these clays, although they contain no marine fossils in this region are, because of their position, probably marine. The amount of depression of the land relatively to sea-level during this period is not definitely known but as evidenced by the clays it was at least 200 feet and probably higher. The occurrence of stratified clays overlain by till at high altitudes—up to 1,200 feet above the sea—in the Capilano valley tributary to Burrard Inlet led Burwash[2] to conclude that the sea stood about 1,300 feet higher than at present, but it is possible that the clays in this valley and the sands over 200 feet in thickness, overlain by a few feet of till which form the seaward part of Point Grey, west of Vancouver, belong to a later, probably local, period of glaciation; for they are unweathered, whereas the older clays are in places weathered, and it is improbable that stratified clays would be left in a mountain valley like the Capilano, following an extensive advance of the glaciers. This occurrence of the stratified clays at such high levels is not easily explained. They are possibly marine but the absence of other evidence of submergence to this height does not favour this view.

The deposition of the Admiralty sediments was followed by uplift of the land and dissection of the drift deposits. Bretz[3] holds that in Puget Sound region the land stood about 1,000 feet higher than at present and that extensive valleys in the drift deposits were formed during this period of erosion. Burwash[4] holds that in the Vancouver region there is nothing that would necessitate a level much higher than at present, unless ice erosion be neglected. Erosion of the drift deposits took place during this period or at some time previous to the latest deposits of till, for the valley occupied by the Fraser at New Westminster is cut in drift deposits and was formed in part at least prior to the last advance of the ice, and the upland area of Point Roberts composed largely of stratified sands and silts overlain by till can not be a remnant of the late glacial delta for it is separated from the mainland by the Recent delta deposits. It is probably a remannt of a more extensive mass of sediments eroded by streams during a period of retreat of the ice-sheet or by the ice-sheet again advancing. In the upper part of the Nicomekl-Serpentine valley, cut in drift deposits, borings have shown that the post-glacial clays

[1] Ibid., p. 85.

[2] Ibid., p. 85.

[3] Ibid., p. 237.

[4] Ibid., p. 91.

have a maximum thickness of at least 300 feet below sea-level. The valley appears to have been formed by stream erosion rather than by ice because of its narrowness. It is, therefore, probable that the land stood considerably higher than now, during this period of retreat of the ice-sheet.

The second advance of the ice-sheet was followed by a period of partial retreat of the ice, during which period, for a time at least, the sea stood 50 to 100 feet higher than it does at present, as is shown by the occurrences of marine fossils already described. A third advance of the ice-sheet took place but probably did not extend much beyond the Fraser valley. Depression of the land relatively to sea-level followed the third advance of the ice, but was at first of small amount, as is shown by the occurrence near New Westminster of the glacial outwash fan 50 to 100 feet above sea-level. At the time of final retreat of the ice-sheet the depression of the land was much greater.

The post-glacial marine submergence in the Vancouver region is well established. It is held by Burwash[1] that the sea stood at least 760 feet and perhaps 800 feet higher than now. There is no doubt that it stood at least 650 feet higher, for well-terraced delta deposits occur at the mouths of the valleys tributary to Burrard Inlet on the north side at various elevations up to this height and it is possible, as stated by Burwash, that it was much higher. The beaches and terraces formed during the period of post-glacial uplift are in places numerous and fairly well-developed but individual terraces or beaches cannot be traced for any great distance and the upper limit of marine submergence is not definitely marked. Hence it is difficult to determine in this region the character of the uplift, whether differential or not. The fact, however, that in the vicinity of Victoria, on Vancouver Island, the upper limit of marine submergence is only about 250 feet[2] and near Nanaimo only about 400 feet shows that the amount of uplift increases in the direction of retreat of the ice-sheet or towards the centre of ice accumulation. The great number and comparatively weak character of the raised beaches show that uplift was somewhat rapid and nearly continuous. It was probably, therefore, associated with deglaciation and is isostatic in character. The post-glacial oscillation of sea-level must have been in part the result of the general rise of sea-level due to the return to the sea of the water bound up in the ice-sheets, but the magnitude of the oscillation shows that it

[1] Ibid., p. 93.

[2] Charles H. Clapp., Geol. Surv. Canada, Guide Book No. 8, Part 3, p. 286, 1913.

could only have been in part due to this cause. No evidence as to what extent the apparent rise of sea-level was due to this cause was found in the Vancouver region. Bretz[3] has pointed out that the existence in the Puget Sound region of outwash gravels near sea-level and the occurrence of post-glacial marine shells at higher altitudes shows that crustal movement was downward after the retreat of the ice, and that this does not bear out the conception of isostatic adjustment, consequent on deglaciation. It is possible, however, that the marine shells are not post-glacial in age but belong to an earlier period of marine submergence, indicated by the occurrences in the Fraser valley, and that the third advance of the ice in the Vancouver region did not reach the Puget Sound region.

No evidence was found in the Vancouver or Fraser delta region to support R. A. Daly's[4] view that a general lowering of sea-level of about 20 feet occurred during post-glacial time, for there is no marked raised beach or any large extent of delta deposits at about 20 feet above sea-level. The lower beaches are somewhat stronger than the higher beaches, indicating a slowing down in the rate of uplift, but even the lowest raised beaches are not exceptionally strong and are difficult to trace. They suggest almost continuous uplift but at varying rates. The upper limit of marine submergence is not well marked although the sea must have stood at a high level for a considerable length of time, for the stratified clays occur in places in the Fraser valley at various altitudes up to over 400 feet above the sea and must have been in large part formed when the sea stood at a high level. The absence of well-marked beaches at high levels is probably due to the occupancy of parts of the region by the ice-sheet and to the comparatively rapid uplift of the land, and the thickness of the clays at high levels is probably due to the source of supply of the materials—the melting ice-sheet—being near at hand and the supply being most abundant at that time.

Summary

The evidence regarding Pleistocene and post-Pleistocene oscillations of sea-level in the Vancouver region, although incomplete and unsatisfactory in some respects, strongly suggests that the oscillations of sea-level were chiefly due to uplift and depression of the land and that two main periods of depression and uplift occurred, corresponding in time to two main advances and retreats of the ice-sheet. The

[3] Ibid., p. 236.

[4] Geol. Mag., Vol. 57, p. 246, 1920.

second period of advance of the ice-sheet was interrupted by a partial retreat of the ice followed by a readvance, and depression of the land during the second period took place mainly after the last advance of the ice, but during the time of occupancy of the region by the ice. The amount of uplift increases in the direction of the maximum accumulation of the ice; and the uplift took place comparatively rapidly and at a fairly uniform rate. It is, therefore, probably isostatic in character. The coincidence of depression and uplift with the advance and retreat of ice during the first period of glaciation suggests that these crustal movements were also isostatic in character. The fact, however, that during the second period of glaciation depression of the land took place mainly during the latest stage of glaciation, is difficult of explanation under the theory of isostasy.

The Distribution of Stringocephalus Burtoni in Canada[1]

By E. M. KINDLE, A.B., M.Sc., Ph.D., F.R.S.C.

(Read May Meeting, 1921)

INTRODUCTION

Stringocephalus burtoni is one of the index or guide fossils of the Middle Devonian in Europe and the British Isles. Thirty-one years ago the late Dr. J. F. Whiteaves[2] read a paper before this Society in which he announced for the first time the occurrence of this species in North America. Billings,[3] as early as 1875, had noted in a collection of fossils from Lake Winnipegosis "a brachiopod resembling Stringocephalus" but Whiteaves first definitely identified this genus and species on this side of the Atlantic.

Dr. Whiteaves' description of this fossil was based on two collections. One was made on the shore of Lake Winnipegosis in Manitoba by J. B. Tyrrell and J. F. Whiteaves in 1888. The other was made at the Ramparts of the Mackenzie during the same season by R. G. McConnell.

These two finds of Stringocephalus at points 1,300 miles apart representing the first discovery of the genus in America were made curiously enough during the same year within a month of each other. For 29 years no additions were made to our knowledge of the distribution of this fossil as represented by the collections of McConnell, Tyrrell, Dowling and Whiteaves at the Ramparts and in Manitoba.

RECENT WORK

In 1917 the writer found *Stringocephalus burtoni* on the south shore of Great Slave lake occurring abundantly in a magnesian limestone. This locality is about midway between the only two previously known North American localities for this fossil. The extension of field work to the lower Mackenzie in 1919 led to the discovery by the writer of *S. burtoni* in the mountain region below Norman. This fossil was found in three different mountain ranges on the lower

[1] Published by permission of the Deputy Minister of Mines.

[2] J. F. Whiteaves: Descriptions of Some New and Previously Unrecorded Species of fossils from the Devonian Rocks of Manitoba, Proc. and Tran's. Roy. Soc. Can., Vol. VIII, 1890 (1891) pp. 93-110, Pl. IV to X.

[3] Rept. of Progress, Geol. Surv. of Canada for 1874-75, p. 68.

Mackenzie by the writer and the geologists of the Imperial Oil Co. Mr. Theodore Link found it in the Bat Hills and on Beaver Tail Mt., the writer in the Carcajou Mt. section. On the Clearwater River E. J. Whittaker secured at the base of the Devonian a fauna which is believed to represent the *S. burtoni* fauna, although *S. burtoni* was not found. A loose specimen of *S. burtoni* was found on the Athabasca by the writer 20 miles above McKay, which, doubtless, originated in the eastern part of the Athabasca basin.

Stratigraphic Position

With the extension of our knowledge of the distribution of *S. burtoni* has come a pretty clear understanding of the stratigraphic position of this fossil and its associated fauna (Fig. 1).

Dr. Whiteaves discussed the age and stratigraphic position of *S. burtoni* in three different papers published in the years 1891 and 1892. In the latest of these, which dealt with the Manitoba Devonian faunas,[4] he states that "the Middle Devonian appears to be represented in this region (Lakes Manitoba and Winnipegosis) by the Stringocephalus zone and the hundred feet or more of fossiliferous dolomite immediately beneath it, and the Upper Devonian by all the beds above the Stringocephalus zone and beneath the Cretaceous." [5] In this paper the Stringocephalus zone of Manitoba is stated to occupy much the same stratigraphic position as the Stringocephalus limestone of Germany and England. No reference is made in it, however, to the *S. burtoni* found by McConnell at the Ramparts of the Mackenzie. In his report on the Mackenzie river Devonian the specimens of *S. burtoni* from the Ramparts had been referred to the Cuboides zone or the horizon which, according to Whiteaves, followed the Stringocephalus fauna in Manitoba. Whiteaves was evidently led to place the Mackenzie and Manitoba specimens of *S. burtoni* at different horizons through accepting McConnell's opinion that all of his Mackenzie river fossils were "from the upper part of the middle division" of the Mackenzie river section. The whole of the Mackenzie fauna was treated by Whiteaves as representing "practically the same geological horizon." [6]

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[4] J. F. Whiteaves: The Fossils of the Devonian Rocks of the Islands, Shores or Immediate Vicinity of Lakes Manitoba and Winnipegosis. Contr. Can. Pal. Vol. I, Part IV, 1892.

[5] Ibid, p. 357.

[6] The Fossils of the Devonian Rocks of the Mackenzie River Basin. Contr. Can. Pal., Vol. I, Pt. III, p. 250.

The rocks from which McConnell's fossils came have now been divided into six formations representing in the Norman district more than 2,000 feet of Devonian sediments.[7] It is not surprising that the attempt to treat the faunas from these different formations as a single fauna made it difficult to place the *S. burtoni* fauna of Manitoba and the Ramparts in the same horizon. Present information makes it clear that *S. burtoni* represents essentially the same geological horizon throughout its known distribution.

The most important lots of McConnell's fossils came from Hay river falls and from the Ramparts, localities 600 miles apart. At both localities the upper part of the Devonian section consists of limestones. It was not discovered during McConnell's reconnaissance survey that the Hay river limestone which carries an Upper Devonian fauna, changes in going north to a shale and sandstone, and disappears altogether 65 miles south of the Ramparts. The limestone, which at the Ramparts is the uppermost formation of the Devonian, lies 1,500 feet or more lower in the section than the Hay river limestone and holds a Middle Devonian fauna. The sections shown in Fig. 1 indicate the relative positions held by these limestones in the Mackenzie Valley Devonian section.

Possible Occurrence in the United States

Prof. Chas. Schuchert[8] has recorded the finding of a loose specimen of *S. burtoni* in southern Minnesota and has expressed verbally the opinion that this fossil would probably be found in the Minnesota Devonian. Prof. C. R. Stauffer, who has been recently working on the Devonian of that State, read at the last meeting of the Palaeontological Society of America a paper on his results. His account of the Devonian faunas which he has found in that State does not appear to lend any support to the theory that the *S. burtoni* fauna extends southward into the United States. So far as present knowledge goes, it may be considered to be in North America a strictly Canadian fauna.

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[7] E. M. Kindle and T. O. Bosworth: Oil-bearing rocks of Lower Mackenzie River Valley. Can. Geol. Surv. Summ. Rept., 1920, Pt. B.

[8] Bull. U.S.G.S., No. 87, 1897, p. 417.

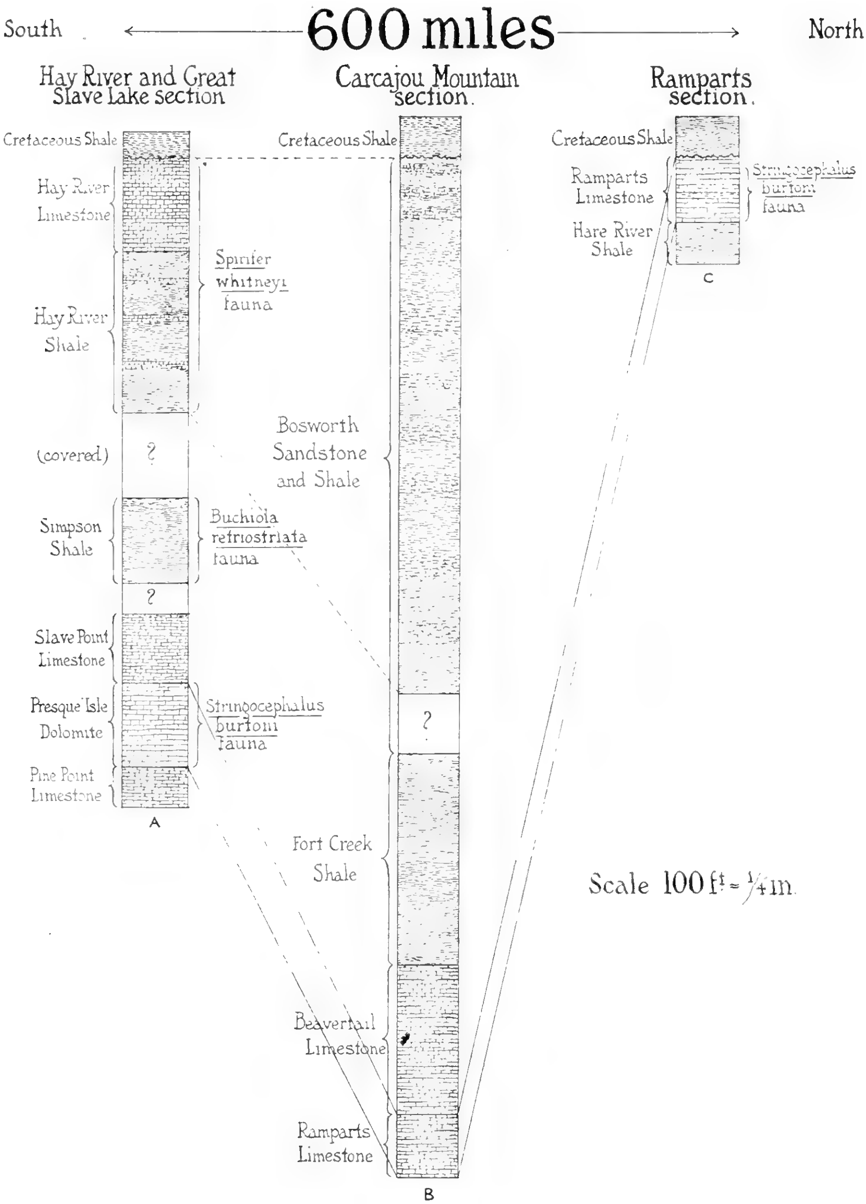

FIG. I

Generalized sections showing the stratigraphic relations of the *Stringocephalus* bearing limes'one in the Mackenzie valley.

Mesozoic Clays and Sands in Northern Ontario

By JOSEPH KEELE[1]

Presented by R. A. A. JOHNSTON, F.R.S.C.

(Read May Meeting, 1921)

INTRODUCTION

In the autumn of 1918 several samples of clay were sent for examination to the clay testing laboratory of the Mines Branch, Department of Mines of Canada. These samples were collected on the bank of Mattagami river by Mr. C. M. McCarthy of Elk Lake from outcrops just north of the lower end of Long Portage.

An examination of the samples convinced the writer that they represented highly refractory clays of rare occurrence in Canada and were undoubtedly of pre-Glacial age.

Small samples from other high grade clays known to occur on Missinaibi river were procured from the owners, and these likewise proved to be pre-Glacial clays similar to those on Mattagami river, 40 miles distant.

It appeared, then, to the writer that there were remnants of a group of sediments in this region which were probably of Tertiary age, or perhaps older, and that it was advisable to visit the localities and examine the deposits.

Two short journeys were made in 1919 and 1920, and evidence was secured which proved not only that the clays were pre-Glacial but also that they were probably of Lower Cretaceous age.

The clays and sands on Missinaibi river, where the most conspicuous outcrops occur, attracted the attention of several previous explorers, who attributed their origin to glacial transport and deposition, some calling them inter-Glacial.

Most of the explorers, however, were chiefly concerned with metallic minerals, and soft deposits like these were not very closely scrutinized. Furthermore, it was inconceivable to them that such soft deposits could have survived the destructive effects of glaciation.

The composition and physical characters of these materials show that they have no relation whatever to glacial products. Sediments like these could not have been laid down in any region sub-

[1] Published by the permission of the Deputy Minister of Mines.

sequent to its glaciation until all the former products of the glaciation had been carried out of the drainage basins and a prolonged era of subaereal weathering of bedrock had set in and to accomplish this would require more time than the whole period assigned to the Pleistocene.

Glaciation and Tertiary erosions have almost destroyed the Lower Cretaceous formation in northern Ontario, leaving only vestiges of it like the deposits under consideration.

The view has hitherto been held that no pre-Glacial rocks later than Upper Devonian were ever laid down in northern Ontario; therefore the discovery of Mesozoic rocks and possibly of Tertiary adds a new chapter to the geology of that province.

Previous History

The first notice we have of these deposits was recorded by Dr. Robert Bell. The locality given was Coal brook, a small tributary of Missinaibi river, and the material exposed was a 3-foot bed of lignite, underlain by sticky blue clay, and overlain by late glacial drift.[1]

In 1880 Mr. E. B. Borron discovered an extensive deposit of white sand and clay on the east side of Missinaibi river, about 5 miles below the mouth of Coal brook.[2]

In 1882 Mr. Borron found an outcrop of what he called yellow ochre with some fine white clay on the eastern bank of Mattagami river, about a quarter of a mile below the north end of Long Portage. This is the outcrop from which Mr. McCarthy obtained the samples he sent to the Mines Branch in 1918.

During the same journey Mr. Borron saw a thin seam of lignite on Mattagami river, about 5 miles below Long Portage. These two localities are given on page 30 of his report for 1882.

In 1890 Mr. Borron went out, equipped with apparatus, for the purpose of testing the lignite seams discovered by Dr. Bell and himself on Missinaibi river.

He devoted most of his attention to borings on the lignite outcrop on Coal brook. A plan of a portion of Coal brook, with the positions and numbers of the holes bored, is given in his report.[3]

Mr. Borron recognized the fact that the clays at this point were quite distinct from the widespread glacial clays of the region, and

[1] Geol. Sur. Can. Rep. Prog., 1877-1878, p. 4C.

[2] Report by E. B. Borron on Part of the Basin of Hudson Bay, Toronto

[3] Report on the Basin of Moose River, E. B. Borron, Toronto, 1890, pp. 65 to 69.

mentions in his report that they might be used for the manufacture of firebrick if ever any metallurgical operations were undertaken in the region.

Other lignite seams which occur farther north on Missinaibi river were examined during the same season, but these appear to be merely beds of indurated peat lying amongst inter-Glacial materials.

In 1904 Mr. J. M. Bell, while engaged in exploration for minerals of economic value in northern Ontario, discovered a bed of white clay on Wabiskagami river, a tributary of Missinaibi river.[1] This deposit is situated about 2 miles west of the one discovered by Mr. Borron in 1880.

In 1908 considerable attention was attracted to the possibilities of the occurrence of merchantable coal in this region, and most of the outcrops of lignite described by Messrs. Bell and Borron were staked by prospectors.

In 1910 Professor M. B. Baker investigated the lignite and iron ore deposits on Mattagami river,[2] and made borings on the lignite seam discovered by Mr. Borron in 1882.

In 1913 Messrs. Tees Curran and H. A. Calkins staked claims and did assessment work on the deposits on Missinaibi and Wabiskagami rivers. The result of their work showed that the clays and sands at that point were over 70 feet thick.

TOPOGRAPHY

A wide belt of lowland plain, underlain chiefly by Palaeozoic rock, encircles the southern and western portion of Hudson bay, in northern Ontario. A great area of Pre-Cambrian rocks, standing at a somewhat higher elevation, lies south of the Palaeozoic plain. The rocks of both the plain and the upland are generally concealed by a thick sheet of glacial drift, principally boulder clay.

A considerable portion of the drainage from the Pre-Cambrian upland flows northward, and the streams which carry it have cut down through the glacial drift, reaching in some places the underlying bedrock.

The Abitibi, Mattagami, and Missinaibi, with their numerous tributaries, are the principal streams of the region. Albany river and its branches drain the country to the west of these streams, but no undoubted occurrence of Cretaceous or Tertiary deposits has, so far, been discovered in the basin of this stream.

[1] Bureau of Mines, Ontario, 1904, Vol. LXIII, p. 160.

[2] Ontario Bureau of Mines, Vol. XX, part I, p. 236.

The most conspicuous feature of the region is the northern margin of the Pre-Cambrian rocks, which rises from 150 to 200 feet above the southern fringe of the Palaeozoic plain.

The rivers have cut post-glacial gorges or canyons in this margin, which are generally longer and steeper than those in any other part of their courses.

The surface of the drift is a gently undulating plain, of the swell and sag type of topography. The depressions are generally shallow marshes or muskegs supporting little or no tree growth, but the higher portions are thickly wooded.

Lakes are almost absent over the greater part of the plain underlain by thick drift, but are numerous farther south, where the drift cover on the rocks is thinner.

The deposits of clay, sand, and lignite, which are described in this paper, lie below the glacial drift, near the northern margin of the Pre-Cambrian rocks. Their distance from the nearest points on the National Transcontinental railway line is 40 to 50 miles.

Geological Outline

The surface of the crystalline rocks of the great Pre-Cambrian upland slopes steeply to the north, and at Long Portage on the Missinaibi and Mattagami and at Coral Portage on Abitibi river they finally disappear beneath younger deposits. Sedimentary formations—shale, limestone, sandstone, and gypsum—then appear wherever bedrock is exposed on the rivers. Most of the sedimentary rocks here are of Palaeozoic age, and include Devonian, Silurian and, perhaps, Ordovician sediments.[1]

The Palaeozoic rocks for the most part are flat-lying and show no indication whatever of metamorphism. Some of the clay layers included in the Upper Devonian rocks are as soft and plastic as many recent clays.

At certain isolated localities along the rivers north of the border of Pre-Cambrian rocks bright coloured clays and sands with lignite seams occur below the universal covering of glacial drift. These rocks are the subject of this paper, and are supposed to be of Lower Cretaceous age. The basal beds of these deposits have not been seen, but presumably they lie unconformably upon black and green shales of the Portage formation, because these rocks are found outcropping a few miles below the Cretaceous beds on Mattagami river.

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[1] Palaeozoic Rocks in Northern Ontario, M. Y. Williams, Summary Report Geol. Surv., 1919, Part G.

Masses of yellow and orange sands covered by glacial drift occur on Abitibi and Mattagami rivers. These sands are presumably of Tertiary origin.

There were at least two periods of glaciation over the region in Pleistocene times. Remnants of inter-Glacial deposits are found at intervals in the region, underlain by Palaeozoic rocks, but none are found in the Pre-Cambrian upland. The grey till, a product of the last glaciation, is spread everywhere and forms the surface of the greater part of the region.

Glaciation

Glaciation has not only profoundly affected the Cretaceous formation in northern Ontario, but has entirely changed the appearance of the pre-Glacial land surface of the region.

At the present day we catch glimpses only of the ruins of the Cretaceous formation at isolated spots on the river banks; and instead of the uneven, rocky topography of pre-Glacial times we see a nearly uniformly level surface underlain by glacial drift.

There were at least two distinct periods during which the land surface was occupied by ice. In the interval between these periods conditions favourable to erosion, weathering, leaching, deposition of sediments, and plant growth, were restored.

The inter-Glacial deposits which were then laid down suffered severely from the subsequent glaciation, but the inter-Glacial remnants are more numerous and much more imposing than are the vestiges of the Cretaceous formation. The last glaciation moved from north to south, carrying with it a huge cargo of till which was deposited in a sheet not only over the Palaeozoic plain, but over the Pre-Cambrian upland for a distance of 100 miles.

This till is very bouldery in places, and is of a uniformly lead-grey colour in the lower part, but the upper portion is weathered to a yellowish grey.

The banks of the rivers are almost entirely composed of this till, and the beds of all the rivers are strewn with boulders derived from it. The Cretaceous beds on Mattagami river are overlain by about 75 feet of the late glacial till.

The till or boulder clay at the base of the inter-Glacial beds is reddish in colour, and, although it contains a good deal of grit as well as boulders, it also contains a fair percentage of plastic clay. The red colour and plastic properties of this till may be due in part to its derivation by erosion from the highly coloured clay beds of the Cretaceous, or, as is more likely, from erosion of the red Salina shales of the Silurian which form part of the bedrock in the region near James Bay.

No inter-Glacial beds have been found on the Pre-Cambrian upland, but a pre-Glacial valley on the east side of Missinaibi river, just below the end of Long Portage, is filled with a very dark coloured, stratified, peaty clay deposit, which is undoubtedly of inter-Glacial age and bears a strong resemblance to the Toronto formation[1] in the inter-Glacial beds at Toronto, Ontario.

Tertiary Erosion and Deposition

It is probable that the Cretaceous deposits were uplifted and wasted by stream erosion and weathering during Tertiary times. It is not definitely known that any Tertiary deposits occur in the region, but certain beds of yellow and orange sands on Mattagami and Abitibi rivers are probably pre-Glacial in origin and may be Tertiary. The most extensive yellow sand deposit on Mattagami river occupies about a quarter of a mile of the east bank, between the mouth of Pike creek and the iron ore deposit at the head of Grand Rapids.

These sands extend below water level and vary in thickness from 10 to 25 feet. They are overlain by only a foot or two of stratified silts from which they are separated by a thin layer of rusty pebbles. The sands are composed entirely of coarse quartz grains often with a cross-bedded arrangement interbanded occasionally with streaks of pea-sized gravel composed mostly of quartz, although pebbles of the harder parts of pre-Cambrian rocks are also present. Occasionally pockets and streaks of micaceous clay are included, as well as rusty and disintegrated cobble stones.

The materials are coarser at the northern end of the deposit, where they finally pass into yellow gravels with pebbles of cobble stone size, and end abruptly against boulder clay.

The sands are compact enough to retain a fairly vertical face, but there are no cemented beds.

The colour of the beds varies from yellow to orange and reddish brown, and appears to be mainly due to a coating on the quartz grains and not to fine material intermixed with the sands.

A similar deposit on the opposite bank of the river evidently formed part of the beds above referred to before the river cut through them.

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[1] Inter-Glacial Period in Canada, Compte-Rendu, Cong. Geol. Intern., Mexico, 1906.

A smaller deposit of the same type of sands occurs a short distance below the foot of Long Portage on Mattagami river, in the bank overlying the fire-clay beds. The deposit, which is enclosed in boulder clay, is limited in width but is about 40 feet thick. The sands are arranged in beds sloping down stream and contain a band of grey and yellow clay about a foot thick. Above the clay bed the materials are yellow gravels and cobble stones. The orange sand and gravels are overlaid by grey fluvio-glacial gravels with included lenses of boulder clay. A solid mass of hard, grey, gritty till carrying unusually large boulders, caps the bank.

The largest deposit of orange sands in the region occurs on the east bank of Abitibi river between Sextant Portage and the head of Long Rapid.

The sands here are about 30 feet thick and extend for a mile along the banks under a capping of boulder clay. The sands are composed almost exclusively of coarse, angular to round quartz grains, sometimes running as coarse as fine gravel. Angular fragments of disintegrated pre-Cambrian schist are mixed with the sand toward its base. The bottom of the deposit lies below water level and was not seen.

The place in the geological sequence to which these sands should be assigned cannot be easily fixed. It is difficult to regard them as pre-Glacial in view of the accepted theories regarding the scouring action of a continental glacier like that which passed over this region. Friable, unconsolidated deposits like these sands would seem to have small chance of surviving such a glaciation. On the other hand, we are confronted with the strongly oxidized and residual character of the materials in the deposits, and their freedom from glacial dirt of any kind. If it is urged that the lack of cementing material would indicate a recent origin it may be pointed out that there are sandstones of Silurian age on Abitibi river with no greater measure of cementing material present.

It would appear that their comparative freedom from materials other than quartz would give these sands economic value as a source of silica. It is probable that they contain too high a percentage of iron to be used in glass manufacture although washing would no doubt reduce this. As the texture of the sands is about right for glass making purposes a few washing trials and chemical analyses would settle the question. There are no sands so pure as these in the Glacial series.

The non-Glacial character of these sands indicates that they have been formed from debris carried by streams from the pre-Cambrian upland and deposited as deltas on the Palaeozoic plain.

It is probable that a long period of weathering caused the accumulation of a considerable amount of coarse disintegrated rock material as well as clay, the transport of the coarser materials having been made possible by an uplift of the land surface in late Tertiary times which would increase the carrying power of the streams.

The scouring of the residual mantle from the pre-Cambrian upland appears to have been fairly complete before glaciation set in. There is very little true boulder clay in the glacial drift upon the pre-Cambrian surfaces except on parts so situated that the ice had previously passed over adjacent Palaeozoic rocks. When the supply of clay collected from the Palaeozoic rocks had been deposited and the ice had extended over the pre-Cambrian surfaces there was apparently no more clay to be obtained.

The purely pre-Cambrian drift is a thin sheet, consisting mostly of silt, sand, gravel, and stones, including a surprisingly small amount of real clay substance.

Character and Thickness of the Cretaceous Deposits

The Cretaceous deposits in northern Ontario occur in isolated outcrops at certain points on Missinaibi and Mattagami rivers, north of the pre-Cambrian rock boundary.

The deposits consist of white sands; pink, white, yellow, black and grey to almost black clays; and lignite.

Few of the outcrops seen above water level along the river banks give a clue to the character of the deposits, and it is mainly from borings that the information is obtained.

The first borings were made in 1890 by Mr. Borron at the lignite outcrop on Coal brook. The following record, selected from his list of borings, illustrates the character of the materials found at this point, from the surface downwards:

Drab and variegated clays	5 feet
Black carbonaceous clays and lignite	7 "
Drab clay	2 "
Black clay and lignite	1 foot
Variegated clays	3 feet
Sandy clay	3 "
Lignite	2 "

Coarse white sand	2 feet
Variegated clay	1 foot
White clay	9 feet
	35 feet

The clays and sands found in this boring are apparently identical in character to those found by the writer when boring on the Mattagami deposit near the foot of Long Portage, except that no lignite seams were found at the latter locality.

The most extensive remnant of Cretaceous deposits at present known in northern Ontario occurs on the east bank of Missinaibi river, about 45 miles north of the Canadian National railway line and about 4 miles above the mouth of Wabiskagami river. The pre-Cambrian rock escarpment is about 6 miles to the south of these deposits.

The Cretaceous beds are exposed for a distance of half a mile along the lower part of the river bank, and in places rise to a height of 30 feet above the low water level. The greater part of the deposit is made up of quartz sand, the particles of which are coated with white clay, but the sand is stained in places to a pink or yellow colour.

The clay is of various colours—white, pink, grey and yellow, but the bulk of the exposed part is mottled pink and white in colour.

The whole deposit is overlain by the late glacial stony clay, and some of this clay is pressed into and intermixed with the Cretaceous clay for a depth of several feet. Two small streams have cut down through the overlying glacial drift, exposing the lower clay and providing convenient points for the examination of the deposit. In one of the sections thus exposed the glacial drift is seen to rest directly on the white sand. The glacial clay has a high content of lime, and some of the lime leached from it has been redeposited in the white sands and has cemented the upper 3 or 4 feet so as to form a protective capping.

The Cretaceous material is found in irregular arrangement and although the sands are stratified in places they generally form lens-like masses. The clay likewise occurs in lenses, some of which are banded in different colours. This banding does not appear to be related to bedding, except that it is due to the varying quantity of iron oxide that accompanied the sediments during their deposition and in that sense may be bedding. In the great masses of mottled clay, however, the discoloured portion and the white clay are mixed without any banding.

Mr. J. M. Bell found material on Wabiskagami river at a point about eight miles above its junction with the Missinaibi, which he describes as follows: "The deposit lies on the right or southern bank of the stream, along which it is traceable for about 400 feet, rising above the summer level to a height of at least about 10 feet. It is overlain by a talus of soft boulder clay which in places entirely obscures the underlying material. The kaolinic clay is soft, plastic, and unctuous, generally almost white in colour, but sometimes stained deep hematite red or yellow ochre by impregnation of iron oxide. Much of it is remarkably free from sand, but other parts contain lenses and small pocket-like areas, composed of grains of clear, glassy quartz sand mixed with pure white kaolin."

The deposit thus described by Mr. Bell lies about 2 miles west of the large body of similar material on the east bank of the Missinaibi. No other deposits of this character are known to occur on Missinaibi river or its tributaries. No lignite was seen in connection with the clays and sands at either of the above localities.

The most extensive outcrops of Cretaceous beds known on Mattagami river occurs on the eastern bank, about a quarter of a mile below the north end of Long Portage. At this point the bright coloured Cretaceous clays outcrop at intervals from beneath the river wash, along the strip of sloping bank between high and low water levels, the greatest vertical height to which the clays rise being about 8 feet. Above this level banks of glacial clay rise to a height of 75 feet.

A number of holes were bored with an auger by the writer at various places along the strip of clay outcrops in order to ascertain the thickness of the clays and the variation of the beds. None of the holes went down very deep owing to the fact that in every case a bed of white or pale yellowish sand was encountered which invariably let water into the hole and put an end to boring operations.

The following three examples summarize the results of the borings:

(1)	Bright red and grey mottled clay........	2′-0″
	Yellow and grey mottled clay...........	2′-0″
	Black clay..........................	3′-0″
	White clay..........................	1′-0″
	Sand..............................	1′-0″
	Water bearing sand..................	1′-0″

(2)	Dark grey, highly plastic clay	3′-0″
	White clay	3′-0″
	White sand with clay bond	10′-0″
	Water bearing sand	
(3)	White clay	3′-0″
	Mottled pink and yellow clay	2′-0″
	Reddish pink clay	2′-0″
	Silty grey clay	3′-6″
	White sand	1′-0″
	Water bearing sand	

An effort was made to find the clay at higher levels by boring through the glacial drift in the high banks. Five holes were started on terraces at different levels on the boulder clay, but none of them succeeded in getting down very far owing to the stones scattered through the clay. There are no surface indications of the fire-clays in the slopes of the higher part of the bank, but the constant slumping of the glacial clay and the thick forest and plant growth are sufficient to conceal any outcrops. The bottom of a small creek which enters the river not far from the fire-clay outcrop was followed up, but, although the little stream had cut deeply into the glacial clays, it did not reveal any fire-clays beneath them.

About six miles below the foot of Long Portage, at the big bend on the Mattagami, another outcrop of fire-clays occurs in the lower part of the bank of the river. The following beds were seen between the overburden of glacial clay and the river level.

Stiff, plastic bluish clay	4′-0″
Well indurated, yellowish sandstone, with abundant fossil plant remains	2′-0″
Light blue-grey clay	2′-0″
Laminated bluish-grey, silty clay	2′-0″
Massive bed of dark grey micaceous plastic clay	3′-0″

A little farther down the stream a bed of hard, black lignite with a woody structure, accompanied by white and black plastic clays, outcrops at intervals near the river level for a distance of 100 yards.

Only about 2 or 3 feet of these beds are exposed below the glacial drift, and from the upturned attitude of the lignite seam they seem to have slumped from a higher level. It is possible that the lignite and the white and black clays properly overlie the section given above.

The three-foot, massive bed of micaceous clay at the bottom of the above section was the only one sampled for testing, as it looked the least promising from a refractory point of view. It, however, proved to be a fire-clay. It was assumed that all the upper beds were fire-clays as well as the ones accompanying the lignite which are similar to those occurring just below Long Portage.

Borings made in this locality in 1910 by Prof. M. B. Baker show that the fire-clays reach a depth below the river of 16 feet, but no lignite appears to have been encountered below the seam which outcrops on the river bank.[1] The bottom of the clay was not reached in the borings so that the material underlying it is unknown.

The greatest thickness of Cretaceous deposits recorded was that reported on by Mr. H. A. Calkins, C.E., who examined the large deposit on Missinaibi river in 1913 for the Montreal syndicate that staked the claims upon it. Mr. Calkins made a series of borings with a Standard earth auger equipment, and in the hole farthest removed from the river bank he found red and white clay below the glacial drift at a height of 74 feet above the river level. As the white and red clay can be seen in the bed of the river at this point a considerable amount would have to be added in order to obtain the entire thickness so that it is probable that there is in the neighbourhood of 100 feet of Cretaceous measures intact in this region. The above data were taken from Mr. Calkins' report, a copy of which was sent to the Department of Mines.

Distribution of Cretaceous Deposits

It is quite probable that Mesozoic clays, sands, and lignites were formerly widespread in northern Ontario, but a long period of pre-Glacial erosion, inter-Glacial erosion, and two distinct periods of glaciation in Pleistocene times have well nigh obliterated them, and now only small detached patches are found at certain points where the rivers have cut down through the overlying glacial debris deeply enough to expose them. Outcrops of these rocks are known at present at five places on the well travelled river routes, and there may be many others on smaller and less travelled streams.

The known outcrops are all situated, with one exception, from one to eight miles north of the northern border of the pre-Cambrian upland. The distance from the outcrops on the Mattagami to those on Missinaibi river is 40 miles, and it is quite possible that Cretaceous deposits were formerly continuous over the intervening area.

[1] Ontario Bureau of Mines, Vol. XX, Part I, p. 236.

The beds on Wabiskagami river are about two miles west of the Missinaibi outcrops. The materials in both localities are alike, and the deposits are very probably continuous, but the stony character of the glacial drift overburden rendered it impossible to prove this by boring.

Sink holes and solution channels in limestone on Mattagami river at Grand Rapids are partially filled with iron ore and clay and a small quantity of lignite. The clays of some of the beds in the limestone cavities are refractory enough to be classed as fire-clays, and it is quite possible that the beds belong to the same period of deposition as the clays and lignite farther south. These clays are 20 miles north of the pre-Cambrian rock boundary.

The known scattered remnants indicate that the Cretaceous clays were once spread over an area at least 40 miles long and 20 miles wide, and it is certain that they originally had a much larger extent of country.

The Cretaceous clays seem to be confined to the northern Palaeozoic plain, as no remnants have yet been found on the pre-Cambrian upland to the south. It is probable, therefore, either that these clays were not laid down at as high a level as that of the upland or that the pre-Cambrian surface was swept bare of Cretaceous sediments before Pleistocene times.

Age and Correlation of the Deposits

As these clays occur in a remote region, isolated from all other known deposits of a similar kind, it is of interest to compare them with clays of a similar character which are used in the clay working industry at accessible localities.

The northern Ontario fire-clays, as far as known, are all situated on the low rather flat area of Palaeozoic rocks which lie between the great central complex of pre-Cambrian rocks and Hudson bay. The bottom of the fire-clay beds was not seen at any point where they were examined as the basal beds lie below water level, and were not reached by borings.

The Palaeozoic rocks found nearest to the clays are sediments of Upper Devonian age, and it is very likely that the fire-clay beds rest directly on these.

The fire-clays are all transported, fine-grained sediments and, as the name implies, they are fairly pure materials, free from an excess of fluxing impurities such as iron, lime, magnesia, and alkalies. Thin seams of well indurated, woody lignite accompany the clays, but none of the seams seen was thick enough to be of economic value. A bed of pure, coarse-grained, quartz sand, in which is intermingled a small amount of white clay, accompanies the fire-clays at one locality.

These materials are undoubtedly of pre-Glacial age, but of more recent origin than Upper Devonian. Their age is approximately fixed by certain fossil plant remains in a bed of sandstone included in the clay beds at a point about 6 miles below the foot of Long Rapid, on Mattagami river.

Through the courtesy of Mr. David White a collection of these fossils was examined by the palaeobotanists of the United States Geological Survey, who stated that "the material you transmitted is so fragmentary that with the few specimens in hand it is impossible to determine even the genera with certainty. However, most of the large fragments belong to a leaf of Taeniopteroid aspect. The nervation suggests some of the later types, such as are found in the older Mesozoic.

It is almost certain that the beds are not younger than Kootenay and they are surely not older than Permian."

As previously stated, no lignite beds were seen in the section containing the fossils, but there is very little doubt that the lignite and its associated clays, which occur about 200 feet farther downstream, belong to the same deposit.

Clays of this type are extremely rare in eastern Canada, the only other known occurrence being one in the Musquodoboit valley in Nova Scotia. The Musquodoboit clays are covered by glacial drift and overlie Lower Carboniferous rocks, but no fossils have yet been found in them. They are very similar to the Lower Cretaceous clays which occur extensively on the Atlantic coastal plain in the state of New Jersey. Certain portions of the clay deposit on the Mattagami correspond in all their physical properties to some of the Musquodoboit clays.

The nearest point in western Canada where such materials occur is at Swan river,[1] Manitoba. At this locality there are lead-grey clays containing a thin layer of lignite and overlain by soft white sandstone. These beds are of Cretaceous age and are generally referred to as Dakota.

Cretaceous sediments of Dakota age occur also in a narrow belt along the southern margin of the pre-Cambrian rocks in the province of Saskatchewan and are evidently the western extension of the Manitoba beds. The Dakota beds in Saskatchewan, as observed by

[1] Summary Report, Geol. Surv. Can., 1917, Part D, page 37D.

McInnes,[1] are made up principally of soft, white sandstone and thin lignite seams, and the clay content appears to be very small.

The most extensive clay beds of Lower Cretaceous age occur in northern Alberta on Athabaska river and its tributaries north of Fort McMurray.[2]

The Athabaska clays overlie Devonian limestone and were deposited near the western margin of the Pre-Cambrian area, where they are associated with incoherent white sands which have become impregnated with bitumen and hence are often referred to as tar sands. Although many of the clay beds in this region yield refractory materials of fairly high grade none of them was found to equal the best of the Mattagami clays.

The exact position of these sediments in the Cretaceous is only approximately known at present, but it seems probable that the Manitoba and Saskatchewan beds are more recent than the Athabaska and northern Ontario series, the latter being probably the oldest of all.

Physical Properties and Chemical Composition of Clays and Sands

The clays contained in the Cretaceous deposits in northern Ontario are of high grade and of a class quite rare in Canada. If they were situated close to transportation and easily mined they would have great industrial value owing to their good working qualities and their refractoriness. Samples taken from the borings on Mattagami river were tested by the writer in the laboratories of the Mines Branch, with the following results

Mattagami River

The clays are smooth and free from coarse grit with good plasticity and working qualities. Only sample No. 10 contained a quantity of coarse quartz grains which had to be separated by washing. The contrast in colour and texture of these materials to the ordinary glacial clays of the region is very striking.

The following table shows the character of the various clays when burned in a commercial stoneware kiln to cone 7.

A portion of each sample was dipped in Albany slip glaze before firing. The glaze was found to be fully matured when the samples were drawn from the kiln.

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[1] Geol. Surv. Can., Mem. 30, p. 65.

[2] Mines Branch, Ottawa, Bull. No. 10, "Notes on Clay Deposits near McMurray, Alberta."

Number of sample	Raw colour	Burned colour	Cone 7 – 1270°C. – 2318°F.	
			Percentage of total shrinkage	Percentage absorption
1	Pink	Buff	16	2
2	Pink	Cream	15	2
4	Buff	Pink	16	3
5	Orange	Red	13	13
6	Orange	Red	12	12
7	Black	White	9	15
8	Drab	Cream	12	8
10	White	White	12	12
11	Light grey	Cream	13	6
12	White	Cream	..	10

These clays fall into two groups: those that are high in iron and those that have a low iron content. The iron has an effect on the colour, particularly in the burned state, and also on the refractoriness. The first group, however, are fire-clays, with the exception of No. 5, which begins to soften at cone 20 – 1,530°C., and is the least refractory of the group. The others do not begin to soften until the deformation points of cones 26 and 27—1,650 to 1,670°C.—are reached.

Samples 7 to 12 are highly refractory, 10 and 12 being No. 1 fireclays as they do not deform at cone 33—1,790°C. This is the first record of the occurrence of No. 1 fireclays in Canada.

Owing to their variety of character these clays are suitable for the manufacture of quite a wide range of clay products. Nos. 1, 2 and 4 are vitrified at the temperature indicated, but have a very high shrinkage which would require to be corrected by mixing. They are suitable for the manufacture of stoneware goods and sewer pipe or other vitrified products as well as firebrick. Clays 7 to 11 are high grade materials, which would be suitable for retorts, crucibles or firebrick, in the crude state, and, if washed, for the manufacture of electric and sanitary porcelain as well as floor and wall tiles.

Only one bed of clay was sampled from the Cretaceous outcrops which occur 6 miles below the foot of Long Portage. This was the massive bed of dark grey, micaceous clay at the bottom of the section; and, although it looked the least promising in the field from a refractory point of view, it turned out to be a No. 3 fireclay that would make a good commercial firebrick.

Glass Sand

The white sands which underlie the clay beds are composed almost entirely of sub-angular and rounded quartz grains, with which is intermingled a small quantity of white clay.

A washing test made upon an average sample of 10 feet in depth of this sand showed that it contained 15 per cent. of white clay.

The sand, when freed from the clay, was found to be of the proper texture for glass making, and the chemical determination indicating 99.8 per cent. silica shows it to be of exceptional purity.

The white clay washed from the sand is very plastic and highly refractory while it burns to a whiter colour than any clay in the overlying beds.

The sand in its natural state contains enough plastic fire-clay to act as a bond when the material is moistened and pressed into brick shapes. A brick of this description is known as gannister brick, its use being principally confined to lining steel furnaces. The test bricks were subjected to frequent burnings up to a temperature of 3,000 degrees F., but they remained soft and friable, as the materials appeared to be too refractory to produce a fused bond. The addition of a little iron and lime oxide would be required in order to produce the necessary bond in firing.

Missinaibi River

Sands

The sand which comprises the greater portion of the deposit exposed on Missinaibi river is made up almost wholly of rather coarse angular quartz particles coated with white clay.

An average sample representing about 15 feet in thickness of the deposit was submitted to a washing test, and was found to yield 5 per cent. of fine white clay. An analysis of the grain size of the washed sand gave the following figures:

Retained on	10 mesh screen	....	8.27 per cent.
" "	20 " "	....	19.47 " "
" "	35 " "	....	38.04 " "
" "	100 " "	....	32.44 " "
" "	200 " "	....	1.33 " "
Through	200 " "	....	.10 " "

A chemical analysis of the washed sand, made by Mr. A. Sadler of the Mines Branch, resulted as follows:

Silicia	97.72	per cent.
Alumina	.42	" "
Iron oxide	.32	" "
Lime	.28	" "
Magnesia	.21	" "
Loss on ignition	.12	" "
	99.07	" "

The iron content of the washed sand is probably too high to permit of its use in the manufacture of white glass, but it would be suitable for green bottle glass. The alumina content is also higher than is desirable, as alumina has the effect of making the glass batch more difficult to melt. The grain size or texture of the sand is right for glass-making as most of it is included between the 20 and 100 mesh screens.

The unwashed sand should be suitable for steel moudling foundry use, as there is just enough clay present to act as a binder but not too much. The clay content is greater than 5 per cent. in some parts of the sand deposit, and quite an appreciable amount of fine white clay could be obtained by washing. There are also lenses of pink and yellowish sand as well as white sand, but the colour in this case appears to be easily washed out in water and a white sand obtained.

It should be noted that there are no sands of this description either in the Glacial or inter-Glacial deposits of the region.

Clays

It would be difficult to mine any of the special parts of the deposit separately, as the white clay, which is the most valuable part, merges into pink, yellow, or grey clay, so that no great quantity of it could be extracted alone.

The mottled pink and white clay, which makes up the greater part of the clay portion of the deposit, was sampled for testing purposes. It is fairly plastic, but gritty, has good working and drying qualities, and burns to a pink, dense body at 1,100°C. When burned to 1,300°C.—the temperature at which firebricks are generally burned—the body is steel-hard and has a greyish-pink colour. The total shrinkage at this temperature is 10 per cent. and the absorption 13 per cent. This material is a fire-clay, as it does not begin to soften until subjected to a temperature of 1,670°C., and could be used to make a good commercial grade of fire-brick or other refractory wares.

This clay could be used also for the manufacture of stoneware pottery, but for this purpose it would have to be washed and screened in order to free it from coarse grit.

The white clay is somewhat more refractory than the mottled clay, and when washed would probably be suitable for the manufacture of white, floor and wall tile and for sanitary ware.

CHEMICAL ANALYSES OF THE VARIOUS CLAYS

	I	II	III	IV
Silica	58.90	55.17	53.78	53.10
Alumina	26.63	28.06	29.58	31.92
Ferric oxide	1.40	5.36	5.09	1.52
Titanic oxide	1.25	not determined	not determined	not determined
Lime	0.56	.25	.44	0.51
Magnesia	0.16	.16	trace	trace
Manganese	0.01	not determined	not determined	not determined
Potash	0.31	.26	trace	0.28
Soda	0.42	.03	trace	0.54
Water	10.30	9.13	11.0	12.35

I. White clay, Missinaibi river. Analyst, M. F. Connor.
II. Mottled clay, Missinaibi river. Analyst, A. Sadler.
III. Mottled clay, Wabiskagami river. Ontario Bureau of Mines.
IV. White clay, Mattagami river. Ontario Bureau of Mines.

The almost complete absence of lime, magnesia and alkalies in these clays shows that they are very different materials from the Glacial or inter-Glacial clays, in which the sum of these active fluxes ranges from 15 to 30 per cent., and makes them easily fusible.

No. IV is an exceptionally high grade clay as regards refractoriness, as it stands as high a temperature as English china clay before deforming, and is the only example of a No. 1 fire-clay so far found in Canada.

ORIGIN OF CLAYS

The Cretaceous clays and sands, found at intervals near the margin of the great pre-Cambrian area in Canada, are derived from the weathering and decay of the older crystalline rocks. The clays have been derived chiefly through superficial weathering and kaolinization of the feldspar in these rocks, while the residual quartz has gone to the formation of the sands. A climate favourable to weathering and leaching, a long period of stability of the region with regard to sea level, abundant plant growth, and leisurely drainage are the conditions which govern the formation, transportation, and accumulation of high grade clays and sands.

Superficial kaolinization was probably general in Cretaceous and Jurassic times over many parts of the area of pre-Cambrian rocks, but the effects of kaolinization do not appear to have extended to any great depth. There was a dearth of residual clay on the pre-Cambrian upland during the period immediately preceding the Pleistocene glaciation, as shown by the almost complete lack of clay in the composition of glacial drift which has been derived solely from pre-Cambrian rock surfaces.

Mr. J. G. Cross made an examination of the pre-Cambrian rocks on Mattagami and Abitibi rivers for the Ontario Bureau of Mines in 1919. He reported the occurrence of kaolinized garnet gneiss on Mattagami river in the vicinity of Long Portage. The kaolinized zone is about 400 feet wide, and is of a whitish colour. The feldspars are entirely altered to kaolin, but unaltered garnet and mica still remain. A pegmatite dike which cuts the gneiss at this point is also semi-kaolinized.

A sample of the material, submitted for examination, is rather too hard to be called a residual clay, but it probably represents a zone of gradation between the unaltered rock and the overlying residual clay, which has been removed. It is precisely the kind of material which, worked over by water, would produce high grade plastic clays such as those found a few miles farther down the river.

This is the only remnant of kaolin resulting from weathering, known to the writer, in the pre-Cambrian area of Canada, but it is not unlikely that other similar deposits are concealed beneath the widespread glacial drift.

The rocks exposed on Missinaibi river, north of the railway, belong principally to the pre-Cambrian schist complex. The prevailing kind of rock is a stratiform, biotite gneiss which, while not necessarily the exact equivalent of the Marshall lake series, bears a strong resemblance to it in appearance and geological relations. Well-foliated, hornblende gneisses of igneous origin are also exposed at intervals. The greatest interest from the point of view of the present investigation lies in the bedrock exposed along the canyon walls at Long Portage. This rock is a binary granite, and probably is an acid differentiate on a large scale from an igneous mass. It is exposed for about a quarter of a mile along the canyon, and is flanked on the north and south by foliated hornblende gneisses. The granite is friable and appears to be softened by incipient kaolinization, and in all probability represents the lower and less altered portion of a mass of more or less completely kaolinized rock. It is this kaolinized part of the rock that has furnished the clay and quartz sand for the Cretaceous deposits farther north. On Mattagami river a wide band of highly kaolinized garnet gneiss occupies a similar position south of the Cretaceous deposits exposed on that river.[1]

There may be other bands of kaolinized rock similar to the above in this region which have escaped observation, for it must be borne in mind that kaolinized rock surfaces are comparatively soft and therefore wear down quickly while the surrounding harder rocks stand up as ridges.

The hard rock ridges are the first to be revealed when the river cuts down through the universal covering of glacial drift, and as these ridges control the down-cutting process, the more deeply buried, softer rocks are seldom brought into view.

It is not known whether the basin in which the clays settled contained salt water or fresh water. A lowering of the land by 300 feet would cause the sea from Hudson bay to cover the Palaeozoic coastal plain and change the shore line to the northern margin of the pre-Cambrian rocks, a distance of 70 miles south of the present limit of tidal water. This limit corresponds approximately with the encroachment of the sea in late Pleistocene times.

Folding of the Palaeozoic rocks with uplift might block the northward flowing drainage from the pre-Cambrian upland and cause temporary fresh water lakes to exist in a depression between the upland and the folded zones. The Silurian rocks on Moose river have been gently folded, while the Devonian rocks which lie between them and the pre-Cambrian escarpment are quite flat and apparently undisturbed, and it is on this area that the Mesozoic clays have been found.

It is simpler, however, to account for the presence of the sediments as the result of marine submergence in Mesozoic times.

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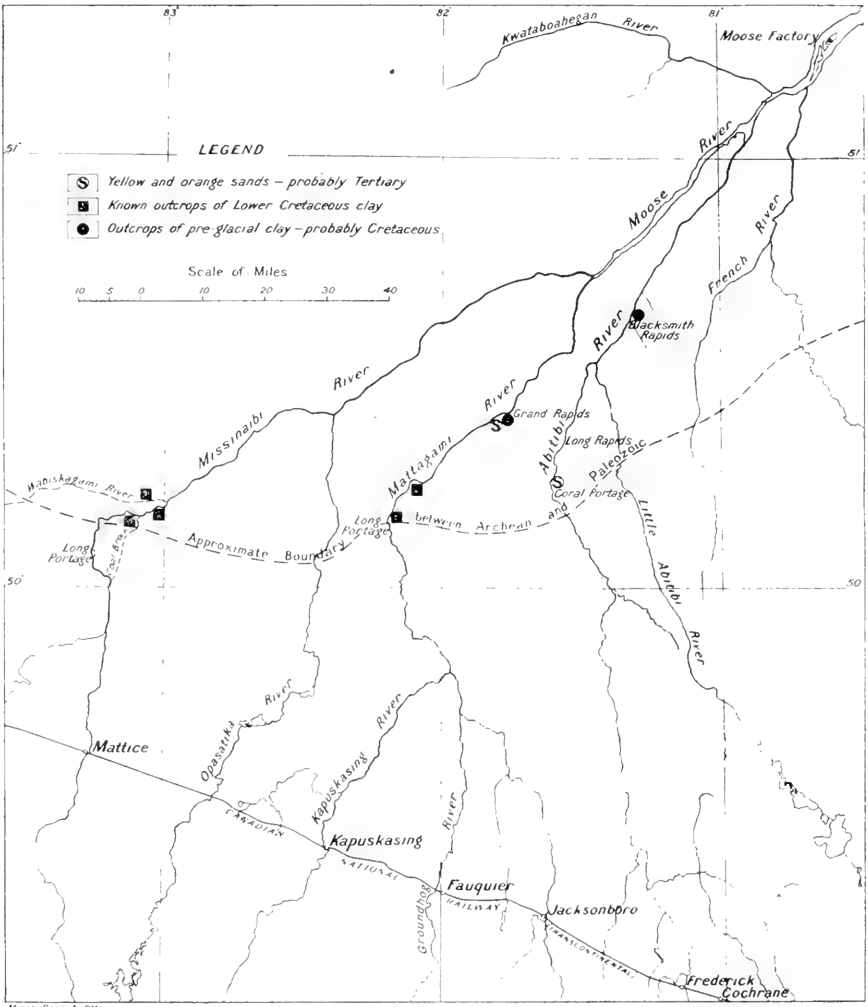
[1] Ontario Bureau of Mines, 1920, Vol. 29, Part 2, p. 17.



Drainage map of part of Northern Ontario

On Triarthrus canadensis, Triarthrus glaber, and Triarthrus spinosus

By W. A. PARKS, Ph.D., F.R.S.C.

(Read May Meeting, 1921)

Triarthrus canadensis was described by J. F. Smith, Jr., in a paper read before the Canadian Institute on January 26, 1861, and published in the *Canadian Journal*, Volume VI, page 275. Billings mentions the species in his account of *Triarthrus fischeri* (Palaeozoic Fossils, Vol. I, page 291) and includes it in a list of Utica fossils on page 953 of the Report of Progress of the Geological Survey of Canada for 1863. Barrande refers to *T. canadensis* in Système Silurien de la Bohême, Vol. I, Supplement, page 429. In the Canadian Record of Science, Volume V, page 175, Ami says: "*Triarthrus canadensis*, with its peculiar genal angle produced into a prominent spine on each side of the head, is most abundant in the Utica shales of the islands in the northern portion of Lake Huron, such as the islands north of Maple Cape, etc." Bassler lists the species as a Collingwood fossil in "American Ordovician and Silurian Fossils."

The holotype, obtained by Smith at Whitby, Ontario, consists of the head only, with both free cheeks preserved but with the axial portion imperfect. The author refers, also, to a single free cheek of larger size but of indifferent preservation. The essential characteristic of the species is the possession of stout genal spines directed backwards and outwards. "The only other species having long spines is *Triarthrus spinosus* (Billings). By reference to Mr. Billings' description the difference in *T. canadensis* will become at once apparent. The horns of the former are slender and cylindrical and point with a slight curve, almost directly downwards to the eighth pair of pleurae. In *T. canadensis* they are flattish and rather thick, with a groove running down the centre, and they extend at an angle of about 40°, evidently not farther than the fourth pair of pleurae."

The above description is accompanied by a rather poor woodcut of the head. No description is given of the rest of the animal nor do any of the references given above contain additional information as to the morphology of the species. As far as I can ascertain a whole specimen has not hitherto been described.

On the Rouge river, about fifteen miles east of Toronto, are three exposures of shale filled with detached cranidia and pygidia of two distinct species of *Triarthrus*. One whole specimen and many free cheeks of a variety of *T. spinosus* were obtained; also, one good specimen and a number of free cheeks of *T. canadensis*. It is a reasonable inference that the numerous cranidia and pygidia belong to these two species. Slabs of shale from Craigleith, Ontario, a classic locality for Utica and Collingwood fossils also contain numerous free cheeks of *T. canadensis*.

The almost perfect specimen of *T. canadensis* (Figure 2) is 18 mm. long, but the largest free cheek found indicates a length of 43 mm. The measurements are as follows:

	mm.
Total length	18.5
Length of head (median)	5.0
Width of head	15.0
Length of thorax	11.0
Maximum width of thorax	10.5
Length of pygidium	2.5
Width of pygidium	5.9

The axial portion is rather more than one-third the total width and the axial furrows are well defined. The body is distinctly arcuate in the thoracic region with the three lobes sharply differentiated. While the cast of the inside of the dorsal crust, with some very thin shell adhering, seems to be quite smooth the mould of the upper surface indicates a minute tuberculation which is most pronounced in the pleural regions.

The head is strikingly like that of *T. glaber* in its general outline and in the proportions of its various parts; in fact, it differs only in the prolongation of the genal angles into spines. The glabella is well defined, narrowing slightly forwards, and rounding abruptly into the rather straight anterior margin. The occipital furrow is conspicuous, concave anteriorly, and with a rather sharp anterior direction near the axial furrows. The two anterior glabellar furrows are convex anteriorly with the two halves well separated at the centre.

The facial suture begins well within the genal angle on the posterior margin, turns slightly outwards, then concavely inward at the marginal furrow, slightly outwards below the eye and rather sharply inwards immediately behind the eye, convexly outwards along the margin of the palpebral lobe, and apparently terminates on the anterior margin but the course of the suture forward from the eye is not clearly revealed.

While this course of the facial suture is distinctly shown on the cast the mould indicates quite as clearly a more simple sigmoidal line from the posterior margin to the rear of the eye. All the free cheeks found conform to this latter pattern leading to the conclusion that it is the normal course of the suture. The explanation seems to be that the suture was an overlapping one which would give a different course on the cast of the interior and the mould of the exterior.

The marginal furrow arises at the point where the axial furrow crosses the line between head and thorax, sweeps outwards and forwards with increasing width and follows the margin of the head to the front; it becomes much narrower in front of the glabella.

The palpebral lobe is close to the glabella, long, and but slightly curved; it is accentuated by a depression internally.

The free sheek is wide in front as in *T. glaber* but the genal angle is drawn out into the spine characteristic of the species. In this specimen the spine could not have been more than two or three millimetres long but it is broken on both sides. There is no indication of the median furrow referred to by Smith.

The occipital ring of the glabella carries a small but distinct tubercle.

The thorax consists of thirteen rings. The axial part of each segment is smooth and rounded, but where decorticated a faint crescentric indentation is seen in the matrix. The pleurae are strongly furrowed and there is a secondary short furrow extending outwards from the axial furrow immediately in front of the posterior margin.

The pygidium is relatively small and seems to have been formed from six primary segments. The axial portion is well defined and the individual rings are narrower and sharper than those of the posterior thoracic segments. The pleural grooves are symmetrical with those of the thorax; the anterior four are well marked but do not reach the margin of the pygidium; the posterior two are ill defined.

As already stated, many free cheeks were found which undoubtedly belong to this species; they indicate specimens of much greater size and show the groove on the spine referred to by Smith (Figure 3). Very similar are the free cheeks from Craiglieth (Figure 1). In both instances I am of the opinion that no significance attaches to the groove; it is probably the result of the flattening of a hollow structure and is observed in spines of *T. spinosus* and other species.

All the detached cranidia found on the Rouge fall distinctly into two series. Those with a glabella narrowing anteriorly, eyes forward and well in, squarish front, and occipital tubercle are ascribed to

T. canadensis. Except for the tubercle they could as well be ascribed to *T. glaber* (Figure 4).

The great resemblance of *T. canadensis* to *T. glaber* has already been referred to. In order to carry the comparison further three of Billings' cotypes of *T. glaber* were obtained from Ottawa through the kindness of Dr. E. M. Kindle. One of these cotypes which Billings evidently used for the head of *T. glaber* is very imperfectly preserved with the free cheeks pushed inwards on both sides and forward on the right. There is no indication of a genal spine, but, in view of the state of preservation, it cannot confidently be stated that there was no spine. This specimen, No. 1939h, Geol. Sur. Canada, is shown in Figure 5.

The two other cotypes, Nos. 1939 and 1939e, Geol. Sur. Can., were evidently used for the description of the body and show nothing as to the character of the genal angle. In the collections of the Royal Ontario Museum, however, is a specimen, No. 205 U, which is absolutely identical with these two cotypes but which reveals the character of the genal angle on one side. There is a distinct short spine, outwardly directed as in *T. canadensis*; it is, however, less developed and arises a short distance anterior to the genal angle proper. Figure 6.

The conclusion seems to be justified, therefore, that we may expect to find eventually a whole series of specimens showing a gradual transition from typical spineless *T. glaber* to the strongly spined *T. canadensis*. It is probable, also, that this series will be an ascending one geologically, as the Rouge exposures with typical *T. canadensis* are undoubtedly very near the top of the Utica.

Triarthrus spinosus was described by Billings in the Report of the Geological Survey of Canada for 1853-56. The species is characterized by a spine on the occipital segment of the head reaching to the third or fourth thoracic ring, a spine on the eighth thoracic ring reaching beyond the pygidium, and genal spines reaching to the seventh or eighth pleurae.

Ami drew attention to the many variations in this species observed by him on specimens from Cummings' bridge near Ottawa—the occurrence of a spine on the ninth instead of on the eighth segment of the thorax; spines on segments eight, nine, and ten; and a tubercle in front of the origin of the spine on the neck segment.[1]

A great many free cheeks undoubtedly belonging to *T. spinosus* occur in the exposures on the Rouge. With these are associated

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[1] Ottawa Naturalist, Vol. I, No. 3, p. 64, 1882. *Ibid*, No. 4, p. 88, Pl. I, 1883

numerous cranidia all remarkably alike and all differing distinctly from the cranidia of *T. canadensis*. Further, a single rather imperfect specimen of *T. spinosus* was found in which the cranidium agrees almost exactly with those referred to above. I am forced to the conclusion that the single specimen and the detached cranidia represent a variety of *T. spinosus* which is described below as *T. spinosus rougensis*.

The striking feature of the variety is the absence of a spine on the neck segment and the occurrence of a very strong spine on the ninth thoracic ring. The genal spines are normal. The failure of the occipital spine on the single whole specimen might be attributed to loss were it not for the fact that no trace of a spine is found on any of the numerous detached cranidia.

The single specimen referred to is shown with considerable restoration in Figure 8. The general proportions are correct but the pleural margins in the anterior thoracic region have been restored. The posterior part of the facial suture is somewhat doubtful; judging from the detached free cheeks the suture does not cut the posterior margin immediately within the base of the spine as shown. The narrow first thoracic ring is possibly due to displacement.

The detached cranidia ascribed to this species and variety are shown by a typical example in Figure 7, and a typical cranidium of *T. spinosus* from Cummings Bridge, Ottawa, in Figure 9.

The Rouge exposures show, also, two types of detached pygidia. There is little doubt that Figure 10 represents the pygidium of *Triarthrus canadensis* and Figure 11 that of *Triarthrus spinosus rougensis*.

The strata exposed on the Rouge river consist of dark and light silty shales, in some places arenaceous, and in others presenting the greyish appearance of typical Lorraine shale. There can be little doubt that, petrographically, these beds show a transition from Utica to Lorraine.

Associated with the two species of *Triarthrus* are vast numbers of flattened orthoceratites, large and small, and the following recognizable species:

Clidophorus cf. foerstei, Ruedemann.
Prolobella trentonensis, Conrad.
Leptobolus insignis, Hall.
Ctenodonta cf. pulchella, Emmons.
Cryptolithus tessellatus, Green.
Cf. *Trocholites ammonius*, Conrad.
Diplograptus sp.

PLATE

Fig. 1. Triarthrus canadensis, free cheek from Craigleith, Ont., X 2.
Fig. 2. Triarthrus canadensis, specimen from Rouge river, X 2.
Fig. 3. Triarthrus canadensis, free cheek from Rouge river, X 2.
Fig. 4. Triarthrus canadensis, cranidium from Rouge river, X 2.
Fig. 5. Triarthrus glaber, Billings' type of head, natural size.
Fig. 6. Triarthrus glaber, variety with spine, Whitby, Ont., natural size.
Fig. 7. Triarthrus spinosus rougensis, cranidium from Rouge river, X 2.
Fig. 8. Triarthrus spinosus rougensis, type specimen, Rouge river, X 2.
Fig. 9. Triarthrus spinosus, typical cranidium from Ottawa, X 2.
Fig. 10. Triarthrus canadensis, pygidium from Rouge river, X 2.
Fig. 11. Triarthrus spinosus rougensis, pygidium from Rouge river, X 2.

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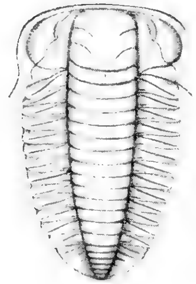

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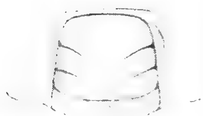

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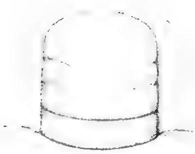

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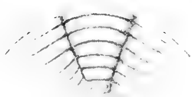

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The Head and Fore Limb of a Specimen of Centrosarus apertus

By W. A. PARKS, Ph.D., F.R.S.C.

(Read May Meeting, 1921)

Monoclonius dawsoni was established by Lambe on a fragmentary skull and part of a squamoso-parietal crest from the Belly River beds of Alberta.[1] At a later date he recognized that the crest did not belong to the same individual as the skull and redescribed it as the type of a new genus and species, *Centrosaurus apertus*.[2]

In his monograph on the *Ceratopsia*, Hatcher quotes Lambe's description of *Centrosaurus apertus* in a footnote and in the text expresses the opinion that the crest does not belong to *Monoclonius dawsoni*.[3]

In 1914 Barnum Brown described a complete skull from the Belly River beds of Alberta as *Monoclonius flexus* and in his preliminary statements returns to the original idea that both the skull and frill first described by Lambe belong to the same species, *Monoclonius dawsoni*. If this view is correct *Centrosaurus apertus* becomes a synonym.[4]

The following year Lambe again returned to the discussion and stoutly maintained the validity of *Centrosaurus apertus* and its distinctness from *Monoclonius dawsoni*. He further maintained that *Monoclounis flexus* of Brown is a synonym for *Centrosaurus apertus*. This opinion is based on two skulls in the Victoria Memorial Museum which reveal the entire anatomy of the head and which, in Lambe's opinion, show the full type of frill described by him for *Centrosaurus apertus*.[5]

Two years later, in 1917, Brown described a complete skeleton of a ceratopsian as *Monoclonius nasicornis* and an incomplete skeleton as *M. cutleri*.[6]

From the above summary it is apparent that both the generic and the specific names of *Centrosaurus apertus* are in doubt. Without

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[1] Cont. Can. Palaeontology, vol. 3, pt. 2, 1902, pp. 57-63.

[2] Ottawa Naturalist, vol. XVIII, No. 4, July, 1904. Trans. Royal Soc. Canada, 2nd Series, Vol. X, Sec. IV, pp. 3-9, 1904.

[3] U.S. Geol. Sur., Mon. XLIX, 1907, p. 93.

[4] Bull. Am. Mus. Nat. Hist., Vol. XXXIII, 1914, pp. 549-558.

[5] Geol. Sur. Can., Mus. Bull. XII, May, 1915.

[6] Bull. Am. Mus. Nat. Hist., Vol. XXXVII, 1917, pp. 281-306.

access to all the type material it would be impossible for the present writer to express a definite opinion; nor is the discussion of the question the object of the present paper.

The genus *Centrosaurus*, as established by Lambe, is applied to those horned dinosaurs in which the fontanelle of the frill lies wholly within the parietals (?), in which epoccipitals are developed, and in which a pair of hook-like processes extend backwards and inwards from the posterior border of the frill. The genus *Monoclonius*, with *Monoclonius crassus*, Cope, as the type, fails to conform with this definition, particularly in that the backwardly directed processes have not been found in the species. Whether this feature is of generic value or whether Brown was justified in reading it into his re-definition of the genus *Monoclonius* need not be discussed here. The present writer prefers to retain the genus *Centrosaurus* until definite evidence is forthcoming that it is identical with *Monoclonius*. He is also prepared to accept Lambe's contention that *Monoclonius flexus* is a synonym for *Centrosaurus apertus*.

The specimen now mounted in the Royal Ontario Museum, Toronto, was found by the museum expedition of 1919 in the bad lands of the Belly River formation on the Red Deer river, Alberta, at a point about a mile south of the river and two and a half miles above Happy Jack ferry, at an elevation of 116 feet (aneroid) above the water.

The animal had fallen on its right side on a bed of blue clay and had been rapidly entombed in sand. At the time of discovery erosion had destroyed the rear of the body, leaving only the head, 17 vertebrae, the scapula, coracoid, and humerus of both sides, the radius and ulna and the manus of the left side, and both sternal bones. The head has the mandible in place and is remarkably perfect throughout.

The skeleton merits a brief description as it shows for the first time any portion of the body of the species and reveals the nature of the coronoid bone and the character of the thyrohyals. That the skeleton belonged to a comparatively young animal is indicated by the distinctness of the sutures, the separation of the epoccipitals and epijugals, and by the fact that its dimensions are somewhat less than those of the type.

Unfortunately Lambe has not published a description of the skulls which he identifies as belonging to *Centrosaurus apertus* but has contented himself with a photographic reproduction. Brown, however, has given a somewhat detailed description of *Monoclonius flexus* with measurements.

The two skulls at Ottawa differ considerably in detail but the relation of the bones seems to be identical. The chief difference is that the forwardly directed processes over the fontanelles are in one case fairly straight, as in the type, but in the other are much more hook-like, as in the present example. Both these skulls are larger and more robust in all their parts than the specimen under review. Assuming the identity of *Monoclonius flexus* and *Centrosaurus apertus* a comparison will be made with the measurements given by Brown for the former and with those of the skull figured by Lambe for the latter. In ascribing the present specimen to either of these species it is at once admitted that certain differences exist. The nasal horn-core is not so distinctly curved forward, the frill is relatively narrower, the fontanelles smaller, and the forwardly directed processes over the fontanelles much less robust. The uppermost sinuosity of the frill margin is not drawn out to a prominent point. The epoccipital ossifications are more distinct and a separate marginal bone between the parietal (?) and squamosal is only faintly indicated. The orbit is less circular and its greatest diameter differently disposed. The suture between the jugal and the squamosal is less vertical, and the lateral temporal fossa has its longer diameter much nearer vertical in position. The lachrymal is higher than that shown in Lambe's figure and there is no distinct indication of the suture with the post-frontal. None of these differences seem to be of sufficient importance to justify a new species and may easily be accounted for by the less advanced age of our skeleton. In fact, there is sufficient difference in the two sides of the frill to equal in importance the differences observed above. The parietal part of the frill on the left side shows a peculiar overlap in the bone outside the fontanelle and this orifice is itself much smaller than on the other side. Whether this is a mere variation in growth or whether it is due to an injury during the life of the animal it is difficult to say.

Measurements indicate that the cranium of our specimen is slightly more than four-fifths the size of that of *Monoclonius flexus*, as the following table will indicate.

MEASUREMENTS OF HEAD

	The present specimen	One of the Ottawa heads	Monoclonius flexus
	mm.	mm.	mm.
Length between condyle and anterior end of rostral	677	780+	840
Total length of skull, approximately, along facial angle	...	...	1570
Total length in straight line from tip of rostral to median point of frill	1228	1340	...
Total length from tip of rostral to posterior edge of posterior processes of frill	1375	...	...
Width between orbits	...	...	290
Width between anterior rim of orbits	218	...	...
Height of skull between posterior end of nasals and border of alveolus	310	370	360
Extreme height of nasal horn from top of nasals, anteriorly	280	...	330
Circumference of nasal horn at base	300+	380	370
Greatest width of crest between borders of squamosals, over top	...	...	1130
Greatest width of crest between borders of squamosals in straight line	460	...	...
Maximum width of crest across parietals in straight line	527	700	...
Width between epijugals	358	500	...
Maximum diameter of orbit, height	135	130	...
Maximum diameter of orbit, width	95	110	...
Anterior end of rostral to epijugal	648	740	...
Anterior end of rostral to infero-anterior edge of orbit	540	555+	...
Epijugal to median posterior edge of crest	763	...	...
Length of right fenestra	230	...	...
Width of right fenestra	160	...	...
Width between tips of supra-orbital horns	177	...	...

A faithful drawing of the skull is given herewith (Plate I); it would be superfluous to redescribe the cranial elements as they seem to correspond accurately with those of the specimens previously referred to. It is to be observed, however, that the present specimen has both supra-orbital horn cores well preserved and that it has both the processes hanging over the fontanelles of the frill. The type of *Monoclonius flexus* has only the left and that originally figured by Lambe only the right. Lambe's later figure, however, shows both processes.

The alveolus of the maxillary is 280 mm. long and contains 29 teeth of the character described by Brown for *M. flexus*. The mouth is very narrow, the width between the cutting edges of the teeth in the rear being only 122 mm. and much less anteriorly.

The nasal horn core is very narrow, being 155 mm. antero-posteriorly and only 57 mm. laterally near the base; it is perhaps somewhat flattened. The general direction of this horn core is forward but the tip is turned slightly back, probably by distortion.

The epoccipitals occur on each sinuosity of the frill and increase in size from the front backwards. On the border of the frill, between the parietal and the squamosal, Lambe's figure shows a separate ossification of considerable size while Brown's shows an emargination with broken edges, suggesting the loss of this element. In our specimen this bone is little more than an enlarged epoccipital which probably increases in size with the growth of the animal.

Thyrohyals (Plate IV) are known in certain dinosaurs but, as far as I am aware, these have not hitherto been found in the *Ceratopsia*. Both these elements were discovered in the present specimen with their anterior ends touching the internal surface of the maxillaries near their posterior extremities, and the posterior ends almost meeting in the midline. The bones are long and slender, the right measuring 168 mm. and the left (slightly broken anteriorly) 162 mm. in length. The anterior end is somewhat expanded, the upper surface flattish and the posterior end inflected slightly outwards. The under surface is more convex in its anterior portion and this convexity rises into a distinct ridge near the outer side of the bone less than half way down. This ridge crosses the bone diagonally and terminates on the inner edge at the posterior extremity, thus giving a twisted appearance to the bone when viewed from the ventral side. The width at midlength is 16 to 18 mm. and the thickness (dorso-ventral) about 12 mm.

The *mandible* (Plates II and III) is worthy of especial mention in that it shows a separate and distinct coronoid. This bone, as a separate element, has previously been observed in the Ceratopsia only in *Triceratops elatus*, Marsh. In this connection Hatcher makes the following comment: "The specimen under consideration (*Triceratops elatus*) furnishes the first example of a free coronoid yet observed in the Ceratopsia, although this element is doubtless present in all the other genera and species of the group, usually, however, being so completely fused with the coronoid process of the dentary as to appear a portion of that element, more especially in old individuals."[1]

The *coronoid* in the present specimen is much larger and more prominent than that figured by Hatcher and Lull. It is applied to the inner surface posteriorly of the coronoid process; it rises distinctly above the process and its posterior margin is as much as 20 mm. to the rear. Viewed from the inner side its outline is rhomboidal with the lower angle drawn out to a point and so twisted that the internal surface becomes a sharp ridge directed intero-posteriorly. Behind the ridge is a distinct concavity which slants forward inferiorly. The extreme lower end where the bone joins the dentary is not clearly shown; its total length may be as great as 170 mm. The upper edge is corrugated for the attachment of muscles.

Measurements of Coronoid

Total height	170 (?) mm.
Greatest width horizontally	54 mm.
Length of postero-superior edge	83 "
Thickness near base, at least	19 "

The *surangular* is a large and stout bone of irregular shape. The upper portion is a vertical flange thinned anteriorly to fit like a wedge between the coronoid and the coronoid process. The external mandibular foramen is a prominent orifice directed down and back; its boundary is formed in part by the posterior margin of the coronoid process. The posterior margin of this flange-like portion of the surangular turns inwards inferiorly, thus forming a concavity on the inner surface of the bone into which the external mandibular foramen opens. The external face of the flange passes gradually into a ridge sloping down and back and becoming the superior margin of the thickened lower part of the bone. The external face of this lower portion is slightly concave. The surangular overlaps the angular both internally and externally. In addition to the external mandibular foramen are four small foramina entering the surangular. The relative size of these differs in the right and left bones; in fact, the

[1] U.S. Geol. Sur., Monograph XLIX, pp. 137.

uppermost is apparently absent on the right side. In the left bone it is situated 32 mm. down and back from the lower edge of the external mandibular foramen.

MEASUREMENTS OF SURANGULAR

Upper point to postero-inferior point	225 mm.
Oblique width of lower thickened portion	46 "
Point between coronoid process and angular to posterior extremity	60 "
Thickness of upper flange	17 "
Vertical height	156 "

In lateral external view the *angular* is relatively high in front but is just perceptible below the surangular in the rear. The external face is slightly concave and the inferior face almost flat. The external inferior angle is distinctly rugose. There are two small foramina near the suture with the dentary and three near the centre (only two on the left side).

MEASUREMENTS OF ANGULAR

Length along external face	77 mm.
Suture with dentary	20 "
Suture with splenial	108 "
Suture with surangular	68 "
Height externally	49 "
Length, inferior	110 "
Width, inferior	50 "

The *dentary* conforms to the general pattern seen in the Ceratopsia. The drawings (Plates II and III), together with the measurements given below, will serve for its description. The internal dental foramina are not well preserved but their presence is indicated by a broken line. The foramina on the external face of the bone are as indicated, but it is likely that more occur as the surface was somewhat injured.

The *coronoid process* is very stout with a sharp hook forward at the upper end and with a very pronounced outward bulge near the base. Its thickness at this point, measured horizontally, is 54 mm. The inner surface shows a sharp ridge running down and back against which the coronoid is set. The upper edge is distinctly corrugated.

The sutures between the coronoid process and the coronoid and surangular are clear and open. The posterior margin of the coronoid process is irregular and is excavated at the point where the external mandibular foramen enters the surangular.

Measurements of Dentary

Total length externally	393 mm.
Height over coronoid process	195 "
Length of inferior margin	300 "
Length of predentigerous portion	53 "
Height of predentigerous portion	114 "
Thickness at base of coronoid process	97 "
Length of alveolus	305 "
Height from summit of 13th tooth to inferior edge	130 "
Anterior edge of coronoid process horizontally to worn surface of teeth	54 "
Maximum horizontal width of coronoid process	57 "
Oblique width of upper end of coronoid process	58 "
External height of 13th tooth	33 "
Worn surface of 13th tooth, height	23 "
Worn surface of 13th tooth, width	12 "
Number of teeth	29

The predentary is of the usual type and is sufficiently defined by the figure and the following measurements:

Measurements of Predentary

Length in straight line from anterior end to posterior end of upper posterior process	238 mm.
Length in straight line from anterior end to posterior end of lower posterior process	280 "
Total height, posteriorly	112 "
Depth of posterior sulcus	84 "
Oblique width from superior margin to lateral ridge	50 "
Supero-posterior width between rami	39 "

The sutures of the *articular* are very indistinct and the character of the *splenial* is sufficiently indicated by the drawing.

General Measurements of Mandible

Total length, tip of predentary to intero-posterior point of articular	670 mm
Tip of predentary to anterior tooth	264 "
Width between external points of surangulars	300 "
Width between intero-posterior points of articulars	145 "
Width of mouth between external cutting edges of teeth, posteriorly	115 "
Width of mouth between external cutting edges of teeth, anteriorly	40 "
From externo-posterior point of surangular to intero-posterior point of articular	103 "

The anterior cervical vertebrae are similar in arrangement to those figured by Lull for *Triceratops prorsus* (Monograph, page 47) except that no trace is visible of the short anterior vertebra. There seems to be only three co-ossified vertebrae as stated by Brown in his Pescription of *Monoclonius nasicornis*.[1]

[1] Bull. Am. Mus. Nat. Hist., Vol. XXXVII, Art. X, p. 288.

The only feature worthy of note is that the axis does not seem to carry a cervical rib as in other forms. No trace of this rib was found on either side although the parts are well preserved; it would be premature, however, to state definitely that this element is lacking. The individual features of the anterior cervicals are sufficiently indicated by the accompanying figure (Plate V, Fig. 1).

The *scapula* (Plate V, Figs. 3 and 4) is of the general type. The only feature worthy of note is that on the internal face of the lower end anteriorly at the suture with the coracoid there was found a well-developed ossified tendon firmly attached and directed inwards and back. The following measurements indicate the relative size of this element:

MEASUREMENTS OF SCAPULA

	Centrosaurus apertus	Monoclonius crassus	Monoclonius nasicornis
	mm.	mm.	mm.
Length	683	660	700
Width of blade, maximum	155		220
Width of proximal end	230		260

The *coracoids* are both rather badly crushed; they are apparently firmly united with the scapulae. The measurements of the right bone are as follows: Length, median, 182 mm.; length, oblique, from point to supero-posterior margin, 288 mm.; length from point to margin of glenoid cavity, 90 mm.

The *humerus* (Plate V, Fig. 2) is massive with a heavy head and stout radial crest. The bone is not well enough preserved to render possible any detailed comparisons. The chief measurements are as follows:

COMPARATIVE MEASUREMENTS OF HUMERUS

	Centrosaurus apertus Right	Centrosaurus apertus Left	Monoclonius crassus	Monoclonius nasicornis
	mm.	mm.	mm.	mm.
Length	543	540	560	600
Width at condyles		172		
Width across radial crest		215		
Minimum girth	228	233		

The *radius and ulna* were found on the left side only. The bones are very badly crushed and distorted, the olecranon process of the ulna being entirely lost. The radius is 338 mm. long and has a minimum girth of 135 mm. The ulna is about 340 mm. between articular surfaces; the minimum girth is 170 mm., the width distally 85 mm. and proximally about 160 mm.

The sternal bones are similar to those figured by Brown for *Monoclonius nasicornis*. The outline, however, is less quadrangular and the thin inner edges do not seem to have been so continuously in apposition. The bones are 340 mm. long, 120mm. wide posteriorly and 80 mm. anteriorly. The maximum thickness of the outer edge is 20 mm. The sternals are slightly longer and distinctly narrower than those of *Monoclonius nasicornis*.

The *manus* (Plate V, Fig. 5) conforms to the general type but there are some differences in proportions, as shown by the following table:

PLATE I

Centrosaurus apertus. Head, about one-tenth natural size.

Ang. *angular;* ant. p. *anterior process of frill;* art. *articular;* cp.1, *coronoid;* cp.2, *coronoid process;* D *dentary;* e.p. *epoccipitals;* epi. *epijugal;* F *frontal;* J *jugal;* L *lachrymal;* M *maxilla;* N *nasal;* n.h.c. *nasal horn core;* O *orbit;* P *parietal;* post p. *posterior process of frill;* pre.d. *predentary;* pre.m. *premaxilla;* p.f. *prefrontal;* po.f. *postfrontal;* Q *quadrate;* q.j. *quadratojugal;* ros. *rostral;* S.ang. *surangular;* s.h.c. *supraorbital horn core;* sp. *splenial;* sq. *squamosal.*

PLATE II

Centrosaurus apertus. Right mandible, external view, about one-fifth natural size. Lettering as in Plate I.

PLATE III

Centrosaurus apertus. Part of left mandible, internal view, about .35 natural size. Lettering as in Plate I.

PLATE IV

Centrosaurus apertus. Right thyrohyal, about five-sixths natural size; left figure, upper view; right figure, lower view.

PLATE V

Centrosaurus apertus.

Fig. 1. Anterior cervical vertebrae. Greatly reduced.
Fig. 2. Left humerus, external view, about one-eighth natural size.
Fig. 3. Left scapula and coracoid, about one-seventeenth natural size.
Fig. 4. Right scapula and coracoid, about one-twelfth natural size.
Fig. 5. Left manus, greatly reduced.

PLATE I

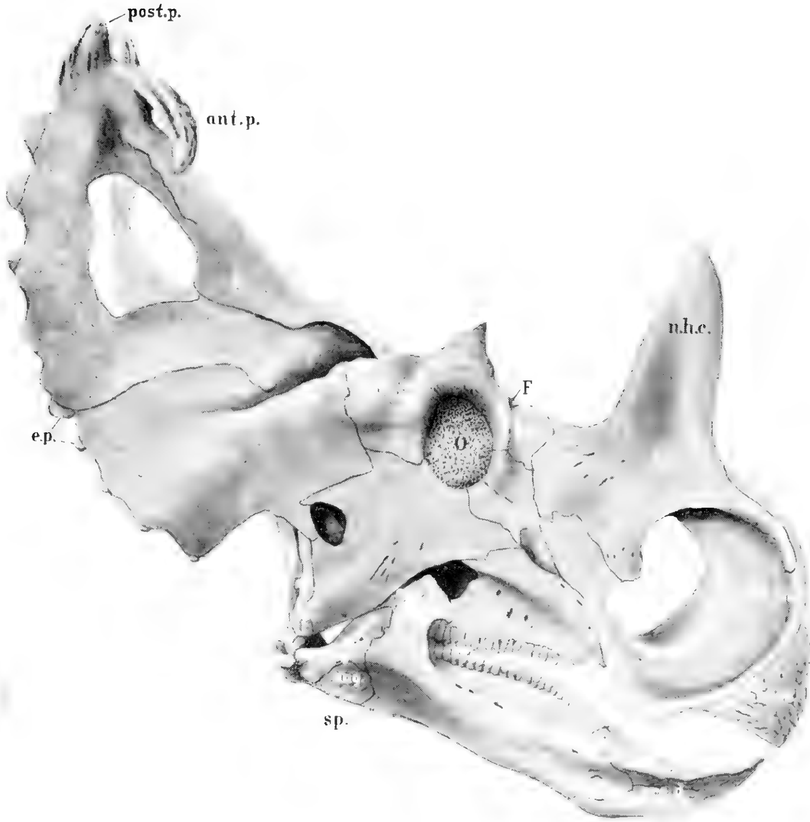


PLATE II

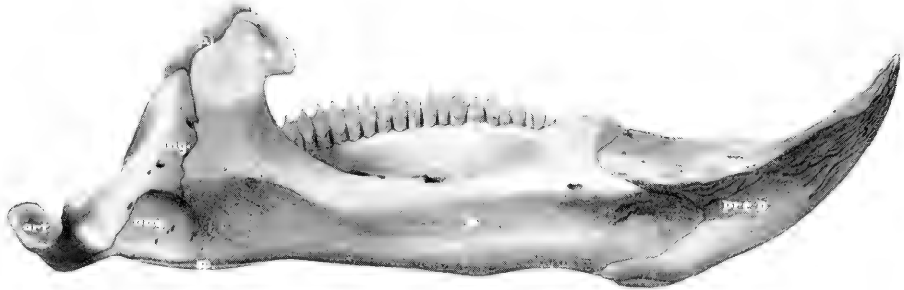


PLATE III

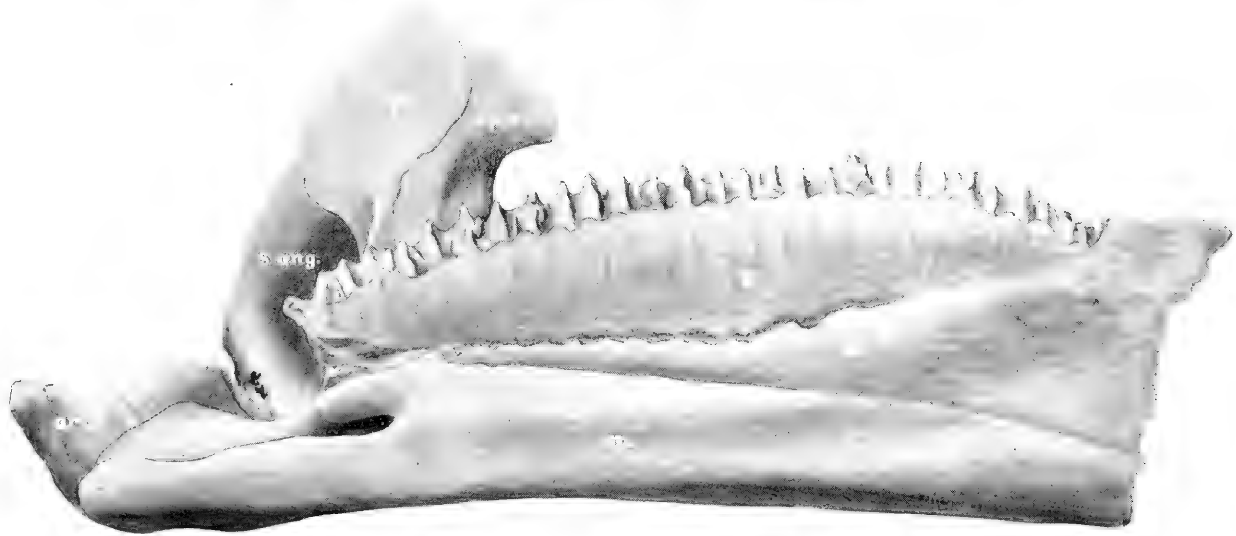


PLATE IV

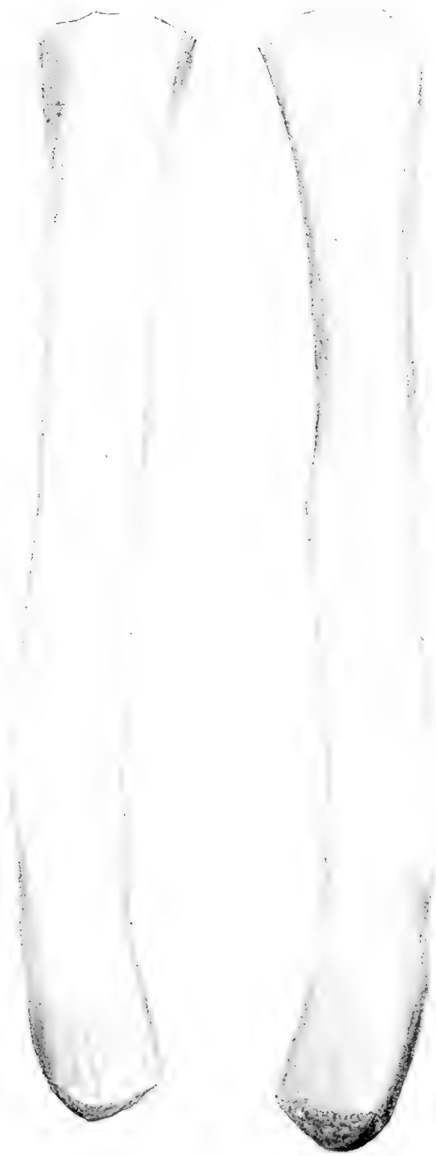
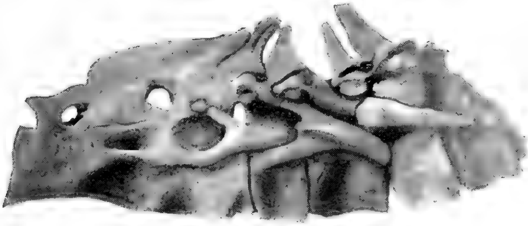


PLATE V



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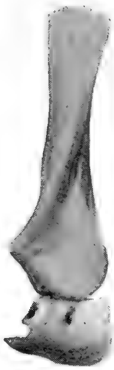

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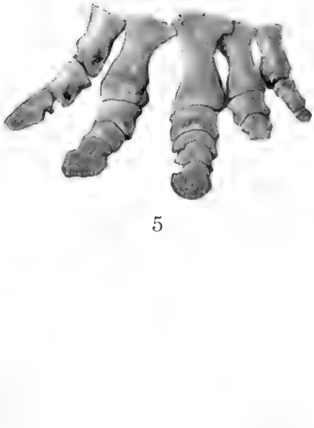

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Comparative Measurements of Manus

	Centrosaurus apertus mm.	Monoclonius nasicornis mm.	Monoclonius cutleri mm.
Metacarpal I, length	80	83	97
width, trans., prox.	56		
" " ant-post., prox.	58		
" II, length	110	127	140
" width, trans., prox.	57		
" " trans., dist.	60		
" III, length	122	130	143
" width, trans., prox.	81		
" " trans., dist.	65		
" IV, length	90	99	105
" width, trans., prox.	65		
" " trans., dist.	50		
" V, length	73	80	
" width, trans., prox.	40		
Phalanx I¹, length	47	56	50
" width, trans., prox.	52		
" I², length	63	64	73
" width, trans., prox., hoof	47		
" II¹, length	41	46	
" width, trans., prox.	58		
" II², length	23	30	
" width, trans., prox.	48		
" II³, length	55	55	61
" width, trans., prox., hoof	55		
" III¹, length	33	38	42
" width, trans., prox.	61		
" III², length	22	27	
" width, trans., prox.	45		
" " " dist.	52		
" III³, length	20	20	
" width, trans., distal	43		
" III⁴, length	43	41	
" width of hoof	45		
" IV¹, length	27	34	36
" width, trans., prox.	47		
" " " distal	46		
" IV², length	18	21	
" width, trans., max.	39		
" IV³, length	12	18	
" width, transverse	28		
" V¹, length	37	43	
" width, trans., prox.	40		
" V², length	17	13	
" width, maximum	23		

On Conularia rugosa from the Lockport Limestone at Hamilton, Ontario

By W. S. DYER, B.A.

Presented by W. A. PARKS, Ph.D., F.R.S.C.

(Read May Meeting, 1921)

In the year 1884 Spencer described a species of Conularia from the Niagara limestone at Hamilton, Ontario, which he named *Conularia rugosa.* The specimen was very imperfect and apparently consisted only of the internal cast. His figures are very poor and his description is not at all clear. Fortunately a beautifully preserved specimen has recently been added to the collections of the Royal Ontario Museum and it is thought that a fresh description and new figures of this species would make a desirable addition to the literature of the Conularidae.

GENUS CONULARIA, *Miller*

CONULARIA, *Miller.* Min. Conchology 3, 1821, p. 107.

Miller's description of the genus is as follows:

"Shell, a four-sided, elongated pyramid, nearly always straight. Cross-section, a square, long rhomb, rectangle, or rhomboid, or the corresponding figures where the straight lines are replaced by curves. Faces of the pyramid flat, convex or concaved; all equal or equal only in opposite pairs. Angles of the pyramid marked by straight grooves. Aperture partially closed by infolding lobes; apex sharply tapering; apical part of the shell divided into a few compartments by thin, convex, probably imperforate septa. Shell smooth or ornamented with a series of ridges, sometimes longitudinal, more often transverse. Shell very thin, formed of chitin, more or less impregnated by lime."

CONULARIA RUGOSA, *Spencer*

CONULARIA RUGOSA, *Spencer.* Bull. Missouri State Mus., 1, 1884, p. 57, pls. 8, 9, Figs. 2, 2*a*; Trans. Acad. Sci. St. Louis, 4, 1884, p. 608, pls. 8, 9, Figs. 2. 2*a*.

Spencer describes the species in the following terms:

"Shell large and broad, pyramidal; medial depression on side scarcely apparent, but producing an abrupt bending of the striae. Surface of shell removed, showing only the internal cast. Broad, flattened, transverse ridges, separated by narrow deep channels, cross the sides of the shell and bend abruptly at medial lines. These are again traversed by shallow longitudinal striae situated closer together than the transverse ridges, but which do not penetrate them to a depth of the separating transverse grooves. But, where the longitudinal striae cross the transverse channels there are punctures in the grooves; and where they cross the ridges there is a depression in the centre of the ridges.

"I have only seen one specimen, which is not entire. The fragment is 13 centimetres long, with two sides partly remaining; the greatest width at base of side (visible) is about five centimetres. In some places the shell is crushed, bringing the ridges and grooves together very closely in a wrinkled manner; and, where not crushed, the surface presents a wrinkled appearance. There are ten transverse ridges and furrows in one centimetre of length. The longitudinal striae and the punctures in the transverse grooves are situated one-half millimetre apart."

The specimen in the possession of the Royal Ontario Museum of Palaeontology was found in chert so flattened that its original shape cannot be correctly determined. The surface ornamentation, however, is well marked.

A description of this specimen follows:

Shell large, tapering uniformly, of moderate thickness. The two edges of the flattened specimen represent the two opposite angles of the original pyramidal shell and, therefore, two adjacent faces are seen, which are divided by a slightly sulcate line. The apical angle is 25 degrees.

The general character of the ornamentation is as follows: Each face is marked by transverse ridges which have a forward inclination from the lateral margins and meet at an angle of 145 degrees along the median line of the face. These transverse ridges are separated by grooves of about twice the width of the ridges. The floor of the groove is not simple but is marked by low, rounded elevations at right angles to its direction. These corrugations are separated by somewhat sharper depressions; their spacing is about half that of the main ridges; and they are not continuous from groove to groove over the summits of the ridges.

Considerable variation in detail is observed in different parts of the shell. In the first place the spacing of the ridges and grooves varies from ten in a centimetre near the aperture to twenty in the same distance near the apex. Another variation is seen in the character of the ridge; in some parts of the shell (Pl. II, Fig. 1) it is sharply defined, with square edges, and with a continuous depression along its centre which expands at intervals to oval scars. In other parts (Pl. II, Fig. 2) the ridges are more rounded and are marked by elevated papillae in place of the depressed scars. These papillae are apparently hollow as minute apertures are observed at their summits in some instances.

Beside the outside wall itself the impression of the outside wall is also seen. This impression is clearly made by the type of ornamentation seen in Pl. II, Fig. 2. Wide, rounded, transverse ridges are separated by narrow grooves. The ridges are marked by rounded, longitudinal elevations and depressions. In the transverse grooves deep punctures are found lying opposite the longitudinal depressions.

The greatest length of the shell is 95 millimetres and the greatest width of one face is 42 millimetres.

Our specimen agrees with Spencer's type in size and shape. The apical angles are approximately the same in both specimens. The angle made by the transverse ridges as they meet to form the line in the middle of each face is also approximately the same. The type of ornamentation which Spencer figures, and which is said by him to characterize the internal cast of the shell, is very similar to the ornamentation observed on the external impression of our shell. The true surface of the shell, however, was not found by him and is described in this article for the first time.

PLATE I

Fig. 1. *Conularia rugosa* ×4/3.

PLATE II

Fig. 1. *Conularia rugosa.* Ornamentation of a portion of the surface near the apex, showing prominent tranverse ridges and small oval pits. ×13.

Fig. 2. *Conularia rugosa.* Ornamentation of a portion of the surface near the aperture, showing the papillae and less prominent tranverse ridges. ×13

Fig. 3. *Conularia rugosa.* Impression of the surface. ×13.

PLATE I

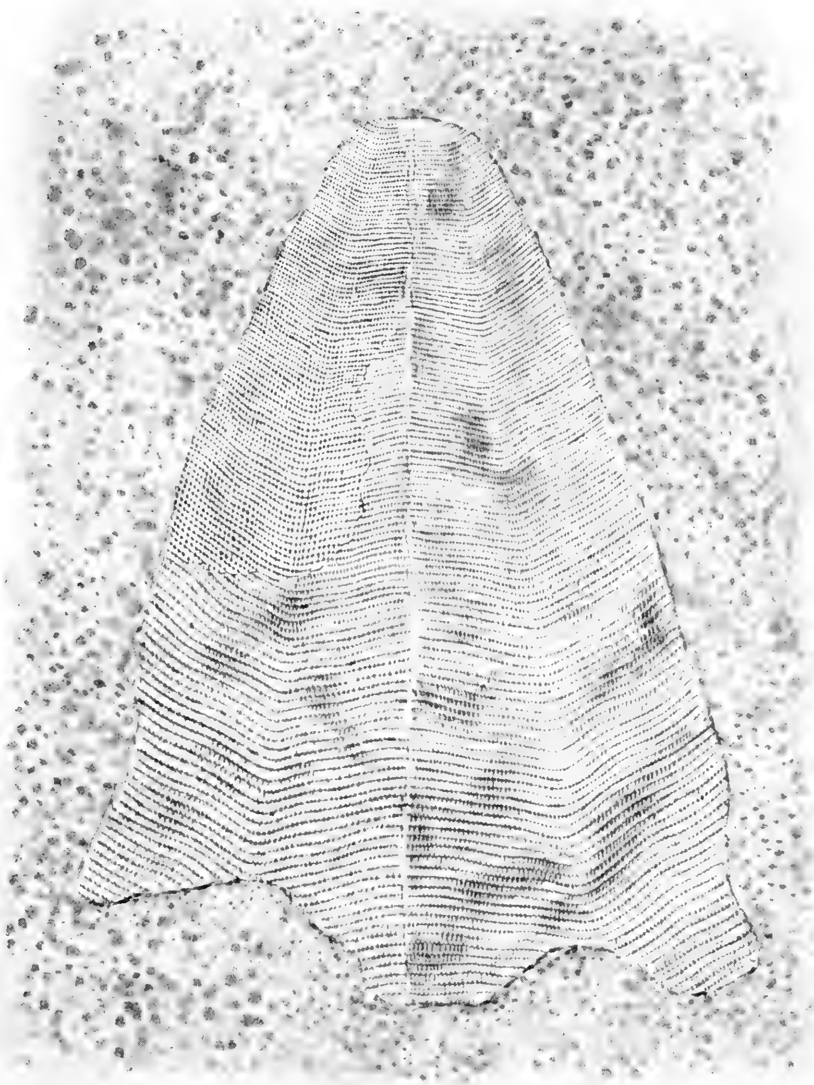
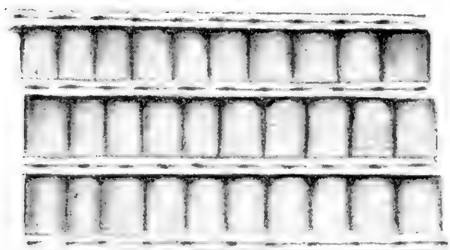
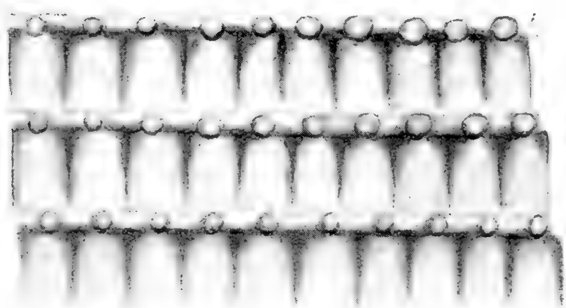


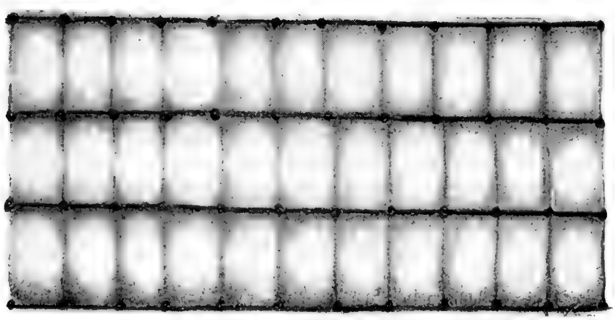
PLATE II



1



2



3

The Annaheim Meteorite[1]

By R. A. A. JOHNSTON, F.R.S.C., and H. V. ELLSWORTH, M.A., Ph.D.

(Read May Meeting, 1921)

While engaged in mowing hay on a meadow on his farm about six miles to the north of Annaheim, Saskatchewan, on July 30, 1916, Mr. William Huiras noticed a peculiar metallic ring when one of the guards of his machine struck some hard substance lying in the grass. On making an investigation to ascertain the cause he was surprised to find a chunk of metallic material of unusual form resting on the tough sod. He removed the specimen to his house and from it, with the aid of hammer and chisel, cut off a small piece which he forwarded to Mr. F. Bradshaw, Chief Game Guardian, Regina, Saskatchewan. Mr. Bradshaw, noting its peculiar appearance, submitted the piece to the Department of Mines for an opinion. The piece, which measured 5 or 6 centimetres in diameter, was possessed of the saucer-like depressions commonly found on meteorites and a qualitative chemical examination showed it to consist mainly of metallic iron with some nickel. Shortly after this negotiations were instituted on the part of the Department of Mines and the specimen was acquired from Mr. Huiras by purchase.

The locality where the meteorite was found may be more accurately defined as a meadow traversed by a small creek on section 32, township 39, range 20, west of the Second Meridian—or about 50° 21′ north latitude and 105° 50′ west longitude.

As received at the Department of Mines the specimen was intact except for the small portion which had been detached by Mr. Huiras as previously noted. It was roughly crescentic in outline and measured 30 centimetres in length and 15 centimetres across at its widest part. One face was flattish while the other was very uneven and marked by two relatively high angular prominences, one on each horn of the crescent and close to the inner curve; near this curve the specimen varies in thickness from 5 centimetres at the centre to 8 centimetres on one of the horns and 9 centimetres on the other. Along curves of the crescent the thickness varies from 2 or 3 millimetres to 3 or 4 centimetres. The weight of the specimen was

[1] Communicated by permission of Deputy Minister of Mines.

11.84 kilogrammes. The surface showed the usual circular depressions found on meteorites; these measured from 1½ to 5 centimetres across and were relatively quite shallow.

Except on the summits of the prominences which have been noted the colour was throughout of a dull iron black though the surface was quite smooth to the touch. The summits of the prominences were coated with a thin brownish incrustation in which impressions of grass blades were well defined. This incrustation, which was alien to the primary character of the specimen, was found to consist of numbers of microscopic plates of selenite intermingled with hydrated oxide of iron. On the slope of the smaller of the two prominences there was exposed a nodular mass of iron sulphide measuring 3 to 5 centimetres in diameter. Apart from a slight tarnish this mass showed no particular evidences of oxidation though it must have been freely exposed to weathering influences.

When sectioned and rubbed down first with fine carborundum and then with jeweller's rouge this iron was found to take a moderately bright polish generally, although a zone about 2 millimetres in width extending all the way around the edge appeared much brighter than did the central portions. Even previous to the employment of etching solutions the Widmanstatten figures became distinctly visible when the polished section was viewed obliquely; examined in this way the field was marked by several series of fine parallel lines brighter as to lustre than the general groundmass.

When the polished section was treated with a 2-per cent. solution of picric acid in alcohol etching proceeded slowly; the major portion of the plate was visibly acted upon, but the material giving rise to the bright lines was to all appearances unaffected and remained in the end as salient ridges lying between the kamacite bands and disposed in such a way as to indicate an octohedral structure for the iron. It was later found that a 10 per cent. solution of nitric or hydrochloric acid had no appreciable action either on the material of these narrow bands or on some minute acicular crystals found enclosed in the kamacite bands—a condition of which full advantage was taken by the junior author of this paper in separating the various mineralogic constituents of the meteorite for analysis.

The kamacite bands were found to vary in width from 1 millimetre to 4 millimetres—the greater number from 2½ to 3 millimetres —so that the iron may be classed as a coarse octahedrite.

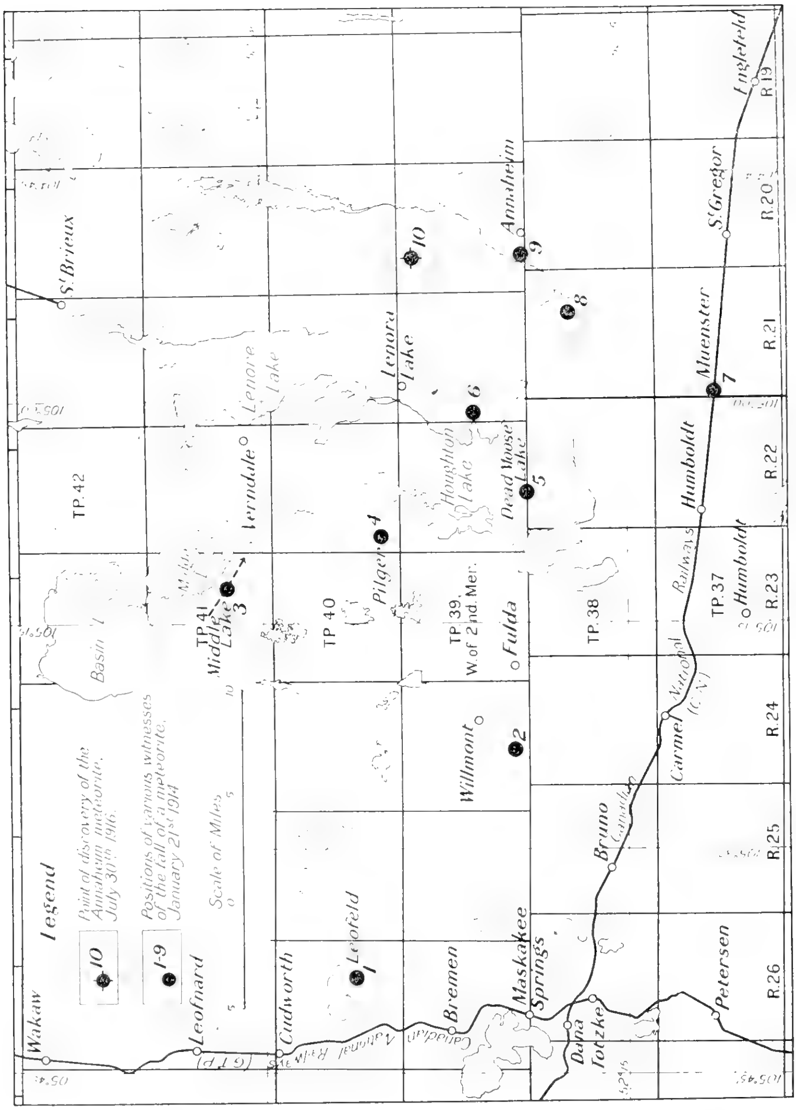
When a slightly etched plate is examined under a magnification of 40 to 50 diameters the kamacite plates exhibit a minute octohedral structure and an abundant development of small needles of schreibersite. With a somewhat coarsely etched plate and a magnification of about 30 diameters the microcrystalline structure of the kamacite bands may be readily studied; the octahedral crystals lie for the greater part in parallel position imparting a beautiful lattice-like appearance to the plate; here and there, however, beautifully defined examples of twinning may be observed; the twinning takes place parallel to the octahedral plane, producing so-called spinel twins.

In spite of its highly crystalline and complex character this iron is quite malleable.

In studying the Annaheim meteorite some features presented themselves in connection with its position and condition at the time of its discovery which point almost conclusively to its having been a comparatively recent arrival and one circumstance at least would indicate that it had fallen during the winter season.

The grass on which it was resting had not undergone complete decay; the black coating was complete over the surface; the iron sulphides so susceptible to oxidation showed only a tarnish as evidence of weathering. These facts may be taken as certain proof that the meteorite had not been lying for a long time where it was found. It was resting on sod unaccompanied by evidences of sharp impact with or excavation of the soil. It would appear to have come to rest on the sod following a period of delay by some intervening medium which had since disappeared; that this medium must have been soft and of very mild abrasive properties is evidenced in the fact that the surface of the specimen was free from marring. The only medium which, under the particular circumstances, involved could comply with these conditions is winter snow.

With these considerations before him the senior author instituted inquiries with a view to ascertaining whether any meteoric phenomena of special interest had been observed in the district about Annaheim within a few years of the time when the metorite was discovered. The result has been a large number of responses from various residents of the district stating that meteoric phenomena of a startling nature occurred there about half-past two o'clock in the afternoon of Wednesday, January 21, 1914. The date is attested by the official record of the substation of the Meteorological Service at Muenster and in a meteorological record kept by Mr. Pius Mutter of Pilger. Further confirmation of the date is furnished in an account of the occurrence contained in the issue of St. Peter's Bote for Thursday, January 29, 1914, published at Muenster by Reverend Peter Windschiegel, to whom the senior author is indebted for his interest in obtaining information. The phenomena in question were observed at Leofeld,


Legend
10
Point of discovery of the Annaheim meteorite. July 30th 1916.
1-9
Positions of various witnesses of the fall of a meteorite. January 21st 1914
Scale of Miles
0 5 10
Wakaw
Leofnard
Cudworth
Bremen
Maskakee Springs
Dana
Totzke
Petersen
Leofeld
Willmont
Fulda
Bruno
Carmel
Humboldt
Muenster
St Gregor
Englefeld
Annaheim
St Brieux
Lenora Lake
Lenore Lake
Middle Lake
Pilger
Houghton Lake
Dead Moose Lake
Basin
Canadian National Railways (G.T.P.)
Canadian National Railways (C.N.)
TP. 42
TP. 41
TP. 40
TP. 39 W. of 2nd Mer.
TP. 38
TP. 37
R. 19
R. 20
R. 21
R. 22
R. 23
R. 24
R. 25
R. 26

Dana, Bruno, Fulda, Middle Lake, Pilger, Dead Moose Lake, Humboldt, Muenster, Annaheim, and also at Mr. Huiras's farm on which the Annaheim meteorite was found. The geographic relations of these points may be clearly understood by reference to the diagram.

(1) Mr. J. Lapinski states in a letter dated at Leofeld, March 8, 1917, that on the day mentioned he heard a loud noise resembling thunder, but much more intense, coming from the north-west and travelling toward the south-east. Horses, cattle, sheep and pigs were startled by it and the house dog manifested much uneasiness. Mr. Lapinski did not see anything to account for the disturbance. Leofeld lies about 25 miles from the Huiras farm on a line running a little to the north of west.

(2) Mr. E. Ludwig, whose farm is situated on the north-east quarter of section 4, township 39, range 24, west of the 2nd meridian about 7 miles in a north-easterly direction from Bruno or about 4 miles west of Fulda, states in a letter dated March 2, 1917, that he was standing about 20 yards from his house and that he first noticed a ball of fire disappearing to the eastward and leaving in its trail a cloud of smoke which remained visible for about half-an-hour. The apparition was followed by a noise like thunder, but he was not favourably situated for observing the effect of this upon animals.

(3) At Middle Lake, Rev. Peter Windschiegel is authority for the statement that the meteor seemed to pass directly over the heads of the people and that it was travelling in a south-easterly direction. It will be noted by reference to the map that the Huiras farm lies about 18 miles almost directly south-east from this point.

(4) Mr. Pius Mutter, writing from Pilger, March 17, 1917, makes the following statement: "I was in my dwelling on N.E.6-40-22 W. of 2nd at the time looking south the winter corral. With the approach of the sound which was like distant thunder the cattle roused and with tails in the air went helter skelter around the stack and then lined up along the east side of the corral staring to the eastward in the direction in which the rumbling seemed to me to have died away.

"Stepping outdoors I saw high above the faint haze in the air a dark wide line of varying density undulating through the haze, and corresponding in position with that in which the sounds appeared to have originated. I judge the meteor to have passed from west to east in an angle of about 10 or 12 degrees north of the vertical."

(5) Mr. F. H. Strueby, writing from Dead Moose Lake on March 28, 1917, said that he was sitting in his house when the first sound was heard; to him this resembled the humming or roaring of a chimney; just then his daughter came running into the house saying that

some unusual sounds were coming from upper reaches of the atmosphere. On going outside Mr. Strueby noticed a cloud well overhead and heard a peal like thunder which lasted about a minute. Horses and cattle were greatly agitated and the house dog manifested a great deal of fear.

(6) Mr. Joseph Weiland, whose farm is situated on section 18, township 39, range 21, west of 2nd meridian, nearly 5 miles to the north-eastward of Dead Moose Lake and about 8 miles in a direct south-westerly line from the Huiras farm, states that he saw the meteor distinctly. To him it passed from westward to eastward at a very high velocity leaving a long trail of white smoke behind. Its passage was followed by a loud roaring noise like thunder lasting about four minutes. The snowbirds and sparrows, which were congregated in large flocks about his place, fluttered about in circular flights as if bewildered at the same time giving voice to notes of alarm. The house dog also showed plain signs of uneasiness. The trail of smoke moved to the south although a contrary wind was noticed at the ground level.

(7) Reverend Peter Windschiegel, writing from Muenster on February 17, 1917, quotes from the official meteorological records for the day in question to the effect that the sky was nearly clear and the weather calm; the maximum and minimum temperatures recorded for the day were +7°F. and −15°F., respectively. He, with others, was indoors at the time and all were unaware of anything unusual, but the Reverend Casimir Cismowski and the Reverend Leo Odjowski, who were outdoors at the time, reported having seen a meteor to the north of Muenster travelling at a very high velocity in an easterly or probably a south-easterly direction; the meteor emitted smoke much like that from a steam locomotive. The phenomenon was followed by sounds like those of thunder, several detonations being distinctly audible. It was estimated that the altitude at which the meteor passed was about 25 miles above the general level of the country.

(8) Mr. John Haas, writing from Annaheim on March 6, 1917, states that on the day in question he and his two boys were hauling wood and were near section 22, township 38, range 21, west of the 2nd meridian at about 2.30 in the afternoon, when their two teams suddenly stopped, showed pronounced evidences of alarm and were controlled only with very great difficulty. Next there came a loud noise like heavy rolling thunder travelling from north-west to south-east and lasting about a minute and a half. The ground shook as it would from a passing train.

The day was cold and calm; the sun was shining brightly and there appeared from the north-west a kind of bright cloud—apparently about 50 feet in length—which faded away to the south-eastward about 4 or 5 minutes afterward.

Mr. Haas pictured the cloud as having a serpentine aspect with a broad expansion near the forward end.

(9) Mr. Wishart H. Poukse, writing from Beauchamp on March 14, 1917, stated that he was on the south-east quarter of section 4, township 39, range 20, west of 2nd meridian at the time of the occurrence under consideration. He first heard a noise like that of a high wind and then a report and on looking upward noticed clouds of smoke, close together at first, but soon trailing out in long strings, rapidly changing form and gradually disappearing without marked change in general position. The cloud appeared to be somewhat north of a point directly overhead and to him appeared to have come from the south. Animals seemingly were undisturbed by the occurrence.

(10) Mr. William Huiras and Mr. Paul Lackmuth were together on the the former's farm at the time. The former describes the phenomena as a roaring sound accompanied by intermittent detonations lasting 2 or 3 minutes. He saw nothing but a cloud of smoke in the air. Mr. Lackmuth likens the sound to a boiler explosion; the smoke, he says, was visible for about half-an-hour.

The item in St. Peter's Bote of January 29, 1914, a free translation of a part of which has been kindly furnished by Reverend Dominic Hofmann of Annaheim runs as follows: "In the afternoon of January 21, 1914, a peculiar phenomenon was witnessed by the people of St. Peter's Colony. Not only the people of Muenster, but also those about Humboldt, Fulda, Dead Moose Lake, Pilger, Bruno and Dana, saw in the heavens a smoking cloud which was moving with great noise. Some even saw sparks issuing from it and heard detonations. The noise was so great that even horses shied."

Although the proof can never be absolute that there is a direct connection between the phenomena observed over the country extending 30 miles or more westward from Annaheim on the 21st January, 1914, and the meteorite discovered by Mr. Wm. Huiras on his farm on section 32, township 39, range 20, west of the 2nd meridian, July 30, 1916, there is certainly much of a circumstantial nature to lead one to this conclusion.

The meteorite had quite clearly not lain long where it was found; it had evidently been cushioned against immediate impact with the soil at the time of its fall; this could only happen through its descending upon snow; that is to say it must have fallen during the winter season.

These are conditions which are entirely fulfilled in the case of the phenomena which have been described.

The statements of eye witnesses generally show that the meteor's direction was north-west to south-east and if we project a line south-easterly from Middle Lake at which position the meteor is stated to have passed right overhead it will pass through the section where the meteorite was found.

Again although observers at Muenster have not indicated the data on which they based their conclusion they estimated the elevation of the meteor as it passed north of there at 25 miles. And if we accept Mr. Mutter's estimate of the angle of elevation as it passed Pilger as approximately correct and there does not seem any good reason for doubting this as he is a good observer, we get an elevation of somewhere between 30 and 37 miles for the meteor as it passed through a point in the vertical plane projected through Middle Lake and the Huiras farm.

Thus in traversing one half of the horizontal distance of 15 miles between the two points it had probably fallen about the same distance vertically. And as the trajectory curve would increase rapidly as the meteorite advanced the latter might be expected to fall somewhere about where the Annaheim iron was found.

Chemical Composition and Metallography

By H. V. Ellsworth

The sample used for the general analysis was taken from a slice about one quarter of an inch thick which had been sawn from near the middle of the meteorite. A rectangular section about one quarter inch square was cut from this slice and drilled in two directions at 90 degrees. The borings, amounting to about 10 grams, were well mixed and a five gram amount was dissolved in nitric acid and made up to a litre. Aliquots of this solution were used for the determination of iron, nickel, cobalt, copper and phosphorus. The remaining borings were used for the carbon determination. Two samples of 7 or 8 grams each for S and P and one of 10 grams for Cr, V, etc., were made up from the skeleton left by the drilling and from a section cut from the same part of the slice.

Analytical Methods

Copper was separated by H_2S in dilute sulphuric acid solution, the sulphide ignited and weighed as oxide, and finally checked by weighing after reduction in hydrogen.

Iron was determined by titration with permanganate following oxidation of organic matter and subsequent reduction.

Nickel and cobalt were separated from iron by four basic acetate precipitations, including an initial and a final precipitation of the iron by ammonia. After evaporating the filtrates and filtering off the small amount of iron hydroxide thus recovered, the nickel and cobalt were precipitated as sulphides, ignited to oxides in a silica crucible, treated with a little $HN0_3$, again ignited to oxides, and finally weighed as metal after reduction in hydrogen. The nickel-cobalt metal was then dissolved in $HN0_3$ and treated with ammonia to separate the minute amount of iron which is usually present. Nickel was then separated from cobalt by the dimethylglyoxime method. The filtrate containing the cobalt was evaporated to dryness several times with strong nitric acid and finally ignited to destroy the remaining organic matter. The cobalt oxide thus obtained was dissolved in hydrochloric acid, precipitated by nitroso-beta-naphthol, ignited and weighed as metal, after reduction in hydrogen.

The nickel found was further checked by a direct precipitation with dimethylglyoxime, the iron being held in ammoniacal citrate solution. The nickel glyoxime thus obtained after solution in dilute nitric acid along with a little citric acid, was reprecipitated by the addition of ammonia and dimethylglyoxime solution. A considerable amount of glyoxime solution is required to effect complete reprecipitation of the nickel salt, so much, in fact, that it would appear that the glyoxime is partly decomposed by even dilute nitric acid. The nickel glyoxime was evaporated to dryness several times with strong nitric acid, ignited, reduced in hydrogen, and weighed.

Direct weighing of nickel glyoxime, after drying at 120°, gives slightly high results, in the writer's experience, probably owing to occlusion of the reagent. The determination as oxide is accurate and in accord with the values obtained by reduction in hydrogen.

Sulphur was determined by the Bamber method on an 8 gram sample, carbon by combustion in oxygen and absorption in barium hydroxide, phosphorus and silicon on a 7 gram sample.

Chromium, vanadium, aluminium, titanium, and manganese were sought and copper was determined in a 10 gram sample by the ether separation method according to Blair and Ledebur.

The results of the general analysis are as follows:

	%
Fe	91.51
Ni	7.84
Co	0.46
P	0.219
S	0.012
Cu	0.08
Si	0.002
C- total	0.01
Cr	0.001
Mn	Very minute trace
Ti, V, Al, Sn	Not detected
Insol in HNO_3 1.2 S. G.	0.003
	100.12

S. G. of bar used for analysis........7.873 at 20.2°C in air.

Separation and Analysis of the Constituents of the Iron

It was soon observed that the ground mass of the iron was attacked by acids much more readily than the other constituents which, by repeated treatment, could be obtained finally as a residue free from ground mass. Accordingly a 68 gram slice was treated with successive portions of 10 per cent. HCl and a residue of about 2 grams obtained consisting of some undissolved ground mass along with lamellae of 38% nickel iron alloy (Pl. V, Figs. 1, 2; Pl. VI, Figs. 3, 4; Pl. VII, Figs. 5, 6, and analysis 2), irregular masses of brittle fractured phosphide (Pl. VIII, Figs. 7, 8; Pl. X, Fig. 12), and innumerable minute, brittle, long, slender crystals of phosphide (Pl. XI, Fig. 14; Pl. XII, Fig. 15, 16; Pl. XIII, Fig. 17). There was also a very little black carbonaceous or graphitic matter. From this residue, washed in alcohol and ether, samples of the various materials were carefully selected under the binocular, quantities somewhat exceeding one-tenth gram being obtained.

The specific gravity of the specimens was determined in a 10 c.c. silica pycnometer with graduated capillary tube stopper in which weighings can be made and repeated with an accuracy of 0.1 mg. All samples were boiled in vacuo until apparently free from air. The temperature was measured to 1/50°C. by a standard thermometer immediately following the last weighing. The results are probably accurate to the first decimal.

Method of Analysis

The composition of the materials being unknown and the quantities small, it was necessary to use a scheme of analysis adapted to the convenient identification and determination of as many elements as possible on the one sample available.

The material was dissolved in aqua regia at room temperature. Sufficient sulphuric acid to displace the aqua regia and leave 0.5 to 1 c.c. excess was added and the solution evaporated on the water bath. It was then heated to fuming, cooled, diluted, and examined for silica. In the presence of silica the evaporation and fuming with sulphuric acid was repeated. Copper was then precipitated by H_2S and weighed as oxide or metal. The solution after separating copper was oxidized with bromine water, boiled with K0H in platinum and filtered. The washed precipitate was ignited in a platinum crucible and fused twice with sodium carbonate. The combined filtrates from the treatment with K0H and the fusions were acidified with nitric acid and P determined as magnesium phosphate or by the molybdate method.

Fusion with alkali carbonate was adopted as providing a convenient test for Cr, Mn, Al and V in addition to removing most of the P. The H_20 insoluble from the fusions was dissolved in HCl and H_2S0_4 and Pt precipitated from sulphate solution. After removal of the Pt, Ni and Co were separated by an initial precipitation of the iron by ammonia followed by five basic acetate precipitations. The iron, with the small amount of P remaining, was tested for Ti and finally precipitated by ammonia and weighed as $Fe_20_3+P_20_5$. The P_20_5, remaining with the iron, was subsequently recovered by the molybdate method and the necessary corrections applied to the values for Fe and P.

In the above method no provision was made for the detection of carbides, but the very minute amount of carbon found in analysis I and its apparent occurrence as graphite locally disseminated in the 38% nickel alloy, as shown by metallographic examination indicated that no important amount of carbide was to be expected.

Finally, it should be noted, that the highest accuracy is not to be expected in the results from the above procedure, especially where only fractions of a per cent. of a constituent are involved, in the first place because of the small weight of sample used, and secondly because of the numerous operations required for the determination of all constituents in one small sample. However, the work was carefully performed and the results are believed to be reliable.

Analysis 2—Lamellae of High Nickel-iron Alloy

S. G.......7.9 at 16.50°C. in air.	%
Fe	60.74
Ni	37.38
Co	0.67
Cu	0.64
P	0.65
Cr, Mn, V, Ti, Si. Insol.	Not detected
C	Minute amount probably present
	100.08

From metallographic and microscopic examination of the complex lamellar structures it seems likely that the P found is due to the presence of attached or partially resorbed microscopic crystals of $(FeNi)_3P$ (Analysis 4). No doubt some were also included loose in cavities. If the analysis be recalculated on this assumption using the theoretical composition of $(FeNi)_3P$ and calculating Co and Cu as Ni we obtain the following values:

	%
Fe	61.55
Ni	38.45
	100.00

This is evidently the same alloy as the "Taenite" isolated by Fletcher from the Youndegin meteorite,[1] and it answers well as to structure and mode of occurrence to the general description of "Taenite" according to Cohen.[2]

It would have been possible to prepare a better sample of this material by selecting only the single lamellae which are usually quite pure, but unfortunately the complex forms with multiple lamellae had to be included to make up sufficient weight, and these were very apt to carry crystals of phosphide.

Physical Properties

The alloy has a brilliant tin-white colour with marked resistance to oxidation. In samples heat tinted by the method of Stead it shows up very beautifully with only a yellow tint even when the

[1] Mineralogical Magazine, vol. XII, No. 56.

[2] Meteoritenkunde Heft I, page 99 er seq.

surrounding ground mass has gone to purple or blue. It appears to be quite unaffected by rust or discolouration under ordinary atmospheric conditions, resembling in this respect, as well as in composition the artificial alloy "Invar." The content of copper may add to its rust resistant qualities since small amounts added to commercial iron and steel are said to decrease corrosion. Under the binocular it was found to be scratched by orthoclase and apatite and not scratched by fluorite. On polished surfaces it stands in slight relief. The lamellae are flexible, but only slightly if at all elastic. Sound pieces could be bent through 180° and back three or four times before fracturing. Measured by a B & S gauge single blades as isolated varied from 0.005 to 0.010 inch in thickness. They are attracted and held by a common horseshoe magnet.

The resemblance of this alloy to invar and its apparent role along with schreibersite (Analysis 3) as a eutectic enveloping the kamacite areas may have a bearing on the physical chemistry of the meteoric irons. Invar[3] is said to contain about 36% nickel and 0.5 per cent. each of manganese and carbon, with melting point 1425°C. and density 8.0.

Analysis 3.—Uncrystallized fractured phosphide (schreibersite?) (Pl. VIII, Figs. 7, 8; Pl. X, Fig. 12).

S. G. = 7.2 at 20.10°C. in air.

	%	Mol. Ratio
Fe	61.28	1.097
Ni	25.62	0.437
Co	0.47	0.008
Cu	0.09	0.001
P	13.06	0.420
Mn, Si, Insol, Cr, V, Ti	Not detected	
	100.52	

These results lead to no very definite formula though the ratios are near $Fe_5(Ni, Co, Cu)_2P_2$, as may be seen below.

Mol. Ratios

Fe........ $\frac{1.097}{5} = 0.219$ .... $\frac{1.097}{0.217} = 5.05$

[1]U.S. Bureau of Standards, Circular 58.

$$\left.\begin{matrix}\text{Ni}\\\text{Co}\\\text{Cu}\end{matrix}\right\}\ldots\ldots\frac{0.446}{2}=0.223\ldots\ldots\ldots\ldots\frac{0.446}{0.217}=2.10$$

$$\text{P}\ldots\ldots\ldots\frac{0.420}{2}=0.210\ldots\ldots\ldots\ldots\frac{0.420}{0.217}=1.93$$

Average.......$\overline{0.217}$

However, it appears that this massive phosphide is not homogeneous. In the first metallographic observations on surfaces only plain polished or etched with bromine water, the phosphide had seemed to be quite pure and uniform, but later it was seen on heat-tinted surfaces that some, at least, of the phosphide areas consisted of a mixture of two constituents, one, the more easily oxidized, of a dark blue colour, the other of a yellow or reddish colour similar to that of 38% nickel alloy or taenite. It may be a reasonable speculation to suppose that the less easily oxidizable component actually is "taenite" which has been included and perhaps partially digested by the phosphide, since the taenite and phosphide occur in a similar relationship as a dual eutectic surrounding the Kamacite areas. If this supposition is correct it is likely that the phosphide is essentially $(FeNi)_3P$ or possibly $(FeNi)_2P$ with some included taenite. Stead, in his exhaustive researches on iron and phosphorous, showed that Fe_3P is the usual form in which phosphorus appears as a compound in iron, this and the compound Fe_2P, which is formed only under exceptional conditions, being the only definite compounds of iron and phosphorus identified by him.

Physical Properties

The phosphide is a brilliant tin-white in colour and very brittle, breaking with a somewhat conchoidal fracture. It has been much fractured in situ (Pl. VIII, Fig. 7; Pl. X, Fig. 12) and the particles as isolated seem to be in a state of strain as they often crumble at the merest touch. It is attracted and held by a common horseshoe magnet. Owing to the extreme brittleness and the minute areas available for testing, it is difficult to determine the hardness. However, fragments as isolated, when rubbed on glass under the binocular are seen to scratch though they crumble in the process. The glass itself was just scratched by orthoclase, while the orthoclase was not scratched when the phosphide was rubbed on it. The hardness is, therefore, about 6 in Mohs scale. Though the phosphide is thus apparently harder than the Kamacite ground mass it polishes lower, forming depressions, owing to its extreme brittleness and its fractured character.

Analysis 4.—Phosphide crystals (Rhabdite?). (Pl. XII, Figs. 15, 16; Pl. XIII, Fig. 17.)

These were obtained by sifting the residue from the solution of the 68 gram slice on a 200 mesh sieve, the crystals passing through. A little whitish silicious matter and some carbon or graphite were visible under the microscope.

	Mol. Ratios	%	
Fe	40.28	0.721	$\left.\right\}\frac{1.442}{3}=0.481$
Ni	41.36	0.705	
Co	0.23	0.004	
Cu	0.77	0.012	
P	15.35	0.494	$\frac{0.494}{1}=0.494$
SiO_2	0.69		
C	Present		
Cr, V, Mn, Ti	Not detected		Average. .0.487
	98.68		

Mol. Ratios

Fe, Ni, Co, Cu	$\frac{1.442}{0.487}=2.961$
P	$\frac{0.494}{0.487}=1.014$

Theoretical Composition for $(FeNi)_3P$

Fe	41.3
Ni	43.4
P	15.3

The results indicate the composition to be $(FeNiCoCu)_3P$ with Fe and (NiCoCu) present in equimolecular proportions.

That the above analysis should yield results leading to so nearly an exact formula is remarkable since it appears that two different types of crystals are present (page 24). It may be that the phosphide can crystallize in two different systems under different conditions, as does FeS_2 in pyrite and marcasite.

The silica found here no doubt represents practically the total amount in the 68 gram slice, occurring either as silicides or as decomposable silicates. The actual amount for the 68 g. slice is very small, however, as the percentage given (0.69) is reckoned on a tenth gram sample of the crystals. The deficiency in the analysis is due to the presence of undetermined carbon.

The crystals are very long, slender and brittle. In the micro-photographs they frequently show cross fractures (Pl. XII, Fig. 16) and often have good sharp terminal faces (Pl. XI, Fig. 14; Pl. XII, Figs. 15, 16; Pl. XIII, Fig. 17).

They are attracted by a horseshoe magnet, but less strongly than the massive phosphide.

Stead gives the melting point of Fe_3P as 1060°C. $(FeNi)_3P$ would probably have an even lower melting point and it is difficult to understand how crystals of this compound could be formed in the Kamacite ground mass of much higher melting point. (Fe 1530° Ni 1452° Co 1478°.)

Analysis 5.—Kamacite ground mass by fractional solution.

Since the ground mass of the iron dissolved readily in dilute hydrochloric acid leaving the other constituents but little attacked, it would appear that its composition might be determined approximately by analyzing the solution resulting from the action of the acid during a short period. A 44 gram piece was roughly polished on all sides and treated with 10% HCl until about 0.7 gram had dissolved. The solution was analyzed with the following results:

Fe	93.10
Ni	6.39
Co	0.48
Cu	0.03
	100.00

The amount of nickel and cobalt found is almost exactly one per cent. less than the total for the iron as a whole (Analysis 1.)

Physical Properties

The Kamacite is soft (a polished surface is just scratched by fluorite) and magnetic. In sections etched by bromine water it is seen to occur as polygonal grains with definite boundaries (Pl. XI, Fig. 12) resembling the ferrite of ordinary iron. Under certain etching conditions Naumaun lines appear.

Analysis 6.—Chromiferous troilite-graphite nodule.

On the edge of one slice about half a nodule remained attached to the iron, the other half having been fused away. The nodule had been between 1.5 and 2 cm. in diameter and globular in form. The central part consisted of troilite while the outer portion consisted of a mixture of troilite and graphite (Pl. XIV, Figs. 19, 20). The iron near the nodule was unusually rich in the massive phosphide of Analysis 3, a thin layer of the phosphide forming a lining between the iron and the zone of troilite-graphite intergrowth, as shown in diagram.

S. S.

Diagram of troilite—graphite nodule, about twice natural size.

1. Iron rich in phosphide.
2. Thin layer of phosphide.
3. Troilite-graphite intergrowth.
4. Chromiferous troilite.
5. Indicating approximate position of grain of apatite.

The central mass of troilite seemed to be pure except around the outer edge where it gradually merged into the troilite-graphite mixture. It exhibited one good cleavage or parting (Pl. XIV, Fig. 19) and was not attracted by a horseshoe magnet. Small pieces of the crushed material to the amount of 0.5 gram were selected under the binocular and on analysis yielded the following results:

S. G. =4.814 at 19.65° in air.

Fe	62.91
Cr	0.96
Ni	0.28
Cu	0.16
Co	Trace
S	35.45
	99.76

The detection of chromium is interesting as suggesting the presence of Daubréeilte, but metallographic examination gave no indications of any foreign material other than graphite. The low values obtained for sulphur and the high values for the metals are difficult to explain, as the sulphur was determined by the alkali carbonate-nitrate fusion method. It is possible, but unlikely, that the small amount of graphite present exercised a reducing action on the melt, resulting in the formation of alkali sulphides and consequent loss of sulphur as H_2S on acidifying with HC1. It is possible also that inclusions of iron or phosphide may have been present. After the analysis had been made it was found that some of the grains of troilite were attracted by a magnet, while others were not. The concentration of phosphide in the neighbourhood of the nodule would lead one to suspect that some may have been mixed with the troilite.

Analysis 7.—Troilite-graphite intergrowth (Pl. XIV, Fig. 20).

It was thought that Daubréelite might be present in the mixture or that at least a higher percentage of chromium might be found in the troilite associated with the graphite. The results of a partial analysis, as shown below, failed to confirm this suspicion.

Fe, Ni, Co	38.26	
Cr.	0.68	
S.	22.35	(Calculated equivalent to 38.94% Fe)
C.	38.71	(By difference after ignition in oxygen)
	100.00	

Analysis 8.—Apatite (?) embedded in Troilite-graphite nodule.

While selecting pieces of crushed troilite for analysis a small grain of colourless to white material was found embedded partly in the central mass of pure troilite and partly in the troilite graphite mixture (see diagram, page 85). The grain was cylindrical in form, about 3 mm. long and 1 mm. in diameter. Qualitative tests definitely indicated lime and phosphoric acid as the most prominent constituents with a little iron and alumina also. Beryllium was not detected. The refractive indices were determined by E. Poitevin and found to be 1.660 and 1.654. There is little doubt that this was apatite, though perhaps slightly abnormal in composition.

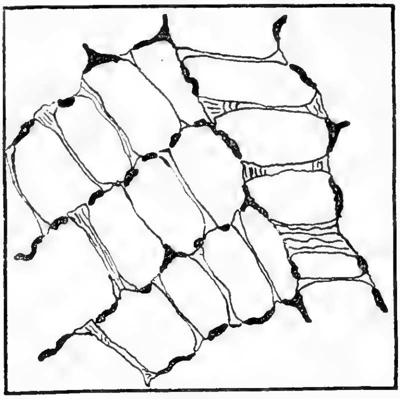
Metallography

Metallographic study of polished surfaces of the Annaheim iron reveals remarkable complexity of structure and composition. At least four distinct constituents are seen to be present in appreciable amounts, each having a definite arrangement with respect to the others. Of these the most prominent and the most remarkable are the structures shown in Pl. V, Figs. 1, 2; Pl. VI, Figs. 3, 4; Pl. VII, Figs. 5, 6, which consist of an iron-nickel alloy containing 38% of nickel, cobalt and copper (Analysis 2, page). This alloy occurs either as single lamellae (Pl. V, Fig. 1; Pl. VI, Fig. 3; Pl. XI, Figs. 13, 14) or as complex lamellar structures somewhat resembling in appearance the cementite-ferrite eutectic perlite. The complex structures consist of alternate lamellae of 38% nickel alloy and 6.87% nickel-cobalt ground mass, the whole surrounded by a layer of the high nickel alloy (Pl. VI, Fig. 4; Pl. VII, Figs. 5, 6). They have evidently been built up by the high nickel alloy in its eutectic capacity enveloping numerous relatively small areas of ground mass. When the 38% nickel alloy occurs as thin single lamellae it appears to be very pure and homogeneous, but the larger complex structures usually contain minute inclusions, which in some cases resemble the ground mass (best detected in heat-tinted specimens). Somtimes others that appear to be partially resorbed crystals of $(FeNiCoCu)_3P$ are present (Analysis 4, page 83). On etching with bromine water the larger structures sometimes develop dark areas (Pl. X, Fig. 11) which the writer had at first taken to indicate the presence of carbon or minute disseminated graphite particles. On reading Stead's work, however, it appears that the black deposit might be due to the presence of dissolved phosphide $(FeNi)_3P$ so that it is uncertain which it is.

Occupying situations, like the 38% Ni alloy, between grains of ground mass are irregular, elongated masses of uncrystallized phosphide (Analysis 3). This phosphide is usually, if not always, much fractured (Pl. VIII, Fig. 7; Pl. X, Fig. 12), showing its brittle character and indicating that forces of deformation either internal or external have been at work subsequent to cooling. Certain masses of this phosphide obtained by dissolving out the ground mass (page 13) showed some indications of what might be rough crystal faces, but these surfaces probably have resulted from contact with the grains of the ground mass.

This phosphide and the 38% Ni alloy together appear to play the part of a eutectic, to the 6.87% nickel ground mass, each contributing to the envelope which surrounds the areas of ground mass.

There is a general regularity in the distribution of the two, however, as indicated in the diagram of a polished surface below, the lamellae of 38% Ni alloy being arranged in groups in each of which a well-



AS

Diagram showing parallel arrangement of lines of phosphide, normal to parallel lamellae of 38% nickel alloy. Heavy black lines indicate phosphide; light lines indicate 38% nickel alloy.

marked parallelism is usually evident. The phosphide in a similar way appears as irregular, but roughly parallel wandering lines which take a direction nearly normal to that of the lamellae of 38% Ni alloy, and form a capping, as it were, to the spaces included between the 38% Ni alloy lamellae. The phosphide thus contributes about half of the cell wall of eutectic enclosing the areas of ground mass.

For the study of the structure, as described above, a rectangular section of the meteorite about 1 cm. in cross-section with all sides polished was found to be very useful as the structure could be followed completely in all three dimensions.

A slight qualification to the above statements is necessary, viz., that the lines of phosphide do not always appear to come into actual contact with the lamellae of the high nickel alloy, but sometimes stop short within a very small distance from them so that the cell walls of high nickel alloy and phosphide are not absolutely continuous, though very nearly so (Pl. X, Figs. 11, 12).

The ground mass which forms the major portion of the metal is seen on a polished surface in general as roughly rectangular areas enclosed by lines of phosphide and 38% nickel alloy. When etched by bromine water each area of ground mass is seen to consist of a number of polyhedral grains with well-defined boundaries, resembling the structure of α iron or ferrite (Pl. VIII, Fig. 8; Pl. XI, Fig. 13).

The areas enclosed by phosphide and high nickel alloy may represent crystals which were stable only under conditions of high temperature and pressure and which, on cooling, were transformed to ordinary ferrite.

The experiment involving fractional solution of the ground mass (Analysis 5, page) indicates that it consists of an alloy of 93.10% iron with 6.90% of nickel, cobalt and copper. In its present condition it may be considered as nickel-cobalt ferrite.

Embedded in the ground mass are very numerous long slender crystals of phosphide $(FeNiCoCu)_3P$ (Pl. XI, Figs. 13, 14; Pl. XII, Figs. 15, 16; Pl. XIII, Fig. 17). These crystals usually have a definite arrangement with long axes either parallel to or normal to the lamellae of 38% nickel alloy. When cut more or less normal to their long axes they appear sometimes square (Pl. XII, Fig. 15), sometimes rhombic in section (Pl. XII, Figs. 15, 16; Pl. XIII, Fig. 17).
d produce a rhombic
l may give a square
vations whether the
the residue from the
ers of these crystals,
results and only two
ssfully mounted and
aps, a millimetre in
differ somewhat in
colour and lustre. One, giving good reflections, was perfectly square in section with angles of 90° and hence was probably tetragonal. The other appeared to be rhombic though, owing to the vicinal character of the faces, there might be a difference of 10° in readings by different observers. This crystal was measured independently by E. Poitevin and myself, the measurements indicating the presence of the front and side pinacoids and a prism *m* near arsenopyrite.

ERRATA SECTION IV.

Page 89 line 16, for Pl. XII., Fig. 15, *read* Pl. XIII., Fig. 17.

Page 89, line 17, *delete* Pl. XIII., Fig. 17.

Page 91, Pl. VI., line 4, for Figs. 7 and 8, *read* Pl. IX., Figs. 9 and 10.

The artificial phosphides of iron have been studied in great detail by J. E. Stead.[1] According to him, in melts of iron containing over 10.2% P, which is the composition of the eutectic, crystals of Fe_3P are produced. In the microphotograph (Loc. cit. Plate IV, No. 5) the crystals of Fe_3P appear mostly rhombic in section, but in the upper right hand quadrant may be seen one which is square in outline. Stead considered that the crystals were rhombic, but it is

[1]Journal of the Iron and Steel Institute, Vol. LVIII, No. 11, 1900.

evident that what has been said regarding sections of the meteoric crystals applies with equal force to Stead's crystals of Fe_3P. The crystal forms in both cases must be considered still open to question.

Physical Chemistry

The Annaheim meteorite presents interesting problems in physical chemistry and the writer believes it would be well worthy of study by iron and steel metallurgists. Certain outstanding peculiarities of structure which seem to defy explanation may be briefly noted. First of all we have the easily fusible phosphide crystals (melting point about 1060° or less) embedded in the 6.87% nickel iron ground mass of much higher melting point (iron 1530°, nickel 1452°, cobalt 1478°), and containing little, if any, phosphorus. Then, though the massive phosphide quite properly appears to function as eutectic, the 38% nickel alloy, with presumably much higher melting point (Invar 1425°), appears to play an equal part in the eutectic partnership. If the structure is interpreted in other ways difficulties still remain. Stead performed an experiment which shows that rough but unquestionable crystals of Fe_3P may be produced in iron containing 1.95% P by repeated long annealing at 900°C. and slow cooling (Loc. cit. Plate XII, No. 20). In this experiment, however, the molecular rearrangement of the phosphide into the crystal form was not complete as 1.06% of P still remained in solid solution in the iron. It may be, then, that the meteoric phosphide crystals represent the final result of a long continued natural annealing process, perhaps under considerable pressure. Stead's crystals on heating to 1100°C. lost their form and coalesced into rounded and elongated masses somewhat resembling the uncrystallized phosphide of the Annaheim iron.

In endeavouring to account for the structures of the Annaheim iron we must consider two factors which may have had a tremendous effect, and which are seldom taken into account in researches on ordinary iron and steel, viz., time and pressure. Enormous pressure to which the iron may have been subjected when in its parent body, according to the operation of Le Chatelier's principle, might have had a considerable effect on the melting points of the various constituents, and a tendency might be expected for the elements to form such combinations as would have the least volume at any particular temperature. Slow cooling through an immense time period would provide opportunity for complete molecular rearrangement and segregation.

PLATE V

No. 1.—68 gram slice of meteorite after partial solution in 10% HCl. Lamellae of 38% nickel alloy in original position unattacked. About twice natural size.

No. 2.—Same as No. 1. Side view.

PLATE VI

No. 3.—Etched by bromine water ×125. Single lamella of 38% nickel alloy with long slender crystals of $(FeNi)_3P$ in parallel position on the left and numerous sections of the same visible in ground mass. Note minute inclusions of massive phosphide on edges of high nickel alloy which are shown enlarged in Figs. 7 and 8.

No. 4.—Unetched 125. Part of lamellar structure of 38% nickel alloy, the lamellae in the central part alternating with 6.87% nickel ground mass. Lamellae parallel to elongation of structure. Note inclusion of massive phosphide on edge of left hand projection of 38% nickel alloy structure. The slightly dark zone on same projection of this *unetched* section may be due to minute disseminated particles of graphitic carbon.

PLATE VII

No. 5.—Unetched ×125. Part of lamellar structure of 38% nickel alloy, lamellae transverse to elongation of structure. Black boundary lines due to relief except at lower right where the dense black represents a broken out line of massive phosphide. Sections of minute phosphide crystals visible in ground mass.

No. 6.—Slightly etched with bromine water ×50. Complete rather simple lamellar structure of 38% nickel alloy joined to lines of massive phosphide (upper right and bottom), which are in such low relief as to be out of focus and show merely as black areas.

PLATE VIII

No. 7.—Unetched ×500. Massive phosphide showing fracturing in situ. The slight projection at the upper side shows the tendency to penetrate between grains of ground mass. Dark parts represent holes where fragments have broken out.

No. 8.—Etched with bromine water ×125. Massive phosphide in characteristic eutectic position at the junction of ground mass areas.

PLATE IX

No. 9.—Etched with bromine water ×500. Single lamella of 38% nickel alloy (in relief) apparently moulded on an irregular mass of phosphide which has subsequently been separated a short distance by movement and squeezing in of plastic ground mass. This is a higher magnification of part of Fig. 1.

No. 10.—Etched with bromine water ×500. Fragment of massive phosphide included in lamellae of 38% nickel alloy and perhaps partially digested. What appear to be partially resorbed phosphide crystals are visible in high nickel alloy This is also a higher magnification of part of Fig. 1.

PLATE X

No. 11.—Etched with bromine water ×125. Lamellar 38% nickel alloy in characteristic eutectic position at junction of ground mass areas, joining with lines of massive phosphide (black, in very low relief at bottom and left) which penetrate between areas of ground mass. The 38% nickel alloy shows a black area as a result of etching, which may be either graphite or the black phosphide decomposition product described by Stead.

No. 12.—Etched with bromine water ×125. 38% nickel alloy at top and fractured phosphide at bottom apparently not quite in contact though a very thin line of phosphide (black) may continue and join the high nickel alloy.

PLATE XI

No. 13.—Etched with bromine water ×125. Lamella of 38% nickel alloy with black boundary due to high relief in ground mass showing typical ferrite grain boundaries. Flocks of phosphide crystals arranged parallel to lamella, some lying across the boundary of adjacent grains.

No. 14.—Etched with bromine water ×500. Lamella of 38% nickel alloy to left showing projection on left side penetrating between grains. On the right phosphide crystals in parallel and normal positions.

PLATE XII

No. 15.—Unetched ×500. Sections of phosphide crystals.

No. 16.—Etched with bromine water ×500. Sections of phosphide crystals showing sharp crystal faces and cross fracturing. The long crystal is doubly terminated with the base on one end, domes or pyramids on the other.

PLATE XIII

No. 17.—Etched with bromine water ×1200. Phosphide crystals apparently tetragonal in form with good terminal faces. The one in long section occurs at the distorted junction of grains of ground mass represented by the dark vertical line. The distorted grain boundary appears to be indicative of plastic movement in the ground mass.

No. 18.—Deeply etched with 2 per cent. picric acid in alcohol. Indications of crystalline structure developed in Kamacite ground mass by deep etching.

PLATE XIV

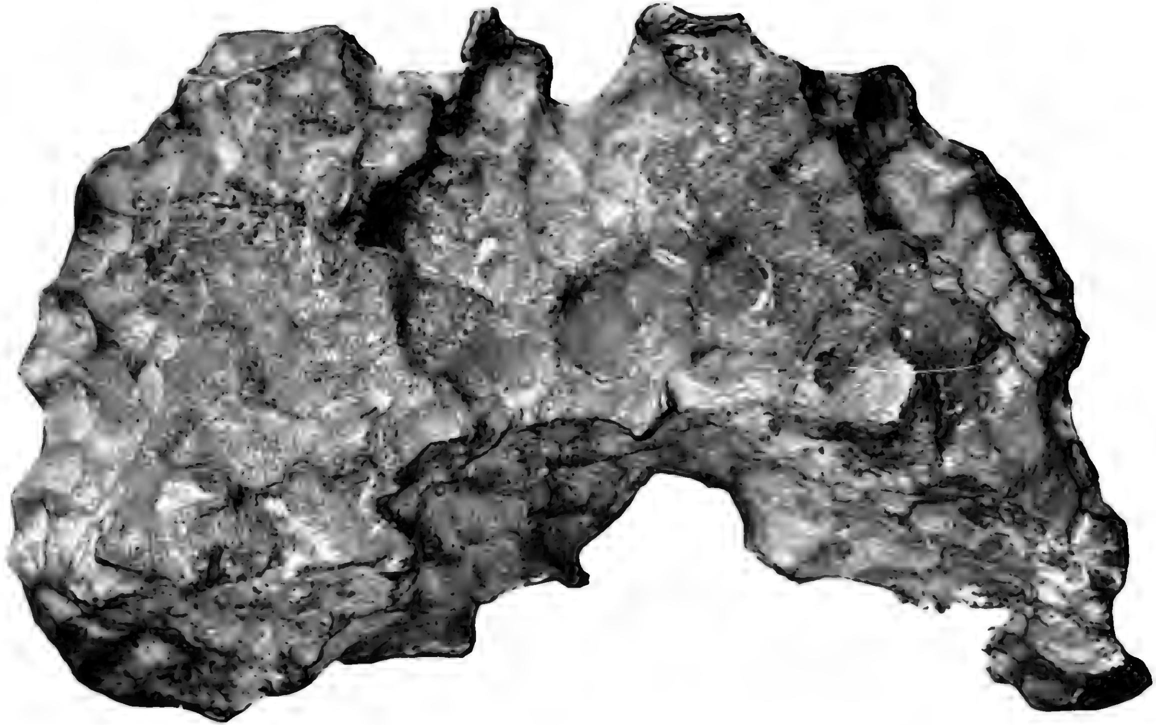
No. 19.—Unetched ×125. Troilite showing parallel lines of cleavage or parting at left. Graphite-troilite mixture at the right.

No. 20.—Unetched ×125. Troilite-graphite mixture in outer zone of nodule Troilite white, graphite black.

PLATE I

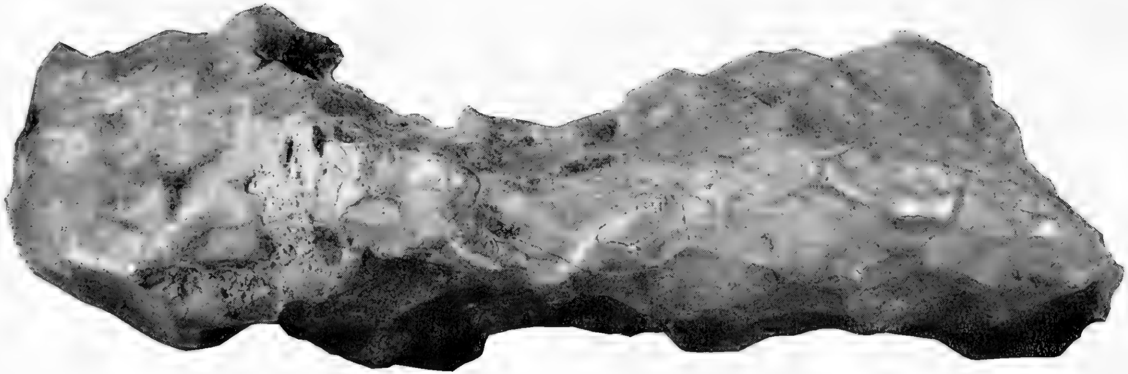
ANNAHEIM METEORITE—Showing surface next to the sod; ½ natural size. *Photo., Geological Survey 38086*

PLATE II



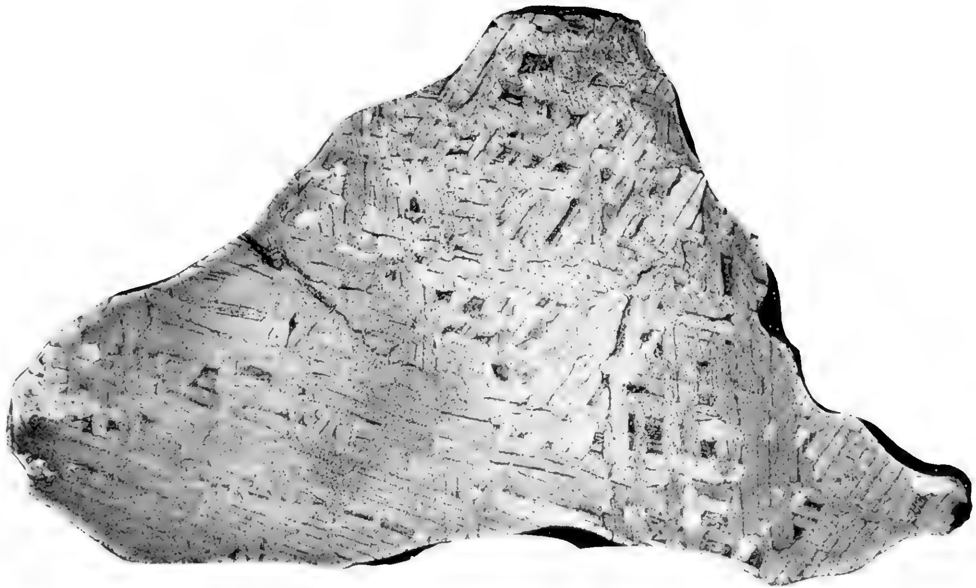
ANNAHEIM METEORITE—Showing incrustation of silenite; $\frac{1}{2}$ natural size. *Photo., Geological Survey 38088*

PLATE III



ANNAHEIM METEORITE—Showing irregular nodule of triolite; ½ natural size. *Photo., Geological Survey 38089*

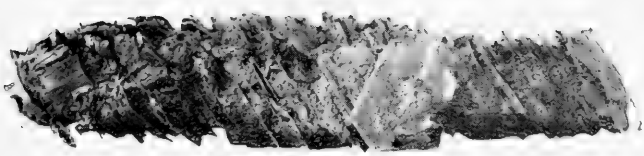
PLATE IV



Annaheim Meteorite—Section etched with 2 p.c. picric acid shows salient edges and folia of high nickel alloy; natural size. *Photo., Geological Survey 46798*

PLATE V

No. 1



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No. 3

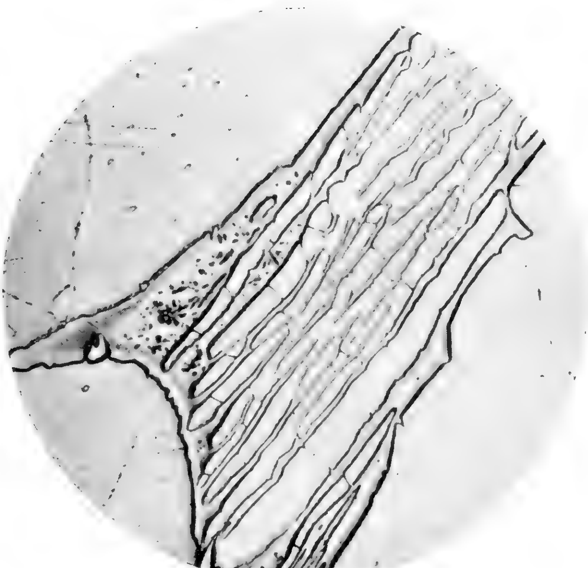

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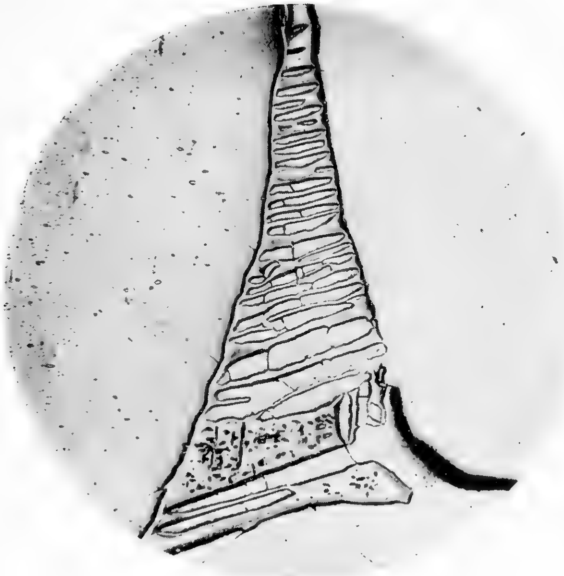
PLATE VII



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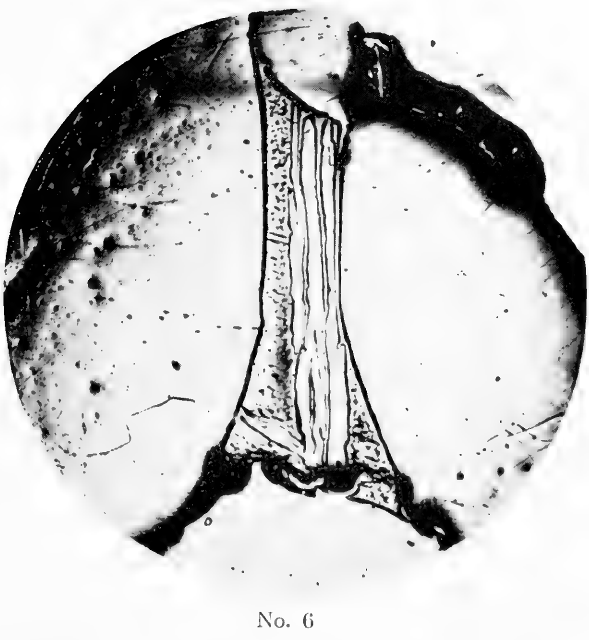

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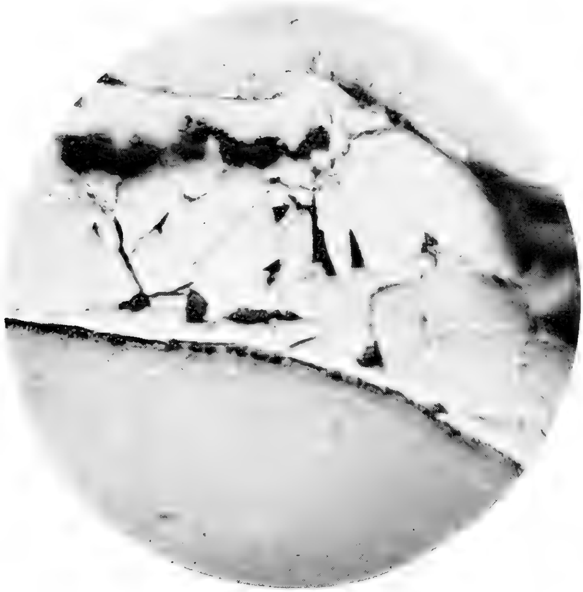
PLATE VIII



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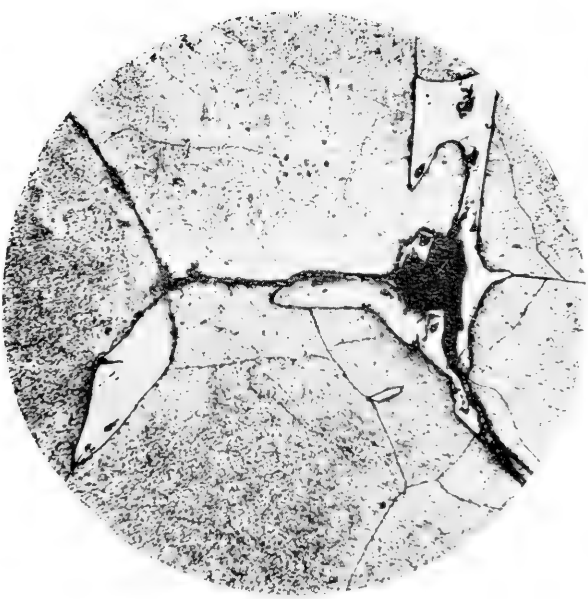

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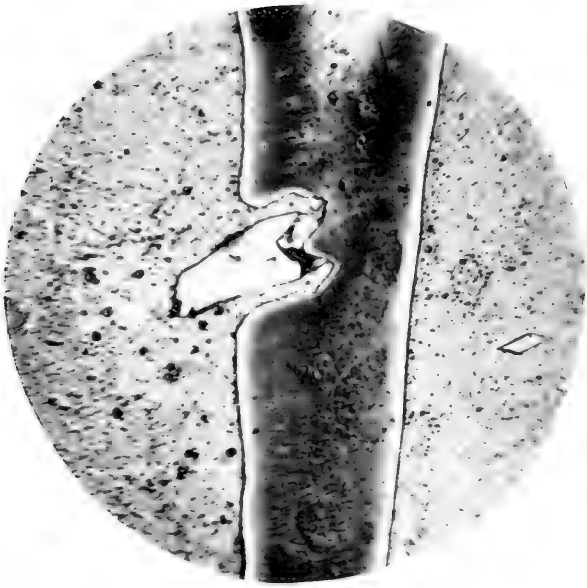
PLATE IX



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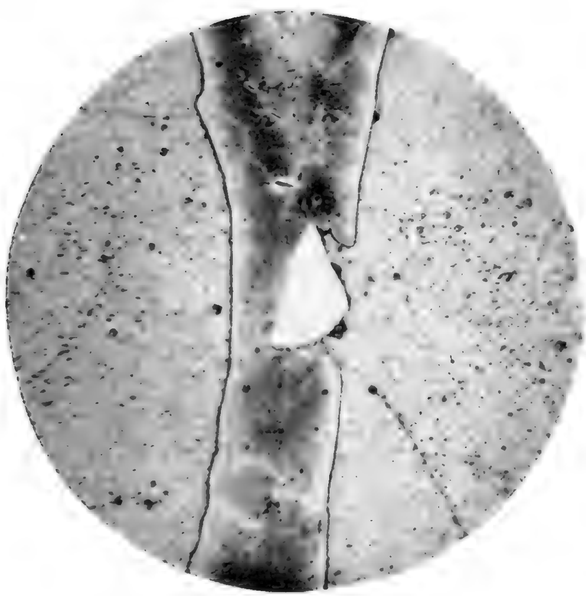

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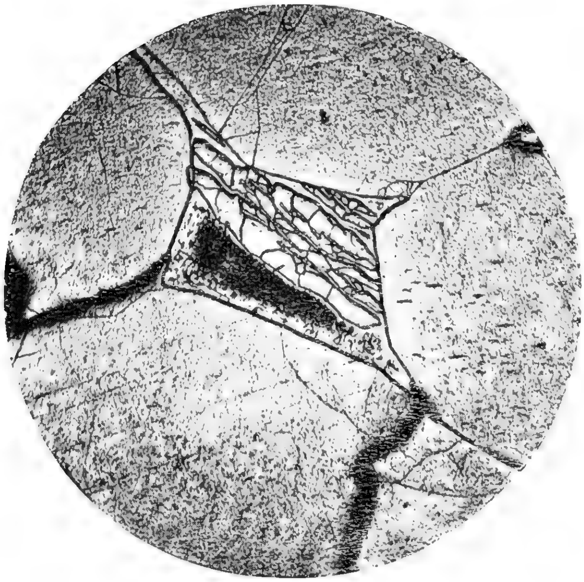
PLATE X



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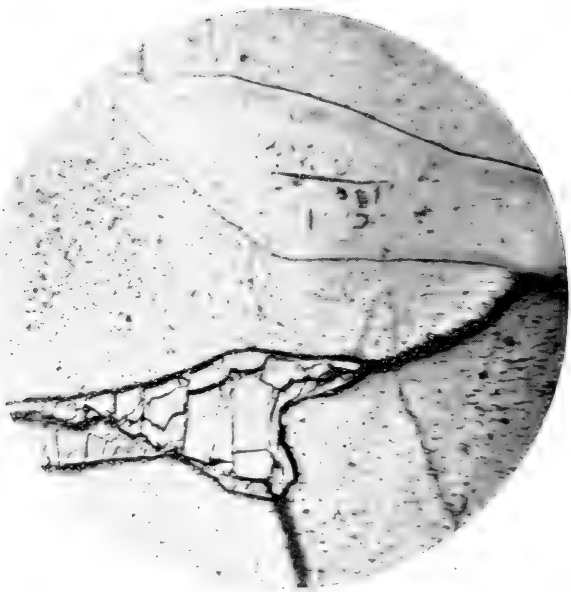

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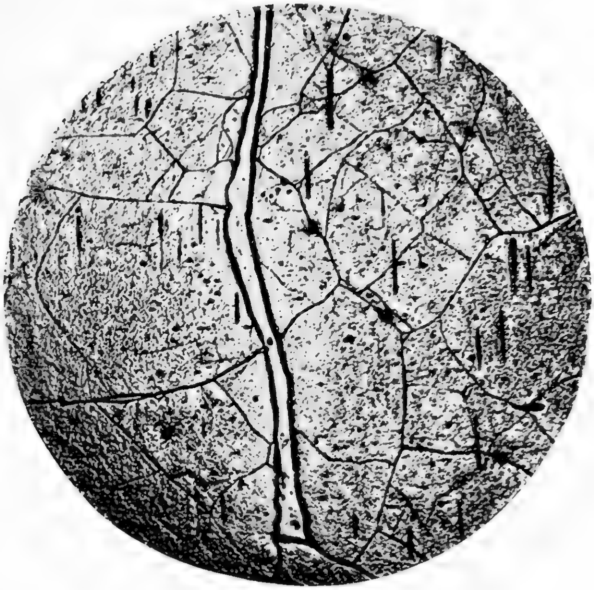
PLATE XI



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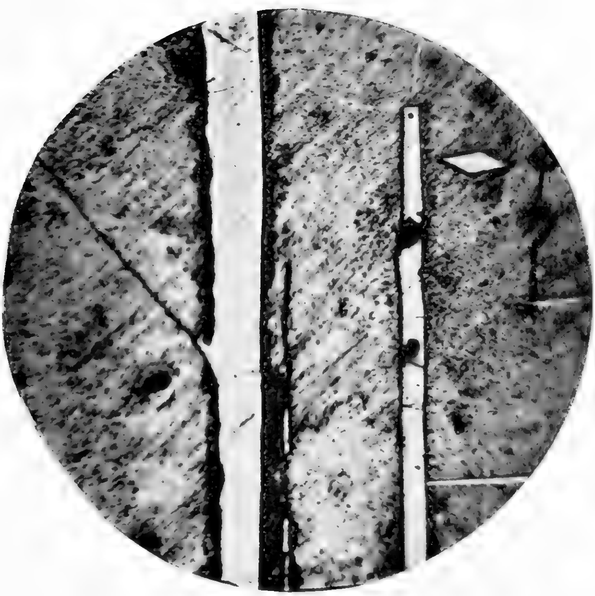

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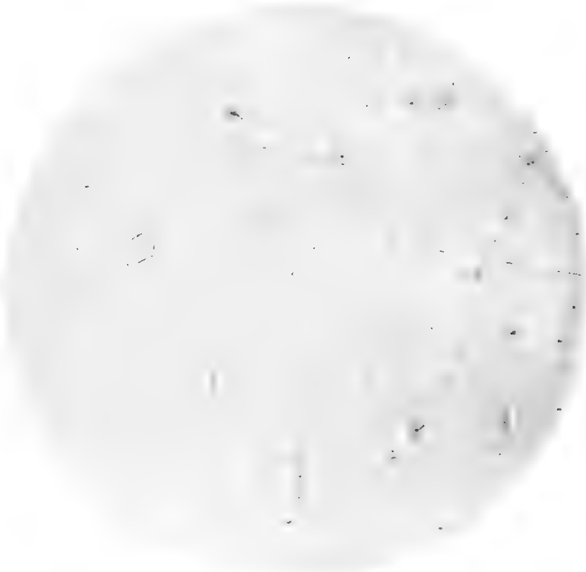
PLATE XII



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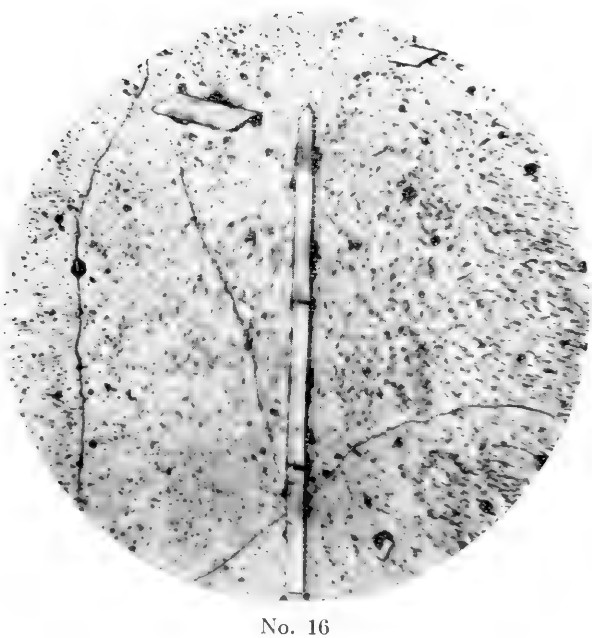

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PLATE XIII

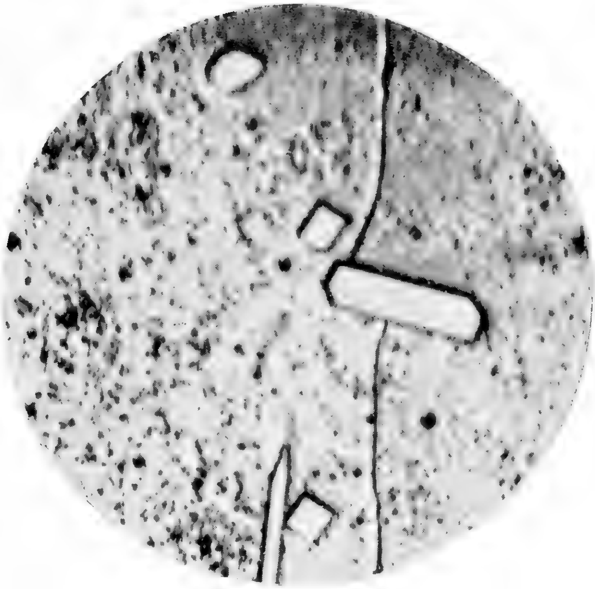

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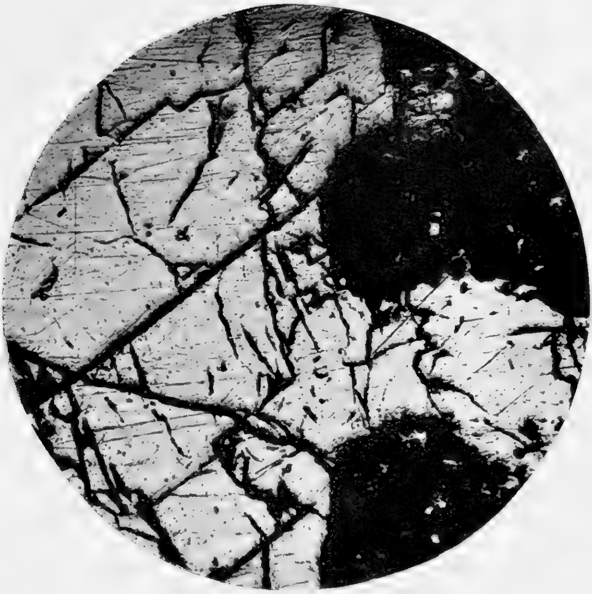
PLATE XIV



No. 19

No. 20

A Supplementary Study of Panoplosaurus Mirus[1]

By CHARLES M. STERNBERG

Presented by W. McINNES, LL.D., F.R.S.C.

(Read May Meeting, 1921)

The genus and species *Panoplosaurus mirus* was founded by the late Mr. L. M. Lambe, F.R.S.C., Vertebrate Palaeontologist of the Geological Survey of Canada.[2] But at the time of his death in 1919 he had completed only that portion of his descriptive work which pertained to the skull and armature.

The present article is intended to supplement that of Mr. Lambe by descriptions of other portions of the type specimen (No. 2759, Victoria Memorial Museum) than those dealt with in his paper.

The writer is indebted to Mr. C. W. Gilmore, of the United States National Museum, for reading and criticizing this paper.

Vertebrae.— The total number of cervical vertebrae cannot be stated as the posterior cervicals in the specimen are covered by the dermal armature which it is not considered advisable to disturb. The six anterior cervicals are well shown.

The atlas and axis (Plate I, Figure 1) are fused together and resemble the corresponding elements in the *Ceratopsia*.[3]

The atlas is long, broad and comparatively low. It is composed of the centrum and neurapophyses firmly co-ossified, as are the other cervicals, and the centrum is the longest of the neck series. It is similar to the atlas of *Monoclonius*, as shown by Brown[4], but differs from that element in *Scelidosaurus*[5] and *Stegosaurus*[6]. The anterior end is deeply cupped and conforms to the shape of the occipital condyle. The cup is sub-elliptical in outline with the greatest diameter transverse. The anterior superior border is notched. Both superior and

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[1] Published by permission of the Deputy Minister of Mines.

[2] Transactions, Royal Society of Canada, 1919, Sec. IV, pp. 39-50, 12 plates.

[3] Monograph of U.S. Geol. Surv., vol. XLIX, by Marsh, Hatcher and Lull, Figure 50. Bull. Amer. Mus. of Nat. Hist., vol. XXXVII, 1917, p. 288, by B. Brown.

[4] Bull. Amer. Mus. of Nat. Hist., vol. XXXVII, 1917, p. 288, by B. Brown.

[5] A Monograph of the Fossil Reptilia of the Liassic Formation, by Owen, Part II, Palaeontographical Soc., 1863.

[6] U.S. Nat. Mus. Bull. 89, 1914, p. 45, by C. W. Gilmore.

inferior surfaces are flat and broad and there is no inferior median keel. The neurapophyses are weak. They are co-ossified with the external, superior border of the centrum, slightly in advance of the midlength. Most of the right neurapophysis is missing, but the left one is perfect and admirably suited to study and descriptive purposes. Just above its co-ossification with the centrum it is slightly constricted and just above this flares out and sends off two thin processes. The anterior of these runs inward and backward and, with its fellow, formed the incomplete roof of the neural canal. The two were evidently bound together by ligaments and there was no neural spine. The posterior of these processes (the postzygapophysis) runs backward and slightly inward. It is coalesced with the prezygapophysis of the axis though the line of demarcation is faintly shown.

The parapophysis is on the lower posterior border of the external surface of the centrum and bears a single-headed rib.

The neural canal is very broad and low, the width being twice the height.

The axis is firmly co-ossified to the atlas but the line of union is plainly seen. The centrum is short and broad, with the lateral surfaces concave and the superior and inferior surfaces nearly flat. The posterior face of the centrum is cupped.

The neural arch is low and massive. Interior to the prezygapophyses the two sides of the neural arch unite, forming a low ridge which runs backward and upward, terminating above in a low, blunt spine. The postzygapophyses are well developed and overhang the posterior border of the axis. The diapophyses are well developed and stand out, at nearly right angles, from the base of the neural arch. They have well-defined, ovate, articular ends which face downward and slightly outward and backward. The parapophyses are not discernible.

Greatest length of atlas centrum......................	84 mm.
Greatest length of axis centrum.......................	54 "
Greatest height of atlas centrum......................	48 "
Greatest breadth of atlas, at anterior edge.............	72 "

The third, fourth, fifth and sixth cervicals are very similar in size and proportions to the axis. The height of the centra increases toward the back, but the neural canal retains its broad, low outline. Both extremities of the centra are cupped. The facet for the articulation of the head of the rib is well defined on the anterior border of the centrum. It rises on the centra as they proceed backward. The prezygapophyses look up and the postzygapophyses look down. Both are well developed and set well apart on the six cervicals seen. The diapophyses are well developed and resemble those of the axis. (Plate I, Fig. 1, d).

The dorsal vertebrae are very similar to those of *Ankylosaurus magniventrus*, as far as seen, though none have ribs ankylosed[7] to them.

The ilium was supported by no fewer than six vertebrae, of which the anterior five are firmly coalesced (Plate I, Figure 2). Four of these are regarded as true sacrals and of the remaining two one is probably a modified dorsal vertebra and the other a caudal vertebra.

The centrum of the dorso-sacral has weathered away but the neural arch and left rib are present. The neural arch and spine are firmly coalesced with the first sacral. To the diapophysis is co-ossified a long, slender rib, the distal end of which lies on the distal end of the first sacral rib and gives support to the ilium.

The centra of the four sacral vertebrae are firmly coalesced, all trace of separation being obliterated. The neural arches and spines are also firmly united, except the neural spine of number four, which is free above the zygapophyses.

The centra are very much modified, the anterior ones being merely a broad, thick plate, almost flat on the inferior surface and concave superiorly. Posteriorly they narrow transversely, thicken, and become more convex inferiorly, making the shape of the posterior centrum more nearly that of a normal centrum.

In *Panoplosaurus* true sacrals have been developed through the modification of caudal vertebrae to a greater extent than in *Stegosaurus*[8] and to a less extent than in *Polacanthus*[9]. Two true sacrals have been added in this way to the primitive number which, according to Hatcher[10], has been found to be two in the case of the Dinosaurs.

The sacral ribs are stout, horizontal processes, broadly expanded at the ends and are composed of the true sacral ribs and the diapophysial laminae thoroughly coalesced throughout. The three anterior ones spring each from two vertebrae and are broadly expanded and thoroughly co-ossified at their distal extremities. The sacral rib of the fourth vertebra differs from the others only in that it springs from one vertebra only and is not united with the others distally. The first two are much stouter throughout than the succeeding ones.

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[7] The Ankylosauridae a New Family of Armored Dinosaurs from the Upper Cretaceous, by Barnum Brown. Bull. Amer. Mus. Nat. Hist., vol. XXIV, 1908, p. 194, Fig. 12.

[8] Gilmore, U.S. National Museum, Bull. 89, 1914, pp. 54, 55, Figs. 22, 23.

[9] Hulke, Phil. Trans. Roy. Soc., vol. 178 B, 1887, pl. 9.

[10] Carnegie, Mus. Mem., vol. I, 1901, p. 32.

The neural spines, except the fourth, are coalesced and form a low, narrow plate.

The bases of the diapophysial laminae are so expanded fore and aft as to overlap the preceding and succeeding ones and coalesce, forming a broad base which roofs over the very broad neural canal.

The neural canal is very much enlarged as in *Stegosaurus*. It is bordered above by the neural arches and below by the centra. It has a breadth of 71 mm. and a height of 55 mm. in the first true sacral. As in *Stegosaurus* its anterior portion is largest. The posterior portion is circular with a diameter of about 14 mm.

Large foramina bounded above by the diapophysial laminae and below by the expanded bases of the sacral ribs furnished exits from the chamber for the nerves. They lead into the large sacral foramina which are not connected with one another by openings through the laminae.

The caudo-sacral is short, broad, and low, with well-developed lateral processes which are expanded distally for articulation with the ilium. It is not coalesced to the true sacrals. The neural spine is partly broken away but seems to have been low. The zygapophyses are small.

The caudal vertebrae are short and broad, indicating a short stout tail. There is one nearly perfect centrum which very closely resembles the one figured by Brown[11] as the ninth caudal of *Ankylosaurus magniventris* (Brown). The anterior face is flat and the posterior face slightly cupped. The bases of the neural arch, lateral processes, and chevron are thoroughly coalesced to the centrum. All of the chevrons, however, were not coalesced to the centra, as shown by one well preserved, free chevron which, judging from its size, is anterior to the one above mentioned.

Ribs.—The first two cervical ribs on the right side are in the rock and articulated to the atlas and axis. The second cervical rib of the left side (Plate I, Figure 3) is free while the first is coalesced with the centrum (Plate I, Figure 1).

The first cervical rib is short and stubby. The proximal end is broadly expanded and from this end it narrows and thickens toward the distal end which is obtuse. Like the first cervical rib of *Stegosaurus, Ankylosaurus* and the crocodile, it is articulated by a single head to the lower posterior border of the centrum.

The second cervical rib is a tri-radiate bone formed by a long, stout, tubercular process, a short capitular process, and a pointed posterior branch. The proximal end of the tubercular process is

[11] Bull. Amer. Mus. Nat. Hist., vol. XXIV, Feb., 1908, p. 195, Fig. 13.

roughly oval in cross-section and has a well-defined articular face, which conforms to the articular face of the diapophysis of the axis. Contrary to the arrangement of the second rib of *Stegosaurus* the main articulation is with the diapophysis and the articulation with the parapophysis was by ligament or cartilage. The distal end of the rib is convex on the outer side and flat on the inner.

Length of first cervical rib	70 mm.
Proximal breadth of first cervical rib	35 "
Length of second cervical rib	83 "

All the larger ribs preserved were found disarticulated and scattered, so it is not possible to definitely place them, though it is thought that all pertain to the anterior dorsal region. None of those present show any indication of ankylosing with the vertebrae as in the posterior dorsals of *Ankylosaurus*. The ribs are long and moderately stout, with well-developed capitulum and tuberculum placed well apart.

The tuberculum is sessile, with the articular face looking inward at about the same angle as the curvature of the upper part of the rib. The capitular process does not form a sharp angle but is the continuation of the gently rounded curve of the upper part of the rib. This would throw the rib, when articulated, well up, making a flat back and broad body cavity as in *Ankylosaurus*. The distal end, where preserved, shows a thickened, rounded end, rather than a spatulate extremity.

Coraco-scapula.—The coracoid and scapula (Plate II, Figure 1) are firmly co-ossified, the suture being indicated only by a slight thickening of the bone.

The scapula is moderately short and small except where it unites with the coracoid and contributes in part to the formation of the glenoid cavity, where it is greatly expanded and thickened. It is thickest and broadest at the superior border of the glenoid cavity.

The blade curves strongly downward proximo-distally and the inner face is strongly concave. Both the downward curvature and the inner concavity are continued throughout the length of the coracoid. This curvature would throw the coracoid in the articulated skeleton well in front of the chest as in *Stegosaurus*, *Triceratops* and *Hadrosaurus*. The thickness of the blade is approximately the same throughout the upper half of its length, but from midlength to its union with the coracoid it gradually thickens. The expansion at the proximal end is only slightly greater than at midlength. The upper end is gently rounded as in *Ankylosaurus* and has a very slightly thickened and rugose border. Both the external and internal faces of the shaft are flat near the proximal end, but the median external portion is gently rounded dorso-ventrally, while internally it is concave in the same direction.

About three-fifths of the distance from the proximal end the superior border of the shaft diverges, forming a prominent ridge on the external surface for about 130 mm. and terminates in a well-developed acromion process (Plate II, Fig. 1a.p.) which points obliquely outward. The presence of an acromion process is a marked point of difference from *Ankylosaurus*[12] and *Stegosaurus*[13]. This ridge is, doubtless, homologous with the spine of the mammalian scapula though it does not divide the upper half of the scapula nor does it reach the distal end of that bone.

Directly below the acromion process there is a large rugose area which probably served for the attachment of the deltoid muscles (Plate II, Figure 1).

At the point where the superior border begins to diverge the edge is thickened and slightly flattened toward the inner side. From this point the internal superior border starts at a lower level than does the outer border and ascends very rapidly to its highest point, which is near its union with the coracoid. At the distal end the scapula is very broad and massive. Its thickness in the glenoid cavity is 85 mm.

The glenoid cavity is large and is an almost perfect semicircle in outline measuring 110 mm. from lip to lip of the external border. The scapula does not contribute as much to its formation as does the coracoid.

Length of scapula..................................	410 mm.
Greatest breadth of scapula (just above glenoid cavity)	195 "

The coracoid is large and massive. In outline it more nearly approaches the coracoid of *Triceratops* than that of *Stegosaurus* though the anterior portion is longer than in *Triceratops* and not so high. The superior border is relatively thin and the inner face is concave. The external surface is moderately flat except the proximal inferior portion, which is greatly thickened to contribute to the formation of the glenoid cavity. The inferior border is thick and the anterior end is thickened and roughened for the attachment of ligaments.

The coracoid foramen (Plate II, Figure 1) is large and elliptical and runs from the external surface diagonally backward emerging on

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[12] Bull. Amer. Museum of Nat. Hist., vol. XXXVII, 1917, p. 196.

[13] U.S. Nat. Mus. Bull. 89, 1914, p. 67.

the inner side slightly in advance of the coraco-scapular union. It is situated considerably below the centre and is completely within the coracoid.

Length of coracoid at midheight	255 mm.
Height at coraco-scapular union	150 "

Humerus.—The humerus (Plate II, Figure 2), as in *Stegosaurus*, is short and massive with the extremities greatly expanded and without medullary cavity. The shaft is greatly constricted below the mid-line, the greatest constriction being at about three-fifths the distance down. The radial crest (Plate II, Figure 2) is well-developed though not so long, relatively, as in *Stegosaurus*.[14]

The radial crest is more clearly defined than in the last-named genus, there being a decided depression between its superior border and the head.

The round, well-defined head is somewhat internal to the centre of the proximal end and is produced backward so as to overhang the posterior border of the shaft. It is large and round to conform to the glenoid cavity. When the bone is erect the articular face of the head looks obliquely downward and the faces of distal condyles obliquely upward. The position of the head and condyles, together with the strong radial crest, implies that in the articulated skeleton the limb would be strongly flexed as in *Stegosaurus* and the *Ceratopsia*. Just below the head, on the anterior internal border of the bone, is a rugose area for the attachment of muscles.

The distal condyles are well differentiated, the external one being the more pronounced.

Greatest length of humerus	430 mm.
Greatest breadth (including radial crest)	240 "
Least diameter of shaft	71 "
Greatest breadth at distal end	186 "

Forefoot.—The left forefoot (Plate VIII, Vol. XIII, R.S.C., 1919) is represented by Metacarpals I, II and III, and their complete digits. They are articulated and in their relative positions though it is not possible to say that these bones represent the complete foot. The drawing shows the foot as it was found in the rock. Metacarpals I and III—the distal and proximal ends are so rotated relatively to one another as to throw the toes well apart, though the proximal ends of the metacarpals are closely applied to each other. Pressure has been exerted on the end of digit III so as to push the ungual over the second phalanx and squeeze that bone back hiding it from the front view.

[14] U.S. Nat. Mus. Bull. No. 89, 1914, by C. W. Gilmore, Pl. 20, Fig. 2.

However, there is no doubt as to the phalangial formula, which is, digit I = 2, II = 3, III = 3. So far as the writer is aware this is the first articulated forefoot of an armored dinosaur to be described.

The metacarpals resemble one another in general shape and proportions. They are not nearly so robust as those of *Stegosaurus* figured by Gilmore, nor are their extremities so much expanded. The transverse expansion at the distal end is less than half the length. They are only slightly constricted medially.

Metacarpal I is shorter and less expanded distally than either of the others. The proximal end, which is flat and slightly rugose, is subtriangular in outline, with the gently rounded apex of the triangle pointing inward (toward the opposite foot). The broad base of the triangle is applied to the broad inner face of the proximal end of metacarpal II. The distal end is convex antero-posteriorly and flat transversely.

The proximal end of metacarpal II is rugose, slightly convex and subquadrate in outline. The anterior face is longer than the other three, which are about equal in length. The sides of the proximal end are broad, forming a surface for contact with the metacarpal on either side. The distal end is convex antero-posteriorly and flat transversely.

Metacarpal III does not differ greatly from metacarpal II, except that the external surface of the proximal end is shorter than the other three sides, and on the inner side of the proximal end is a large rugose area, evidently for the attachment of ligaments which bound the foot together.

The lengths of the three digits are approximately equal. The proximal phalanx of digit I is moderately long and narrow as compared with the other proximal phalanges. The proximal end is flat and the distal end is slightly convex antero-posteriorly and flat transversely.

The proximal phalanx of digit II is short and broad, the length being but half the breadth. The proximal end is concave and the distal end convex antero-posteriorly. The superior and inferior surfaces are slightly concave and pitted with small foramina.

The proximal phalanx of digit III is much the same as that of digit II both in size and shape. The second phalanges of digits II and III differ only in being shorter.

The ungualar phalanx of digit I is moderately long and slender and tapers from its proximal end, which is broadest, to a rounded apex. The unguals are all flattened hoof-like bones which in life were doubtless incased in a horny nail.

The unguals of digits II and III differ from that of digit I only in being broader, especially at the distal extremity.

Above digit III on the sand rock is what seems to be the impression of a thick skin without scales. This is segmented to conform to the number of phalanges and seems to indicate that the toes, though separate from one another, were encased in a thick padding.

Length of metacarpal II through its middle..........	105 mm.
Proximal breadth of metacarpal II..................	50 "
Distal breadth of metacarpal II.....................	52 "
Length of digit II..................................	110 "

The only parts of the hind foot preserved are one metatarsal, probably the second of the right foot, one proximal phalanx, and two unguals. The metatarsal is almost identical in shape, with metacarpal II described above, but is considerably larger, measuring 130 mm. in length. The phalanges resemble those of the front foot but are larger.

Tibia and Fibula.—The right tibia and fibula were found together and are complete except for part of the distal end of the tibia (Plate II, Figure 3). The information lost with the missing portion is partly supplied by the left tibia. The tibia is short and stout, constricted medially, and greatly expanded at the extremities. The proximal end shows that there were two condyles for articulation with the femur, though no detailed description can be given because of their crushed condition. There is no cnemial crest discernible. The least diameter of the shaft is just below the midlength.

Only the external one-third of the distal end is present. This portion is quite thin antero-posteriorly. The inner portion, as shown by the fragmentary left tibia, is broader and cupped for the articulation of the astragalus.

The tibia is shorter than the humerus. It is evident that the hind limb of *Panoplosaurus* was relatively much shorter than that of *Stegosaurus* or *Scelidosaurus* in which genera the tibia is longer than the humerus. Judging from this and *Ankylosaurid* remains seen in the field it appears probable that the hind limbs of the *Ankylosauridae* were little longer than the fore limbs.

The fibula is a long straight bone with slender shaft and expanded extremities. The expanded ends are so rotated relatively to one another that their longest diameters are nearly at right angles to each other. The fibula articulates with the tibia much as in *Stegosaurus* but is relatively shorter. On the posterior face of the fibula near its midlength there is an ovate, rugose area 50 mm. in length.

Greatest length of tibia	385	mm.
Greatest breadth of tibia at proximal end	163	"
Breadth of shaft at narrowest point	77	"
Length of fibula	310	"
Greatest breadth of proximal end	58	"
Greatest breadth of distal end	72	"

PLATE I

Panoplosaurus mirus

Fig. 1.—Atlas, axis and third cervical vertebrae. Left lateral view. $\frac{1}{3}$ nat. size.

Fig. 2.—Sacrum with dorso-sacral and caudo-sacral vertebrae. Inferior view. $\frac{1}{5}$ nat. size.

Fig. 3.—Second cervical rib, left side. External and internal view, $\frac{2}{3}$ natural size.

a.—Atlas; ax.—axis; c^3—third cervical; cr^1—cervical rib No. 1; c-s—caudo-sacral vertebra; d.—diapophysis; d-s—dorso sacral; n—neural spine; n.c.—neural canal; n.s.—inferior neck scutes; p.—parapophysis; S—sacral vertebrae; t—tuberculum.

PLATE II

Panoplosaurus mirus

Fig. 1.—Left coroco-scapula. External view. $\frac{1}{5}$ nat. size.

Fig. 2.—Left humerus anterior view. $\frac{1}{4}$ nat. size.

Fig. 3.—Right tibia and fibula anterior view. $\frac{1}{4}$ nat. size.

a.p.—Acromian process; c.f.—coracoid foramen; d.—rugose area for attachment of deltoid muscles; f.—fibula; r.c.—radial crest; t.—tibia.

PLATE I

Fig. 1

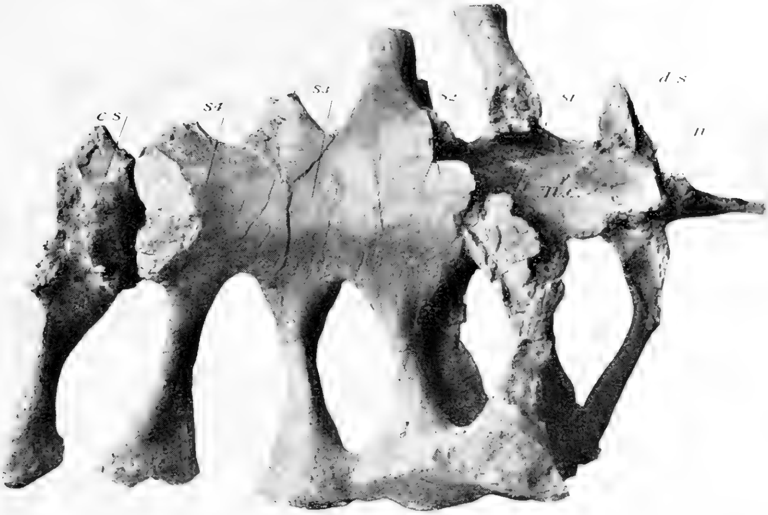

Fig 2

Fig. 3

PLATE II

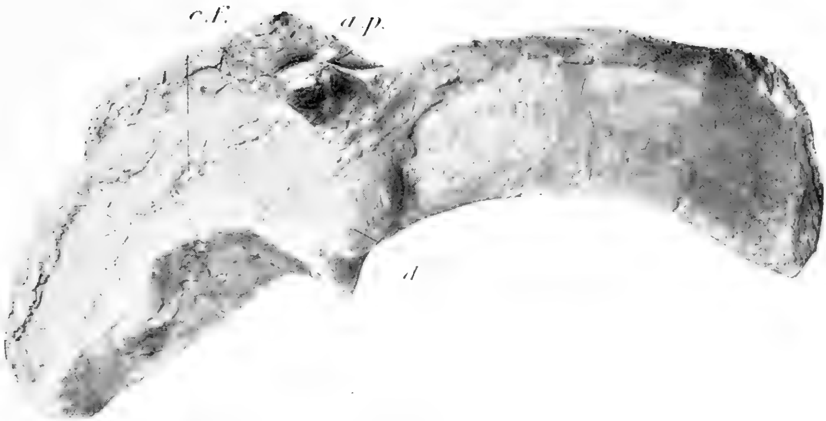

Fig. 1

Fig. 2

Fig. 3

On the Mispec Group (Devonian)

By G. F. MATTHEW, LL.D., F.R.S.C.

(Read May Meeting, 1921)

In arranging and naming the stratified rocks in and near St. John, N.B., while their age was still to a great extent uncertain, and fossils had been found in but a few places, they were divided into several groups partly on the basis of the degree of metamorphism which they exhibited and partly from other causes, as, for instance, their apparent succession; they were found to lie in the following order:

The Portland Group
The Coldbrook Group
The St. John Group
The Little River Group
The Mispec Group

The highest of these (viz., the "Mispec") is that which forms the subject of the following communication, but they all were characterized by slaty cleavage in the finer beds. The writer emphasizes the slaty condition of the "Mispec" because in this it differs from the overlying formations and resembles those below. But as the "Mispec" was sometimes found to rest on other rocks than those of the Little River Group, it has evidently been formed independently of that group and not with it as at first was supposed.

Most palaeobotanists will agree with Sir William Dawson and Mr. David White that the plant beds of Perry in Maine are Upper Devonian; therefore a knowledge of the facts bearing on the age of the "Mispec" Group, which is the stratified formation that immediately underlies the Perry beds in their eastern extensions would be of some importance in connection with the latter. So I propose to tell what has been learned of the geological age of the "Mispec" beds, since Sir William made his study of the strata around St. John.

The relations of other formations which have a bearing on the age of this group may also be mentioned here. About thirty miles to the northward of St. John are limestones whose Lower Carboniferous brachiopods have long been known; these give us one horizon of a fixed geological value. Just beyond and to the northward of these (and above them) is the southern edge of the great Carboniferous area along the south side of the Gulf of St. Lawrence, extending across the northern shore of Nova Scotia, which includes the extensive coal beds of that province.

But while the Lower Carboniferous marine forms fix with sufficient exactitude the age of the Coal Measures above them, no marine species are contained in the beds of the Little River Group near St. John, so their geological age could not be determined by that means; and the plant remains were not of such a nature as to settle the question. It is true that Sir William Dawson pronounced them "Middle Devonian" but his verdict as to their age has been questioned and by some observers denied.

Another series of deposits which, though not occurring within the corporate limits of St. John is well represented in other parts of New Brunswick and Nova Scotia, is that which was first described in this region as the New Red Sandstone. It presents the following succession:

1. Bright red sandstone, uniform in colour and texture.
2. Grey (Pebble) conglomerate (holding the position of the effusive or volcanic rocks in other places).
3. Red conglomerate and red shale in several repetitions.

This series is the Newark formation as seen in New Jersey and elsewhere.

To revert to the other end of the geological scale as seen at St. John one may say that the Portland Group was found to consist of granitic and other intrusive and metamorphosed rocks as granite, gniess, altered schists and limestones, in which last, however, only the simplest forms of life were found. It forms a geological complex upon which the later formations rested. Upon this complex with a manifest discordance the Cambrian beds of the St. John Group rested. Remains of trilobites were found in it (first by the late Rev. C. R. Matthew), whose exact age as Primordeal was determined by the late Professor C. F. Hartt, at that time a student at Harvard College with the late Louis Agassiz.

Above the Cambrian, etc., at St. John there is an overlying series of beds in which certain land plants were found, which were studied by Sir J. William Dawson and by him determined to be of Middle Devonian age. These Mrs. M. C. Stopes, Dr. H. M. Ami, Mr. David White and others now say are Carboniferous. These plants have been found in measures which Sir William personally studied and the antiquity of these measures has been upheld by A. Gesner, L. W. Bailey, G. F. Matthew, R. W. Ells, and others who have studied the strata.

It is because the age of the Mispec Group may shed some light upon this difficult question that the writer has made the Mispec Group the subject of this article. The group was first observed at the top of a synclinal fold of the strata between Little river and Mispec river, on the eastern side of St. John Harbour. No determinable fossils were found in it, but the lower angle of dip and the distinct change in the composition and source of the sediments showed the diversity of this group from the rocks below. (Here also there was a reduction in the dip of the measures from 20° or 15° to 5° which further on was reduced to horizontality, and eventually to the reappearance of the grey shales with plant remains that had been observed on the north side of the synclinal fold.)

Such was the evidence upon which the Mispec Group was separated from the beds below, and on tracing the latter further westward this divergence was seen to be more marked.

The Mispec was found to recur to the south side of Lepreau Basin near its head, extending thence westward where with the plant-bearing beds below it extends beneath the Upper Devonian, which dips westward and passes beneath the waters of the Bay of Fundy. It is accompanied by a remnant of the pre-Cambrian complex ridge which there shows itself for the last time. There is a group of small islands in the Bay of Fundy called "The Wolves," where these portions of the complex reappear for the last time.

From this point westward the Mispec Group appears on the north side of the Laurentian complex, showing in Bliss Island and the headlands that project from the shore around the eastern entrance to L'Etang harbour. At Beaver harbour the Mispec Group was also observed on the road which leads westward from the head of the harbour and on Black's harbour it also appears. On this northern side of the Laurentian complex the various exposures of the Mispec rocks have beds at low angles dipping to the north and in this corresponding to the Mascareen series (Silurian) further west. The numerous beds of conglomerates which are found in the Mispec Group of this district show the dip very clearly.

Fortunately the Geological Survey of the United States, when undertaking the investigation of the Eastport quadrangle, placed the fossils collected by Messrs. C. L. Berger and E. S. Bastin in the hands of the late Prof. Henry S. Williams for determination. These fossils have an important bearing on the age and condition of the Upper Silurian measures in that part of Canada. The Canadian surveyors had found a Silurian series in Passamaquoddy bay which they called the Mascareen, dipping to the north at a low angle, and another group of slates to the south of the Mascareen, dipping at a high angle and much broken up by intrusives; in these last slates they found no fossils, and for this reason did not include them in the Silurian. In the extension of this group into the State of Maine, though the rocks were largely of volcanic origin, some slates with fossils were found. Hence it is now thought that these also should be included in the Silurian strata, and that there is here a break in the Silurian such as occurs at St. John in the upper part of the St. John Group where Ordovician fossils are found.

The condition of the several groups of the Palaeozoic, etc., as they show in and near St. John from this point of view may be presented in the following table:

ROCKS AT ST. JOHN

PORTLAND GROUP

Very great unconformity

Cambrian.....	Coldbrook Group and Etcheminian Series St. John Group (3 divisions)	Base of Palaeozoic, including Cambrian and Base of Ordovician	Limit of slaty cleavage
	UNCONFORMITY Ordovician (Middle and Upper wanting)		
Silurian.......	Bloomsbury volcanics 1 m. thick at Quaco	Quoddy slate Dennys slate } at Eastport	
	UNCONFORMITY		
	Little River Group Dadoxylon Sandstone Cordaite slate and Sandstone	Mascareen Beaver Harbour Eastport, etc., slates	
	UNCONFORMITY		
Lower Devonian.....	Mispec Group Conglom. and dark red slates	Unknown at Eastport	

GREAT UNCONFORMITY

Here eruption of Nerepis, St. George, etc., granite

Upper Devonian.....	Conglomerate Red sandstone Dark red shale Gray sandstone and shale	Perry plants Upper Dev. *fide* J. W. Dawson & David White, Pocono beds.

UNCONFORMITY

Mesozoic....	Bright red sandstone conglomerate Red shale and sandstone.	Newark formation of N. Jersey, Conn., etc.

RESUMÉ

To sum up what the author has written in reference to the "Mispec Group" it may be said that there is reason to think it has an important bearing on the age of the plant beds above and below it, geologically.

That it has yielded no determinable land plants may be due to its continental origin and the coarseness of much of the material of which it is composed. It appears to be Lower Devonian, being younger than the land plants from the "Fern Ledges" near St. John and older than those from Perry in Maine, both of which have been described by Sir. J. William Dawson.

The group has been observed at various points from St. John to L'Etang Harbour and on both sides of the Laurentian Complex, which forms a ridge on the hills back of St. John, being in all cases a distinct formation unconformable to the rocks above and below.

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SECTION V

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Significant Alterations in the Positions of Certain Neuroblast-Nuclei of the Embryonic Retina: a Study in Bio-Dynamics

By JOHN CAMERON, M.D., D.Sc., F.R.S.E., F.R.S.C.

(Read May Meeting, 1921)

The histological material upon which the present research is founded was prepared by the writer in 1902 while engaged in a study of the histogenesis of the amphibian retina in the laboratory of the late Professor Wm. His at Leipzig. During 1905 three papers(1) were published, dealing with the results of these researches, in which attention was directed mainly to a study of the myelospongium network and the visual elements. During this investigation some peculiar phenomena manifested by the neuroblast-nuclei, particularly of the ganglionic layer, were detected. However, the interpretation of these threatened to carry the research so far beyond the limitations originally imposed upon it that it was decided to postpone the publication of the nuclear changes to a later date. Meanwhile, in 1916 Dr. R. J. Gladstone and the writer (2) pointed out that in the cell-elements of the blastoderm, the nascent endoplasm immediately investing the nuclei was a derivative of nuclear metabolism. Further, in 1917 the writer (3) published in these Transactions a paper in which it was affirmed that in developing striated muscle the achromatic material which undergoes fibrillation was, partly at least, a product of the metabolic activity of the nuclei of the myosyncytium. With the publication of these later papers the writer feels that the time is now ripe to make known the results of his observations on the neuroblast-nuclei of the embryonic retina, more particularly as these results are confirmatory of his earlier conclusions.

The material for this research was chosen from Amphibia, as the comparatively large size of the nuclei in this vertebrate class makes them ideal for cytological study. Avian and mammalian types were likewise studied, but owing to exigencies of space the results of the examination of the amphibian forms will be alone referred to.

An extensive amount of experimental research upon the adult retina has been carried out, especially within recent years, and a useful bibliography will be found in a recent paper by Detwiler (4) on this subject. The most elaborate study of the embryonic retina within recent years is that by Bernard.(5) I wish that space would permit me to do full justice to the work done by this observer. We both chanced to be working on the embryology of the retina simultaneously and unknown to each other. It was, however, remarkable to note how closely our results were in agreement. Bernard's work will, therefore, be found referred to in the course of this paper.

If the inner wall of the optic cup be examined by the higher powers of the microscope it will be found to exhibit the same structural arrangement as the wall of the neural tube. This is just as one would expect seeing that the cup is a derivative of the latter. Thus, one will observe next to the external limiting membrane[1] the usual layer of germinal nuclei in active karyokinesis. Now, if the direction of separation of the daughter-nuclei be studied it will be ascertained that this is usually the same, namely, parallel to the external limiting membrane (see Fig. 1). Further, it should be noted that the long axes of the daughter-nuclei lie always at right angles to the external and internal limiting membranes, as shown in Fig. 1 and Fig. 2.

If the relationship of the germinal nuclei to the newly formed neuroblast-nuclei be further studied several significant facts with reference to the later phases of nuclear division manifest themselves. For example, it will be found that when the metaphase of mitosis, as exhibited in Fig. 1, gives place to the kataphase, the relative positions assumed by the daughter chromosomes in the resting nucleus can be readily elucidated. Thus the elongated nucleus in Fig. 1 has probably been recently produced by mitosis, and it will be noted how remarkably bipolar it is. Therefore the centrosome in relation to it must have at first assumed a position somewhere near the centre of one lateral margin. The neighbouring kataphase in Fig. 1 gives the clue to this, for the daughter-nuclei to be derived from that mitotic figure will take up a position alongside the elongated resting nucleus. Further, it will be observed that the long axes of the daughter-nuclei lie in a plane at right angles to the direction of separation of the karyokinetic figure. We thus become confronted with a subtle problem in bio-dynamics in relation to the phenomena of karyokinesis.

During the early developmental stages the neuroblast-nuclei in the outer layers of the retinal wall retain their radial arrangement,

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[1]Owing to the invagination of the optic vesicle its lining membrane becomes the external limiting membrane of the retina.

but those nearest to the internal limiting membrane become tilted over more and more until their long axes ultimately lie parallel to the internal limiting membrane. That is to say each of these nuclei becomes rotated through an angle of approximately 90°. The writer can find no record of this alteration in orientation having been previously observed. However, it can be detected without difficulty in the frog-embryo nineteen days after fertilization. It is interesting to watch these nuclei becoming gradually tilted over more and more by some unseen force during the next few days. which certainly exhibit great strides in the development of the amphibian retina. This rapid advance is, of course, due to the fact that in the very early stages of its career the frog-embryo becomes a free swimmer and therefore the development of its optical apparatus has the full light of day as nature's stimulus to accelerate histogenesis. It is therefore remarkable to note how much progress has been accomplished even by the twenty-first day (see Fig. 4), though this particular embryo proved to be a rather precocious example. The latter Fig. afforded the clue as to the direction in which the neuroblast-nuclei were tilted, for it was found that the overturned nuclear poles became directed consistently towards the point of exit of the optic nerve fibres at the optic disc (Fig. 4).

If these ganglionic nuclei be closely studied by means of the highest powers of the microscope from the nineteenth day onwards it will be ascertained that a portion at any rate of each primitive axis-cylinder is discharged from its associated nucleus in the form of a material which in the nascent condition is very resistant to staining agents. In many cases this discharge is so active that the nuclear pole is drawn out as a fine point into the commencement of the axis-cylinder (see the nuclei marked with an X in Fig. 3). One of the most remarkable facts regarding these amphibian neuroblast-nuclei is that in the early stages they are practically devoid of a cytoplasmic investment (Fig. 3). Even at the thirty-fifth day (see Fig. 5) the perinuclear material is still of the scantiest. Indeed, it is only towards the end of development that the cytoplasm of the ganglionic cells can be detected as a distinctive investment.

This comparative nakedness of the retinal neuroblast-nuclei during the early developmental stages compels one to look for another source of the optic nerve axons since these make their appearance as early as the nineteenth day. For example, the narrow band of faintly stained material extending to the left from the nuclei marked X in Fig. 3 represents the earliest rudiment of the retinal layer of optic nerve fibres, which, as the Fig. shows, lie in their usual position next to the internal limiting membrane. Note once more the intimate relation of one of these primitive axons to the pole of the nucleus at X. It is unfortunate that the axons do not stain well during the early stages, which indeed represent the critical phases of their histogenesis. On this account they are never displayed to advantage in microphotographs, and therefore the problem of their origin would be best discussed in the laboratory over the microscopic field. Fortunately, however, both Bernard and the author have been able to demonstrate that the neuroblast-nuclei which later form the external nuclear layer of the retina extrude their achromatic contents into the bases of the developing rods and cones, while the writer (6) has also described this discharge of material by neuroblast-nuclei in other parts of the developing nervous system. There is thus a growing belief in the fact that the nuclei, of embryonic tissues at least, are great centres of metabolic activity, the latter being manifested by the discharge at regular intervals of a peculiar material which in the nascent condition is practically achromatic in its reaction towards staining agents. The production of this material has been previously demonstrated by the writer (3) in embryonic striated muscle, and by Dr. R. J. Gladstone and the writer (2) in the developing blastoderm.

From this viewpoint the causation of the overturning of the neuroblast-nuclei that give rise to the ganglionic layer of the retina is probably as follows:

1. The primitive axis cylinders of the amphibian optic nerve are partly formed by the discharge of achromatic material from the *outer* poles of these nuclei.

2. So far as the author can at present determine the axon is always connected with the outer nuclear pole.

3. These axons become in due course directed towards the point of exit of the optic nerve from the retina.

4. They exert traction at a very early stage upon the nuclear poles from which they have emerged, the result being that these poles, which might appropriately be termed the "axon (6)," are rotated through an angle of approximately 90° and become in every case directed towards the optic disc.

The question that next arises is, Why do the neuroblast-nuclei that give rise to the external and internal nuclear layers of the retina exhibit no evidences of this overturning movement. The answer to this is not difficult. These nuclei discharge achromatic material from both their outer and inner poles so that a condition of equilibrium results. The description of the phenomena associated with these outer

Fig. 1 shows that the plane of separation of the dividing germinal nuclei is at right angles to the limiting membrane of the retina. 15th day frog embryo ×1500. Early stages of mitosis exhibited on the right.

Fig. 2 is a section of the retinal wall in a 19th day frog-embryo. The neuroblast-nuclei will be observed to lie for the most part with their long axes at right angles to the limiting membranes.

p.c.l.—pigment cell layer.
i.l.m.—internal limiting membrane.

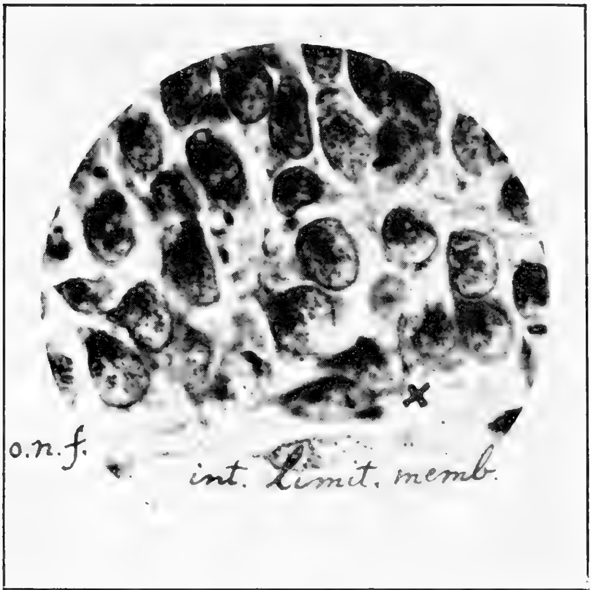

FIG. 3 is a magnified view of the portion of Fig. 2 next to the internal limiting membrane. Two of the neuroblast-nuclei at x have become tilted over to the extent of 90°, while others in the vicinity show earlier stages of this displacement. *o.n.f.*—rudiments of optic nerve fibres.

FIG. 4. The axon-poles of the tilted over nuclei in the ganglionic layer are directed uniformly towards the point of exit of the optic nerve fibres. Frog-embryo at the 21st day.

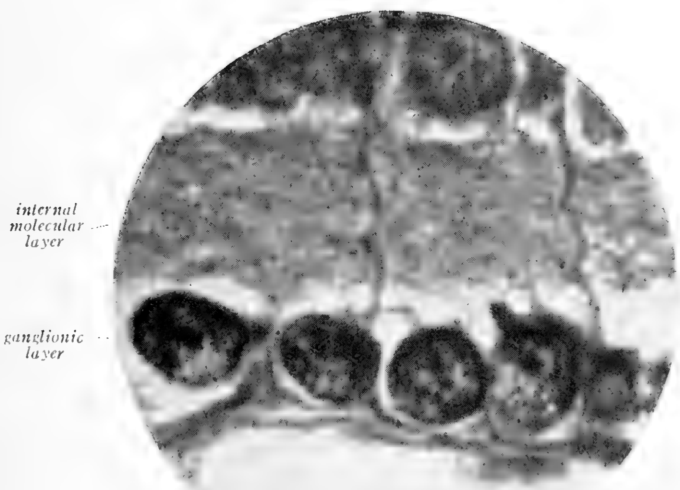

FIG. 5. The nuclei of the ganglionic layer of a 35th day frog embryo. Note that their cytoplasmic investments are still extremely scanty. Two fibres of Müller are seen traversing the internal molecular layer. ×2250.

nuclear layers, however, would prolong this paper unduly. It will, therefore, have to be reserved for a future communication.

It is likewise interesting to note the alteration in the shape of all the retinal neuroblast-nuclei during development. In the early stages, as the Figs. show, these are consistently bipolar in character, but by the thirty-fifth day they have assumed the rounded or spherical shape of the adult (Fig. 5). The most satisfactory explanation of this phenomenon appears to be that during the earlier developmental stages, when the metabolic activity of these nuclei is probably at its maximum, their achromatic contents are discharged from their poles. This, by a simple problem in dynamics, would compel them to assume a bipolar outline. During the later and probably less active stages of histogenesis the nuclear metabolized material is discharged at all points in the periphery of the nucleus, which would render it physically incapable of assuming a shape other than that of a sphere. At least this is the explanation which, in the light of our present knowledge, suggests itself with most emphasis to the writer.

The biological problems involved in this research are so diverse and far reaching in character that it is impossible to do full justice to them in this short paper, which will, therefore, require to be regarded as a preliminary communication.

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Coloured Thinking and Allied Conditions

By D. FRASER HARRIS, M.D., D.Sc., F.R.S.E., F.R.S.C.

(Read May Meeting, 1921)

When one sensation, say a sound, involuntarily calls up another sensation, say that of light or colour, we say the percipient has linked sensations, or one of the synaesthesiae. This particular form, coloured hearing (*audition colorée, farbiges Hören*), is by far the commonest.

Musicians seem peculiarly liable to experience colours when tones or voices are heard; thus we read of organ notes as being violet, violin green, a human voice as brown or yellow, and so on. Some coloured hearers always see dark colours along with notes of low pitch, and pale or bright colours with those of high pitch. Such linked sensations are called sound- or phono-photisms.

Much rarer are the cases where the other sensations produce light or colour, but such are known; thus we can have—an odour calling up a colour (an olfacto-photism); a taste calling up a colour (a gusto-photism); heat or cold sensations calling up a colour (thermo-photism); and lastly pain calling up a colour (an algeso-photism). Specific examples of these are—smell of musk recalling scarlet and gold; an acid taste being described as yellow; a cold sensation as white, rheumatic pains grey, and toothache black.

Examples of Synaesthesiae are—"Who is that speaking in a dark-brown voice?"; Schubert's music calls up a sunny green; full-toned speech is like a coloured picture, whispering is like a black and white engraving, a musty smell is like grey and red, an acid taste calls up yellow, something hot in the mouth gives a sense of whiteness. "The gorse in bloom is like a thousand silver trumpets"; bright lights arouse the sounds of high pitched notes; dim, or dull colours those of low pitched. Schubert's music calls up the smell of young pine trees. "The sharp perfume had in it something provocative and exciting that was like a sound." "Scarlet was like the sound of a trumpet." "To remember some words is to touch a flower."

Beethoven said he would make the blind girl "hear moonlight."

"I can smell the sunset."

Distinct both from synaesthesia and from coloured thinking is the thought-form or psychogram.

It is the faculty of seeing certain concepts—the numerals, days of the week, months of the year, the alphabet and so forth—as occupying collectively some definite positions in space.

Thus certain seers always think of the numerals one to a hundred as arranged in the form of a ladder stretching up into the sky to the right or the left, as the case may be.

Other seers think of the days of the week as on a curve with Wednesday at the apex, still others visualize the months as arranged on a rainbow or other huge form dying away into space.

Thought-forms may be yet more irregular as when the alphabet is exteriorized in the form of steps and stairs ascending or descending from the observer.

Coloured thinking proper is the association of a colour with an exteriorized concept. Certain persons find that they cannot attentively think of anything, cannot visualize, without arousing or suggesting colour. This may be called chromatic mentation, or psychochromaesthesia, and such persons coloured thinkers or psychochromaesthetes.

The concepts most commonly coloured are the hours of the day, the days of the week, the months of the year, the letters of the alphabet, proper names and so forth.

To those who never experience this sort of thing it is unintelligible. There is no kind of agreement between the colours associated with any one thought on the part of a number of coloured thinkers. Thus the vowel "u" is for eight different persons thought of as in eight different colours—grey-white, yellow, black, brown, blue, green, brown-yellow and dark grey respectively. To one person August is white, to another crimson, to a third heliotrope. There is no attempt at agreement.

The following are the characteristics of this curious capacity:

1. The very early age at which these associations were fixed. "Ever since I can remember," "Ever since childhood I have always had," "I do not remember the time when I had not," etc., are the phrases used by coloured thinkers asked when they first noticed the phenomenon.

Children of only nine and ten years give most satisfactory and definite accounts of their psychochromes. This feature was recognized by Francis Galton in his classic examination of the subject in 1883.[1]

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[1]Inquiries into human faculty and its development: MacMillan, London, 1883

2. The second characteristic of coloured thinking is the unchangeableness of the colour thought of. Middle-aged people tell us there has been no alteration in the colours or even in the tints and shades of them ever since they can remember having thought in colours at all. Galton's remarks were, "They are very little altered by the accident of education," "they are due to 'Nature not nurture.'"

Just as their origination is, apparently, not due to the influence of the environment, so the environment exercises no modifying influence on them during a long life.

3. The third characteristic of psychochromes is the extreme definiteness in the minds of their possessors. Contrary to what might reasonably be expected, the colours attached to concepts are not vague or incapable of accurate verbal description. A coloured thinker is most fastidious in the choice of terms to give adequate expression to his mental imagery. One of these is not content in speaking of September as grey, he must call it steel-grey, another speaks of dull white, silvery white, the colour of watered silk, and so on. One child speaks of March as "art blue;" another of 6 p.m. as "pink*ish*." The degree of chromatic precision which can be given by coloured thinkers to their visualizings is as extraordinary as any of the extraordinary things connected with this curious subject.

4. The fourth characteristic is the complete non-agreement between the various colours attached to the same concept in the minds of different coloured thinkers. Thus nine persons think of Tuesday thus—brown, purple, dark blue, brown, blue, white, black, pink and blue. Again, September is thought of as pale yellow, steel-grey and orange by three different coloured thinkers respectively. Once more, the vowel "i" is thought of as black, red-violet, yellow, white and red respectively by five persons gifted with chromatic mentation; the colours are essentially one's own; these psychochromes are not shared.

5. The fifth characteristic is the hereditary nature of the condition. Galton's own phrase was "very hereditary." The extremely early age at which coloured thinking reveals itself would of itself indicate that this propensity was either hereditary or congenital. Heredity from father to son is quite common. In a case well known to myself, the brother, nephew and first cousin of a coloured thinker are all coloured thinkers. In common language, it "runs in families," but there is no more unanimity in the family in this obscure subject than there is

apt to be in many families in regard to subjects of much commoner experience. Three persons of the same family think of March as brown, steel grey and orange respectively.

6. The sixth characteristic of coloured thinking is its unaccountableness. "I cannot account for it in any way" seems the all but universal remark made by these seers. No line of research seems to lead to any explanation of more than an occasional psychochrome. Many persons, regarding it as a childish survival, have not cared to confess to possessing it at all or have never tried to trace it to a probable source. Possibly, in some few cases, the impressions left by early picture books and paint boxes may have been responsible for some of the mental colours. In a very few instances, such an association as the following may account for the colour of a thought—The earliest February I can remember was snowy; through the whiteness of snow the thought of February came to be coloured white.

But it is clear that if environmental influences are operative in anything like a large number of cases, the colours for such concepts as the months of the year ought to be far more uniform than they are. No common origin of external source can make one person think of August as white, another brown, another yellow, a fourth crimson. If August is white to one person because it is the month of white harvest, then it ought to be white to all persons capable of receiving any impressions from the colours of harvest. But to the vast majority of persons it is perfectly absurd to think of August as having any colour at all; and to the few who think it coloured, it has by no means the same colour; all seems confusion.

A little light is thrown on coloured thinking by some consideration like the following; psychochromaesthetes are liable to associate with concepts of something pleasant the colours they like, and with things unpleasant the colours they dislike. Ellen Thorneycroft Fowler, in a private communication, was good enough to inform me that she has always associated with herself, her birthday, the month of her birthday and the first letter of her name, the colour blue, because blue is her favourite colour. But on the other hand, another person whose favourite colour is heliotrope never associates this colour with any concept whatever; all seems confusion.

The associating of a colour with a person is commoner than it might be thought; it is known as "coloured individuation."

There is here and there a little method in this chromatic madness; thus, the colours of the words denoting colours themselves are appropriately coloured for most coloured thinkers; that is, white is white black black, and so on.

Again, in most cases, the colour of the initial letter determines the colour of the whole word; if "d" is black then *decide* will be black; if the numeral I is white, then 10, 100, 1000, and so on, will all be white.

It might be thought that the coloured thought of a word would be the colour of the sum of the colours of the letters composing the word; but this is not so; for in one case "Tuesday" is white, and the component colours are blue-black, grey, brown, yellow, brown, white and yellow; colours which, when mixed, could not possibly "make" white.

The relative frequency of the colours met with on analyzing 100 psychochromes is: white 24%, brown 24%, black 17%, yellow 11%, green 7%, blue 5%, red 4%, pink 3%, cream 3%, orange 1%, and purple 1%.

Coloured thinking is by no means confined to women, as some persons have assumed; I have found it very nearly as frequent in men.

It should be remarked that the colours are never present to consciousness with the vividness of a hallucination, probably because they are related to concepts and not to sensations. They are not all the time present to the seer as he speaks or reads, but only when compelled for some reason or another to visualize (exteriorize) his concepts. He then finds he cannot visualize certain concepts as uncoloured.

Galton believed that coloured thinkers were as a rule above rather than below the intellectual average. He mentions a number of well-known men to which I have been able to add some equally distinguished names. It is certain that coloured thinkers are not abnormal mentally; it would be more correct to describe them as in this respect supra-normal after the same manner that geniuses are supra-normal. Just as genius, if not inherited, cannot be acquired, so neither can coloured thinking.

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Further Experiments on Conditions Influencing the Life History of the Frog

By A. T. CAMERON, F.R.S.C.

(Read May Meeting, 1921)

The following are the chief results outlined in a series of papers by Cameron and Brownlee (Trans., 1913 to 1915):

1. Frogs (*R. pipiens*) freeze at a temperature of $-0.44° \pm 0.02°$C., in a manner very similar to that of solutions isotonic with their body fluids. The minimum body temperature which they will survive for one hour is $-1.25° \pm 0.15$ C.° The cause of death is probably a specific temperature effect on the co-ordinating centres of the central nervous system. Those controlling lung respiration may be specially concerned. Exsected hearts will survive a temperature of $-2.5°$ for one hour, but are killed by a temperature of $-3.0°$ for one hour. Similarly, Brunow has shown that muscle tissue survives $-2.9°$ but is killed by $-3.0°$ (*R. fusca*) and Garten and Sulze have shown that nerve survives even lower temperatures (*R. esculenta*).

It is not improbable that longer exposures to low temperatures would prove fatal to *R. pipiens* at temperatures higher than $-1.25°$. There is no climatic adaptation, nor any periodic adaptation due to hibernation. Frogs surviving degrees of cold such as those occurring during a Manitoban winter (usual minimum about $-40°$C.) do so below the surface, near the margins of, or submerged in the water of springs, and are themselves never subjected to temperatures below the freezing point of water.

There seems to be a slight variation in the death temperature from cold of different species of frogs (*R. pipiens, clamitans, sphenocephala*) amounting to some tenths of a degree Centigrade.

2. The highest temperature at which *R. pipiens* can maintain life continuously under such conditions that its own body temperature cannot be lowered by evaporation of water, is about 18°C., while continued subjection to a slightly higher temperature under these conditions will prove fatal in a few days. The time of exposure required to produce a fatal result decreases steadily with rise of temperature, a few minutes at 40° proving fatal. (All the temperatures refer to the actual body temperature of the frog.) The effect appears to be specifically one of temperature. Recovery, when un-

consciousness supervenes, occurs within two or three hours, or not at all. Somatic death occurs before the death of heart, brain, and nervous system, and muscle. The actual cause of death has not been ascertained. Similar results were obtained for *R. clamitans*. Babák and Amerling's results with *R. fusca* and *esculenta* indicate that considerable variations exist in different species in the resistance offered to high temperatures.

The same relationship between temperature and time of survival exists for exsected muscle. At the lower temperatures (below 35°) heat-rigor does not ensue.

3. Specimens of *R. pipiens* completely immersed in Winnipeg tap-water (a very hard water) during late winter and spring (1914-15) lived on the average 16 days, the extremes noted being 3 and 52 days. The frogs remained perfectly normal for some time, but at a variable period before death ensued—usually several days—they commenced to swell. This was due in all cases to the absorption of water, which in most cases was accompanied by retention of absorbed nitrogen (dissolved in the tap-water) resulting in a degree of buoyancy which tended to keep the frogs at the surface of the water. Such nitrogen can be retained in large amounts, the maximum observed being in a frog of initial weight 60.5 grams, which absorbed 16 grams of water, and retained 22.5 cc. of gaseous nitrogen.

If the frogs were removed from water at any stage before death occurred they recovered completely in a few days. If allowed to remain they ultimately died, death being presumably connected, physically or chemically, with the distension.

In the intervening years I have made a number of observations bearing on the above and similar facts dealt with in these papers. These will now be described briefly.

Experiments at Maximal Temperatures.

Lord Lister states that frogs are killed by being held in the hand for about a quarter of an hour. In an experiment with *R. pipiens* already described I found that breathing ceased after 10 minutes, there were convulsive movements after 15 minutes, and the animal was unconscious after 20 minutes, with rapid and strong heart-beat. It recovered in 10 minutes. With this can be contrasted the following observations:

R. temporaria (South of England). August 13th, 1915.

A full grown frog was held for 15 minutes in my hand. There were convulsive struggles after 7 minutes. The animal was unconscious at the end of 15 minutes, but with a strong heart-beat. It was left in contact with cold water and recovered in 12 minutes. Three other frogs, only a quarter grown, treated in the same way, were quite unconscious with no sign of heart-beat at the end of 15 minutes. They were left in contact with cold water. Two showed hearts feebly beating 30 minutes later, and recovered completely in less than one hour. The third had not recovered in three hours.

R. esculenta (near St. Ouen, Picardy). May 11th, 1916. Small frogs, 10 to 15 grams. Two frogs were held in my hand for 15 minutes, a thermometer in the hand registering 36.4°C. In each case the heart was beating feebly when the frog was removed, but the animal was unconscious, and did not recover. A third, held in the hand of an R.A.M.C. sergeant, at a temperature of 36.3°C., gave precisely similar results.

These experiments, though not very accurate, perhaps illustrate the variations in resistance to temperature of different species of frogs; but the difference in results is probably largely due to the difference in size of the animals, and therefore the difference in time of adaptation to the temperature of the hand.

It was also found that *R. esculenta* would survive a temperature of 30°C. for one hour (thermometer through gullet in stomach), but would not survive 34°, while tadpoles (presumably *esculenta*) would survive for one hour at 31-32°, but even 15 minutes at 34°C. was fatal.

Immersion Experiments.

The following experiments were carried out in Winnipeg in the winter of 1919-20, advantage being taken of the fact that the Winnipeg water supply had been changed in the interval to a very soft water (lake source), containing (September) only 120 parts of solid per million, as compared with 1,158 in the previous experiments. A rough determination showed that one litre of this water contained 3.2 c.c. of oxygen and 7.8 c.c. of nitrogen. During the winter the hardness slightly increased (separation of ice in the lake supply), calcium and magnesium salts showing a definite increase.

Experiment 1.—Commenced October 17th, 1919. Three male frogs (each 67 grams) and three females (each 90 grams) were submerged in running tap-water so that they were retained permanently below the water surface. On the 18th the water flow stopped for some time. One frog became slightly buoyant, but the buoyancy had disappeared on the 19th. On the 26th the water temperature rose to 16°, and two frogs were distinctly swollen. The temperature fell to 10°, and the frogs became normal. The frogs remained quiescent for long periods as if hibernating. On November 7th and 14th, through cessation of water-flow (pressure changes), one female frog breathed air for a short period. The results of the experiment are summarized in the following table:

No.	Sex	Date of death	Period of immersion	Period of buoyancy before death	Approx. initial weight	Water absorbed	Nitrogen retained	Remarks
			days	days	gm.	c.c.	c.c.	
1.	F.	Nov. 22	36	0	67	?	0	Red leg.
2.	F.	Nov. 26	40	?	90	20	?	Slight red leg.
3.	M.	Dec. 4	48	0	—	—	0	Red leg.
4.	M.	Dec. 6	50	?	67	23.5	0.5	Red leg.
5.	F.	Dec. 8	52	?	90	30.5	0	Slightly buoyant on Dec. 7.
6.	M.	May 5	200	0	—	—	0	No red leg.

It will be observed that the average life of these frogs is much longer than in previous observations, while retention of nitrogen only occurred to a slight extent in two cases. The death of the sixth frog was probably due to temperature fluctuations, increased temperature permitting oedema. The thumb swellings were very marked in this frog previous to death.

Experiment 2.—Commenced December 15th. Four male frogs, weighing 58 to 60 grams, and four females, 51, 67, 68, 69 grams respectively, were immersed in flowing water in a closed glass vessel, in such fashion that changes of water pressure could not possibly cause entrance of air into the closed space. The initial temperature was 11°. It fell slowly to 4.4° on April 9th, and then slowly rose. The frogs remained quiescent at the bottom of the vessel until buoyancy forced them towards the surface. The results are summarized in the table.

No.	Sex	Date of death	Period of immersion	Period of buoyancy before death	Approx. initial weight	Water absorbed	Nitrogen retained	Remarks
			days	days	gm.	c.c.	c.c.	
1.	M.	Dec. 31	16	0	59	0	0	Red leg.
2.	F.	Jan. 5	21	2	68	13.5	8.5	Cancer; red leg.
3.	F.	" "	21	1	68	12.5	14.5	Red leg.
4.	M.	Jan. 7	23	3	59	9	20	Red leg.
5.	F.	Jan. 8	24	2	68	15.5	27.5	Red leg.
6.	M.	....	34	13	59	10.5	22.5	Removed before death. Practically normal in 5 days. Remained so till May 5th.
7.	M.	May 14	151	?	59	?	?	Red leg. Slightly swollen and buoyant.
8.	F.	....	151	—	51	3.5	0	Removed from water.

The frog removed on May 14th, after complete immersion in water for 151 days, did not breathe for several seconds, then commenced to breathe feebly, trying to touch the nares with its forelegs, as if they were choked up. The breathing continued to be feeble and irregular until, after three minutes, the frog commenced to be active, when breathing became normal. On the 15th its weight has fallen to 51 grams, and on the 29th to 46 grams. It was then very active and quite normal.

(The actual absorption of water was therefore about 8 or 9 c.c.)

These experiments show that frogs can survive throughout the winter submerged under water. Also, that with increasing hardness of water there is a greater tendency to the retention of nitrogen gas. In the first experiment, early in the winter, this only occurred slightly in two out of six cases. In the second experiment most of the frogs died earlier, and contained large amounts of gas. It is uncertain to what extent red leg was a contributing factor in producing death of these frogs.

It was noted in these and some preliminary experiments that when the water in which the frogs were immersed rose above a certain temperature absorption of water commenced. Further examination indicated that a temperature above 16°C. produced a delayed absorption, the oedematous condition disappearing when the temperature fell distinctly below this figure. Even partial immersion of frogs in one inch of water produced such effects, indicating that the production of oedema is not due entirely to oxygen-deficiency. (The rise of temperature was sometimes due to fall in water pressure in the mains, so that the flow ceased, and the water in the immersion vessel became stagnant and rose to room temperature.)

That want of oxygen can also produce an oedema is shown by the following experiment.

A frog weighing 59.5 grams was immersed in a 350 c.c. conical flask, which was completely filled with water, closed and kept at a temperature of 12°-14°. In three hours about 3 c.c. of gas was given off, which was found to be nitrogen. After 14 hours the frog appeared to be dead. It was removed and weighed. The weight, 66 grams, indicated an absorption of 6.5 c.c. of water. It responded to all external stimuli, even croaking. It recovered in five hours, in ten its weight had fallen to 63 grams, and in 33 hours to 61 grams.

It was noted during these experiments that frogs can croak under water even after immersion for some days, indicating separation of nitrogen (and perhaps some carbon dioxide) as gas in the lungs. From time to time in such immersed frogs bubbles of gas are given off from mouth and nares.

Freezing Experiment.

While the experiments at low temperatures indicate that under experimental conditions frogs can only be frozen to about one degree below the freezing point of their body-fluids for one hour without being killed, the numerous observations of other investigators on various insects quoted in earlier papers seem to indicate a possibility that even in the case of the frog a very slow lowering of temperature might produce a supercooling which would prevent death. A single experiment was made to test this point.

Twelve frogs were immersed in water in a large pail on February 2nd, 1921. This was immersed in a much larger tank, also containing water, and placed in the open. The frogs were thus exposed to slow cooling in the centre of a water mass of about 20 inch side, exposed to an external temperature varying between −10° and −20°C. Immediately the frogs came in contact with the cold air at the water surface they dived to the bottom of the pail, and as the temperature fell they gradually became completely motionless. A glass tube was immersed with the lower end at the stratum of water in which the frogs lay, and a thermometer lowered into it from time to time gave the approximate temperature to which they were submitted. In 24 hours this fell to −1.5°, remained at about that point or slightly higher for the next 30 hours and then sank to −3°. It remained between −2° and −4° for three days, when it rose to freezing point, the external temperature having risen to +2.5°. The pail was removed to room temperature, and the frogs allowed to thaw gradually. They were all dead. Muscle failed to respond to electrical stimulus.

This experiment is not conclusive. It indicates, however, that even if marked supercooling can take place—a very doubtful hypothesis—any cooling slow enough to produce no fatal result must take place at a considerable depth below earth or water, and thus is not in disagreement with the assumption that frogs pass the winter in such cold climates as Manitoba below water.

The following observations by other investigators, not previously mentioned in this series of papers, have a bearing on the problems under consideration.

Knauthe (1891) found that frogs could survive a 12 hours' exposure to temperatures of −1° to −5°, in which their body temperatures sank from −0.2° to −0.8°C. Few recovered when the body-temperature reached −0.9°.

Eleanor S. Brooks (1918) has made a series of observations indicating that frogs can survive immersion in water for 75 minutes at all temperatures between 0° and 35° without injurious effects.

Professor A. Willey (1918) states: "In the summer time frogs can survive a moderate duration of immersion; in winter they voluntarily submerge themselves and hibernate under water, becoming inactive. A male frog (*Rana virescens*) was placed in a shallow dish covered with a perforated zinc plate weighted down securely, the whole being completely submerged in an aquarium on December 31st at a temperature of 19°C. On January 8th the cover was raised and the frog remained motionless in the resting attitude. On being stimulated with a glass rod it failed to react at first, but within a minute it became aroused from its lethargy, raised its head above water, came out of the dish and then swam vigorously away. The next day it was perfectly normal and very active. The winter submergence of the frog (*R. temporaria*), as observed under laboratory conditions, was described by G. Newport in 1851."

Professor Philip Cox, of the Department of Biology of the University of New Brunswick, Fredericton, has very kindly sent me the following account of his observations:

"I have some rare advantages as regards a water supply at the ordinary winter temperature of surface spring water.

"The aquaria, two in number, are in my lecture room on table supports of the usual height. They are of glass and metal . . . . about 32″ x 18″ x 16″ in dimensions. The inflow and outflow are by separate pipes, and the supply is from a spring on the ascending ground, just behind the Arts building, and covered by a low shed. These tanks were installed to keep fish, clams, crayfish, and frogs for biological study and have admirably served the purpose.

"The frogs are principally *R. virescens*, with an odd *R. clamitans*, and are collected about September 20th each year. They are put into the tanks which remain filled with water to within three inches of the top (cover).

"At first I put in a few bits of board, which floated, and on which the frogs were inclined to sit day and night, taking an occasional plunge and returning to their forms; but as the temperature of the room was seldom below 60°F., they persisted in sitting on their perches until far into the winter and as a result fell off in condition. A few very large ones would, however, dive to the bottom and remain among the coarse algae and pebbles, seldom coming to the surface. As the winter advanced they were joined by more from the surface until about the middle of January few were left at the surface. The *R. clamitans* were inclined to hang to the surface the longest.

"Two years ago I fitted shelves just far enough below the surface to admit of the frogs resting there with their eyes and tips of the snouts out of water. This resulted in helping to keep them in better flesh and it was observed that the circulation of the blood was stronger and more rapid than under the former conditions. These perches, however, were later abandoned for forms on the bottom, where, if not disturbed, they remained motionless for long periods. As the light (the tanks are near a big window) must exercise a disturbing influence or hibernation under these conditions, I am planning to cut it off next winter.

"We rarely have over 20 individuals to a tank, generally fewer, and sometimes we have a few to liberate in the spring.

"About 12 per cent. sicken and die, the cause being apparently a marked accumulation of gas under the skin, and a distension of the veins on the under surfaces of the hinder parts of the body and limbs. We rarely have a death before the middle of December, and none after about the middle of March. Owing probably to increasing buoyancy affected individuals rise to and remain at the surface, where they die in a few days. . . .

"The temperature of the tank water is the result of the temperature of the room and the rate of flow, and seldom drops below 54°F. the first two months, but later may fall to 35°F. . . . Probably death from gas accumulation is rare in nature."

Summary and Conclusions

The experimental data detailed in this series of papers, considered along with the results of other observers which have been quoted, lead to the following conclusions bearing on the life history of frogs living in temperate and cold climates.

There appear to be slight variations in the temperature limits in different species, though it is doubtful if the maximal temperatures which such frogs can survive vary by more than a few degrees, and the minimal by more than some tenths of a degree Centigrade.

R. pipiens cannot survive a permanent body temperature higher than 18°C. and it is evident that such frogs as this species can only survive a summer heat for such a time as evaporation of water from their body fluids will permit the retaining of their own temperature below this limit. A temperature of 30° is fatal in six hours, of 32° in two hours, and such summer shade temperatures are often reached in these latitudes.

R. pipiens and similar species cannot survive body temperatures of −1.25°C. for more than one hour, under laboratory conditions. During this period super-cooling ceases, and the body fluids and tissues freeze. It is possible that under natural conditions a very slow cooling may induce super-cooling at so slow a rate that death does not occur. It seems almost certain that once tissue freezing commences and lasts for more than the negligible period of one hour, no recovery can take place. Such slow super-cooling could only take place if the frogs were immersed deeply in earth, slime, or water. There is no evidence that they can burrow in earth, or even do so in thin slime. If they are below water the problem does not usually arise. Undoubtedly large numbers do survive such winters as are experienced in central Canada below water at the outlets of springs. Others are probably immersed in slews and river water.

I have shown that *R. pipiens* can survive complete immersion in fresh running water for a period of 150 to 200 days, and the survivors show no ill effects, and relatively little loss of weight. It seems a normal reflex for a frog, exposed to cold air, to dive beneath water, and in the immersion experiments they take up such a quiescent condition as must be considered to be actual hibernation.

Under experimental conditions, especially when a large number of frogs are confined together below water in a relatively small vessel, certain of these may become oedematous, and buoyant, nitrogen gas being retained within the body of the frog, and death following from the oedema and gas distension. Such nitrogen gas appears to be normally got rid of in part through the lungs by the expiration from time to time of small bubbles of gas. My experimental methods did not entirely exclude the possibility of some carbon dioxide being also present in small amount, though it could only amount to a very small percentage of the retained gas. It is probable that this water-absorption and gas-retention does not take place to a great extent under natural conditions. The cause of it has not been ascertained. The harder the water the more likely is it to occur, and it may perhaps be induced by an increase in calcium or magnesium ions. It takes place at low temperatures.

I have made some observations which appear to show that frogs wholly or partially submerged in water which is allowed to rise in temperature above 16°C., or wholly submerged in water in which there is an oxygen deficiency, suffer some change leading to an upset of osmotic regulation, with a resulting oedematous condition.

References

The three papers, by Cameron and Brownlee, contain a fairly complete list of references on the subjects dealt with.

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The Effect of Light on Growth in the Mussel

By A. G. HUNTSMAN, B.A., F.R.S.C.

(Read May Meeting, 1921)

At the Atlantic Biological Station a series of experiments was carried through by Miss Mossop in 1919 in an effort to determine the effect of varying natural conditions on the growth of the sea mussel—*Mytilus*. These conditions were not varied enough to show to what extent light is a determining factor in growth. In the summer of 1920, therefore, I devised and carried through an experiment in which it is believed that light was the only variable factor.

Two boxes (25½ in. long and 11¾ in. square in cross section) with partly open ends were so constructed that no light could directly penetrate to a central compartment (see Figure 1), and the inner

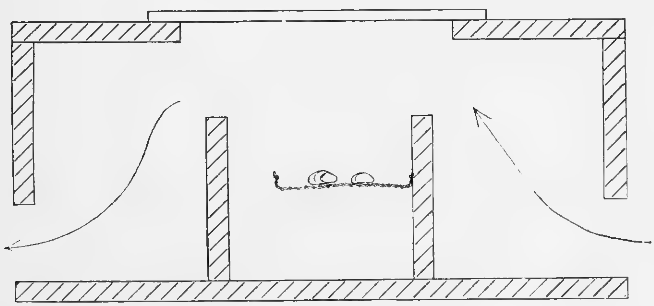

FIG. 1
Longitudinal section of box used in experiment.

surfaces were coated with lampblack so as to prevent any light from being reflected to that compartment. As the two partitions in each box were incomplete, water could readily pass lengthwise through it.

In the top of each box an opening 11⅜ in. long gave access to the central compartment, and was closed in one case by a wooden cover and in the other by a glass one. The boxes were fastened beside each other to a floating breakwater, past which a moderately strong tidal current almost constantly flowed.

After the lapse of nearly a month (Aug. 8 to Sept. 3) it was found that an alga (*Ectocarpus confervoides siliculosus*, as kindly identified by Mr. A. B. Klugh) was growing in the central compartment of the "light" box, and two hydroids (*Bougainvillia* and *Tubularia*) in that of the "dark" box. Small mussels from 7 to 8 mm. in length were obtained from the fronds of rockweed (*Ascophyllum*) growing in the intertidal zone near a large mussel bed. About twenty of these were placed on galvanized wire screening in the central compartment of each box.

After 24 days the mussels were taken out, measured, and replaced. After another period of 19 days they were again taken out, measured, and then preserved in formaldehyde solution.

Even before they were measured it was quite evident that the mussels in the dark had grown much more rapidly than those in the light. There was also noticeable some difference in shape, the former being somewhat thinner (see Figure 2). The results of the measurements are given in averages in the accompanying graph (see Figure 3). It is seen that the increase in length was over three times as great in the dark as in the light.

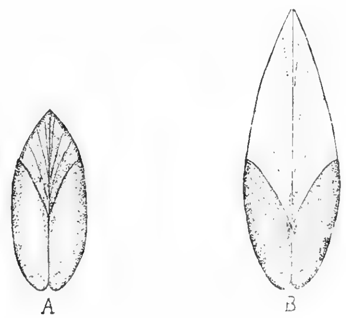

FIG 2

Mussels at end of experiment; dorsal view, ×2½

A—from lighted box. *B*—from darkened box

The difference in shape between the two lots suggested the possibility that the growth of the mussels was not correctly indicated by the changes in length. Three mussels were taken from each lot for the purpose of making a detailed study of the matter. The average ratio of depth to length was found to be identical for the two lots, namely 0.55, but the average ratio of the thickness to the length was greater in those from the "light" box (0.46) than in those from the "dark" box (0.42).

An attempt was then made to discover whether the increase in weight had been greater in those that had been exposed to light than was indicated by their dimensions. Considering the volume to be the product of the three dimensions in mm. multiplied by a constant

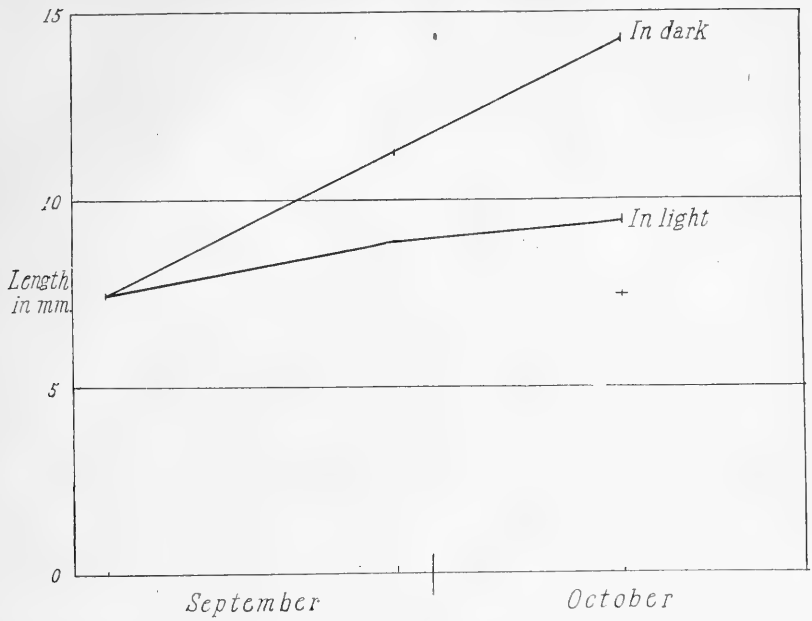

FIG. 3

Average increase in length of the two lots of mussels in the experiment

K, the ratio of the volume to the weight of the shell in mgm. was determined. The specimens from the "dark" box gave the following results.

No.	Length x Depth x Thickness x K=Volume	Weight	Volume to weight
1	11.85 × 6.4 × 5.6 × K=428 K	47.6 mgm.	9.00 K to 1
2	14.35 × 8.2 × 5.9 × K=694 K	83.5 mgm.	8.32 K to 1
3	15.2 × 8.4 × 5.9 × K=753 K	77.0 mgm.	9.78 K to 1
		Average	9.03 K

The specimens from the "light" box gave the following results:

No.	Length x Depth x Thickness x K=Volume	Weight	Volume to weight
1	10.05 × 5.8 × 4.4 × K=257 K	37.8 mgm.	6.79 K to 1
2	10.0 × 5.45 × 4.5 × K=245 K	46.6 mgm.	5.27 K to 1
3	9.1 × 4.75 × 4.4 × K=190.5 K	35.0 mgm.	5.43 K to 1
		Average	5.83 K

The soft parts of these same specimens were then dried at approximately 100°C. until there was no further loss in weight and their weights determined. The ratios of the volumes to these weights were as follows:

"Dark" box				"Light" box			
No.	Volume to weight		=ratio	No.	Volume to weight		=ratio
1	428 K to	9.9	=43.2 K	1	257 K to	6.8	=37.7 K
2	694 K to	15.4	=45.1 K	2	245 K to	11.1	=22.1 K
3	753 K to	20.4	=37.0 K	3	190.5 K to	8.6	=22.2 K
	Average		=41.8 K		Average		=27.3 K

It is clear from these results that the individuals grown in the dark had a greater volume (to the amount of more than 50%) per unit weight both of shell and of living matter than had those grown in the light. This may be expressed in another way, namely, that those exposed to the light had a greater mass of shell and living matter per unit of volume that had those kept in the dark. As the actual volume of the former was very much less than that of the latter, it may be inferred that the increase in volume in those exposed to light was retarded to a greater extent than was the increase in weight as compared with those increases in specimens kept in the dark.

We have no data as to the weight of the shell and of the living matter in these specimens at the time the experiment was started, but we do know their lengths. They had been living under conditions somewhat intermediate between the light and dark extremes of the experiment. If we consider that they were intermediate in ratio of thickness to length and of dry weight of living matter to volume between the individuals from the "light" box and those from the "dark" box, we may calculate the ratio of the increase in mass in the specimens kept in the dark to that in those exposed to light, taking as a basis the increase in average length of the specimens.

The specimens kept in the dark increased in average length from 7.5 mm. to 14.4 mm., and those exposed to the light from 7.5 mm. to 9.5 mm. It can be shown that if the other dimensions increased proportionately the former specimens increased in volume by an amount **8.2** times as great as did the latter $\left\{\frac{14.4^3-7.5^3}{9.5^3-7.5^3}=8.2\right\}$.
By correcting for the greater thickness and the greater relative dry weight of the specimens exposed to light it has been calculated that

the amount of the average increase in mass of the specimens kept in the dark was **3.11** times as great as that of those exposed to light.

	Thickness to length	Weight to volume (aver. of shell and body)
"Dark" specimens........	0.42	1.54 X
"Light" specimens........	0.46	1 X
Original specimens.........	0.44	1.27 X

NOTE.—X is a constant.

$$\frac{\left(\frac{14.4^3 \times 0.42}{1.54\,X} - \frac{7.5^3 \times 0.44}{1.27\,X}\right)}{\left(\frac{9.5^3 \times 0.46}{1\,X} - \frac{7.5^3 \times 0.44}{1.27\,X}\right)} = 3.11$$

It may be asked what the significance is of the differences between the two lots in regard to shape and relation of weight or mass to volume. The light rays have doubtless hindered growth by injuring some or all of the tissues of the mussel. The shell of the mussel is quite opaque as it contains a large amount of black pigment. Indeed it was expected that owing to this protective coat light would be found not to have any effect upon the mussel's growth. The shell increases in length and depth by additions to the free margin, and it is there that the living material is unprotected by shell or only imperfectly protected by the thin growing edge. As it has been found that the light retarded growth chiefly in respect to increase in length and depth, it is fairly certain that the greatest injury has been done to the more or less exposed growing edge of the mantle at the margin of the shell. For this reason length and depth are not satisfactory criteria of the rate of growth when differences of lighting occur.

There were definite indications of the importance of light in developing the full intensity of the black pigment in the shell. The newly formed shell in the specimens kept in the dark was almost invariably of a more or less light brown colour, in striking contrast to the very black original shell. In the other lot the contrast was slight or not at all evident.

There are very few accounts in the literature of the effect of light upon the growth of animals. Higginbottom (1850, p. 435) found that the tadpole of *Rana temporaria* "advances in growth equally well in the dark and in the light." Torrey and Martin (1910) found that in a species of *Obelia* more hydranths regenerated in the dark than in daylight during the same time, and in the regeneration of single hydranths a larger number of annuli was produced in darkness than in daylight. It has long been known that so long as accumulated foods material last the growth of plants is greatly accelerated in the dark. Also Downes and Blunt (1877, p. 496) found that "light is inimical to the development of bacteria and the microscopic fungi associated with putrefaction and decay," and that "under favourable conditions it wholly prevents that development." This effect of light on plants is therefore observable in the case of the mussel as well as in Obelia, and is doubtless very general among marine animals. The occurrence of many attached marine animals only on the lower surfaces of stones or in similarly protected situations when in shallow water has been perhaps generally explained as due to their avoidance of the light. In the experiment described the two species of hydroids grew in the middle compartment of the "dark" box only. The true explanation may be that in direct sunlight they are not only retarded in growth, but actually killed off.

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The Effect of Thyroid Feeding on Rats on a Vitamin-deficient Diet

By A. T. CAMERON, F.R.S.C., and ANDREW MOORE, B.A., B.Sc.

(Read May Meeting, 1921)

Cameron and Carmichael have proved that when young white rats are fed desiccated thyroid tissue in daily amounts bearing a constant ratio to their (changing) weights, there is definite retardation in the rate of growth, and at the same time they have confirmed the observations of Hoskins, Herring, and others, that such feeding produces marked hypertrophy of certain of the body organs, especially heart, kidneys, liver, and adrenals. They have also shown that this action is due to thyroxin, the specific chemical compound secreted by the thyroid, and isolated by Kendall.

In one of the early experiments of this series, by accident the rats were fed a vitamin deficient diet (oatmeal and water) and it appeared that thyroid accelerated the marked loss of weight which this diet produced. We have therefore endeavoured to ascertain whether the administration of thyroid along with a diet deficient in vitamins gives simply additive effects, or whether the results produced by either alone are increased or modified.

Experimental Results

We carried out a preliminary experiment on eight pigeons. Two were used as controls, three fed on polished rice, and three on this with daily doses of desiccated thyroid (0.38 per cent. iodine) in the ratio of 1:5,000 of body-weight. The results were uncertain, but the combined treatment produced a greater and more rapid fall in body-weight and earlier death. It is doubtful if the onset of a definite polyneuritis was accelerated. The pigeons were dissected and the organs weighed, but the figures yielded no definite conclusions.

Four experiments have been carried out with young white rats. In each, rats from the same litter and of the same sex were employed, and were subjected to preliminary observation over several days on an unlimited bread and milk diet until the growth-rate was normal. In the first experiment a direct comparison was made between rats on an unlimited bread and milk diet, and others on unlimited ground oatmeal and water (growth promoting vitamin deficiency). After eighteen days the animals were chloroformed, dissected, and the organs weighed. In the remaining three experiments one or more rats were used as controls (C, in the tables) and fed the bread and milk diet, others were fed this with administration of thyroid ($+T$), others fed the vitamin-deficient diet ($-V$), and others this, plus thyroid in the same ratio ($+T\ -V$). The thyroid was always fed immediately after the animals were weighed in the morning, the dose being based on the body-weight in a constant ratio; it was given mixed with water and flour or oatmeal (according to the diet) to a thin paste, in which form it was always completely eaten.

Experiment 1.—Seven females of a litter born January 8th, 1921. Treatment commenced on the 80th day of age. On the 98th day the animals were killed and dissected. At autopsy of Rat No. 6 the lymph glands of the throat showed considerable development of pus. This condition has been observed after feeding thyroid, and parathyroid, and does not, therefore, indicate any special result of the treatment.

The body- and organ-weights are shown in Table I.

Experiment 2.—Eight females of a litter of twelve born September 30th, 1920. Treatment commenced on the 70th day of age. On the 84th day the animals were killed and dissected. The body- and organ-weights are shown in Table II.

Experiment 3.—Five male rats of a litter of eleven born February 1st, 1921. Treatment commenced on the 39th day of age. On the 10th day of treatment the thyroid-fed rat developed typical tetany and died in less than an hour. The others were killed and autopsied. The body- and organ-weights are shown in Table III.

Experiment 4.—A litter of four males and five females born January 30th, 1921. Feeding commenced on the 71st day of age. On the 80th day a thyroid-fed female was found dead and the remaining females were killed. The body- and organ-weights are shown in Table IV. The thyroid-fed animal, No. 3, at autopsy showed considerable drying out of surface tissues, and much decomposition within the abdominal cavity. The percentage figures for organ-weights are probably too low. The ($+T-V$) male rat died on the afternoon of the 92nd day (21st of treatment), and the others were immediately killed and autopsied. In these cases the body-weights of that morning (before feeding) were used for calculating the percentage organ-weights. The body- and organ-weights are shown in Table V. The muscle used for comparison was the right

TABLE I

Age	Control rats				Vitamin-deficient rats				
	Rat 1	Rat 2	Rat 3	Average	Rat 4	Rat 5	Rat 6	Rat 7	Average
Days	gm.	gm.	gm.		gm.	gm.	gm.	gm.	
77	60.5	53	57.5		42.5	50.5	48.5	54	
80	70	57	58.5		44	51.5	50	50.5	
86	82	68	70.5		42.5	54	51.5	50	
92	92	80.5	78.5		38	52	47	48	
98	96.5	91.5	84.5		38	49.5	43.5	43.5	
Difference in weight	+26.5	+34.5	+26		− 6	− 2	− 6.5	− 7	
Weight of Organs									
Liver	5.5	4.5	4.9		2.5	3.2	3.1	3.1	
Kidneys	0.88	0.93	0.85		0.56	0.60	0.62	0.72	
Heart	0.46	0.42	0.43		0.25	0.28	0.26	0.26	
Spleen	0.354	0.307	0.202		0.083	0.121	0.127	0.075	
Lymph glands	0.129	0.140	0.089		0.038	0.022	......	0.027	
Adrenals	0.026	0.018	0.022		0.014	0.016	0.016	0.018	
Thyroid	0.0122	0.0121	0.0137		0.0103	0.0093	0.0054	0.0099	
Muscle	0.189	0.184	0.142		0.061	0.094	0.076	0.087	
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
Liver	5.7	5.0	5.8	5.5	6.6	6.4	7.2	7.0	6.7
Kidneys	0.91	1.01	1.00	0.97	1.47	1.21	1.42	1.65	1.44
Heart	0.47	0.46	0.51	0.48	0.66	0.56	0.59	0.59	0.60
Spleen	0.37	0.34	0.24	0.32	0.22	0.24	0.29	0.17	0.23
Lymph glands	0.13	0.15	0.11	0.13	0.10	0.04	......	0.06	0.07
Adrenals	0.027	0.019	0.026	0.024	0.037	0.032	0.036	0.041	0.049
Thyroid	0.0126	0.0132	0.0162	0.0140	0.0270	0.0188	0.0122	0.0227	0.0202
Muscle	0.190	0.201	0.168	0.186	0.160	0.189	0.174	0.200	0.181

TABLE II

Age.	Controls			+T. (1:20000)			−V			−V+T (1:20000)		
	Rat 1	Rat 2	Mean	Rat 3	Rat 4	Mean	Rat 5	Rat 6	Mean	Rat 7	Rat 8	Mean
Days	gm.	gm.		gm.	gm.		gm.	gm.	gm.		gm.	
67	82.5	63.5		80	78.5		67.5	85		89.5	83	
70	97	82		94	96		86	99		106	100.5	
77	120	103.5		106.5	111.5		66	78.5		73.5	69.5	
84	138	123		115	118		75	95		84	75	
Gain in weight	+41 +42%	+41 +50%	+46%	+21 +22%	+22 +23%	+22.5%	−11 −13%	−4 −4%	−8.5%	−22 −21%	−25.5 −25.5%	−23%

Weight of organs

Liver	6.8	3.0		7.6	4.8		3.0	4.7		8.1	4.6	
Kidneys	1.31	1.10		1.36	1.48		0.76	0.92		1.00	0.94	
Heart	0.77	0.73		0.83	0.87		0.38	0.54		0.56	0.49	
Spleen	0.409	0.412		0.472	0.462		0.155	0.245		0.244	0.208	
Testes	1.72	1.37		1.23	1.20		1.56	1.51		1.41	0.74	
Adrenals	0.020	0.027		0.021	0.025		0.018	0.022		0.020	0.020	
Thyroid	0.0057	0.0037		0.0025	0.0043		0.0067	0.0070		0.0086	0.0050	
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
Liver	4.9	2.4	3.6	6.5	4.1	5.3	4.0	4.9	4.4	9.7	6.1	7.9
Kidneys	0.95	0.89	0.92	1.18	1.25	1.21	1.01	0.97	0.99	1.18	1.26	1.22
Heart	0.56	0.59	0.57	0.72	0.74	0.73	0.51	0.57	0.54	0.67	0.65	0.66
Spleen	0.29	0.33	0.31	0.41	0.39	0.40	0.21	0.25	0.23	0.29	0.27	0.28
Testes	1.24	1.11	1.17	1.07	1.01	1.14	2.08	1.59	1.83	1.68	0.99	1.33
Adrenals	0.014	0.022	0.018	0.018	0.021	0.019	0.024	0.023	0.023	0.024	0.027	0.025
Thyroid	0.0041	0.0030	0.0035	0.0021	0.0036	0.0028	0.0089	0.0073	0.0081	0.0102	0.0066	0.0084

tibialis anterior. The lymph glands dissected were all those microscopically visible in the anterior triangles along the internal jugular veins and above the level of the thyroid cartilage.

Discussion

Table VI summarises the results as far as the gross changes in body-weight are concerned. When two animals were under similar treatment in the same experiment the mean of the percentage figures has been used. The percentage gains of weight of the controls have been accepted as standards, and the amounts by which the treated animals fell short of these standards have been considered as due to the treatment and as representing the weight not gained. The last two columns contrast the percentage loss of weight (weight not gained)

TABLE III

Age	Rat 1	Rat 2	Rat 3	Rat 4	Rat 5
	C.	+T (1:5000)	−V	−V+T	−V+T
Days	gm.	gm.	gm.	gm.	gm.
36	36	37	35.5	35	39.5
39	43	49	47	44.5	52.5
44	59.5	60.5	40.5	38	40
49	65.5	68.5	46	41	42
Gain in weight	+22.5 +52%	+19.5 +40%	−1 −2%	−3.5 −8%	−10.5 −20%
Weight of organs					
Liver	4.4	5.0	3.2	3.5	3.6
Kidneys	0.74	0.99	0.57	0.69	0.69
Heart	0.36	0.52	0.26	0.30	0.30
Spleen	0.180	0.239	0.114	0.122	0.114
Lymph glands	0.076	0.063	0.026	0.031	0.034
Testes	0.321	0.257	0.134	0.087	0.095
Adrenals	0.017	0.016	0.014	0.016	0.019
Thyroid	0.0053	0.0063	0.0037	0.0040	0.0034
	per cent.	per cent.	per cent.	per cent.	per cent.
Liver	6.5	7.5	6.6	8.4	8.2
Kidneys	1.10	1.54	1.16	1.64	1.58
Heart	0.54	0.81	0.53	0.71	0.69
Spleen	0.27	0.37	0.23	0.29	0.26
Lymph glands	0.113	0.098	0.053	0.074	0.078
Testes	0.48	0.40	0.27	0.21	0.21
Adrenals	0.025	0.025	0.028	0.038	0.043
Thyroid	0.0079	0.0098	0.0074	0.0116	0.0078

of an animal fed thyroid on a vitamin-deficient diet and the sum of such losses produced by the thyroid treatment alone, and the deficient diet alone, to animals of the same sex and litter. In such experiments it is essential that rats of the same litter and sex be used and it is difficult to secure many litters sufficiently large to permit averages in one experiment. In the second experiment the thyroid dosage was 1:20,000, in the others, 1:5,000. The animals were treated at different ages and for different lengths of time. The agreement between the two columns is, therefore, surprisingly close, and we consider that it indicates that as far as gross changes of body-weight are concerned the thyroid and the deficient diet merely produce additive effects.

TABLE IV

FEMALE RATS

Age	Rat 1	Rat 2	Rat 3	Rat 4	Rat 5
	C.	C.	+T (1:5000)	−V	−V+T
Days	gm.	gm.	gm.	gm.	gm.
68	65	82	69	71	78.5
71	70	87	74	76	86
74	76	91	73	73	75
77	71	94	67	64	64
80	76	101	58	64	62
Gain in weight	+6 +9%	+14 +16%	−16 −22%	−12 −16%	−24 −28%
Weight of organs					
Liver	4.9	6.8	3.5	4.8	4.3
Kidneys	0.95	1.04	0.91	0.75	0.82
Heart	0.38	0.46	0.36	0.31	0.35
Spleen	0.214	0.304	0.076	0.179	0.170
Lymph glands	0.105	0.091	0.059	0.087	0.081
Adrenals	0.023	0.029	0.027	0.022	0.025
Thyroid	0.0090	0.0093	0.0079	0.0080	0.0071
Muscle	0.155	0.178	0.121	0.134	0.109
	per cent.	per cent.	per cent.	per cent.	per cent.
Liver	6.5	6.7	6.0	7.5	6.9
Kidneys	1.25	1.03	1.57	1.17	1.32
Heart	0.50	0.46	0.62	0.48	0.56
Spleen	0.28	0.30	0.13	0.28	0.27
Lymph glands	0.14	0.09	0.10	0.14	0.13
Adrenals	0.030	0.029	0.046	0.034	0.040
Thyroid	0.0119	0.0092	0.0136	0.0125	0.0114
Muscle	0.204	0.176	0.209	0.209	0.176

TABLE V

MALE RATS

Age	Rat 5	Rat 2	Rat 3	Rat 4
	C.	+T (1:5000)	−V	−V+T
Days	gm.	gm.	gm.	gm.
68	86	83	86	90
71	91	88	90	91
78	107	95	88	75
85	120	104	81	71.5
92	139	113	85	57
Gain in weight	+48	+25	−5	−34
	+53%	+28%	−6%	−37%
Weight of organs				
Liver	7.8	10.3	5.3	4.0
Kidneys	1.22	1.71	0.83	0.91
Heart	0.55	0.76	0.41	0.37
Testes	1.66	1.86	1.74	1.05
Spleen	0.358	0.442	0.201	0.139
Lymph glands	0.076	0.095	0.048	0.082
Adrenals	0.026	0.025	0.019	0.024
Thyroid	0.0111	0.0047	0.0069	0.0045
Muscle	0.271	0.184	0.180	0.091
	per cent.	per cent.	per cent.	per cent.
Liver	5.6	9.1	6.3	7.0
Kidneys	0.88	1.50	0.97	1.59
Heart	0.40	0.67	0.48	0.65
Testes	1.19	1.65	2.05	1.84
Spleen	0.26	0.39	0.24	0.24
Lymph glands	0.055	0.084	0.056	0.144
Adrenals	0.019	0.022	0.022	0.042
Thyroid	0.0080	0.0042	0.0081	0.0079
Muscle	0.195	0.163	0.224	0.160

It is more difficult to draw definite conclusions from the figures for organ-weights. The effect of thyroid has been established, but not much is known definitely of the effect of vitamin-deficiency. McCarrison has shown, and Vincent and Hollenberg have confirmed that starvation produces adrenal enlargement, and McCarrison has obtained this with vitamin deficiency (also a starvation). This has been confirmed by Kellaway.

In considering our own figures it is obvious that in cases where there has been a marked decrease in weight percentage figures are misleading since a more marked wastage of certain tissues would lead to apparent increases in others. The deficient diet appears to produce an increase in liver, heart, and kidneys (the percentage figures are higher than the controls, even when calculated on the basis of body-weight prior to treatment), but it is doubtful if these are more than the relative increases produced in starvation. The adrenals show no actual enlargement on deficient diet only, though the percentage figures are distinctly higher. No marked differences are seen in the thyroid figures, and it was noted that on the deficient diet the thyroid does not enter into the resting condition (as under thyroid treatment, when the gland is noticeably pale at autopsy) but is bright red in colour and apparently functioning actively. This holds true also in the combined treatment. Both thyroid treatment and diet deficiency produce marked loss of body-fat.

A much larger number of experiments are evidently necessary for definite conclusions. Unfortunately the combined effects of the thyroid and vitamin deficiency usually give such an early fatal result that the changes in body organs cannot become very marked.

We wish to acknowledge the assistance of Mr. J. Carmichael in carrying out some of the experiments.

TABLE VI

Expt.	Percentage Gain or Loss in Weight				Percentage Gain or Loss in Weight compared with control as Standard			Sum of (+T) and (−V)
	C.	+T	−V	+T−V	+T	−V	+T−V	
2	+46	+22.5	−8.5	−23	−23.5	−54.5	−69	−78
3	+52	+40	−2	−14	−12	−54	−66	−66
4 (F)	+12.5	−22	−16	−28	−34.5	−28.5	−40.5	−63
4 (M)	+53	+28	−6	−37	−25	−59	−90	−84

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Glycogen in the Heart and Skeletal Muscles in Starved and Well-fed Animals

By J. J. R. MACLEOD, F.R.S.C., and D. J. PRENDERGAST

(Read May Meeting, 1921)

It is known that the heart muscle contains a relatively high percentage of glycogen and that this substance is particularly abundant in the conducting structures of the organ. (1) It is also known that the percentage of glycogen in the heart remains at a high level in diabetes whereas it diminishes considerably in skeletal muscles in this disease. (2) These facts bear an interesting relationship to the results recently obtained by one of us (J. J. R. M.), working in association with L. G. Kilborn, concerning the distribution of glycogen in the tissues of various marine animals. In these investigations it was found that the primitive heart of the dog fish (*Squalus sucklii*) contains much more glycogen than the skeletal muscles or even the liver (3).

It seemed of interest, therefore, to investigate the behaviour of the glycogen in the heart and muscles of rabbits and dogs after periods of starvation or feeding with carbohydrate-rich food, and we offer the results in the present communication.

METHODS

The observations were made partly on rabbits and partly on dogs, the animals being either starved or fed with abundance of carbohydrate-rich food (oats, carrots and maize for rabbits, dog biscuit for dogs) for three or four days preceding that on which they were killed. Water was allowed during the starvation period. The animals were killed by stunning, immediately bled, and the tissues to be examined removed as quickly as possible and placed on ice so as to diminish post-mortem glycogenolysis in the interval during which the necessary weighings were being made. Portions of the tissues were then cut into thin slices which were repeatedly pressed between several layers of filter paper until this no longer became stained by blood, the slices being then weighed and dropped into 60 per cent. KOH solution, the volume of which was equal to that of the weighed tissue. For a strictly accurate determination of the glycogen content of the tissue several sources of error are incurred by the above procedure, but there appears to be no way of avoiding them. Two of these errors are particularly important: (1) post-mortem glycogenolysis cannot be entirely stopped and it may proceed at different rates in different tissues; (2) it is impossible to be certain that the slices of tissues have been dried to the same degree. It might appear as if these errors would be eliminated by dropping the tissues into alcohol immediately after their excision and then drying them to constant weight before digesting with the potash solution. Although we have employed this method on several occasions we have not thereby obtained results that would seem to justify its adoption, and we have therefore endeavoured to eliminate the errors by repetition of the observations on a sufficient number of animals. The glycogen was determined by a slightly modified form of Pflüger's method and all results were obtained in duplicate and none are recorded unless the duplicates checked satisfactorily.

Results and Conclusions

The following conclusions appear to be warranted by the results:

1. *The heart contains a decidedly higher percentage of glycogen after starvation than after feeding with carbohydrate-rich food.* In order to demonstrate this in *rabbits* it was necessary to take three animals for each observation so as to obtain a sufficient amount of heart for accurate determination of the glycogen.

In the hearts of three groups of three fed animals each, there was 0.150, 0.090, and 0.083 per cent. of glycogen; average 0.108. In the hearts of three groups of three starved animals each, there was 0.160, 0.165 and 0.207 per cent. of glycogen; average 0.177.

The same results were obtained in *dogs*, in which case the heart was large enough to permit, in each animal, of separate determinations in auricle and ventricle.

Fed 3-4 days:

Ventricle:	0.497,	0.526*,	0.617;	average, 0.547
Auricle:	0.50,	0.454*,	0.648;	average, 0.534

Starved 3-4 days:

Ventricle:	1.00,	0.583*,	1.05;	average, 0.878
Auricle:	0.828,	0.428*,	0.542;	average, 0.600

The ventricle is seen to contain, on an average, more glycogen than the auricle but the result is of little value since a considerable pro-

*These animals were in an unusually poor condition of general nutrition.

portion of the auricle consisted of blood vessels and other non-muscular tissue. Considering the ventricle alone, much more glycogen was found in every case in the starved animals than in those that were well fed. The least difference occurs in the case of two animals that were both in very poor general condition.

Taking the result as a whole, it is plain that glycogen is deposited in the heart of rabbits and dogs during the first three days of starvation to an extent that is greater than when carbohydrate-rich food is being ingested. This accumulation is particularly evident in the ventricle.

2. *The Skeletal muscles usually contain a higher percentage of glycogen after feeding with carbohydrate-rich food than during starvation and the difference is more evident in dogs than in rabbits.* The observations were made on the same animals as were employed for those on the heart and the results are given in the same order. In the case of the rabbits red and pale muscles were separately investigated, the *soleus* and *semitendinosus* being taken to represent red, and the adductor magnus to represent pale muscle. In the case of the dogs, the muscles used were the *soleus* and *adductor magnus*.

Rabbits	*Fed*—pale muscle	0.39,	0.225,	0.136;	average,	0.325
	red muscle	0.27,	0.46,	0.396;	average,	0.375
	Starved—pale muscle	0.23,	0.44,	.....;	average,	0.335
	red muscle	0.34,	0.34,	.....;	average,	0.340

Only in the case of the red muscle is there uncertain evidence of a higher percentage of glycogen due to feeding. It is of interest to note that the average of all estimations for red muscle is 0.361 per cent. (min. 0.27, max. 0.396) and for pale muscle, 0.329 per cent. (min. 0.225, max. 0.440).

Dogs	*Fed*—	1.16,	0.98,*	0.735;	average,	0.958
	Starved—	0.38,	0.436,	0.821;	average,	0.546

There is very decided evidence that starvation reduces the percentage of glycogen, although the degree to which the reduction occurs is not equal in different animals. It is possible that the variability depends on the amount of glycogen remaining in the liver but unfortunately this was not controlled in these observations. The average percentage of glycogen in the muscles of the starved dogs is 0.549 (min. 0.38, max. 0.821) which is above that for all the observed muscles of both fed and starved rabbits. This difference between the two species becomes very distinct in the case of fed animals.

*See note on p. 38

3. *The percentage of glycogen in the heart is much higher in dogs than in rabbits, both during starvation and after feeding.* Thus, the average of all the determinations for the whole heart in fed dogs is 0.540 per cent. and in starved dogs 0.739 per cent.; in fed rabbits the average is 0.108 and in starved rabbits, 0.177 per cent.

4. *In the rabbit the percentage of glycogen in the heart is always less than that in the skeletal muscles whereas in the dog the heart (ventricle) contains a higher percentage than the skeletal muscles in starved animals but a decidedly lower percentage in those that are fed.* These facts are best brought to light by comparison, not of averages but of determinations made on the two tissues in individual animals. The following figures will serve to illustrate these relationships:

(Per cent. Glycogen)

Animal	*Condition*	*Skeletal Muscles*	*Heart*
Rabbit 2a	Starved	0.23 (pale) 0.34 (red)	0.165
Rabbit 3a	"	0.44 (pale) 0.34 (red)	0.207
Rabbit 2	Fed	0.225 (pale) 0.460 (red)	0.090
Rabbit 3	"	0.360 (pale) 0.396 (red)	0.083
Dog 5	Starved	0.38	1.00
Dog 6	"	0.436	0.583
Dog 7	"	0.821	1.05
Dog 8	Fed	1.16	0.497
Dog 9	"	0.98	0.526
Dog 10	"	0.735	0.617

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On Pentose Compounds in Tissues of Marine Animals

By CYRIL BERKELEY

Presented by E. E. PRINCE, LL.D., F.R.S.C.

(Read May Meeting, 1921)

The presence of pentoses has been recorded in the tissues of a large number of terrestial animals. The sugar has most commonly been found combined with the purine base guanine and phosphoric acid to form guanylic acid, which is the acid component of the β. nucleoproteins, and the wide distribution of pentoses in animal tissues has usually been attributed to the presence of these compounds. The only other pentose derivative whose presence has been fully established is inosinic acid which occurs widely distributed in muscle tissue and has a similar constitution to guanylic acid, but contains hypoxanthine instead of guanine. In a recent paper the writer brought forward evidence indicating that adenylic acid, the corresponding compound containing adenine, should be added to the list.[1]

The physiological significance of these compounds is unknown, but guanylic and adenylic acids have a very special physiological interest since they have both been shown to be component parts of plant nucleic acid. Doubt seems to exist as to whether they are to be associated with nuclear substance in animal tissues. Certainly no pentose has been found in animal nucleic acids whose composition has been closely investigated. On the other hand statements suggesting that the amount of pentose present in animal tissues is proportional to their richness in nuclei are to be found in the text books.[2]

The only complete survey of the pentose content of the various organs in one animal which might bear on this subject is that carried

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[1]Berkeley, C., *Journ. Biol. Chem.*, 1921, XLV, 263.

[2]Thus: Abderhalden, E., "Text-book of Physiological Chemistry," first edition, p. 22, "The quantity of pentoses contained in the separate organs varies greatly and depends directly upon the amount of nucleic substances present," and Mathews, A. P., "Physiological Chemistry," second edition, p. 173, "It seems probable, though there is really nothing known about it, that guanylic and inosinic acid may be in the cytoplasm of the cells in which they occur, though they may be in the nucleus." On the other hand, Jones, W., "Nucleic acids; their chemical properties and physiológical conduct," 1914, p. 8, "It should not be understood that β. nucleoproteins are protein salts of nucleic acid, nor that they are constituents of cell nuclei."

out by Grund[3] on the ox. The conclusion is drawn by this author that the amount of pentose present is proportional to the richness of the organ in nuclear substance. The present writer found that the relation between the pentose content of various organs of the dog-fish (*Squalus sucklii*) is similar to that found by Grund for the ox, but that the absolute amounts present are somewhat greater in the former case.[4]

For some time past determinations of pentose in various tissues of marine animals have been made as opportunity offered. The main object has been to find a suitable raw material from which to prepare the pentose compounds for closer characterization, but the results obtained seem worth considering in their bearing on the question of the relation between the quantity of these compounds present and the richness of the tissues in nuclei. They are also of some interest from the general standpoint of comparative bio-chemistry since few determinations of pentose in the tissues of marine animals have hitherto been published.

Methods

The organs examined were taken from freshly killed animals. In all cases except that of the mud shark, of which only one specimen was available, they were taken from several animals and samples drawn from the mixed material for analysis. The organs were cut into small pieces and brought rapidly into alcohol. After standing a few days the material was finely minced and kept in alcohol, which was changed at intervals, until dehydrated as far as possible. It was then pressed, dried at air temperature, finely ground, sieved, exhaustively extracted with ether, and again air dried. In this way material free from most of the connective tissue and containing about 10 per cent. of moisture was obtained. The figures quoted have been calculated to the material dried to constant weight at 100°C.

The determinations were made on the air-dried material direct by the method of Tollens and Kröbe as modified by Grund and the results calculated as xylose. They cannot, therefore, be taken as an absolute measure of the amount of pentose present since this is unquestionably mainly derived from nucleotides whose pentose constituent has been shown by Levene and Jacobs[5] to be *d*-ribose and,

[3]Grund, G., *Zeit. Physiol. Chem.*, 1902, XXXV, 111.

[4]Berkeley, C., *Journ. Biol. Chem.*, 1920, XLI, p. liv. These determinations have been requoted in this paper for comparison with the other figures given.

[5]Levene, P. A., and Jacobs, W. A., *Ber. Chem. Ges.*, 1909, XLII, 3247.

in the case of inosinic acid, these authors have shown that considerably less than the theoretical amount of furfurol is obtained by distillation with hydrochloric acid of specific gravity 1.06.[6] In the absence of knowledge of the furfurol equivalents of the pentoses present it seemed best to calculate on the basis of a known relationship. The results thereby obtained are comparable amongst themselves and with those obtained by Grund.

The possibility of errors being introduced into the method of determination by substances other than pentoses which might be present in animal tissues is discussed in some detail by Grund. The conclusion is reached that glycogen is the only compound likely to remain after exhaustive treatment with alcohol and ether which could introduce an appreciable error, and this only in the case of the liver. Of the tissues dealt with in this paper only the livers (digestive glands) of the mollusks contained enough glycogen to effect the pentose determinations. Samples of all the livers and many of the other tissues were treated by Pflüger's method of glycogen determination. The glycogen found was distilled with hydrochloric acid and the distillate treated with phloroglucin according to the Tollens and Kröbe method of pentose determination, but only in case of the molluskan livers was a weighable amount of precipitate obtained. In these cases a corresponding correction has been applied to the pentose determination. Small quantities of glycogen were found in a few other tissues which are noted in the tables which follow.

[6]Levene, P. A., and Jacobs, W. A., *Ber. Chem. Ges.*, 1908, XLI, 2703, and 1909, XLII, 1198.

PISCES

Sub-Class	Species	Pentose (as Xylose) per cent.								
		Pancreas	Spleen	Kidney	Liver	Heart	Muscle	Ovary	Ripe Ovary	Testis
Elasmobranchii	Mud-shark (sp?)	0.92	0.80	0.74	....	0.42	none	....	....	....
	Dog-fish (*Squalus sucklii*)	2.28	0.67	0.65*	0.72	0.38	0.35	pres-ent	none	0.92
	Rat-fish (*Hydrolagus colliei*)	1.42	1.02	0.99	0.74	....	0.41	....	....	0.98
Teleostomi	Spring Salmon (*Oncorhynchus tschawytscha*)	....	0.87	1.29	1.48	....	....	....	....	....
	Herring (*Clupea palasii*)	....	....	....	1.77	....	....	0.71	0.48	0.30
	Alaska Cod (*Gadus macrocephalus*)	....	1.77	1.70	1.65**	....	0.35	....	....	0.35

*The connective tissue from the dog-fish kidney was analyzed separately and found to yield 0.48 per cent. of pentose.
**A small quantity of glycogen present.

Phylum	Class	Species	Pentose (as Xylose) per cent.			Glycogen correction (as per cent. Xylose)
			Digestive Gland	Gonad	Tube	
Mollusca	Gastropoda	*Polynices lewisii*	1.02	1.26	.....	0.13*
		Thais lamellosa	0.95			0.20
	Pelecypoda	*Saxidomus gigantea*	0.76			0.55
Echinodermata	Asteroidea	*Evasterias troschellii*	0.77	....	.....	Trace present
Annulata	Polychaeta	*Eudistylia gigantea*	....	....	0.99	....
		Mesochætopterus taylori	....	....	10.33	....

*This applies only to the determination in the digestive gland.

It is to be noted in the cases of the fishes that the organs which, on general histological grounds, would be expected to be richest in nuclei are not those which have the highest pentose content. The testes, for instance, would be expected to consist almost entirely of nuclear material and these are by no means the richest in pentose. This is particularly noteworthy in the case of the Alaska cod and the herring, which were spawning at the time the material was collected. It is less marked in the cases of the two elasmobranchs examined, but this might be connected with the fact that these fishes do not ripen their sexual products all at one time and the testes were not ripe in the same sense as those taken from the teleosts. Even in the case of the elasmobranchs, however, the pentose content of the testis is found considerably lower than that of the pancreas though it would not be anticipated that the latter would be so highly nucleated.

These expectations have been confined by comparing sections of some of the tissues, stained to demonstrate the nuclei.[7] The sections of the testes of the teleosts are found to be dense with nuclei whilst in those of the elasmobranchs they are comparatively widely separated, whilst the pancreas of the elasmobranchs is found to be considerably poorer in nuclei than the testes. Another illustration of this point is given by the separate pentose determinations in the soft tissue and the connective tissue of the kidney of the dog-fish. The latter yields very nearly as much as the former though it is very much less densely nucleated.

The pancreas could only be examined in the elasmobranchs. It was found so diffused in the teleosts that it was practically impossible to collect enough material for analysis. It is interesting to note that in all three of these cases it is the organ containing most pentose. This is in accordance with such observations as have previously been made on mammalian organs. So uniformly has this been found to be the case that it would seem to be justifiable to look for some connection between the pentose nucleotides and the physiological function of the pancreas.

From the standpoint of comparative bio-chemistry the most interesting thing about the results obtained from the fishes seems to be the generally higher pentose content of the organs of the teleosts than those of the elasmobranchs except in the case of the testes, of which an explanation has already been suggested. More work is required, however, before it can be concluded that this is invariably the case.

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[7]I am much indebted to Mr. H. Dunlop, of the University of British Columbia, for preparing and mounting these sections.

The presence of pentose in the ova of the herring and its complete absence in those of the dog-fish is also worth noting. It should be mentioned, however, that in the former case the material examined was fertilized spawn, whilst in the latter it was ripe ova taken from the ovary.

The absence of glycogen in all but traces in the livers of the fishes examined is in general agreement with the observations of Lang and Macleod[8], but does not support their suggestion that "the glycogen content of fishes is very low in the summer months and high in the winter," since the fishes whose examination is here recorded were all caught during the winter months. It would seem that in these animals glycogen is very largely replaced by oil as a reserve material.

In the case of the mollusks, pentose has been determined quantitatively only in the digestive gland and gonad, though it has also been found present in the siphon muscle. The complete separation of the two organs was very difficult in the pelecypod *Saxidomus gigantea* and the small gastropod *Thais lamellosa*. They were, therefore, analysed together in these cases. In the large gastropod *Polynices lewisii* it was comparatively easy after the material had been hardened in alcohol. It is to be noted that in this case there is no great difference between the pentose content of the two organs though the gonad contains much more nuclear material.

The figures quoted are corrected for the error introduced into the pentose determinations by the glycogen present, as already explained. The amount of glycogen is much greater in *Saxidomus gigantea* than in the gastropods. The writer has found this to hold in comparing other pelecypod and gastropod mollusks in connection with other work.

In the light of the observations recorded by Starkenstein and Henze [9] and others of the presence of pentosans in molluskan livers it is worthy of note that no pentosan has been found in any of the mollusks examined. It seems likely that β. nucleoproteins have been mistaken for pentosans in these instances.

The occurrence of furfurol-yielding substances in the tubes of the polychæte worms *Eudistylia gigantea* and *Mesochætopterus taylori* was quite unexpected and seems worth recording. The results have, therefore, been included in the above table. The yield of furfurol from the tube of *Mesochætopterus taylori* is very much higher than has been obtained from any other marine animal material. The furfurol-

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[8]Lang, R. S., and Macleod, J. J. R., *Quart. J. Exp. Physiol.*, 1918-20, XII, 331.
[9]Starkenstein, E., and Henze, M., *Zeits. Physiolog. Chem.*, 1912, LXXXII, 417.

yielding substances present in these tubes seem, however, to be of an entirely different nature to the others dealt within this paper. They are insoluble in water and are not readily extracted. They are at present under investigation.[10]

The work herein recorded was carried out at the Marine Biological Station, Nanamio, B.C.

[10] The substance present in the tube of *Mesochætopterus taylori* has recently been shown to be a compound of the nature of chondroitin sulphuric acid (Berkeley, C., *Journ. Biol. Chem.*, 1922, L, in the press), the furfurol-yielding component of which is glucuronic acid.

Studies in Anoxaemia: Oxygen Unsaturation of the Arterial Blood

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The effects produced on animals by deficiency of oxygen in the inspired air are widespread, the respiratory and circulatory functions being amongst the first of the body to react through changes occurring in the nerve centres which control them.(1) The numerous tests of the reaction of man to decreasing percentages of oxygen, which formed a part of the medical examination of candidates for the aviation services during the war, have furnished us with most valuable information of the objective and subjective symptoms of anoxaemia, but they throw very little light on the exact nature of the physiological changes which are responsible for these symptoms. There have been in general, two views regarding this question, the one that a lowering of free oxygen in the tissue fluids itself serves to account for the symptoms, and the other, that the oxygen deficiency causes secondary, incompletely oxidized substances to appear and that these act as poisons.(2) The following investigations have been undertaken to throw light on this aspect of the problem and although they are not as yet completed it has been thought advisable to place certain of the results on record.

Since the earliest effects of anoxaemia are observed most definitely in the functions of the respiratory and circulatory systems, attention has been paid mainly to these and since the controlling centres are highly sensitive to anaesthetics the use of the latter has been avoided by employing decerebrate animals for the experiments. The operation of decerebration was performed by the method described by Sherrington only such animals as recovered entirely from the shock of the operation and in which the breathing and blood pressure were normal being used for the anoxaemia experiments.(3) To bring about the anoxaemia the trachea was connected through a wide-bore cannula with a pair of very sensitive valves, one of which (the inspiration valve) was connected with a large thin-walled rubber balloon kept moderately full with a mixture of oxygen and nitrogen which was delivered into it from a large (100 litre) gas meter. The other (expiration) valve was connected with a Gad-Krogh registering spirometer of a known capacity, the volume of respired air being determined by measuring the time taken for this to fill. The arterial blood pressure was recorded by the usual methods from one of the femoral arteries and a cannula was inserted in the opposite artery for the purpose of collecting samples of blood on which to measure the degree of oxygen unsaturation. This was done by using Barcroft's differential blood gas manometer as follows: a narrow straight pipette, graduated in 0.1 c.c.s., was connected with the artery and 2 quantities of 0.2 c.c. each of the blood were delivered immediately, and without coming in contact with air, under about 0.3 c.c. of a weak solution of sodium carbonate, and saponin, contained in the two small "bottles" of the apparatus. One of the bottles was rotated so as to lake the blood and render it completely saturated with oxygen and both were then attached to the manometer tubes and placed in a water bath at room temperature until there was no further shrinkage of the fluid in the manometer. On now shaking the manometer the blood in the bottle that had not previously been shaken became laked and absorbed oxygen from the air of the bottle so that a slight negative pressure resulted, the extent of which was indicated by the manometer. Finally a solution of potassium ferricyanide was mixed with the laked saturated blood on one side and the positive pressure created by the oxygen thereby evolved also read on the manometer. From these two values the percentage of unsaturation was calculated.

Samples of alveolar air were also collected by the method described elsewhere, and analysed in the Haldane apparatus. In an actual experiment the procedure was to measure the volume of air breathed, to analyse samples of alveolar air during several short periods of time while the animal was still breathing outside air, and when the results were found to be tolerably constant to take samples of blood. The inspiration valve was then connected with the rubber bag and the volume of breathing measured and the alveolar air analysed at regular intervals of 10 minutes, duplicate samples of blood being also taken usually at the same periods, although sometimes it was necessary to omit one or more of these.

Results

Although observations have been made over a wide range of oxygen percentages the most important for our present purpose are those in which alveolar air contained between 8.3 and 10.8 per cent. of oxygen. From these experiments the following results are of interest:

1. During the first ten minutes after causing the animal to breathe oxygen-poor air, the respiratory volume becomes increased

and the arterial blood definitely unsaturated with oxygen. This is shown in Table I.

TABLE I

No. of Experiment	Oxygen capacity of blood. Per cent. of full saturation	Percentile increase in resp. volume	Per cent. 0^2 in alveolar air (average)
41	..	12.5	9.05
43	90	9.5	8.85
45	92.1	12.	9.55
47	89.7	14.2	8.3
49	90	21.5	8.8

It is probable that unsaturation of the blood realy occurs at higher percentages of oxygen in the alveolar air than those recorded here, but it is difficult to demonstrate it when this is above 10. In one experiment in which the alveolar oxygen stood at 10.9, the respirations were greatly excited over the normal (97 per cent. increase) and the arterial blood was 96.0 per cent. saturated with oxygen (Expt. 42) but we have discounted this experiment because the cat was hyper-excitable owing to the decerebration being decidedly in front of the anterior corpora quadrigemina.

In a previous paper it was pointed out that a certain increase in breathing usually occurs within a few seconds after connecting the tracheal cannula through valves with a closed system of wide bore tubing and that this increase is probably accounted for in some way by the slight resistance to the movement of air since it cannot be related to increase in $C0_2$ or deficiency of 0_2 in the air breathed. In the present experiments this possible source of error has been avoided by using the thin-walled rubber bag as described above. When the bag contained air of normal composition its attachment to the inspiration valve had no effect on the breathing.

2. During the subsequent ten minute intervals of anoxaemia the volume of air breathed may either increase or decrease, although the percentage of oxygen in the inspired air has remained unaltered. It is, therefore, important to compare the behaviour of the oxygen unsaturation of the blood with these changes in respiration. This is done in Table II.

TABLE II

No. of Expt.	Condition	1st 10 min.	2nd 10 min	3rd 10 min.	4th 10 min.	5th 10 min.
I						
49	1. Per cent. change in resp. volume	21.5	18	12.3	....	....
	2. Alveolar—O_2 (per cent.)	8.8	....	7.9	....	....
	3. Per cent. of O_2—saturation of blood	90	....	87.1	....	....
43	1. Resp.	9.5	−15.2	−6.3	....	....
	2. Alv.−O_2	8.85	10.0	10.35	....	....
	3. Blood unsaturation	90	90	82.6	....	....
42	1. Resp.	97	76	38	....	....
	2. Alv.−O_2	10.9	10.8	....	....	....
	3. Blood unsaturation	96	71.8	....	....	....
II						
48	1. Resp.	....	23	54	....	....
	2. Alv.−O_2	....	10.3	10.5	....	....
	3. Blood unsaturation	....	91.4	93.5	....	....
45	1. Resp.	12	38.5	....	52.5	55
	2. Alv.−O_2	9.55	....	....	10.15	10.55
	3. Blood unsaturation	92.1	....	....	96.7	96.7
47	1. Resp.	14.2	31.5	....	....	....
	2. Alv.−O_2	8.3	9.65	....	....	....
	3. Blood unsaturation	89.7	94.4	....	....	....
41	1. Resp.	12.5	30.4	115	....	....
	2. Alv.−O_2	9.05	10.65	10.8	....	....
	3. Blood unsaturation	....	92.5	94.9 90.5	....	....

The results grouped under "I" show a decrease and those under "II" show an increase in breathing. Considering first of all the experiments of Group II it will be observed that the oxygen saturation of the blood runs in the same direction as the change in breathing and that the percentage of oxygen in the alveolar air increases as the breathing increases. These results indicate that although relative deficiency of oxygen in the blood, and presumably, therefore, a decreased tension of oxygen in the plasma, may be directly responsible for the stimulation of respiration at the beginning of anoxaemia (cf. Table I) such cannot be the cause of the still greater stimulation which developes later. Since, as our results show, the blood becomes more, and not less saturated with oxygen as the anoxaemia progresses, we must conclude that some other respiratory stimulant has made its appearance and the question arises as to its nature. The gradual development of the hyperpnoea during the anoxaemia suggests that it must depend on the appearance by incompletely oxidised acid substances in the tissues and blood and that these stimulate the respiratory centre by raising the H-ion concentration of the blood. To test this hypothesis it will be necessary to make very careful measurement of the H-ion concentration of the blood at various stages in anoxaemia.

It will be observed that it is only about in one half of the animals that increased breathing became developed during the later stages of anoxaemia, and that in the others (Group I) the opposite occurred, namely, a gradual decline. This decline in breathing was associated with a decided decrease in the saturation of the blood with oxygen and we believe that a gradual failure of the respiratory centre is responsible for the result. It is significant that the animals of this group did not recover from the anoxaemia, after being allowed to breathe outside air, nearly so well as those of Group II. In No. 49 the breathing became very slow and the blood remained unsaturated in one half hour after the anoxaemia; in No. 43 marked Traube-Hering waves developed on the blood pressure tracing and the breathing became markedly periodic; and in 42 the respirations suddenly ceased shortly after disconnecting the animal.

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