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DE

LA SOCIÉTÉ ROYALE

DU

CANADA

TROISIÈME SÉRIE—TOME XIII

SÉANCE DE MAI 1919

EN VENTE CHEZ

J. HOPE ET FILS, OTTAWA; LA CO. COPP-CLARK (LIMITÉE), TORONTO

BERNARD QUARITCH, LONDRES, ANGLETERRE

1920

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AND

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OF

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OF

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1920

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THE ROYAL SOCIETY OF CANADA

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THE ROYAL SOCIETY OF CANADA

LIST OF FELLOWS, 1919-1920

The date given is the date of election; c, denotes a charter member.

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1919—Auclair, L'abbé Elie-J., Université Laval, *Montréal.*

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1905—Bruchési, S. G. Mgr. Paul, Th.D., archevêque de Montréal, *Montréal.*

1902—Chapais, Thomas, Litt.D., chevalier de la Légion d'honneur, membre du Conseil législatif, *Québec.*

1916—Chartier, Chanoine Émile, Ph.D. (Romain), Litt.Lic. (Paris), M.A. (Laval), professeur à l'Université Laval, *Montréal.*

1914—Choquette, Ernest, membre du Conseil législatif, *Saint-Hilaire.*

1917—Chouinard, H.-J.-J.-B., LL.B., C.M.G., *Québec.*

1890—David L.-O., chevalier de la Légion d'honneur, sénateur, *Montréal.*

1885—DeCelles, A.-D., C.M.G., LL.D., Litt.D., chevalier de la Légion d'honneur, *Ottawa.*

1919—Delâge, Cyrille-F., surintendant de l'Instruction publique, *Québec.*

1918—Després, L'abbé Azarie-Couillard, *Frelighsburg, Quebec.*

1918—Fauteux, Aegidius, B.Litt., *Montréal.*

1898—Gérin, Léon, *Coaticook.*

1911—Gosselin, Monsignor Amédée-E., M.A., *Québec.*

1918—Groulx, L'abbé Lionel, M.A., Ph.D., Th.D., *Montréal.*

1908—Lemieux, Rodolphe, LL.D., membre du Conseil privé du Canada, officier de la Légion d'honneur, ancien Président général, *Ottawa.*

1908—Mignault, Pierre-Basile, LL.D., C.R., *Ottawa.*

1914—Montpetit, Édouard, LL.B., Dipl. Sc. Pol. (Paris), officier de l'Instruction publique, *Montréal.*

1916—Morin, Victor, B.A., LL.D., *Montréal.*

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1903—Paquet, Monsignor Louis-Ad., Th.D., *Québec.*

1919—Pelletier, Georges, *Montréal.*

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1906—Raymond, Ven. Archdeacon W. O., LL.D., *Toronto, Ont.*

1917—Riddell, Hon. William Renwick, LL.D., *Toronto, Ont.*

1899—Scott, D. Campbell, Deputy Superintendent General of Indian Affairs, *Ottawa.*

1900—Scott, Rev. Frederick George, C.M.G., *Quebec.*

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1905—Wood, Lt.-Col. William, *Quebec.*

1908—Wrong, George M., M.A., University of Toronto, *Toronto.*

Section III.—MATHEMATICAL, PHYSICAL AND CHEMICAL SCIENCES

1914—Allan, Francis Barclay, M.A., Ph.D., University of Toronto, *Toronto.* (Life member).

1909—Allen, Frank, M.A., University of Manitoba, *Winnipeg.*

1918—Archibald, E. H., M.A., Ph.D., F.R.S.E., University of British Columbia, *Vancouver, B.C.*

1915—Bain, James Watson, B.A. Sc., University of Toronto, *Toronto.*

1899—Baker, Alfred, M.A., LL.D., University of Toronto, *Toronto*, (Ex-president).

1916—Bronson, Howard L., B.A., Ph.D., Dalhousie University, *Halifax.*

1913—Burton, E. Franklin, B.A., Ph.D., University of Toronto, *Toronto.*

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1897—Dawson, W. Bell, M.A., Ma.E., D.Sc., M. Inst. C.E., *Ottawa.*

1918—DeLury, Alfred T., M.A., University of Toronto, *Toronto.*

c—Deville, E., LL.D., I.S.O., Surveyor General, *Ottawa.*

1891—Ellis, W. H., M.D., University of Toronto, *Toronto.*

1910—Eve, A. S., D.Sc., McGill University, *Montreal.*

1909—Fields, John Charles, Ph.D., F.R.S., University of Toronto, *Toronto.*

1902—Glashan, J. C., LL.D., *Ottawa.*

1891—Goodwin, W. L., D.Sc., Queen's University, *Kingston.*

1908—Harkness, James, M.A. (Cantab. & Lond.), McGill University, *Montreal.*

1914—Johnson, F. M. G., M.Sc., Ph.D., F.I.C., McGill University, *Montreal.*

1911—Kenrick, Frank B., M.A., Ph.D., University of Toronto, *Toronto.* (Life member).

1915—King, Louis Vessot, M.A. (Cantab.), D.Sc., McGill University, *Montreal.*

1910—Klotz, Otto, LL.D., F.R.A.S., Director Dominion Observatory, *Ottawa.*

1911—Lang, Col. William R., D.Sc., F.I.C., University of Toronto, *Toronto.*

1913—MacKenzie, A. Stanley, B.A., Ph.D., D.C.L., LL.D., President of Dalhousie University, *Halifax.*

1900—McGill, Anthony, B.Sc., LL.D., Chief Analyst, *Ottawa.*

1909—McIntosh, Douglas, Ph.D., University of British Columbia, *Vancouver, B.C.*

1903—McLennan, J. C., Ph.D., University of Toronto, *Toronto.*

1911—McClung, Robert K., M.A., D.Sc., B.A. (Cantab.), University of Manitoba, *Winnipeg.*

1899—Miller, W. Lash, Ph.D., University of Toronto, *Toronto.* (Life member).

1919—Parker, Matthew A., B.Sc., F.I.C., University of Manitoba, *Winnipeg.*

1918—Patterson, John, M.A., Physicist with Meteorological Service of Canada, *Toronto.*

1910—Plaskett, J. S., B.A., D.Sc., Astrophysical Observatory, *Victoria, B.C.*

1896—Ruttan, R. F., M.D., C.M., D.Sc., McGill University, *Montreal.*

1917—Satterly, John, A.R.C.Sc., D.Sc., M.A., Physics Building, University of Toronto, *Toronto.*

1899—Shutt, F. T., M.A., D.Sc., F.I.C., F.C.S., Chemist, Central Experimental Farm, *Ottawa.* (Life member).

1913—Stansfield, Alfred, D.Sc., A.R.S.M., McGill University, *Montreal.*

1901—Stupart, Sir Frederic, Kt., Director of the Meteorological Service, *Toronto.*

1917—Sullivan, Charles Thompson, B.A., M.Sc., Ph.D., McGill University, *Montreal.*

1909—Tory, H. M., M.A., D.Sc., LL.D., President of the University of Alberta, *Edmonton, Alta.*

Section IV—GEOLOGICAL SCIENCES (INCLUDING MINERALOGY)

1896—Adams, Frank D., Ph.D., D.Sc., F.R.S., F.G.S., McGill University, *Montreal.* (Ex-president).

1900—Ami, Henry M., M.A., D.Sc., F.G.S., *Ottawa.* (Life member).

c—Bailey, L. W., M.A., LL.D., University of New Brunswick, *Fredericton.*

1911—Brock, Reginald W., M.A., F.G.S., F.G.S.A., University of British Columbia, *Vancouver, B.C.*

1918—Camsell, Charles, B.A., Geological Survey, *Vancouver, B.C.*

1900—Coleman, A. P., M.A., Ph.D., F.R.S., University of Toronto, *Toronto.*

1919—Collins, William H., B.A., Ph.D., *Ottawa.*

1912—Dowling, D. B., B.Sc., Geological Survey, *Ottawa.*

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1902 Adami, J. G., F.R.S., M.A., M.D. (Cantab. and McGill), LL.D., F.R.S.E., McGill University, *Montreal.*

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1916—Hunter, Andrew, M.A., B.Sc., M.B., Ch.B., Edin., University of Toronto, *Toronto.*

1917—Huntsman, Archibald Gowanlock, B.A., M.B., Biological Department, University of Toronto, *Toronto.*

1912—Knight, A. P., M.A., M.D., Queen's University, *Kingston.*

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1916—Lloyd, Francis E., M.A., McGill Uuiversity, *Montreal.*
1900—Macallum, A. B., Ph.D., D.Sc., LL.D., F.R.S., Administrative Chairman of Research Council of Canada, Ottawa. (Ex-president).
1888—Mackay, A. H., LL.D., B.Sc., Superintendent of Education, *Halifax.* (Life member).
1919—Macleod, J. J. R., M.B., Ch.B., University of Toronto, *Toronto.*
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1909—McMurrich, J. P., M.A., Ph.D., University of Toronto, *Toronto.*
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1908—Nicholls, A. G., M.A., M.D., D.Sc., Dalhousie University, *Halifax.*
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1914—Roddick, Sir Thomas G., Kt., M.D., C.M., McGill University, *Montreal.*
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1909—Vincent, Swale, M.D., D.Sc., University of Manitoba, *Winnipeg.*
1915—Walker, Edmund Murton, B.A., M.B., University of Toronto, *Toronto.*
1912—Willey, Arthur, D.Sc., F.R.S., McGill University, *Montreal.*

CORRESPONDING MEMBERS

Section I

Salone, Émile, professeur d'histoire au Lycée Condorcet, 68 rue Jouffray, *Paris.*
Hanotaux, Gabriel, de l'Académie française, 21 rue Cassette, *Paris.*
Lamy, Étienne, secrétaire perpétuel de l'Académie française, 3 place d'Iéna, *Paris.*
Lorin, Henri, professeur d'histoire coloniale à l'Université de Bordeaux, 23, quai des Chartrons, *Bordeaux.*

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Thomson, Sir Joseph J., O.M., F.R.S., *Cambridge, England.*

Section IV

White, Charles David, B.Sc., United States Geological Survey, *Washington, D.C.*

Section V

Osborn, Dr. Henry Fairfield, Columbia University, *New York, N.Y.*

RETIRED MEMBERS

1902—Barnes, H. T., D.Sc., F.R.S., McGill University, *Montreal.* (Life member).
1895—Callendar, Hugh L., M.A., (Cantab.), F.R.S., *London, England.*
1899—Charland, Pére Paul-V., Litt.D., *Quebec.*
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1897—Cox, John, M.A. (Cantab.), *London, England.*
1891—Fowler, James, M.A., Queen's University, *Kingston.*
1904—Gordon, Rev. Charles W., LL.D., *Winnipeg.*
c—Haanel, E., Ph.D., Director of Mines, *Ottawa.*
1911—Leathes, John B., B.A., F.R.C.S., B.Ch. (Oxon.), *Sheffield, England.*
1909—Macbride, Ernest W., M.A., F.R.S., *London, England.*
1889—Mair, Charles, *Prince Albert, Sask.*
c—Osler, Sir W., Bt., M.D., F.R.C.P., F.R.S., *Oxford, England.*
1902—Owens, R. B., M.Sc., Franklin Institute, *Philadelphia, U.S.A.*
1898—Parkin, G. R., C.M.G., LL.D., *London, England.*
1914—Peterson, Sir William, K.C.M.G., LL.D., McGill University, *Montreal.*
1900—Poole, H. S., M.A., F.G.S., *Spreyton, Stoke, Guildford, England.*
1890—Roberts, C. G. D., M.A., *London, England.*
1900—Rutherford, E., B.A. (Cantab.), M.A., F.R.S., *Manchester, England.*
1910—Thomson, E. W., F.R.S.L., *Ottawa.*
c—Watson, J., M.A., LL.D., *Kingston.*
1900—Willison, Sir John S., LL.D., *Toronto.*
1910—Wilson, Harold A., F.R.S., *Houston, Texas.*
c—Wright, R. Ramsay, M.A., B.Sc., *Bournemouth, England.* (Ex-president).

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1883–1884	L'honorable P.-J.-O. Chauveau.
1884–1885	Dr. T. Sterry Hunt.
1885–1886	Sir Daniel Wilson.
1886–1887	Monsignor Hamel.
1887–1888	Dr. G. Lawson.
1888–1889	Sir Sandford Fleming, K.C.M.G.
1889–1890	L'abbé Casgrain.
1890–1891	Very Rev. Principal Grant.
1891–1892	L'abbé Laflamme.
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1894–1895	Sir J. Macpherson LeMoine.
1895–1896	Dr. A. R. C. Selwyn, C.M.G.
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1897–1898	L'honorable F.-G. Marchand.
1898–1899	T. C. Keefer, C.M.G.
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1905–1906	Dr. Alex. Johnson.
1906–1907	Dr. William Saunders, C.M.G.
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1908–1909	Dr. J.-Edmond Roy.
1909–1910	Rev. Geo. Bryce, LL.D.
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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.

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 Landsmarks Association of Canada.
Waterloo Historical Society.

Quebec

Société du Parler français au Canada, Québec.
Société de Géographie de Québec.
Société d'Économie 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.

Prince Edward Island

Natural History and Antiquarian Society of Prince Edward Island.

THE ROYAL SOCIETY OF CANADA

PROCEEDINGS FOR 1919

THIRTY-EIGHTH GENERAL MEETING

SESSION I.—(*Tuesday, May 20*).

The Royal Society of Canada held its thirty-eighth annual meeting in the Chateau Laurier on May 20, 21 and 22.

The President, Hon. Mr. Rodolphe Lemieux, took the chair at 10 a.m., and having called the meeting to order, requested the Honorary Secretary to call the roll.

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

OFFICERS OF THE SOCIETY

President............Hon. Mr. Rodolphe Lemieux.
Vice-President.......Dr. R. F. Ruttan.
Honorary Secretary...Mr. Duncan C. Scott.
Honorary Treasurer...Dr. C. Gordon Hewitt.
Honorary Librarian...Mr. D. B. Dowling.

SECTION I.—Auclair, E.-J.; Barbeau, C.-M.; Choquette, E.; David, L.-O.; DeCelles, A.-D.; Delâge, C.-F.; Fauteux, A.; Gérin, Léon; Lemieux, R.; Mignault, P.-B.; Morin, V.; Myrand, E.; Pelletier, Georges; Poirier, Pascal; Rouillard, Eugène; Scott, H.-A.; Sulte, B.

SECTION II.—Brett, G. S.; Burpee, L. J.; Coyne, J. H.; Cruikshank, E. A.; Currelly, C. T.; Doughty, A. G.; Edgar, P.; Falconer, Sir Robert; Herrington, W. S.; Hutton, Maurice; Leacock, Stephen; Lighthall, W. D.; Mavor, James; McLachlan, R.W.; Raymond, W. O.; Riddell, W. R.; Scott, D. C.; Shortt, Adam; Skelton, O.D.

SECTION III.—Baker, Alfred; Burton, E. F.; Dawson, W. Bell; DeLury, A. T.; Deville, E.; Eve, A. S.; Fields, J. C.; Glashan, J. C.; Johnson, F. M. G.; King, L. V.; Klotz, O.; Lang, W. R.; MacKenzie, A. S.; McIntosh, D.; McLennan, J. C.; Plaskett, J. S.; Ruttan, R. F.; Satterly, J.; Shutt, F. T.; Stansfield, A.

SECTION IV.—Ami, H. M.; Bailey, L. W.; Coleman, A. P.; Collins, W. H.; Dowling, D. B.; Dresser, J. A.; Faribault, E. R.; McConnell, R. G.; McInnes, W.; Parks, W. A.; Tyrrell, J. B.; Walker, T. L.; White, James.

SECTION V.—Buller, A. H.; Cameron, J.; Faull, J. H.; Grant, Sir James; Hewitt, C. G.; Huard, V.; Hunter, A.; Huntsman, A. G.; Macallum, A. B.; MacKay, A. H.; MacKenzie, J. J.; Macleod, J. J. R.; McMurrich, J. P.; McPhedran, A.; Moore, C.; Prince, E. E.; Willey, A.

Letters of regret for absence were received from the following:

Miller, W. G.; McGill, Anthony; Bruchési, Mgr. Paul; Chartier, Emile; Roy, Camille; Harrison, F. C.; Roddick, Sir Thomas G.; Burgess, T. J. W.; Macphail, Sir Andrew; Fraser, C. McLean; McClung, R. K.; Paquet, L. A.; Lewis, F. J.; Longley, J. W.; Peterson, Sir William; Montpetit, E.; Garneau, H.; Després, C.; Grant, W. Lawson; MacMechan, Archibald; Howay, Judge F. W.; Cappon, James.

The following Fellows are reported as being still on military service:

Adami, J. G.; Adams, F. D.; Brock, R. W.

It was moved by Dr. Pelham Edgar, seconded by Mr. Lawrence J. Burpee, 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 1918-1919

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 in the Chateau Laurier on May 21, 22 and 23. The meeting was well attended and the accommodation which was given the Society by the management of the Chateau was, as in former years, excellent.

Owing to the formation of a fifth section, it has been more difficult to make provision for the meetings of the Sections, but it is hoped that the arrangements we have made this year will prove satisfactory.

1.—Proceedings and Transactions of the Society

An examination of the volume this year will show that the space allotted by the Council to the Transactions has been exceeded by 38 pages. A bound copy is laid upon the table for inspection and the volume will be distributed promptly after the meeting.

Sir Clive Phillips-Wolley

The Council is gratified to note the large programme of papers to which you will give consideration at this meeting. The increase in the number of papers and their importance indicate the active interest which the Fellows are taking in the objects of the Society.

II.—Election of New Fellows

This year there were vacancies in all the Sections. Voting was closed on the 1st of April. 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

L'abbé Elie-J. Auclair.
Cyrille-F. Delâge.
Georges Pelletier.

Section II

Walter S. Herrington, K.C.

Section III

Matthew A. Parker, B.Sc., F.I.C.

Section IV

Willam H. Collins, B.A., Ph.D.
Robert A. A. Johnston.
Thomas Leonard Walker, M.A., Ph.D.

Section V

John Cameron, M.D., D.Sc., F.R.S.E.
J. J. R. Macleod, M.B., Ch.B.

III.—Deceased Members

It is with deep regret that we record six vacancies in the ranks of the active Fellows which have been caused by death: Sir Clive Phillipps-Wolley, Mr. J. Ross Robertson, Dr. John B. Tingle, Mr. Lawrence M. Lambe, Dr. Frank F. Wesbrook, and L'abbé Auguste Gosselin. Dr. John Reade, one of the Charter Members of the Society, who was retired in 1911, also died during the year.

The biographical sketches were written respectively by the Honorary Secretary, Mr. Irving Robertson, Dr. F. T. Shutt, Mr. William McInnes, Dr. Adami, Mgr. L.-A. Paquet and Mr. W. D. Lighthall.

SIR CLIVE PHILLIPPS-WOLLEY

It is with regret that we record the death of Sir Clive Phillipps-Wolley, who had been elected to Fellowship with Section II of The Royal Society of Canada in the year 1913. He was in every way an ornament and source of strength to the Society. He was born on April 3, 1854, at Wimborne, Dorsetshire, England, the son of Mr. R. A. L. Phillipps, M.A., F.R.G.S. He was educated at Rossal School and was for some years Her Majesty's Consul at Kertch. He left the diplomatic service to read law, and was called as a barrister at the Middle Temple (Oxford Circuit) in 1884. In 1876 he inherited the Wolley property, Woodhall, Hamwood, Shropshire, when he assumed the name and arms of Wolley. He came to British Columbia in 1896, and was thereafter occupied in mining activities and journalism and general literary work. His Majesty the King honoured him with knighthood in 1915.

His graphic prose style added interest to his books on travel and big-game hunting, his poetry was instinct with love of nature. The Society in 1914 published examples of Sir Clive's poems. A perusal of these contributions will convince the reader that he was possessed of a delicate fancy, appreciated British Columbia life and scenery, and had the skill to translate and interpret what he saw and felt.

He took a deep interest in the affairs of Canada and the British Empire and was constant in his efforts to advance his adopted country and to harmonize her interests with a broader and more effective union of all the British Dominions.

Owing to the great distance of his residence from our place of meeting and the unsatisfactory state of his health, it is to be regretted that he was not present at any of our annual meetings.

It should be recorded here that his only son, Lieutenant-Commander Clive Phillipps-Wolley, was lost on his ship, the "Hogue," when she was torpedoed and sunk by a German submarine in September, 1914. The writer had the privilege of conversing with him shortly after that tragedy, and his tone of brave resignation and absolute confidence was worthy of all our best traditions. This short sketch of a remarkable personality may well close with this admirable characterization: "Those who knew Sir Clive never doubted that what he wrote or spoke was the frank and free expression of his thought and the desire of his heart. As a poet and as a citizen he was incapable of perfunctory loyalties, or mere conventional patriotisms. He was not even able to be reticent on such matters. Those who agreed or disagreed with him knew his clear-grained human worth and brave old wisdom of sincerity."

John Ross Robertson

JOHN ROSS ROBERTSON

John Ross Robertson was born at Toronto on December 28, 1841. He was the son of John Robertson, a successful merchant of Toronto, and Margaret, daughter of Hector Sinclair, Stornoway, Island of Lewis, Scotland. He was educated at Upper Canada College. During his student years he occupied his leisure in acquiring a knowledge of the printer's craft and established the *College Times*, the first pioneer schoolboy organ of the Dominion, which was issued from his father's house, and he obtained an extensive knowledge of the business of printing and publishing at the offices and workshops of established Toronto newspapers. In 1861 he established a newspaper called the *Sporting Life*, which developed into a journal called the *Grumbler*, a satirical weekly paper.

In 1866 he founded the *Daily Telegraph*, which gained a high reputation among the newspapers of Canada during the five years of its existence.

Mr. Robertson then spent three years in London, England, as a business representative and correspondent of the *Toronto Globe*. His varied experience had given him a very full knowledge of publishing conditions and newspaper opportunities, and in 1876 he founded the *Evening Telegram*, financially assisted by Mr. Goldwin Smith. The paper was immediately successful, and Mr. Robertson succeeded in developing it into a newspaper of great interest and usefulness. The financial success of his paper enabled him to indulge his passion for historical collections. His valuable compilations dealing with the early history of Toronto and the Province of Ontario, entitled him, in the opinion of the Fellows of the Royal Society, to election as a Fellow; in 1914 he was admitted, and until his death he continued in active membership in the Society.

His interest in public affairs naturally led him into politics and for four years, from 1896–1900, he sat in the Dominion House of Commons for East Toronto. There was hardly any measure to his public service, and as years went by honours were offered him which he did not accept, but which he no doubt valued as evidences of the appreciation of his fellow citizens. In 1907 he was offered a Knighthood and a seat in the Senate.

His historical work and his eagerness to accumulate minute details of the early life of the country had brought him into association with our Society, but his highest claims to the gratitude of his countrymen were his great public spirit and his well-considered philanthropy.

The greatest item of that manifold service was his untiring ministry to suffering childhood. The Hospital for Sick Children, Toronto, was the outstanding interest of his later days. He toured the world for new ideas in equipment, collected through the influence of his newspaper the funds necessary for its efficient upkeep, and from its revenue sufficient to erect a summer home for "his family" on Toronto island, a perfectly equipped residence for nurses, a model infants' department, a pavilion for tubercular children and a unique pasteurization plant. A great hospital which extends its healing mercy to an entire province and, thanks to his princely legacy, need never turn a sick child from its doors, is the enduring monument which John Ross Robertson left to his trusteeship of that prosperity which his fellow citizens vouchsafed to him.

JOHN BISHOP TINGLE

John Bishop Tingle, Professor of Chemistry in McMaster University, Toronto, who died at the age of 51 after a brief illness on August 5, 1918, had enjoyed fellowship in The Royal Society but a few months, having been elected by the unanimous vote of Section III at the Annual Meeting in May last. It had been fully expected that Dr. Tingle by his scholarly attainments and his researches in the field of organic chemistry might for many years add greatly to the interest and value of the Society's meetings and transactions.

Dr. Tingle received his early training at the Royal Grammar School, Sheffield, and in 1884 entered Owens College, Manchester, where he studied and worked under the late Sir Henry E. Roscoe. In 1887 he proceeded to the University of Munich, studying there under Claisen and von Baeyer and taking the degree of Doctor of Philosophy in 1889. While at Munich his studies were essentially in organic chemistry, his dissertation for the degree dealing with the action of ethyl oxalate on aliphatic ketones.

On his return to England, Dr. Tingle first held a junior position on the staff of the Heriot-Watt College, Edinburgh, and later accepted the post of Research Assistant to F. R. Japp, then at the Royal College of Science, London. He later held the important positions of lecturer in chemistry at the Merchant-Venturers' Technical College, Bristol, and subsequently at Gordon's College, Aberdeen.

In 1896 he came to America and was successively professor of Chemistry at the Lewis Institute, Chicago (1897–1901), Illinois College, Jacksonville (1901–1904) and assistant in charge of organic chemistry at Johns Hopkins University under Professor Remsen (1904–1907). During his residence in the United States, Dr. Tingle became sub-editor and abstractor in organic chemistry on the staff of the *American Chemical Journal*. His work in the latter position

John Bishop Tingle

was characterized by great care and precision, for his study of current literature in his chosen field was extensive and exhaustive, and he spared no pains in making his abstracts clear, complete, and useful to the student and investigator. It was his long training as abstractor on the staff of the Journal of the Chemical Society (England) which specially qualified him to take such an important part in organizing the organic abstracts for the American society.

Dr. Tingle was appointed professor of chemistry at McMaster University, Toronto, in 1907. In this important post he laboured energetically and faithfully until his death, accomplishing an excellent work for the future of Canadian chemistry in the thorough training he gave his students. It was perhaps as a teacher that Dr. Tingle did his best and most valuable work for the country of his adoption, one which is bearing good fruit to-day in many a Canadian educational institution and laboratory. It was a work for which he possessed a special talent. The foundations of chemistry in fact and theory were well and truly laid and the student found himself on graduation thoroughly equipped to proceed in post-graduate studies to successful investigation in such a field of chemistry as he might choose for his life work. The writer of this sketch wishes to particularly emphasize that Dr. Tingle was insistent in all his teachings on the importance of careful, accurate, clean craftmanhip. He held that theory was useless and sometimes worse than useless, misleading, unless the student had the knowledge of how theory was deduced and how it could be applied in practice. He laid special stress on the fact so often lost sight of in our teaching institutions, that manipulative skill—craftmanship—of the highest order was essential to the success of the chemist in no matter what branch of the science he might eventually work. Orderly, cleanly, careful laboratory practice was with him a *sine qua non*, a necessary prerequisite to orderly and clear reasoning.

In his own original work as embodied in upwards of thirty publications Dr. Tingle wholly concerned himself with problems of organic chemistry; it centred chiefly round two points, the mechanism of the "Claisen reactions" and the nature of the products and the mechanism of nitration in the benzene series. His last paper, which did not appear in print until after his death, was concerned in elucidating certain minor points previously undetermined and was intended to clear the way for a comprehensive study of the laws governing nitration and the means by which nitrations could be held in control. Though for periods in his professional life, and especially between 1890 and 1896, research was impossible, he carried through to a successful issue a very large number of investigations in this his chosen field. It is not too much to say that Dr. Tingle considered organic research as his life work; evidently it was the one in which was his heart and the one in which he was looking forward had his health been spared to devote all his time and energy. As an organic chemist he certainly held a first place among Canadian chemists.

Dr. Tingle translated and edited several important works in chemistry. For a long time "Spectrum Analysis," by Landauer and Tingle was the only comprehensive work on the subject in English.

Dr. Tingle was a kind and generous man, as so many of his friends and students can testify. Especially worthy of mention was his personal interest in his students and their work, exciting their ambition and enthusiasm for advanced study and doing all that he was able towards assisting them in obtaining in post-graduate work those conditions in which they could best proceed with their chosen science. His was a high ideal and his students and fellow workers were undoubtedly influenced thereby. In the death of Dr. Tingle Canada has certainly lost a devoted and skillful worker in the field of organic research and one of her best, most efficient, and most successful teachers in the science of chemistry.

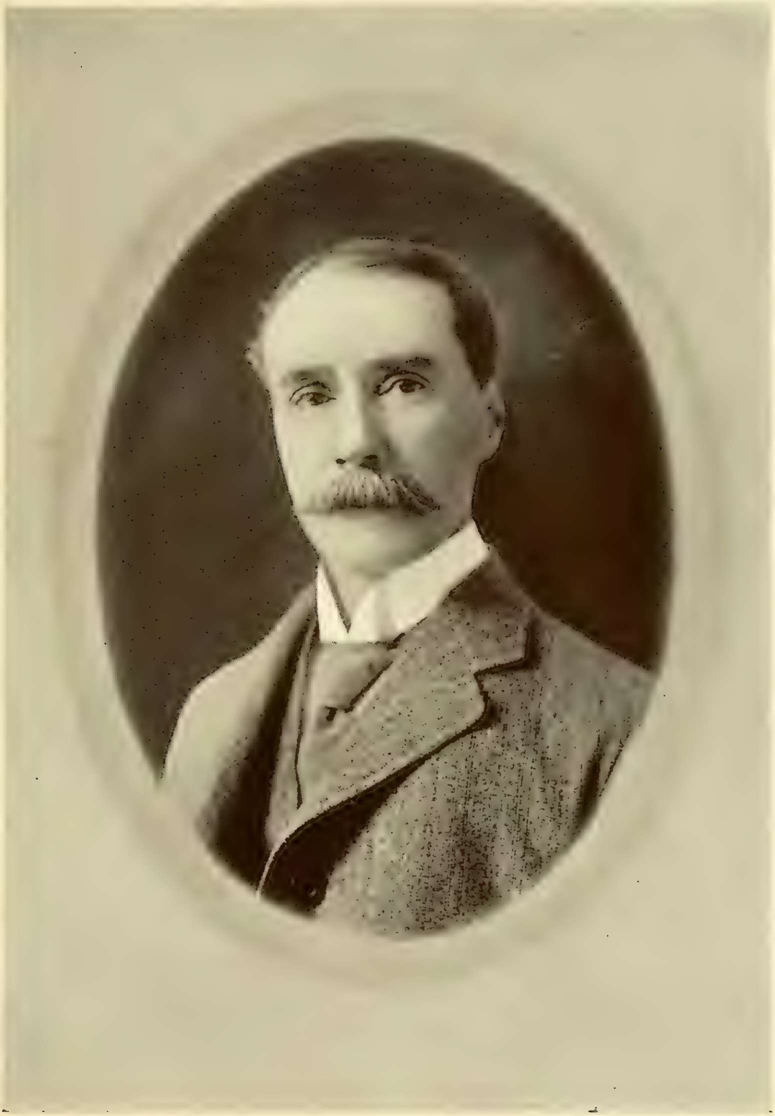
LAWRENCE MORRIS LAMBE

Lawrence Morris Lambe, who was elected a Fellow of the Royal Society of Canada in 1900 and was a life member, died at his residence, Argyle avenue, Ottawa, on March 12, 1919. His death has taken from the Society one who always had a very keen interest in all its activities. He held the office of Secretary of Section IV from 1903 to 1906, and the office of Honorary Treasurer of the Society from 1906 to 1914. After his retirement from that office he was appointed a permanent member of the Council.

Mr. Lambe was Vertebrate Palæontologist of the Geological Survey, and his sudden death has taken from the staff of the Survey one of its best known scientists.

Death, which was due to pneumonia, followed a very brief illness. Mr. Lambe was born in Montreal, the son of Wm. B. Lambe, advocate of Montreal, and Margaret Morris, daughter of the late Hon. Wm. Morris. He was educated at private schools and graduated from the Royal Military College in 1883. Mr. Lambe took a keen interest in military matters and at one time held a commission as lieutenant in the Governor-General's Foot Guards.

The connection of Mr. Lawrence Lambe with the Geological Survey of Canada dates from 1885 when he received his permanent



Lawrence Morris Lambe

appointment. He took up vertebrate palæontology after a rather long training in the study of invertebrate fossils with the late Dr. J. F. Whiteaves. His published papers include, besides contributions to these two branches of palæontology, a number of papers on marine sponges of the present seas. The long list of his contributions to natural history and palæontology, which number nearly 100 titles, shows clearly the breadth of his interests. His best known invertebrate work is, "A Revision of the Genera and Species of Canadian Palæozoic Corals."

Nearly all the papers prepared during the last fifteen years of his life, however, dealt with vertebrate palæontology. In this subject his name stands pre-eminent in Canada. Among the important papers which he prepared in recent years, were those describing the Triassic fishes of the Rocky Mountains. We are also indebted to him for important contributions to our knowledge of the Devonian fishes of New Brunswick.

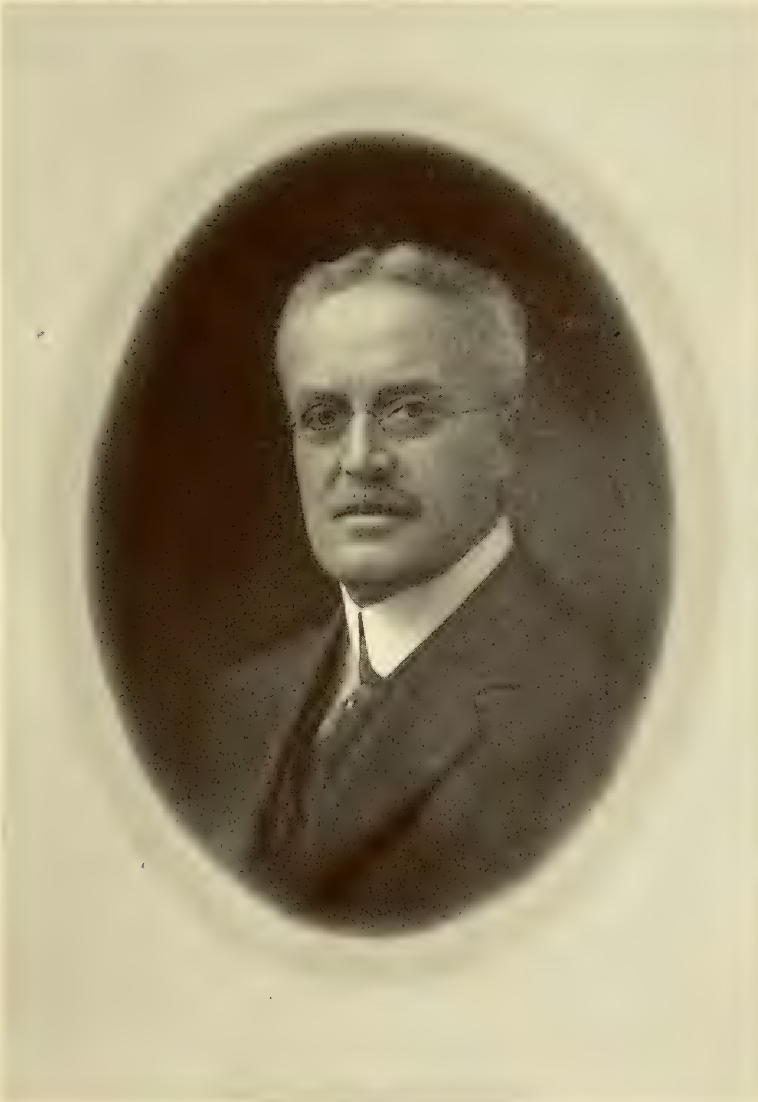
During recent years he had devoted himself chiefly to the study of the remarkable vertebrate fauna of the Red Deer river valley in Alberta, which region is considered by some of the highest authorities to be the richest region for vertebrate fossils in the world. Already he had described some of those enormous and bizarre dinosaurs which are being found in this section of the Canadian Cretaceous and he was engaged on this work at the time of his sudden death. The Transactions for this year will contain some of his unfinished work, including an uncompleted memoir describing a remarkable new genus and species (*Panoplosaurus mirus*) of armed dinosaur from the Belly River deposits of Alberta. His work secured for him an international reputation and he will be remembered as one of a famous band of North American vertebrate palæontologists. Palæontology has lost one of its most ardent students and one who was destined, had he not been struck down in the full vigour of life, to add a wonderful chapter to the history of the development of animal life on this continent.

Mr. Lawrence Lambe belonged to that small group of men who find in their work their greatest pleasure. Palæontological work was to him indeed a labour of love. The little worries of life seemed never to penetrate his optimistic temperament. His friends will long remember the cheery smile and kindly word with which he always greeted them. Mr. Lambe accomplished much toward revealing Canada's early vertebrate life and wherever such knowledge is cherished his death will be deeply regretted.

FRANK FAIRCHILD WESBROOK

The subject of this sketch was the son of H. S. Wesbrook, a well-known citizen of Winnipeg, and of his wife, Helen Marr Fairchild. He was born in 1868, and graduated from the University of Manitoba in 1887. Three years afterwards he took the degree of M.D., C.M. Following a summer course at McGill University he continued his studies at St. Bartholomew's and King's College Hospitals in London. It was his intention to return to Winnipeg and settle in practice, but in the summer of 1891, he crossed to Dublin to undertake the noted maternity course at the Rotunda Hospital, and this changed the whole direction of his life. There he came into contact with E. A. Hawkin, a Fellow of St. John's College, Cambridge, the most brilliant British bacteriologist of his day. Under his leading young Wesbrook had opened up to him the fascinations of research and the possibility of elucidating the problems of disease. As a result he went to Cambridge and remained there for several years, at first working in the Pathological Laboratory. It may be remarked that he was the first Canadian medical student to enter for graduate work in Cambridge, and his welcome there was cordial, as well for his personality as for the pioneer character of his studentship. His friendliness, his frankness, his open appreciation of his surroundings, and his genial, exuberant vitality, attracted every one. For his important research work in the laboratory he was granted a British Medical Association Exhibition, followed in 1894 by the John Lewis Walker Studentship in Pathology of the University, a valuable studentship with more than a thousand dollars a year for three years. With this assistance he spent some months at the Institute of Hygiene and of Pathology in the University of Marburg, studying more particularly the epidemiology of cholera. The chief published outcome of his work there was a study upon destructive effects of direct sunlight upon growths of the cholera and other micro-organisms. The reputation which he gained from this sound work and training led to his being called in 1895 to the Chair of Pathology and Bacteriology in the State University of Minnesota.

With his accustomed energy he threw himself heartily into the work of the Medical Institute, becoming Dean of the Faculty in 1906 and retaining the post until he left the University. He planned and arranged the admirable laboratory and he widened the influence of the University as a servant of the State. As a member of the State Board of Health he was enabled to co-ordinate the efforts of the Government with the scientific equipment of the University, and developed a plan of laboratory diagnosis and supervision of infectious disease which has become the model for other States and indeed for



Frank Fairchild Westbrook

other countries. His valuable services in the realm of public health were recognized by the United States Government, which appointed him a member of the Advisory Board of the Hygienic Laboratory and Public Health Service, by the American Public Health Association which elected him President in 1905, and by his nomination as President of the section upon State and Municipal Hygiene at the International Congress of Hygiene and Demography held at Washington in 1912.

Notwithstanding the influential position which was his in the United States, the call in 1913 to be President of the new University of British Columbia was too attractive to be resisted. He saw the opportunity to direct the establishment of a noble institution along noble lines. When he accepted, everything was full of promise, but almost immediately the financial and labour crisis smote the province and following upon this came the Great War. His strong inclinations were to offer himself for service, where as an expert in epidemic disease and sanitation he could have been of great value. He longed intensely to take his part at the front, but he realized full well that his first duty was with the young university and that by remaining at his post he could give effective assistance by training university men. But the strain told upon him; it manifested itself during the last year by increasing blood pressure and evidences of arteriosclerosis, that bane of those who overdrive their brains. The end came on October 20th, 1918.

There was nothing formal or academic in his personality. He was sane in mind as he was strong in body, as loyal to his principles as to his friends, and there was no more loyal friend. He was one whom men accepted as a leader, because being whole-hearted he inspired trust, such trust as intellectual brilliance alone can never command.

The following resolution passed by the Board of Governors of the University of British Columbia at their first meeting after his death is evidence that he carried into his new position the qualities that had everywhere made him eminent in friendship and science.

"During the too short period of his Presidency, much was accomplished, and though the ideal on which his heart was set is still far from achievement and progress has been delayed by war and other causes, he always met impediments with resolute courage and disappointments with manly fortitude. This Board found him ever resourceful, never sparing of his own strength, or time, or comfort, always passionately devoted to the purpose of making this University one of the great schools of the British Empire and a source of strength and progress to this Province.

"The members of this Board wish to express their feeling of personal bereavement in the loss of a friend and comrade as well as a leader. The genial nature, complete unselfishness, simple sincerity and kindly human sympathy of the late President were revealed in all his personal and official relations."

L'ABBÉ AUGUSTE GOSSELIN

C'est avec un vif regret que la Société royale du Canada a vu disparaître, le 14 août 1918, dans la personne de M. l'abbé Auguste-Honorin Gosselin, docteur ès lettres de l'Université Laval et de l'Université d'Ottawa, l'un de ses membres les plus actifs, les mieux renseignés et les plus assidus.

L'abbé Gosselin faisait partie de notre Société depuis l'année 1892. Il s'intéressait particulièrement à ses travaux, et il lui apportait régulièrement le concours de son talent, la contribution de sa science historique remarquable.

Né le 29 décembre 1843, à Saint-Charles de Bellechasse, de Joseph Gosselin, cultivateur, et de Angèle Labrie, il tenait en quelque sorte du sol canadien lui-même ce patriotisme franc, ce culte de notre passé, de nos traditions et de notre histoire, qui marque tous ses écrits.

Il fit ses études classiques et son cours théologique au Séminaire de Québec où il brilla par ses succès, qui resta toujours le foyer préféré de son intelligence et l'attrait de son cœur, et auquel il ne manqua jamais, dans ses ouvrages, l'occasion de rendre un hommage ému. Ses aptitudes d'écrivain se révélèrent de bonne heure; et en parcourant l'"Abeille" des anciens jours, on trouve parmi les élèves collaborateurs du petit journal Québecquois, qui eut tant de vogue, le nom de Auguste Gosselin.

Après quelques années de probation cléricale et d'études ecclésiastiques, l'abbé Gosselin fut ordonné prêtre, dans sa paroisse natale, le 30 septembre 1866, par Sa Grandeur Mgr Baillargeon. D'abord secrétaire de l'Archevêque de Québec, il fut nommé en 1868, vicaire à la Cathédrale; puis l'année suivante, il prit la direction de la nouvelle paroisse de Sainte-Jeanne de Neuville où il construisit l'église et le presbytère et demeura jusqu'en 1886, époque où il fut transféré à la paroisse de Saint-Ferréol qu'il gouverna pendant sept ans.

Son amour pour l'histoire, pour l'histoire religieuse surtout, l'obsédait depuis longtemps; et c'est au milieu des fonctions absorbantes du ministère qu'il composa son œuvre maîtresse, la *Vie de Mgr de Laval*, en deux forts volumes de 700 pages chacun.

L'Abbé Auguste Gosselin

L'abbé Gosselin avait dès lors conçu le plan général de son histoire des Évêques et de l'Église catholique du Canada à laquelle, dans sa solitude de Saint-Charles où il s'était retiré en 1893, il travailla jusqu'à sa mort, et qu'il eut le regret de laisser inachevée. Tel qu'il est, cet ouvrage d'ensemble comprend sept gros volumes, sans compter une étude préliminaire sur la mission du Canada, une histoire abrégée de Mgr de Laval, et une monographie de Henri de Bernières, à laquelle il faut ajouter celles de Jean Bourdon, de Jean Nicolet et du Docteur Labrie, ainsi que quelques mémoires présentés, en différents temps, à la Société Royale.

Notre collègue collabora pendant plusieurs années à une revue de Normandie qui accueillait avec bonheur ses communications, et se réjouissait de le compter parmi ses meilleurs ouvriers.

Il visita l'Europe à deux reprises. Chercheur actif et observateur averti, il consigna dans un journal assez volumineux les impressions de son premier voyage, et il confia les souvenirs du second à des "Lettres de voyage" qu'il réunit en un seul recueil et publia en 1910.

Sous des manières fort originales et un langage qui, parfois, étonnait par son imprévu, l'abbé Gosselin cachait une intelligence très vive, une érudition étendue et curieuse des moindres détails. On lui reproche même d'avoir déparé quelques pages de ses livres en poussant trop loin, sous prétexte d'exactitude, l'exposé de certains faits dont le récit très circonstancié détonne sous sa plume, sans du reste, rien ajouter à la vérité de l'histoire.

Son style se distingue par la facilité, le naturel, et l'élégance. Il est plus soigné dans les premières publications que dans les plus récentes, lesquelles trahissent une certaine hâte et laissent voir quelques négligences. Clarté dans l'ordonnance des matières, abondance de la documentation, narration vivante, jugements ordinairement sûrs, aperçus judicieux sur notre existence religieuse et nationale, voilà des qualités que nous sommes heureux de reconnaître dans l'œuvre littéraire et historique de l'abbé Gosselin et qui ont fait à l'auteur une réputation très enviable et très méritée.

La postérité saluera en lui, avec gratitude, le premier historien de l'Église du Christ et de l'épiscopat catholique au Canada.

DR. JOHN READE

The subject of this sketch was a charter member of the Society. At his request he had been placed upon the retired list, but he continued to take an active interest in our work, and, in many ways, promoted the welfare of the Society.

He was born at Ballyshannon, County Donegal, on the 13th of November, 1837. He was educated at Queen's College, Belfast, came to Canada in 1856, studied law, then served three years as Rector of Lachute Academy, and officiated from 1864 to 1870 as a clergyman of the Church of England in the Province of Quebec.

In the sixties he became a writer on the staff of the Montreal *Gazette*, and its literary editor in 1879. In that position he spent the rest of his long life. His death occurred peacefully at his residence on the afternoon of the 26th of March, 1919, in his eighty-second year.

Although, by reason of a very delicate constitution, his life was spent in retirement, his vast stores of knowledge, his clear and moving style, and his universal kindness of disposition, brought him a host of friends and several high literary distinctions. He was elected in 1896 a Fellow of the Royal Society of Literature of Great Britain, received the LL.D. from Ottawa University in 1906, was President of the Montreal Branch of the American Folk-Lore Society (of which he was co-founder with Professor Penhallow), of the Society of Canadian Literature, the Canadian Society of Historical Studies, and the English Section of the Royal Society of Canada.

He poured out his accumulations of learning, chiefly in articles contributed to Canadian magazines, and to many learned societies. These articles were on varied subjects; for example: "Some Wabanaki Songs," "Thomas D'Arcy McGee as a Poet," "Exploration before Columbus," "British Canada in the Last Century" (the 18th), "Some Curious Kinships; An Essay in Philology."

He compiled a complete list of early Canadian writers of verse. His leading articles in the *Gazette* on historical subjects were always learned, interesting, wise, and punctiliously correct; and to these he added the delightful antiquarian column, published every Saturday, headed "Old and New," which he signed by the well-known initials "R. V." In 1870 he published the volume entitled "Merlin and Other Poems." The title poem was in the style of Tennyson's "Idylls of the King"; it was composed on the occasion of the visit to Canada of Prince Arthur, afterwards Duke of Connaught. The subject enabled him to treat in prophetic strain of the glories of the Victorian reign, and the future of the New Dominion. The volume contained several more characteristic poems—amongst them the exquisite "Goodnight," and "In My Heart are Many Chambers." His style was refinement itself, and, at his best, no writer could be more sweet and sadly touching.

It is not too much to say that Dr. Reade was looked up to by the whole literary and journalistic world of Canada. He counted among his devoted friends the intellectuals of the Dominion.

John Reade

IV.—The Honorary Advisory Council for Scientific and Industrial Research

The work of the Honorary Advisory Council for Scientific and Industrial Research has suffered during the last year through the operations of the Military Service Act, as a large number of scientific workers became engaged in military work either in Canada or overseas. The Military Service Act even affected the number of those who are awarded studentships and fellowships, as, out of twenty-five of the latter available, only four were awarded at the beginning of the academic year in October last.

The deficiency in the supply of scientific workers caused some of the proposals for scientific research, accepted by the Research Council, to lapse, and some to be suspended. After the armistice was signed, however, many of the scientific workers engaged in military service in Canada were released and, in consequence, some of the projects of the Research Council along scientific lines were taken up, but this occurred too late to overtake the time lost through suspension of the investigations for seven or eight months.

It is expected that for the coming year, with the handicap that the war imposed removed, the work of the Research Council will develop very greatly and a large number of new projects will be taken up which will involve considerable expenditure and the engagement of a large number of research men.

It is hoped, now that peace has come, that the universities will be able to resume their normal life and make extensive provision for scientific research and for the training of the very large contingent of researchers who are necessary to the development of the industries of the country.

The Research Council has urged the establishment of a National Research Institute at, or in the vicinity of, Ottawa. This organization is to be on a modest scale at first, but will grow as the needs of such an institute on a larger scale will develop. The sum of $500,000, it is estimated, will be needed for the building, which will comprehend, at least, fifty laboratory unit rooms, and some fourteen or fifteen rooms for offices, library, and so on, and $100,000 was asked for equipment and another $100,000 for the salaries of the staff of the Institute for the first year.

The recommendation was accepted by the Reconstruction and Development Committee of the Cabinet, but no action has been taken thereon by the Cabinet itself. The matter is now before a parliamentary committee appointed to investigate the development of scientific research in Canada, and on its final recommendation will depend largely the future of industrial and scientific research in the Dominion.

V.—Permanent Quarters for the Society

The opening sentences of this report dealing with the difficulties of making arrangements for the annual meeting simply emphasize the necessity for permanent quarters for the Society. This has never been lost sight of by the Council, and it is the intention to keep the matter before the Government and the Minister of Public Works. The pressing need for increased accommodation for the Archives and for the War Memorials makes the outlook somewhat more hopeful, as it is thought that in some of the projected buildings it should be possible to provide for the Society without incurring any additional expenditure.

VI.—Library of the University of Louvain

Your attention is called to the fact that the Society proposes to take part in the restoration of the library of this historic university. The library is on our exchange list, and it is proposed to present, at the first convenient time, a complete set of the Proceedings and Transactions.

VII.—Tercentenary of the Landing of the Pilgrim Fathers

The year 1920 will mark the cycle of 300 years since the landing of the Pilgrim Fathers at Plymouth. These Colonists laid the foundation of British institutions on this continent and it is thought to be highly fitting that at the next annual meeting special reference should be made to this event. The Council would recommend that the Society should decide upon some way of commemorating this important event in order that contribution may be made to our present cordial relations with the United States.

VIII.—Report of the Honorary Librarian

Accessions to the Library by means of exchanges with the scientific societies have been below normal. European exchanges have been delayed. Shortly after the signing of the armistice, large packages were received from Spain and Italy, and it is expected that many will be received from other countries as shipping facilities improve. During the year about 220 volumes have been received, and of this number 44 were in bindings.

No contract for binding was undertaken this year, although only about one quarter of the library, 2,000 volumes, is thus protected. The continuation of the binding of sets should be given consideration as soon as our finances are adequate, since requests are coming in for the loan of books that are not found in other libraries.

Regulations to govern the lending of books to members and other students should receive the consideration of the Society, as the value of a library is more in its use than its acquisition.

A working card catalogue of about 9,000 entries affords means for finding almost all the books, and is approaching the semi-complete stage to be found in all growing collections.

An effort has been made to get together authors' sets, especially the works of Fellows of our Society. Responses to the invitation to contribute have been prompt in many cases, but a great many have, apparently, forgotten the matter.

The members who have sent donations towards completing these sets are distributed throughout the Society somewhat as follow, Sec. I, 3 members; Sec. II, 13 members; Sec. III, 1 member; Sec. IV, 5 members; Sec. V, 4 members.

For the present year the contributions to these sets include:

Coyne, J. H., 2 volumes. (Talbot Papers.)
Lambe, L. M., 34 pamphlets and 1 volume. (Palæontology.)
Lesueur, W. D., 1 volume. (Count Frontenac.)
Routhier, A. B., 1 volume. (Paulina.)
King, W. L. Mackenzie, 1 volume. (Industry and Humanity.)

From authors not members:

Cay, F. P., 1 pamphlet.
Hall, J. C., 2 pamphlets.
Hopkins, J. C., 1 volume. (Union Government.)
MacKinlay, J. M., 2 volumes. (Church Dedications in Scotland.)
Malchelosse, G., 1 volume. (B. Sulte et son œuvre.)

Extra Accessions and New Publications:

Italian Consul General, 3 illustrated books. (Italian Marine.)
Albano, I., 4 publications. (Rio de Janeiro.)
Argentine Scientific Society.
Writer's Club of Washington.
Journal of Science and Technology. (New Zealand.)
Academy of Sciences, Utah.
Barcelona Museum. (Spain.)
British Bureau of Scientific Research.

IX.—The following is the financial statement of the Honorary Treasurer for the year ending April 30, 1919. The statement includes the Government grant account and the general account and it has been audited by two members of the Society: Dr. Adam Shortt and Dr. J. C. Glashan—who were appointed for that purpose:

FINANCIAL STATEMENT OF THE ROYAL SOCIETY OF CANADA FOR THE YEAR ENDING APRIL 30, 1919.

GOVERNMENT GRANT ACCOUNT

Receipts

By	Balance in Bank of Montreal, May 1, 1918	$ 3,159.80
"	Grant from Dominion Government	4,666.66
"	Bank interest on account	70.70
		$ 7,897.16

Expenditures

To	Printing and publication of *Transactions*	$ 6,334.24
"	Maintenance of library and librarian's salary	732.29
"	Clerical assistance	370.57
"	Insurance	46.00
"	Miscellaneous expenditures	12.00
"	Cheques outstanding on April 30, 1918	60.00
"	Balance in Bank of Montreal, April 30, 1919	347.63
		$ 7,902.73
	Less outstanding cheque	5.57
		$ 7,897.16

GENERAL ACCOUNT

Receipts

By	Balance in Merchants Bank of Canada, May 1, 1919	$ 1,996.00
"	Annual and life subscriptions	1,095.00
"	Sale of transactions	29.37
"	Interest on investments	501.80
"	Bank interest on account	34.30
		$ 3,656.47

Expenditures

To	Railway fares of members	$ 723.91
"	Expenses of Annual Meeting	209.65
"	Miscellaneous expenditures	27.80
"	Balance in Merchants Bank of Canada on April 30, 1919	2,791.08
		$ 3,752.44
	Less outstanding cheques	95.97
		$ 3,656.47

Audited and found correct:

ADAM SHORTT
J. C. GLASHAN } *Auditors*

C. GORDON HEWITT,
Honorary Treasurer.

Ottawa, May 7, 1919.

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

It was moved by Dr. Ernest Myrand, seconded by Dr. Victor Morin, that the election of l'abbé Élie J. Auclair, M. Cyrille F. Delâge and M. Georges Pelletier, as Fellows of Section I, be confirmed.—Carried.

It was moved by Dr. Maurice Hutton, seconded by Mr. Lawrence J. Burpee, that the election of Mr. Walter S. Herrington as a Fellow of Section II, be confirmed.—Carried.

It was moved by Dr. Maurice Hutton, seconded by Mr. Lawrence J. Burpee, that Section 8 of the By-laws be suspended and that Dr. Stephen Leacock, whose Fellowship ceased in 1918 by reason of the operation of the By-law, be re-instated; that Section 6 of the By-laws be suspended and that Professor George Sydney Brett, who obtained a majority of the votes cast in Section II at the recent election, but who could not be reported elected, as two of the ballots were unsigned, be elected a member of the Section.—Carried.

It was moved by Dr. Alfred Baker, seconded by Professor Alfred T. DeLury, that the election of Mr. Matthew A. Parker, as a Fellow of Section III, be confirmed.—Carried.

It was moved by Dr. L. W. Bailey, seconded by Dr. A. P. Coleman, that the election of Dr. William H. Collins, Mr. Robert A. A. Johnston, Dr. Thomas L. Walker, as Fellows of Section IV, be confirmed.—Carried.

It was moved by Dr. J. J. MacKenzie, seconded by Dr. A. H. R. Buller, that the election of Dr. John Cameron and Dr. J. J. R. Macleod, as Fellows of Section V, be confirmed.—Carried.

It was moved by Dr. J. J. MacKenzie, seconded by Dr. J. P. McMurrich, that, upon recommendation from Section V, the By-laws be suspended and Sir Auckland Geddes, Principal of McGill University, Montreal, be elected a Fellow of The Royal Society of Canada as a member of Section V.—Carried.

The following new Fellows who were present were then introduced:—L'abbé Élie-J. Auclair, M. Cyrille-F. Delâge, M. Georges Pelletier, Mr. Walter S. Herrington, Mr. George S. Brett, Dr. W. H. Collins, Dr. Thomas L. Walker, Dr. J. J. R. Macleod. L'abbé Scott, who was not present at the meeting last year, was also introduced.

Reception at Government House

On the afternoon of Tuesday, May 20th, His Excellency the Duke of Devonshire, Honorary Patron of the Society, and the Duchess of Devonshire, entertained the Fellows and Delegates from Associated Societies at a reception at Government House. Tea was served in the ball-room, and as the weather was favourable it was possible to visit the gardens. Their Excellencies received the members of the Society very graciously, and the interest which they showed in the work of the Society was greatly appreciated.

The Presidential Address, Tuesday Evening.

The Presidential Address was delivered on Tuesday evening in the Concert Hall of the Chateau Laurier. The chair was occupied by the Vice-President, Dr. R. F. Ruttan. The President's subject was "Le Canada, la guerre et demain." The address will be found printed in full as Appendix A.

SESSION II.—(*Wednesday Afternoon, May 21.*)

The President took the chair at 2.30 p.m.

It was moved by Dr. J. J. MacKenzie, seconded by Dr. R. F. Ruttan, that the Report of Council be adopted.—Carried.

The reports of the following Associated Societies were then presented:

The Historic Landmarks Association; The Royal Astronomical Society of Canada; Women's Canadian Historical Society of Ottawa: Institut canadien-français; The Elgin Historical and Scientific Institute; Ontario Historical Society; Niagara Historical Society: The Women's Canadian Historical Society of Toronto; Huron Institute; The Literary and Historical Society of Quebec; Natural History Society of Montreal; Antiquarian and Numismatic Society of Montreal; Miramichi Natural History Association; Nova Scotia Historical Society; Nova Scotian Institute of Science, Halifax; New Brunswick Historical Society, St. John; Société historique de Montréal; The Women's Historical Society of St. Thomas.

Dr. John Cameron, the newly elected Fellow in Section V, was then introduced to the Society.

It was moved by Mr. Dresser, seconded by Mr. McInnes, that: Whereas, at a meeting of Section IV held at the Chateau Laurier on Tuesday, May 20, 1919, a proposal for the employment of returned soldiers initiated by the Canadian Mining Institute was discussed; be it resolved, that The Royal Society of Canada endorse, as an emergency measure, the proposal of the Canadian Mining Institute for the employment of mining men who have returned from the front, as outlined in the accompanying memorandum, and that the resolution be brought before a general meeting of the Society for consideration.—Carried.

The Popular Lecture

As announced in the proceedings of last year, the Society received a gift of $250 to be devoted to the delivery of a "Sir John Murray Memorial Lecture" on Marine Scientific Research, or on Life in the Sea, with special reference to Fishery Researches. The donor chose Professor E. E. Prince, LL.D., F.R.S.C., to deliver this address.

On Wednesday evening a large audience assembled in the concert hall of the Chateau Laurier to hear Professor Prince's address. The lecture, which was illustrated with lantern slides and moving pictures, was listened to with much interest by those present.

SESSION III.—(*Thursday Afternoon, May 22.*)

Re Copyright

Moved by M. Rouillard, seconded by Principal Hutton: Resolved, That the attention of The Royal Society should again be drawn to the important subject of Copyright; that reference to the Proceedings of the Society in past years will disclose the fact that the Society has always considered this question most important, and that it is now opportune again to record our view and to urge upon the Government the necessity of placing on the Statute Book a Copyright Act that will give authors adequate protection.—Carried.

It was moved by Mr. Currelly, seconded by Mr. Lighthall, that the members of Section II are of the opinion that the time is opportune for the establishment in selected centres of Canada of a series of Industrial Art Museums, which it would be advisable to combine with Museums of War Material, and that the Council of The Royal Society of Canada be requested to forward to the Dominion Government a petition to this end.—Carried.

REPORTS OF THE SECTIONS

Section I

PROCÈS-VERBAL DE LA SECTION I

Étaient présents: Messieurs E. Rouillard, V. Morin, L.-O. David, R. Lemieux, L. Gérin, A. Fauteux, E. Choquette, E. Auclair, H.-A. Scott, G. Pelletier, B. Sulte, C. Delâge, A.-D. DeCelles, P.-B. Mignault, P. Poirier, E. Myrand et C.-M. Barbeau.

Se sont excusés de leur absence: Messieurs E. Montpetit, H. Garneau, Mgr. L.-A. Paquet, M. l'abbé C. Després. M. Rouillard présidait aux séances.

Travaux lus ou présentés:

(*a*) *Histoire.*

1. Louis Rouer de Villeray, par P.-G. Roy.
2. Jean-Baptiste-Louis Franquelin, par P.-G. Roy.
3. Journal inédit du siège de Québec, par A. Fauteux.
4. Les premiers volontaires au Canada, par G. Lanctôt.
5. Nos évêques d'après leur historien, par Mgr. L.-A. Paquet.
6. Les sœurs de Sainte-Anne, par l'abbé E.-J. Auclair.
7. Jacques Cartier était-il de la noblesse, par Régis Roy.
8. Pierre Ducalvet, par B. Sulte.

(*b*) *Traditions populaires:*

9. Anecdotes du terroir, par Jules Tremblay.
10. Légendes et anecdotes de l'Islet, par J.-E.-A. Cloutier.
11. Carmel, une légende des Cris, par L.-A. Prud'homme.

(*c*) *Études littéraires:*

12. Ménage et ses élèves, par H. Ashton.
13. L'effort littéraire du Canada français, par F. Rinfret.

Travaux acceptés comme lus:

14. Sir Wilfrid Laurier, par R. Lemieux.
15. Le pardon des ajoncs d'or, par l'abbé C. Roy.
16. Les "mi-carêmes," par E. Bilodeau.

Deux séances se tinrent conjointement avec la section II.

L'étude de l'histoire vient au premier rang avec huit essais préparés par cinq membres de la section et deux étrangers. Celle des traditions populaires—une innovation relative, à la Société royale—s'inaugure avec cinq travaux fournis par deux membres de la Section et deux invités. Les études littéraires viennent ensuite avec deux essais contribués par deux étrangers. En tout seize travaux par sept membres de la section et sept étrangers sont remis au comité de lecture pour examen et publication.

Après lecture des anecdotes du terroir, M. Ernest Choquette proteste contre l'introduction de ce genre de travaux à la Société royale, affirmant qu'on ne doit point réhabiliter des choses que les éducateurs cherchent à détruire depuis cinquante ans. M. Marius Barbeau soutient énergiquement la thèse contraire. Plusieurs membres prennent part à la discussion qui n'aboutit à aucune conclusion formelle.

La question de réforme en procédures d'élections des candidats—préparée antérieurement par un questionnaire écrit et communiqué par le secrétaire aux membres—est discutée. On devient d'accord sur la proposition suivante formulée par M. V. Morin et appuyée par M. L.-O. David et M. Ernest Choquette:

"Résolu de créer un comité d'examen des candidatures à la section I, comprenant trois membres élus chaque année, dont le devoir est d'étudier le mérite des candidats et de faire un rapport motivé sur chacun en indiquant ceux qui ont leurs préférences." La commission doit prendre en considération toute candidature à elle proposée par un membre de la section. Elle peut elle-même provoquer des candidatures. Le secrétaire devra préparer des fiches bibliographiques sur les auteurs canadiens. Tout membre doit voter librement pour les candidats de son choix sur la liste officielle."

On remet à plus tard la discussion du projet de modifier le titre de la section I de manière à lui faire comprendre les sciences de langue française et les arts.

Élections des dignitaires pour le prochain exercice:

Président, M. Victor Morin;

Vice-président, M. Ernest Myrand;

Secrétaire, M. Marius Barbeau.

Comité d'examen des candidatures: messieurs Adjutor Rivard, Ægidius Fauteux et Léon Gérin.

Comité de lecture des travaux: messieurs P.-Georges Roy, Ægidius Fauteux et Benjamin Sulte.

Comité de publication: messieurs Sulte et Barbeau.

Représentant au comité général de nomination des dignitaires: messieurs Sulte et Morin.

Résolu de demander au gouvernement de Québec de nommer une commission pour la conservation des monuments historiques de Québec qui, l'un après l'autre, sont détruits, sans qu'on se rende compte de leur valeur.

Résolu de proposer que trois vacances en tout soient établies pour l'élection de candidats au cours du prochain exercice.

Résolu d'exprimer les regrets de la section au sujet de la mort de M. l'abbé Auguste Gosselin, un de nos plus anciens membres, et de demander que des notes biographiques sur lui soient introduites dans nos rapports, comme il est d'usage.

C.-Marius Barbeau,
Secrétaire de la Section I.

On the motion of M. Eugène Rouillard, seconded by M. Victor Morin, the report of Section I was adopted.

REPORT OF SECTION II

Section II held five sessions, on Tuesday, Wednesday and Thursday, at which 19 Fellows were present, as follows:

Messrs. Brett, Burpee, Coyne, Cruikshank, Currelly, Doughty, Edgar, Falconer, Sir Robert, Herrington, Hutton, Leacock, Lighthall, Mavor, McLachlan, Raymond, Riddell, D. C. Scott, Shortt, Skelton.

Twenty-one papers were read, in full, by summary or by title.

Since its last meeting Section II has lost the following members, through death or resignation: Sir Clive Phillipps-Wolley, Mr. John Ross Robertson and Sir William Peterson.

Two Fellows have been added to the membership of the Section, Mr. Walter S. Herrington and Professor George S. Brett. The Section proposes to elect three members next year.

Mr. Charles Hill-Tout having failed to attend meetings of the Society since 1915 forfeits his membership. The Section, nevertheless, decided to retain his name on the active list for another year.

Resolutions were adopted by the Section in favour of the establishment of regional museums, and also urging upon the Government the importance of an adequate Copyright Act.

Dr. Raymond and Judge Riddell were elected to represent the Section on the general Nominating Committee.

The following officers were elected for 1919-20:

President, Principal W. Lawson Grant; Vice-President, Brigadier General E. A. Cruikshank; Secretary, Mr. Lawrence J. Burpee.

The Printing Committee consists of Dr. Adam Shortt, Hon. Mr. Mackenzie King and Mr. L. J. Burpee.

The members of the Advisory Committee on Nominations of the Section are: Dr. Shortt (Chairman), Professor Edgar (Secretary), Dr. Coyne, Mr. Lighthall, Professor MacMechan and Mr. Hill-Tout, with the President and Secretary.

LIST OF PAPERS, SECTION II:

1.—Presidential Address: Humour and Satire. By Maurice Hutton, M.A., LL.D., F.R.S.C.

2.—John Galsworthy, Artist and Prophet. By S. H. Hooke, M.A.

3.—Shakespeare's Treatment of Dramatic Time. By W. J. Alexander, B.A., Ph.D.

4.—The River Gods. By John Macnaughton, M.A., LL.D., F.R.S.C.

5.—Present-day Tendencies in Poetry. By Edward Sapir, Ph.D.

6.—The Coming Canadian Novel. By J. M. Gibbon.

7.—Lord Lovel and Lady Nancy; a Traditional Ballad. By W. J. Wintemberg.

8.—The Revolt Against Reason; a contribution to the history of thought, from 1600 to 1900. By G. S. Brett, M.A.

9.—The Economic Foundations of Society. By R. M. MacIver, M.A.

10.—The Position and Outlook of Political Economy. By Stephen Leacock, B.A., Ph.D., Litt.D.

11.—The Significance for Canadian History of the Work of the Board of Historical Publications. By Adam Shortt, C.M.G., M.A., LL.D., F.R.S.C.

12.—The Slave in Upper Canada. By Hon. William Renwick Riddell, LL.D., F.R.S.C.

13.—The Museum Question in Canada. By Charles T. Currelly, M.A., F.R.G.S., F.R.S.C.

14.—Trench Life in France and Flanders, 1915-1916. Leaves from the Journal of a Canadian Field Officer on the Western Front. By Brig.-General E. A. Cruikshank, LL.D., F.R.S.C.

15.—Legends of Long Point. By James H. Coyne, M.A., LL.D., F.R.S.C.

16.—The Voyage of the *Hope*, 1790-1792. By Judge Frederick W. Howay, LL.B., F.R.S.C.

17.—Some notes on the Minutes of the Town Meetings of the Township of Sidney. By Walter S. Herrington, K.C.

18.—Overland Journey of the Argonauts of 1862. By Judge Frederick W. Howay, LL.B., F.R.S.C.

19.—A Loyalist and a Radical. By Archdeacon W. O. Raymond, LL.D., F.R.S.C.

20.—A Contemporary Account of the Navy Island Episode, 1837. By Hon. William Renwick Riddell, LL.D., F.R.S.C.

21.—The Blackstones in Canada. By Hon. William Renwick Riddell, LL.D., F.R.S.C.

LAWRENCE J. BURPEE,
Secretary.

On the motion of Dr. Maurice Hutton, seconded by Mr. Lawrence J. Burpee, the report of Section II was adopted.

REPORT OF SECTION III

Five sessions of the Section were held, all of which were well attended by Fellows and others interested in the programme.

The attendance of Fellows was satisfactory, but not as large as had been anticipated, several members who had expected to be present writing at the last minute that they were unavoidedly prevented from coming to Ottawa for the meeting. Those present at the sessions were as follows: Messrs. Baker, Burton, Bell, Dawson, DeLury, Deville, Eve, Fields, Glashan, Johnson, King, Klotz, Lang, MacKenzie, McIntosh, McLennan, Plaskett, Ruttan, Satterly, Shutt, Stansfield.

A noted visitor and scientist, in Professor Dayton C. Miller, D.Sc., of the Case School of Applied Science, Cleveland, Ohio, was present by invitation, and gave an illustrated address on his investigations into the nature, pressure, velocity and form of air waves from the discharge of large guns at the proving grounds at Sandy Hook, U.S.A., in connection with the study of shell shock.

The programme was of unusual interest and importance. Fifty-one papers were read in full or in abstract, a large number of which dealt with researches carried out in England and Canada for the British Admiralty, in relation to anti-submarine warfare and kindred subjects by Fellows of the Section and their co-workers. The discussions following the papers were exceptionally interesting and valuable. A list of the titles, with authors, is appended.

The election of Officers for the ensuing year resulted as follows: President, Dr. A. S. Eve; Vice-President, Dr. J. C. Fields; Secretary, Dr. Frank T. Shutt.

The Committee appointed to urge upon the Government the establishment of a Dominion Laboratory for Scientific Measurements, etc., reported that reports had been received from several scientific societies, but that these had not yet been collated.

The following resolutions were carried by the Section:

That Dr. Burton and Dr. Shutt be appointed the Printing Committee for the ensuing year.

That Dr. Eve, Dr. Klotz, Dr. King, Dr. Ruttan and Dr. Burton be appointed the Editorial Committee for the ensuing year. All papers presented to the Section to be submitted to this Committee.

That in the opinion of Section III, it is desirable, in the interest of efficient publication of its papers, the printing of such papers should be entirely in the hands of the Editorial Committee of the Section. And the Section hereby requests that the proportional share of the annual grant for printing be allocated by the Council to the Section.

That there be appointed at each annual meeting a Committee on Membership, whose duties shall be to investigate the qualifications of candidates nominated for election into Section III of the Royal Society, to report thereon to the Secretary, and, in a communication addressed to all the members of the Section, a recommendation of such candidates shall be made as are most likely to advance the best interest of the Section. The Committee for the ensuing year to be Professor McLennan, Professor Fields, Dr. King, Dr. Shutt and Dr. Plaskett.

That the name of Dr. Howard T. Barnes be placed on the retired list.

That all vacancies in the Section occurring throughout the year be filled in the usual manner at the April elections.

The President expressed the deep sense of regret of the Section on the loss sustained by the death of Professor J. Bishop Tingle, an authority and able research worker in the field of organic chemistry.

List of Papers Read in Section III

1.—Presidential Address. Some Outstanding Problems of Modern Physics. By Louis Vessot King, D.Sc., F.R.S.C.

2.—Algebraic Analysis associated with the Expansions known in the Theory of Bessel's Functions as Kapteyn Series. By Professor J. Harkness, F.R.S.C.

3.—Use of Analogy in Vector Analysis. By Professor Alfred Baker, LL.D., F.R.S.C.

4.—On a Derivation of Jamet's Equation of a Ruled Surface from the Equations of Gauss. By Charles T. Sullivan, Ph.D., D.Sc., F.R.S.C.

5.—Vacuum-grating Spectra of Certain Elements. By Professor J. C. McLennan, O.B.E., F.R.S. and H. J. C. Ireton, M.A.

6.—Studies in Ultraviolet Spectra with a Fluorite Spectograph. By Professor J. C. McLennan, O.B.E., F.R.S., and J. F. T. Young, M.A.

7.—On the Helium Content of the Natural Gases of Canada. By Professor J. C. McLennan, O.B.E., F.R.S., and Professors E. F. Burton, John Satterly and H. F. Dawes.

8.—On the Use of a Jamin Interferometer for Estimations of Helium when mixed with Air. By Professor J. C. McLennan, O.B.E., F.R.S. and R. T. Elworthy, B.Sc.

9.—On a Continuous Flow Method of Purifying Helium by the Use of Charcoal. By R. T. Elworthy, B.Sc., and Evan Edwards, M.A.

10.—On the Estimation of the Helium Content of Mixtures of Gases by the Use of a Katharometer. By V. F. Murray, M.A., B.Sc.

11.—On Permeability of Balloon Fabrics for Hydrogen or Helium. By V. F. Murray, M.A., B.Sc., and R. T. Elworthy, B.Sc.

12.—Composition of Vapour and Liquid Phases of Mixtures of Nitrogen and Methane. By H. A. McTaggart, M.A., and Evan Edwards, M.A.

13.—On the Optical Transparency of Certain Samples of Fluorite. By J. F. T. Young, M.A., and H. J. C. Ireton, M.A.

14.—Experiments on Acoustic Depth Sounding carried out in the Gulf of St. Lawrence, September, 1915. By Louis V. King, D.Sc., F.R.S.C.

15.—On the Theory and Design of Electrically Operated Aerial and Submarine Sound Generators and Receivers. By Louis V. King, D.Sc., F.R.S.C., McGill University.

16.—On the Design of Continuously Tunable Diaphragms. By Louis Vessot King, D.Sc., F.R.S.C., McGill University.

17.—Measurements of Temperature Gradients in Air Contained between Parallel Planes Maintained at Different Temperatures. By G. H. Henderson, M.A.

18.—The Variation of the Coefficient of Viscosity of Gases with Temperature. By Robert Clark.

19.—The Velocity of Sound and the Ratio of the Specific Heats. By T. C. Hebb.

20.—A New Method for the Determination of the Size of the Colloidal Particles. By Professor E. F. Burton, F.R.S.C.

21.—The Absorption of Gases by Carbonized Lignite. By Stewart McLean, M.A.

22.—Determination of the Density of Absorbing Substances. By Stewart McLean, M.A.

23.—Light Absorption by Crude Rubber. By R. C. Dearle, Ph.D. and E. R. I. Pratt, B.A.

24.—Elastic Constants of Calendered Crude Rubber. By H. A. Braendle, B.A.

25.—The Performance and Work of the 72-inch Telescope. By J. S. Plaskett, D.Sc., F.R.S.C.

26.—Tests of the Figure of the 72-inch Mirror. By J. S. Plaskett, D.Sc., F.R.S.C.

27.—The Spectroscopic Binary and Eclipsing Variable, U Ophiuchi. By J. S. Plaskett, D.Sc., F.R.S.C.

28.—The Spectroscopic Orbit of 1 Geminorum. By Reynold K. Young, Ph.D.

29.—The Correction Factor of the Canadian Standard Anemometer and the Most Probable Maximum Velocity and the Possible Extreme Velocity in Gusts. By J. Patterson, M.A., F.R.S.C.

30.—The Study of the Advance of the Ripple in Front of an ascending Column of Liquid. By J. C. Thompson, B.A.

31.—On the Production and Purification of Helium from Natural Gas. By John Satterly, F.R.S.C., John Patterson, F.R.S.C., E. F. Burton, F.R.S.C., and H. F. Dawes, Ph.D.

32.—On the Combustibility of Mixtures of Hydrogen and Helium. By John Satterly, F.R.S.C., and E. F. Burton, F.R.S.C.

33.—On the Latent Heats of Methane and Ethane. By John Satterly, F.R.S.C., and John Patterson, F.R.S.C.

34.—On a Curious Effect Observed when Nitrogen is Dissolved in the Condensate obtained at Liquid Air Temperature from Natural Gas. By John Satterly, F.R.S.C.

35.—The Analysis of Simple Periodic Curves by a Projection Method, with special Reference to Tidal Problems. By A. Norman Shaw, D.Sc., and Violet Henry, M.Sc., with an introduction by Dr. W. Bell Dawson, Superintendent of Tidal Surveys.

36.—The Mutual Potential Energy of Small Magnets and Circular Coils. By A. Norman Shaw, D.Sc.

37.—The Electrical Conductivity of Concentrated Solutions of Highly Deliquescent Salts. By A. Norman Shaw, D.Sc., and M. E. Wheeler, M.Sc.

38.—The Effects of Ageing in Standard Weston Cells of a Modified Type. By A. Norman Shaw, D.Sc., H. E. Reilley, M.Sc.

39.—The Synthesis of β—Palmitodistearin and β—Stearodipalmitin. By George Stafford Whitby.

40.—Note on the Preparation of the Silver Salts of the Fatty Acids and their Behaviour towards Ammonia. By George Stafford Whitby.

41.—Anhydrous Hydrogen Peroxide. By O. Maass and W. Hatcher.

42.—The Hydrate of an Oxonium Compound. By O. Maass and J. Russel.

43.—Apparatus to Control Supercooling in Molecular Weight Determinations by the Freezing Point Method. By O. Maass.

44.—The Estimation of Sulphates in a Concentrated Electrolyte and the Determination of Sulphur in Foods. By V. K. Krieble, Ph.D., and A. W. Maugaum.

45.—The Analysis of Maple Products. Paper II. Our Present Knowledge of the Composition of the Products of Maple Sap. By J. F. Snell, Ph.D.

46.—The "Alkali" Contents of Soils as Related to Crop Growth. By Dr. Frank T. Shutt, F.R.S.C., and E.A. Smith, M.A.

47.—Possible Economies in the Electric Smelting of Iron Ore. By Dr. Alfred Stansfield, F.R.S.C.

48.—The Hydrolytic Decomposition of Platinum Salts. 1. The Hydrolysis of Potassium Chloroplatinate. By E. H. Archibald, Ph.D., F.R.S.C.

49.—The Estimation of Iron and the Separation of Iron from Manganese by means of Nitrosophenylhydroxylamine Ammonium (Cupferron). By E. H. Archibald, Ph.D., F.R.S.C., and Ruth V. Fulton.

50.—The Atomic Weight of Carbon. By Dr. D. McIntosh, F.R.S.C.

51.—Crystallization from Supersaturated Solutions and Supercooled Liquids. By Dr. D. McIntosh, F.R.S.C.

FRANK T. SHUTT,
Secretary.

On the motion of Dr. Shutt, seconded by Dr. L. V. King, the report of Section III was adopted.

REPORT OF SECTION IV

Section IV begs to submit the following report:

Four sessions of the Section were held, at which thirteen members were present: Dr. L. W. Bailey, President; Mr. J. A. Dresser, Vice-President; Mr. William McInnes, Secretary; Dr. H. M. Ami, Dr. A. P. Coleman, Dr. W. H. Collins, Mr. D. B. Dowling, Mr. E. R. Faribault, Mr. R. G. McConnell, Dr. W. A. Parks, Mr. J. B. Tyrrell, Mr. T. L. Walker, Mr. James White.

Two members of the Section, Dr. F. D. Adams and Dr. R. W. Brock, are absent on overseas service.

The following new members were elected during the year: Dr. W. H. Collins, Mr. R. A. A. Johnston, Mr. T. L. Walker.

The officers and committees elected for the coming year were: President, Mr. J. A. Dresser; Vice-President, Dr. H. M. Ami; Secretary, Mr. William McInnes.

Committee on Nominations: Mr. J. A. Dresser (for 2 years), Mr. William McInnes (for 1 year).

Committee on Printing: Mr. E. R. Faribault, Mr. James White, Mr. William McInnes. The two last named to act with the General Committee.

The following members were elected to act with the Council in the selection of candidates for membership, in accordance with the provisions of Section 6 of the By-laws: Mr. R. G. McConnell, Mr. J. B. Tyrrell and Mr. James White.

There are six vacancies in the membership, and it was resolved by the Section that four new members be elected next year.

The following resolutions were adopted by the Section:

That the Section endorse, as an emergency measure, the proposal of the Canadian Mining Institute for the employment of mining men who have returned from overseas; and that this resolution be laid before the general meeting of the Society for consideration.

That By-law No. 6 be amended by cancelling the special provisions respecting elections to Section IV, and that the provisions in the By-laws in respect to elections that apply to Sections I, II and III, be made applicable to Section IV also.

The following papers were read at the sessions of the Section:

1.—Presidential Address: The Palæogeography of Acadia. By L. W. Bailey, LL.D., F.R.S.C.

2.—The Glacial History of Prince Edward Island and the Magdalen Islands. By A. P. Coleman, M.A., Ph.D., F.R.S.C.

3.—The Delta of the Little River Group and Its Peculiarities. By G. F. Matthew, D.Sc., F.R.S.C.

4.—The Origin of the Purcell Trench, British Columbia (Kootenay Lake Valley). By S. J. Schofield, M.A., B.Sc., Ph.D.

5.—Description of a New Genus and Species (Panoplosaurus mirus) of Armoured Dinosaur from the Belly River Beds of Alberta. By L. M. Lambe, F.G.S., F.R.S.C.

6.—Preliminary Description of a New Species of Trachodont Dinosaur from the Belly River Formation of Alberta. By W. A. Parks, B.A., Ph.D., F.R.S.C.

7.—Extensions of the Monteregian Petrographical Province to the West and Northwest. By J. Stansfield, B.A., M.Sc.

8.—The Problem of the "Burn-out" District of Southern Saskatchewan. By. J. Stansfield, B.A., M.Sc.

9.—Two Plant Associations from Areas near Radville, Sask. By Carrie M. Derick, M.A.

10.—A Method for Sketching Crystals with Steeply Sloping Faces. By Eugene Poitevin, B.Sc.

Respectfully submitted,

WILLIAM McINNES,
Secretary.

On the motion of Mr. William McInnes, seconded by Mr. John A. Dresser, the report of Section IV was adopted.

REPORT OF SECTION V

Section V held four regular sessions and one special session.

The following Fellows were present:—Sir James Grant, Professor Macallum, Professor McMurrich, Professor Macleod, Professor Hunter, Professor MacKenzie, Dr. Hewitt, Professor Buller, Dr. Mackay, Professor Prince, Professor Cameron, Professor Moore, Professor Faull, Dr. Huntsman, Canon Huard, Dr. McPhedran and Professor Willey.

In the absence of the Chairman of the Section, Principal Harrison, the Vice-Chairman, Dr. Faull, occupied the chair.

Professor McMurrich and Professor Buller were elected representatives of the Section upon the General Nominating Committee, Professor McMurrich to act for two years, Professor Buller for one year.

Dr. Hewitt, Professor Prince and Dr. Macallum were appointed the Sectional Printing Committee, Dr. Hewitt and Professor Prince to act upon the General Printing Committee.

It was recommended that Sir Thomas Roddick, who has been absent through illness, be retained in the Section for one year.

Dr. Macallum and Principal Harrison were nominated to act with the Council in the election of new Fellows to the Section.

The only Fellow of Section V who is still on active service is Professor Adami.

Three new Fellows were elected to the Section, Professor Macleod and Professor Cameron in the regular course, Sir Auckland Geddes upon a special request from the Section under a suspension of the regular by-laws.

The officers for the ensuing year are as follows: President, Dr. J. H. Faull; Vice-President, Professor A. P. Knight; Secretary, Professor J. J. MacKenzie.

It is recommended to Council that two new Fellows be elected to the Section next year.

Thirty-two papers were read at the sectional meeting, as follows:

1.—Presidential Address: Dairy Bacteriology and its Earlier Investigators. By Dr. F. C. Harrison, B.S.A., D.Sc., F.R.S.C.

2.—(I) The Reality of Nerve Energy. By D. Fraser Harris, M.D., D.Sc., F.R.S.C.

3.—(II) On Functional Inertia and Functional Momentum. By D. Fraser Harris, M.D., D.Sc., F.R.S.C.

4.—West Coast Exploration. By Arthur Willey, D.Sc., F.R.S., F.R.S.C.

5.—Comparative Studies of Purine Metabolism in Various Representative Mammals. By Andrew Hunter, F.R.S.C., and F. W. Ward, B.A.

6.—A Report on the Infestation of Grain Supplies. By C. Gordon Hewitt, D.Sc., F.R.S.C.

7.—The Naso-orbito-prosthionic Index. A New Craniometric Method and What it Discloses. By John Cameron, M.D., D.Sc., F.R.S.E.

8.—(1) A Study of Marine Bacteria in the Straits of Georgia, B.C. By Cyril Berkeley, late Government Bacteriologist, India.

9.—(2) Some Apparent Effects of the Severe Weather of the Winter and Spring (1915-16) on the Marine Organisms in the Vicinity of Departure Bay, B.C. By Dr. C. McLean Fraser, F.R.S.C.

10.—(3) The Lump-fish, Its Natural History and Economic Importance. By Professor Cox and Miss Marian Anderson.

11.—(4) The Utilization of Dog-fish and Selachian Fishes of Eastern Canada. By Professor J. W. Mavor.

12.—(5) The Sea-Mussel and a Discussion of its Commercial Value. By Miss Bessie K. C. Mossop.

13.—(6) The Growth Rate in Pacific Salmon, Parts I and II. By Dr. C. McLean Fraser, F.R.S.C.

14.—(7) Copepods Parasitic on Fish from Vancouver Island Region, B.C. By Dr. C. McLean Fraser, F.R.S.C.

15.—(8) Some Fishes of Vancouver Island. By Dr. Barton A. Bean and A. C. Weed.

16.—(9) The Ovum of the Hag-fish (Myxine). By Professor E. E. Prince, F.R.S.C.

17.—The Distribution of Canadian Diatoms. I. By L. W. Bailey, LL.D., F.R.S.C., and A. H. Mackay, LL.D., F.R.S.C.

18.—The Behaviour of the Respiratory Centre and the Acid-Base Equilibrium in Decerebrate Animals. By J. J. R. Macleod, M.B., Ch.B. (Aber.), D.P.H. (Cantab.)

19.—1. The Muscular System of *Gryllus Pennsylvanicus* Burm. By E. Melville Du Porte, M.Sc.

20.—Studies on Timber-Destroying Fungi. By J. H. Faull, F.R.S.C.

21.—Development of the Geoglossaceae. By G. H. Duff, M.A.

22.—The Parasitism of *Fomes Applanatus*. By J. H. White, M.A., B.Sc.F.

23.—Recherches biométriques sur le *Bartonia virginica L.*, par le Frère Marie-Victorin.

24.—The Function of the Chromaphil Tissues. Preliminary Communication. By Swale Vincent, M.D., D.Sc., F.R.S.C., and I. Pearlman.

25.—Observations on Vase-Motor Reflexes. Preliminary Communication. By Swale Vincent, M.D., D.Sc., F.R.S.C., and Daizo Ogata.

26.—Les réactions humorales de l'organisme contre l'infection et l'intoxication, par le Dr Albert LeSage.

27.—The Function of the Subsporangial Swelling of the Sporangiophore of Pilobolus. By Professor A. H. Reginald Buller, F.R.S.C.

28.—Note on the Diatonic and Tempered Musical Scales. By Swale Vincent, M.D., D.Sc., F.R.S.C.

29.—Osmotic Properties and Conditions of Certain Plant Cells at Low Temperatures. By Francis J. Lewis, D.Sc., F.R.S.C., F.L.S., and Gwynethe M. Tuttle, M.Sc.

30.—A Further Note on the Bacteriology of Swelled Canned Sardines. By Wilfrid Sadler, M.Sc., and Irene Mounce, B.A.

31.—An Egg of Struthiolithus chersonensis Brandt. By B. A. Bensley, Ph.D., F.R.S.C.

32.—The Inheritance of Earliness and Lateness in Wheat. By W. P. Thompson, Ph.D.

All of which is respectfully submitted.

John J. MacKenzie,
Secretary.

On the motion of Professor J. J. MacKenzie, seconded by Dr. C. Gordon Hewitt, the report of Section V was adopted.

The report of the nominating committee was then presented by Mr. McInnes. The following nominations were made:—President, Dr. R. F. Ruttan; Vice-President, Dr. A. P. Coleman; Honorary Secretary, Mr. Duncan C. Scott; Honorary Treasurer, Dr. C. Gordon Hewitt; Honorary Librarian, Mr. D. B. Dowling.

It was moved by Mr. McInnes, seconded by Hon. Mr. Justice Riddell, that the report of the Nominating Committee be received and adopted.—Carried.

It was moved by Mr. Burpee, seconded by Dr. Currelly, that the following Fellows be appointed Auditors for the year 1919-20: Dr. Adam Shortt and Dr. J. C. Glashan.—Carried.

It was moved by Dr. Victor Morin, seconded by Mr. R. W. McLachlan, that the following Fellows constitute the General Printing Committee of the Society for the year: Dr. Sulte, Mr. Barbeau, Mr. Burpee, Mr. Scott, Dr. Shutt, Dr. Burton, Mr. Dowling, Mr. McInnes, Dr. Hewitt and Dr. Prince.—Carried.

Mr. Lemieux, the retiring President, suggested that the Society should place on record its appreciation of the hospitality extended by His Excellency the Duke of Devonshire to the Society at their Annual Meeting, and of the honour which he showed the Society by his attendance at the Presidential Address.

It was moved by Mr. J. A. Dresser, seconded by Dr. A. S. MacKenzie, that the thanks of this meeting be presented to the officers of the Society and the members of the Council for their very efficient services during the past year.—Carried.

The meeting was then declared adjourned by the newly elected President, Dr. R. F. Ruttan.

APPENDIX A

PRESIDENTIAL ADDRESS

LE CANADA, LA GUERRE ET DEMAIN

BY

Honourable RODOLPHE LEMIEUX, LL.D, F.R.S.C.

Nous voici de nouveau réunis, à l'heure solennelle où, dans le palais de Versailles, s'écrit la page la plus mémorable des fastes de l'humanité. Le Canada, dont l'effort glorieux au cours de la sanglante tragédie, a dépassé toutes les prévisions, méritait de figurer à ce congrès des peuples et ses représentants officiels ont eu raison d'y réclamer leur place. Hier encore, à peine connu des chancelleries, notre jeune pays entre de plein pied dans la grande histoire.

Voilà, certes, un fait et une date que notre Société royale ne devait pas ignorer. Voilà un événement qui impose une tâche redoutable à celui que vos bienveillants suffrages ont appelé à la présidence de 1919.

MESDAMES ET MESSIEURS, je ne crois pas exagérer quand je dis que pendant plusieurs générations successives on ne cessera d'évoquer le souvenir de l'épouvantable guerre qui a bouleversé trois mondes à la fois: l'Europe, l'Asie et l'Afrique; le souvenir de ces quatre terribles années—bien autrement terribles que celle d'il y a quarante-huit ans—hantera pendant des siècles la mémoire de nos descendants, et plus les années se succéderont, moins on réussira à comprendre qu'une nation chrétienne de nom, moderne entre toutes par ses progrès dans toutes les sciences, que cette nation considérée, quoique bien gratuitement, comme un des plus fermes appuis de l'ordre social, a pu à ce point s'abandonner à ses instincts brutaux, rapaces et sauvages que de déclarer une guerre ouverte à la civilisation chrétienne et de perpétrer de sang froid des atrocités et des infamies qui ont dépassé en cruauté tout ce que l'humanité avait encore vu et souffert depuis qu'il y a une civilisation digne de ce nom. Car, ce qu'il y a eu de plus rare et de plus inouï dans cette avalanche de forfaits, commis par les puissances germaniques et leurs alliées de Turquie et de Bulgarie, c'est qu'ils avaient été non seulement annoncés publiquement, recommandés expressément en des traités militaires classiques, mais encore codifiés, expliqués, justifiés, savamment inculqués d'avance aux armées qui toutes, au jour fixé, en emportèrent par millions d'exemplaires le catalogue complet avec notes détaillées et graphiquement expliquées. Ce fut donc, à la lettre, la science mise au service du crime élevé au rang d'un devoir patriotique. Il faut par conséquent admettre que les Germains du vingtième siècle se sont efforcés de dépasser en barbarie leurs ancètres, les Huns du cinquième siècle de notre ère. Il faut bien croire, Mesdames et Messieurs, que la guerre, comme certains fléaux de la nature, comporte des compensations qui, sans en rendre les ravages moins longs et ruineux, souvent même impossibles à réparer, servent cependant indirectement et en dernière analyse la cause de la civilisation et de la liberté, soit qu'elle jette par force les peuples et leur histoire sur d'autres routes d'un meilleur avenir, soit qu'elle ouvre enfin les yeux de ces nations sur les périls intérieurs et extérieurs qu'elles ne voyaient pas, et sur la fausse sécurité où elles s'endormaient sans se douter de ce que serait leur réveil. Il faut bien qu'il en soit ainsi, puisque la guerre a trouvé des apologistes sérieux, convaincus, très informés, même éloquents chez deux ou trois grands écrivains, tels que Joseph de Maistre, Proud'hon et Victor Cousin. Mais ce n'est pas à discuter cette thèse que je vous convie, elle nous entraînerait trop loin. C'est à d'autres considérations que je désire m'appliquer rapidement avec vous. Cette guerre de quatre longues années est riche, en effet, en leçons dont le monde pourra faire son profit, s'il veut seulement s'en donner la peine. C'en est une, à la fois dure et éloquente que l'Histoire vient une fois de plus de donner à cette séculaire institution qui s'appelle le régime monarchique, la Royauté. Quelle est douc cette étrange fatalité, qui pousse les institutions humaines, même les plus considérables, à creuser leur propre tombe, à s'y précipiter à l'aveugle, à force de présomption ? Ce fut là le sort de la monarchie française qui, au dire de ses adversaires, lassa par son absolutisme la patience d'un peuple qui ne demandait cependant qu'à être fidèle à ce pouvoir royal auquel il devait son unité territoriale et politique, en même temps que son prestige souverain dans le monde. Et cette même fatalité ne fit-elle pas surgir Cromwell en Angleterre, où le sort tragique de Charles I et celui moins sanglant de Jacques II auraient dû, semble-t-il, servir d'avertissement ? Heureusement pour elle, la nation anglaise, devenue maîtresse de ses destinées, sut très sagement rentrer dans la tradition royale et garder chez elle un régime où l'ordre s'harmonise dans la liberté.

Voïci que cette fois, l'Allemagne s'abîme honteusement, croulant sous ses propres crimes et ses iniques violations du droit des gens. A Berlin, à Vienne, à Munich, comme à St-Pétersbourg, c'est un régime arrogant, hautain, ambitieux, d'un absolutisme sans frein qui vient de sombrer ignominieusement dans un désastre qui paraît aujourd'hui sans remède. Et comment ne pas remarquer que l'impérialisme allemand est aujourd'hui, comme il y a six siècles et demi, la victime de ce même rêve insensé de monarchie universelle, héritage fatal que les Césars romains ont légué d'abord à l'Allemagne du moyen âge, puis à l'Autriche-Espagne de Charles-Quint et de Philippe II, ensuite à la France de Napoléon I qui s'appelait en 1804 le successeur de Charlemagne, et enfin, encore une fois, à l'Allemagne de nos jours.

Cette leçon que vient de donner au monde une épouvantable guerre n'est pas la seule, il s'en faut; il y en a une autre, peut-être encore plus salutaire et d'un usage à coup sûr, plus général que la précédente. C'est une leçon que la sagesse populaire a depuis longtemps résumée dans une sentence bien connue qui dit que "*L'homme s'agite mais Dieu le mène,*" par quoi il faut entendre que les desseins et les entreprises que forment les chefs des nations aboutissent la plupart du temps non point aux fins qu'ils s'étaient proposées, mais à des résultats entièrement différents, souvent même absolument opposés et contraires.

Un ou deux exemples illustreront suffisamment cette vérité. Lorsque, par le traité d'Amiens, en mars 1802, Bonaparte assurait à la France la rive gauche du Rhin, il permettait aux princes allemands de se dédommager en prenant aux princes-évèques leurs territoires ecclésiastiques; par la sécularisation de ces territoires et par d'autres bouleversements simultanés du même genre, il arriva que le nombre des États d'empire fixé par la traité de Westphalie à 343, fut ramené, en 1802, à moins de 150. C'était évidemment faciliter l'unification future de toute l'Allemagne et préparer l'état de choses que M. de Bismarck se chargea plus tard de consommer. Bonaparte avait donc travaillé pour le roi de Prusse et préparé cette unité germanique qui a failli anéantir la France.

Louis XIV, cent dix-sept ans plus tôt en 1685, avait été encore plus mal inspiré. Sans doute il se flattait de travailler à l'unification religieuse de la France en révoquant l'édit célèbre que son grand-père Henri IV avait promulgué quatre-vingt-sept ans auparavant et que le cardinal Richelieu, ce grand Français, avait maintenu, disant dès 1617: "La diversité de religion peut bien créer de la division en l'autre monde, mais non en celui-ci." Son successeur, le cardinal de Mazarin, pensait de même et suivit la même politique. Aussi, loin de rendre service à son royaume, le Roi soleil l'affaiblit considérablement par la révocation de l'édit de 1598 et la perte qu'elle entraîna de 200 mille familles d'industriels, de commerçants, de marins et de soldats qui émigrèrent et allèrent enrichir le Brandebourg, la Prusse, la Hollande et l'Angleterre. La politique de Louis XIV avait manifestement fait fausse route.

Et voici, maintenant qu'un empereur d'Allemagne, Guillaume II, croyant faire la conquête du monde en annihilant d'abord la France et l'Angleterre, pour asservir ensuite le reste des nations européennes, a fait tout juste le contraire: il a perdu sa couronne, ruiné son empire, rendu à la France un prestige immense dans le monde entier, livré à l'Angleterre un commerce des plus vastes et fourni à la diplomatie européenne et américaine l'occasion de convier à la liberté des nations tenues depuis des siècles sous le joug odieux de la tyrannie allemande, autrichienne, hongroise, russe et ottomane. L'ex-empereur se rend compte, à son tour, que l'homme a beau s'agiter, c'est Dieu qui le mène! Tel est, en effet, le résultat le plus clair de cette immense liquidation politique et sociale à laquelle nous assistons et qui demande que nous nous y arrêtions un moment. Dans cette liquidation qu'on peut bien appeler colossale, ne faut-il pas mettre au tout premier plan, cette coïncidence extraordinaire qui fait que, par l'effondrement et sous les ruines de trois empires, fruits d'un odieux esprit de conquête et d'un despotisme sans entrailles, on voit renaître aujourd'hui à la liberté des nationalités trop longtemps subjuguées, violentées dans leurs corps et leurs âmes. Sans doute la malheureuse Pologne ne retrouve pas ses limites d'avant 1772, encore moins celles du temps où elles s'étendaient de la Belgique à la mer Noire; elle retrouve cependant des frontières naturelles et historiques. La Bohême recouvre, elle aussi, son autonomie, renoue la chaîne des temps et rejoint ainsi par dessus des siècles la glorieuse époque d'il y a près de sept cents ans, alors que son roi était l'un des plus puissants souverains de la chrétienté. Et que dire de cet empire ottoman, l'opprobre et le fléau de l'Europe depuis cinq siècles! Que de fois depuis cent cinquante ans il a déjoué les projets de réformes promises cependant à ces gouvernements anglais et français qui croyaient leurs pays intéressés au maintien du Turc sur le Bosphore. "Je ne discute pas, disait Lord Chatham, avec quiconque me dit que le maintien de l'empire ottoman n'est pas pour l'Angleterre une question de vie ou de mort." Les populations musulmanes eussent profité de ces réformes, de même que les chrétiens, sujets du sultan; mais tout a été inutile, et les éternels massacres d'Arménie, de Bulgarie et d'ailleurs n'ont jamais été vengés, que nous sachions, par l'Europe chrétienne.

Quelle plus heureuse transition pourrions-nous trouver, Mesdames et Messieurs, pour exalter aujourd'hui, comme il convient, la participation des États-Unis à la guerre. Bien que la sagesse du fondateur de la grande république l'eut prémunie, dans un mémorable discours d'adieu, contre les dangers qu'entraînerait pour sa paix et sa sécurité la tentation de s'immiscer dans les intrigues et les troubles de l'Europe, il ne pouvait échapper à la perspicacité, au patriotisme vigilant du président Wilson que cette attaque des puissances germaniques, vouées aux traditions les plus réactionnaires, contre la France et l'Angleterre, les deux citadelles, dans le monde de la liberté et du progrès démocratique, que cette nouvelle invasion des Barbares, avec son militarisme effréné, constituait un péril immense pour le Nouveau-monde autant que pour l'Ancien. D'autre part, les écueils où pouvait échouer une politique qui rompait en visière à celle qu'avait recommandée l'immortel Washington, les difficultés qu'une population d'origine allemande pouvait susciter à une pareille innovation, demandaient que le chef de la république voisine usât de prudence, de précautions et d'atermoiements, d'une diplomatie en un mot que seul le génie le plus sûr de lui-même et le plus averti pouvait se permettre. Nous savons tous avec quelle maîtrise le président Wilson se tira de ces dangers, aussi avec quel élan et quelle bravoure les armées américaines arrivèrent sur le théâtre de la guerre et quels triomphes elles y remportèrent.

Il est encore trop tôt pour dire les services qu'est appelée à rendre au monde la Ligue des Nations, mais rendons hommage à l'éminent homme d'État, le président Wilson, qui en a eu l'idée et qui l'a défendue avec toute la force de ses convictions chrétiennes et démocratiques. Les plus décourageants pronostics sont venus se briser contre l'armure d'un pacifisme éclairé et qui ne prête à aucune équivoque. Ce sera l'essai sincère, unanime, non pas du règne définitif, éternel, de la paix et de la bienveillance parmi les hommes, mais d'un régime et d'un tribunal qui s'emploieront à une fin certainement des plus humanitaires et sublimes.

Ce n'est certainement pas avec les odieux traités de 1815 qu'il faudra comparer ceux qui vont très prochainement se signer entre nos alliés et les puissances germaniques. Les traités élaborés au congrès de Vienne il y a un siècle, se proposaient de rétablir en Europe, autant que faire se pouvait, l'état territorial et le régime politique d'avant la Révolution française. C'était un régime aristocratique et féodal qui devait servir de base à la *Sainte Alliance*. Les libertés populaires, l'indépendance des peuples, le *self government* des nations, c'étaient là des idées étrangement antipathiques aux puissances du nord, Autriche, Prusse et Russie qui, sous la dictée de Metternich, imposèrent la paix à l'Europe. C'est tout le contraire qui distinguera la paix de Versailles en 1919. C'est par certains aspects aux traités de Westphalie de 1648 qu'il conviendrait de comparer ceux d'aujourd'hui. Ces traités consommaient d'une part l'irrémédiable déchéance de l'empire d'Autriche de son hégémonie en Europe, et reconnaissaient d'autre part l'ascendant suprêmement désirable de la France, de sa civilisation, de ses lettres, de ses arts. Ces traités, en outre, consolidaient l'indépendance de chacun des états dont se composait ce soi-disant "Saint empire romain de nation germanique."

Les traités de 1919 vont rendre leur indépendance à des peuples, asservis jusqu'à ce jour à des nations barbares; ils mettent leur liberté sous la protection d'une ligue dont on ne tardera pas à sentir les bienfaits; ils relèguent l'Allemagne à sa barbarie et donnent à l'Angleterre, à la France, à l'Italie, aux États-Unis de nouvelles occasions de répandre les bienfaits d'un régime unique de liberté, de travail et de progrès, en même temps qu'ils assurent à ces nations l'ascendant moral dont de pareils services sont assurément la récompense méritée.

Il nous reste, pour épuiser l'actif de cette liquidation politique et sociale, à nous réjouir du précieux service que la dernière, Dieu le veuille, des invasions germaniques, aura rendu à nos deux grandes patries.

Pour nous, Canadiens, l'événement capital de notre époque a été ce rapprochement, mieux que cela, cette confraternité nouvelle de la France et de l'Angleterre, confraternité d'autant plus solide et durable, qu'elle est désormais fondée sur des services mutuels qu'il est impossible de trop vanter. Ce n'est pas le moment de réchauffer d'anciens griefs, mais on appréciera d'autant mieux cette alliance entre les deux nations dont nous sommes issus qu'il y a eu entre elles dans le dernier siècle tantôt une amertume de mauvaise augure, tantôt une tension de rapports qui pouvait tourner au tragique. Soit par crainte, soit par esprit de rivalité, l'Angleterre a plusieurs fois fait obstacle à des entreprises françaises dont le commerce anglais, l'industrie et la civilisation anglaises, devaient bénéficier bien plus encore que la France; telle est l'expédition d'Alger en 1830, tel encore le percement de l'Isthme de Suez en 1869. N'insistons pas, et réjouissons-nous que les Allemands aient rendu au monde, quoique bien à contre cœur, un service dont le Canada devrait savoir tirer parti dès à présent pour parachever, ici, une entente loyale basée sur l'égalité de droits et de devoirs entre ces deux mêmes races désormais sincèrement amies en Europe.

On ne s'expliquerait pas que dans cette revue nous passions sous silence la révolution politique et sociale qui a bouleversé la Russie et failli compromettre l'issue de la guerre.

Nous savons depuis longtemps qu'une grave révolution est violente et implacable en proportion de ce que l'a été le régime qu'elle renverse et prétend remplacer. "S'il était possible, dit Macaulay, à un peuple élevé sous un régime despotique et cruel de renverser ce régime sans commettre lui-même des actes de cruauté et de folie, la moitié des objections qu'on oppose à ce régime tomberait de soi-même, car il faudrait bien en conclure que le despotisme n'avait produit aucun effet pernicieux sur la mentalité et la moralité de ce peuple.

Assurément, ajoute Macaulay, nous déplorons les actes de violence qui sont le fait des révolutions, mais plus ces actes ont été violents, cruels et impitoyables, plus il en faut conclure que cette révolution était nécessaire . . . . la violence et l'ignorance d'un peuple étant toujours en raison directe du régime d'oppression et d'ignorance sous lequel on l'avait forcé à vivre." Ce lumineux écrivain savait assez l'histoire de toutes les révolutions pour proclamer une si grande vérité, que d'ailleurs l'exemple de la Russie confirme.

Il n'est, malheureusement, que trop facile de faire toucher du doigt les circonstances calamiteuses qui ont traversé trois fois en un millier d'années la destinée du peuple russe, qui ont faussé même son caractère, lequel, de jovial, spontané, prompt aux saines émotions est devenu avec le temps, triste, craintif et concentré. Quel malheur, par exemple, que l'horrible invasion tartare ait brusquement mis fin au treizième siècle, à cette civilisation normande des Varègues qui semblait dès le neuvième siècle, vouloir rivaliser en Russie avec celle que les Normands, de France, d'Angleterre et de Sicile fondaient dans ces contrées. Le despotisme asiatique tua, en Russie comme ailleurs, toute initiative, tout esprit de liberté et de progrès.

Ce fut une autre calamité que cette politique de conquête et d'oppression que les grands Russes, de religion grecque, poursuivirent sans relâche contre les Slaves catholiques de l'ouest, les Polonais, les Ukrainiens, les Lithuaniens et contre les Finlandais, tous peuples qui saluent la présente guerre comme l'aurore de leur délivrance du joug moscovite.

Une dernière calamité, et non la moindre, vint aggraver les deux autres; je veux dire cette pénétration savante, cette invasion germanique, pacifique, il est vrai, mais d'autant plus dangereuse et perfide, qui depuis deux siècles, à l'appel des tzars et tzarines de race allemande, s'est infiltrée dans tous les rangs, dans les douze catégories de cette terrible bureaucratie, formidable rempart de l'absolutisme, qui s'isolait de la nation pour la mieux asservir, et y a constitué l'appui le plus solide, le plus fanatiquement dévoué à une autocratie sans pitié. L'Allemagne, dit un publiciste contemporain, est depuis longtemps toute-puissante, dans tous les domaines de la vie nationale russe, et y a usurpé la plupart des fonctions importantes de l'empire. Il n'a pas fallu moins que la perspective sinistre du sort réservé à une nation sœur—la Serbie—menacée de tomber sous le joug de l'Autriche-Hongrie, pour réveiller la vraie Russie et lui mettre l'épée à la main. Mais, comme la trahison était partout, dans le commandement et dans l'état-major militaire, le slavisme russe fut finalement battu. A la vérité, il renversa le Tzar et sa dynastie, en mars 1917 et parut un moment avoir regagné le terrain perdu; mais, sans hésiter, le Kaiser sut s'aboucher avec les chefs de l'anarchisme russe et précipiter leur pays dans la pire des révolutions sociales. C'est alors que parut le *Bolchévisme*, c'est-à-dire le Socialisme communiste.

Cette doctrine n'est assurément pas nouvelle. Sans remonter plus loin que le dix-huitième siècle, nous savons que le communisme fit fortune à Paris en 1795, où Babeuf, père du *Babouvisme* et son ami Maréchal, auteur du *Dictionnaire des Athées*, lançaient de concert le foudroyant manifeste où se lisait: "La révolution française n'est que l'avant-coureur d'une autre révolution bien plus solennelle et qui sera la dernière. Ce que nous voulons, c'est l'égalité complète; ce que nous demandons, ce qui est sublime, c'est le bien commun ou la communauté des biens. Peuple de France, ouvre les yeux et le cœur à la plénitude de ton bonheur; reconnais et proclame la *République des Égaux*."

Une doctrine plus scientifique, quoique prêtant à une critique qui ne le sera pas moins, c'est la doctrine collectiviste de Karl Marx (1818-1883) qui a eu une si grande vogue en Russie et même dans certaines universités allemandes. De là son rôle dans les allures révolutionnaires des partis avancés, comme ils s'appellent.

Cette doctrine insiste sur l'évolution économique des sociétés. Au régime patriarcal elle constate qu'a succédé le régime du petit producteur autonome, et à ce dernier, supprimé à son tour, la production *capitaliste;* or, la production apparaît aujourd'hui sous la forme collective dans les ateliers ou dans les mines. Il y a donc, dit Marx, une contradiction mortelle pour l'organisation actuelle entre ces deux faits; d'une part, la production collective et, d'autre part, la centralisation des moyens de production entre les mains de la classe privilégiée des capitalistes. Par conséquent, conclut Marx, il y aura forcément une expropriation des capitalistes par la classe ouvrière; le travail étant devenu collectif, la propriété deviendra à son tour collective et sociale!

Non, pas nécessairement! Mesdames et Messieurs, puisque l'équilibre entre le travail et le capital pourra se rétablir par d'autres moyens, tels que les syndicats obligatoires, les chambres d'arbitrage et la conciliation, la participation du travail aux bénéfices du capital, les assurances ouvrières, etc., etc., et ainsi les revendications sociales des masses verront s'ouvrir devant elles cet avenir de légitime bien-être et de sécurité auquel elles ont incontestablement droit.

La société qui se prépare sera bien différente de celle qui déjà s'élimine: les courbes auxquelles les observateurs ramènent l'évolution des phénomènes sociaux de notre époque ne s'arrêteront pas comme beaucoup le pensent: elles vont se prolonger dans leur direction même et assez longtemps encore. Toute l'organisation sociale est ébranlée par la poussée des masses. Forces d'en haut qui émanent de la capacité productive de l'homme; forces d'en bas qui viennent de la nécessité du mieux-vivre; entre les deux, notre société se débat. A nous de concilier ces deux forces en établissant entre elles une relation juste, équitable, pouvant conduire à un système social admissible par tous, dans la société future, parce qu'il répondra à la nécessité.

Ce n'est pas par la révolution, mais par l'évolution que notre pays voudra faire face aux situations nouvelles. Logique avec les événements et fidèle à son passé traditionaliste, le Canada saura démontrer que l'inéluctable de demain ne lui fait pas peur aujourd'hui. "*Un citoyen sain dans la cité saine,*" telle est la formule nouvelle qui s'impose. Atteindre le chef de famille et les siens à travers toutes les phases de leur existence quotidienne, depuis le nouveau-né qu'il faut aider à ne pas mourir, l'enfant qu'il faut éduquer, l'adulte dont il faut faire un collaborateur vaillant de la productivité nationale, jusqu'à l'infirme, jusqu'au vieillard auquel il faut tendre la main: voilà la politique qui, dans la mesure même où elle favorise l'expansion naturelle de toutes les facultés et de toutes les ambitions légitimes, assurera l'entente et la paix entre les hommes et entre les classes.

En ces jours de révolution sociale, dont les grondements se font entendre même au milieu de nous, le grand danger de notre continent, de notre pays, c'est le matérialisme, c'est la soif des jouissances, c'est le culte de Mammon: trop de richesses en haut, trop de misère en bas. Or, le devoir des puissants, le rôle des intellectuels, c'est de se pencher vers les humbles, les petits, les faibles, de se solidariser avec eux.

Tout homme a une âme immortelle; la vie n'est qu'un passage. Il est ici-bas pour atteindre, après la mort, un bonheur sans fin dans la possession de son Dieu. Tout doit être sacrifié à cette fin. Et c'est pour cela que nous ne voulons pas de longues journées de travail qui abrutissent l'ouvrier et le séparent trop longtemps de sa famille; c'est pour cela que nous voulons pour lui un salaire équitable; c'est pour cela qu'il faut le prémunir contre les mille périls qui rendent sa sécurité si précaire: l'accident du travail, la maladie, le chômage, la vieillesse; c'est pour cela que nous voulons pour l'ouvrier le repos du dimanche afin qu'il puisse se recueillir, se cultiver, goûter à son loisir les joies de son foyer et avoir une journée entière sa fenêtre ouverte sur la nature et sur le ciel, loin de la fumée de l'usine et du bruit de l'atelier. C'est ainsi qu'il développera en lui le sentiment de sa dignité et de sa vocation d'être humain, tout ce qui peut l'arracher au servage industriel, empêcher qu'il ne devienne une machine et qu'il oublie son âme rachetée du sang d'un Dieu.

Vous vous rappelez le début célèbre de l'Ênéide, de Virgile. Enée raconte l'entrée dans la ville de Troie du cheval gigantesque qui enfermait en ses flancs la ruine de la cité:

"La fatale machine franchit nos murs, grosse de soldats armés. Elle entre enfin, elle entre et s'avance menaçante jusqu'au centre de la ville. O ma patrie, ô Ilion! sainte demeure des dieux! Quatre fois ses vastes flancs retentirent du bruit des armes. Mais, insensés que nous sommes, entraînés par un aveugle transport, nous poursuivons notre entreprise, et nous plaçons le monstre fatal dans l'enceinte sacrée de la citadelle. Alors Cassandre élevant sa voix prophétique nous prédit nos malheurs. Mais un dieu voulait que Cassandre ne fut jamais crue des Troyens. . . . . "

Je ne relis jamais sans effroi ces vers du grand poète en songeant à la facilité et à la légèreté avec laquelle nous laissons s'introduire dans notre jeune et beau pays cet internationalisme menaçant qui avance peu à peu dans la cité sous le couvert d'un faux humanitarisme. Là aussi, comme dans les vastes flancs du fatal cheval de Troie, retentissent des bruits d'armes. Ne l'oublions pas, en face du péril qui menace le monde, c'est par l'action sociale issue d'une pensée religieuse, s'inspirant de la plus haute morale chrétienne, que nous enrayerons les mouvements de haine, de colère et de désespoir qui, laissés sans frein, submergeraient la société.

Au demeurant, il en sera de ces choses ce qu'en décidera le régime démocratique où nous entrons de plus en plus à pleines voiles. La démocratie, c'est l'avènement des masses profondes au gouvernement du pays, et par suite l'égalité des droits et la puissance du nombre, et ce nombre sera d'autant plus digne de notre confiance et de nos sympathies qu'il sera plus éclairé. N'est-ce pas de ce régime démocratique que dépend aussi l'avenir de ce grand et riche pays qu'est le nôtre ?

On eut certainement traité de visionnaire, en 1913, quiconque aurait cru possible que le Canada fut entraîné dans une entreprise si gigantesque, en des pays si éloignés et contre un adversaire de pareille taille. Même en Europe la guerre ne paraissait pas certaine, en dépit des ambitions et des jalousies qui ne sommeillent jamais parmi les nations. Cette participation de notre pays à un si épouvantable bouleversement général, a eu des conséquences auxquelles on ne pensait guère au commencement et dont on peut aujourd'hui mesurer l'importance capitale. On a fait en Europe plus ample connaissance avec nous, si bien que nos nombreux rapports par-delà l'Atlantique vont devenir de plus en plus intimes et profitables.

Il est évidemment dans l'intérêt du peuple canadien de resserrer ses relations de toutes natures avec nos deux mères-patries, puisque, aussi bien, c'est d'elles deux que dérivent toutes nos idées politiques, civiles et religieuses. Au fond l'Angleterre et la France occupent à elles seules les deux pôles de la civilisation; elles n'ont pas fait autre chose depuis dix siècles qu'avancer sur deux lignes parallèles vers le même but qui a été de rendre sans cesse un peu plus complète la liberté humaine. Les méthodes ont pu différer, par suite de la différence des caractères nationaux, mais elles se sont complétées l'une l'autre, l'Angleterre concentrant ses efforts sur les progrès d'une constitution politique sans rivale, la France sur l'égalité naturelle et désirable des citoyens devant la loi. Et n'est-ce pas sur cette double voie que notre peuple est orienté ? Le Canada aspire à obtenir l'unité dans la diversité. Ce n'est pas uniquement pour assouvir et éteindre un antagonisme de races que se consomma l'acte de la Confédération, en 1867, mais aussi pour réaliser cette unité politique si nécessaire au progrès d'un peuple. Un célèbre publiciste français du siècle dernier se posait un jour la question: "Qu'est-ce qu'une nation ?" et répondait: "ce qui fait que les hommes forment un peuple, c'est le souvenir des grandes choses qu'ils ont faites ensemble et la volonté d'en accomplir de nouvelles."

Dans la majestueuse ordonnance de l'Empire britannique, ce mot d'*Empire* ne saurait prêter à équivoque. Le Canada, tout comme l'*Australie*, la *Nouvelle-Zélande*, le *Sud-Africain*, sont autant de jeunes nations qui entendent retenir et développer leur autonomie bien qu'étant fermement décidées à coopérer avec la métropole, à la réalisation pratique de leur triple idéal de liberté, de justice et de progrès économique, et cela par les voies les plus pacifiques. Les liens si heureusement élastiques qui nous attachent à ce vaste empire, ceux aussi que nous entendons resserrer avec une France sagement libérale, aideront au développement graduel de nos immenses ressources, en même temps qu'à la sauvegarde de notre individualité canadienne qu'une annexion à la grande république voisine compromettrait infailliblement et pour toujours.

La victoire "en chantant "n'a certes mis fin—pas plus au Canada qu'ailleurs—aux maux que la guerre a déchaînés en 1914. Les problèmes de reconstruction comportent une ère d'épreuves dont il serait puéril d'ignorer l'importance. Notre épreuve financière sera redoutable entre toutes; elle ne sera finalement surmontée qu'au prix d'efforts acharnés et de lourds sacrifices, au prix de l'abnégation, de la sagesse et de la prévoyance de tous. Il faudra non seulement subvenir aux besoins de la liquidation, procéder à la restauration monétaire du Canada et à la consolidation de la dette flottante, pourvoir au déficit de la balance économique vis-à-vis de l'étranger, mais encore faire face aux énormes charges de la dette de guerre.

J'ai, quant à moi, assez confiance dans la virilité du peuple canadien, pour voir dans l'avenir plus de légitimes raisons de confiance que de motifs d'anxiété. Hume l'avait d'ailleurs observé:

"Toute taxe nouvelle crée chez celui qui y est assujetti une faculté nouvelle de la supporter, et toute augmentation des charges publiques accroît proportionnellement l'activité industrielle du pays."

Pour faire face à l'ère critique qui s'ouvre et dont la cherté de la vie et les conflits du travail sont comme les signes avant-coureurs, le Canada doit s'engager résolument au développement de sa richesse nationale, sous ses trois formes: ressources naturelles, force de production, pouvoir d'épargne. Oui, de l'esprit d'effort ne séparons pas l'esprit d'épargne. Si la production crée la richesse, l'épargne la conserve et la féconde au profit de l'avenir.

Le développement de nos ressources; dont nous ne connaissons pas même encore toute l'étendue et toute la richesse, gagnera au fait que nous occuperons une place considérable, toujours grandissante dans le monde. Ce qui sera non moins précieux c'est que le génie canadien, soit politique, soit scientifique et littéraire, trouvera le plus grand avantage et beaucoup de prestige à se produire sur ce vaste théâtre, comme s'y sont manifestées déjà à l'étonnement et à l'admiration de tous, nos aptitudes militaires.

Excellence, Mesdames, Messieurs, je ne saurais terminer cette étude, sans adresser en votre nom, au nom de la Patrie, un salut à cette jeunesse canadienne, qui dès le début de la Grande Guerre a couru à la mort allègrement, joyeusement, comme vers une aventure qu'il est beau d'affronter.

Ce n'est pas sans un serrement de cœur que je me fais votre interprète. Mon fils unique est tombé devant Arras, le 29 août 1918. Avec tant d'autres, il a sacrifié sa jeune vie, pour le triomphe du droit et de la liberté. Il a légué à sa famille le crucifix qu'il portait et son testament se résume en une phrase: "*Dites-leur que j'ai fait mon devoir.*" Vous me pardonnerez ce souvenir personnel. En remémorant cette parole d'un enfant qui repose aujourd'hui dans la terre ancestrale, j'ai voulu vous élever avec moi à la hauteur de ces héros anonymes qui firent si généreusement le suprême sacrifice. En somme, de quoi sont faites nos idées, nos aspirations, nos règles morales, nos vertus, nos énergies généreuses, toutes ces qualités par où nous entendons nous élever au-dessus de l'instinct et des fatalités de la nature, sinon des efforts et des exemples de nos devanciers, fixés dans le génie de la race par un ressouvenir continuel et par la volonté de ne pas dégénérer? "*Non omnis moriar,*" est-il dit quelque part. Non, ce n'est pas un vain rêve, les morts de la Grande Guerre ne sont pas morts; le meilleur de leur être peut, ici-bas même, survivre en nous: ils peuvent penser et agir en nos esprits et par nos bras. L'homme est plus qu'un simple produit de la nature: Dieu, le grand artiste, lui a donné une âme immortelle. Et c'est cette âme de nos héros, toujours vivante, toujours agissante qui nous convie à faire, nous aussi, notre devoir envers notre pays, trop souvent hélas! déchiré par les factions. Écoutons la voix de ces intrépides défenseurs de la civilisation. Si, répondant au sublime appel entendu naguère dans les tranchées de Verdun: *Debout les morts!* ils pouvaient se redresser, Anglais, Français, Canadiens, tous, ils nous diraient: "Ne nous pleurez pas, mais continuez-nous dans l'union sacrée du devoir!"

Oui, cette splendide jeunesse canadienne qui s'est offerte en holocauste pour sauver la civilisation menacée, qui ne rêvait ni de conquêtes, ni même de gloire militaire; nous lui devons plus qu'un souvenir attendri. Nous lui devons de nous hausser jusqu'à l'idéal pour lequel elle mourut.

Que le lendemain de la guerre soit donc pour nous digne de la grande victoire dont nos jeunes gens furent avec les alliés les héros et les artisans. Les principes éternels que leurs armes ont fait triompher, nous les traduirons dans nos mœurs, dans nos lois. Et rappelant ici, avec une légère variante, une parole récente prononcée à l'Académie française, je dirai à mon tour:

"Les beaux mots abstraits que les drapeaux alliés déploient sur le monde, nous en ferons, non pas l'étiquette d'une politique étroite et sectaire, mais notre réalité sociale . . . . Égalité de tous les citoyens devant la loi et l'opinion, quels que soient leur opinion ou leur culte; fraternité sincère, fraternité comme aux jours des tranchées, s'opposant aux luttes stériles de races. Révisons ce qui doit être révisé, renouons les liens qui furent imprudemment dénoués; mais qu'il ne soit pas dit, Canadiens, que nous entrons dans la Société des Nations sans parvenir à reédifier ici même au Canada, la Société des Canadiens!"

L'ensemble harmonieux que nous rêvons pour notre pays ne doit être au dessous ni des intentions, ni des moyens des deux grandes races qui l'habitent. L'heure est propice à cette instauration, puisque toutes deux, victorieuses sur terre et sur mer, fêtent aujourd'hui la fin d'une hantise effroyable et saluent l'aurore lumineuse d'une ère de véritable paix.

APPENDIX B

THE METEOROLOGICAL SERVICE OF CANADA

BY

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

METEOROLOGICAL SERVICE REPORT

Weather forecasts have, as in the past, been issued from the Central Office twice daily throughout the year for all parts of the Dominion, exclusive of British Columbia, for which province they are issued from Victoria, B.C. In addition to the Dominion forecasts, a bi-daily bulletin is wired to Newfoundland and disseminated widely in that colony. At the request of the British Air Ministry, a special bulletin with forecast included has since March, 1919, been wired twice each day to an officer of the Royal Air Force in St. John's, and very great care has been exercised to make these bulletins of value to aviators. The percentage of verification of Canadian forecasts, exclusive of British Columbia, has been 86·4.

The Monthly Meteorological Record is now printed as promptly after the close of each month as the receipt of reports from the more distant stations will allow, and mature consideration has confirmed the wisdom of adopting this monthly form of publication in place of an annual climatological report. *The Monthly Map* has been continued in its old form, and nothing better has been suggested by the agriculturists whose requirements it is intended to serve; also as means of retaining the service of voluntary meteorological observers, it serves a most useful purpose, as these most valued persons greatly appreciate the Dominion-wide information it contains regarding weather conditions.

The Daily Map is now eagerly looked for by an ever-increasing number of persons interested in meteorological phenomena.

For various duties in connection with the Service, 390 persons, chiefly observers, have been in receipt of pay, and of this number 37 were employed in the Central Office.

During the season of navigation storms were not of frequent occurrence on the Great Lakes. Twenty-one gales were recorded, and of these, only five reached the force of fresh or heavy in some localities, while others just reached gale force and were not of a general character. In the St. Lawrence, fifteen gales occurred, most of which were quite moderate. In the Maritime Provinces there were thirty gales, the heaviest of which attended the passage of a disturbance across Cape Breton on the 14th of November.

The percentage of verification of storm warnings was 81·6.

Magnetic Observations

During the fiscal year ending March 31, 1919, photographic records of the daily changes in the Magnetic elements were obtained without material loss. At Agincourt the Declination, Horizontal Force and Vertical Force are recorded and at Meanook the Declination.

During excessively cold weather some difficulty has been experienced in keeping the driving mechanism in operation at Meanook, and to overcome this, and also to make provision for installing more complete equipment, it has been proposed to construct an underground room to house the clocks and differential instruments.

Tables showing the Magnetic character of each day of the year are sent to the International Commission on Terrestrial Magnetism. An analysis of the reports received from all Magnetic observatories in the world is made by the Commission, and a report issued giving the five most quiet days each month and the five most disturbed days, and in conformity with the request of the Commission these days are used in analysing the Magnetic data obtained at both Agincourt and Meanook. The final results for the year 1916 are now in the hands of the printer, and those for 1917 are in course of preparation.

At the request of the Surveyor-General, index corrections for the compass attachments on 68 surveyor's theodolites were determined at Agincourt, and the results sent to him. Assistance was also given to members of his staff in standardizing their Total Force instruments at Agincourt both before and after their field work and instructions as to the method of observing.

Assistance was given to Mr. French of the Dominion Observatory in standardizing his magnetometer, both before and after his field work.

A special report on the changes taking place in the Magnetic elements during the solar eclipse of June 8, 1918, was made to Dr. Bauer, Director of the Department of Terrestrial Magnetism, Carnegie Institution, Washington, which he has included in his paper published in "Terrestrial Magnetism," Vol. XXIII, Nos. 3 and 4, on "Results of Magnetic Observations Made During the Solar Eclipse of June 8, 1918."

The accompanying tables give a summary of the results obtained at Agincourt and Meanook for the fiscal year 1918-19.

Magnetic disturbances were of frequent occurrence. The most pronounced were on the following dates: 1918—April 4, 5; May, 16, 17; June, 9, 10; August, 15, 16, September, 21; October, 15, 16. 1919—February, 27, 28; March, 20, 21, 22.

Summary of Results of Magnetic Observations at Agincourt for Fiscal Year 1918-19

Month	Mean Monthly Values			
	D West	H	Z	I
1918	° ′	γ	γ	° ′
April	6 38·1	15921	58392	74 44·9
May	38·4	924	365	44·3
June	37·8	928	360	44·0
July	37·3	924	348	44·1
August	38·0	910	346	44·8
September	38·4	902	334	45·1
October	39·0	895	342	45·6
November	39·2	898	333	45·3
December	39·7	892	324	45·5
1919				
January	39·0	898	323	45·2
February	39·6	896	318	45·2
March	40·2	885	305	45·6

Daily and Monthly Averages

Month	D			H			Z		
	Mean daily range		Absolute monthly range	Mean daily range		Absolute monthly range	Mean daily range		Absolute monthly range
1918	From hourly readings	From max. and min.		From hourly readings	From max. and min.		From hourly readings	From max. andmin.	
	′	′	° ′	γ	γ	γ	γ	γ	γ
April	13·6	30·9	2 09·6	52	124	552	31	81	350
May	14·2	24·1	1 17·1	59	119	808	31	64	484
June	13·3	23·1	1 24·1	59	99	501	25	59	348
July	15·4	22·8	0 51·5	56	90	271	28	54	269
Aug.	17·5	29·2	1 19·8	61	108	441	36	86	470
Sept.	15·0	30·4	1 24·0	60	118	616	44	94	538
Oct.	10·1	27·2	1 35·5	49	125	559	38	88	506
Nov.	8·5	22·9	1 26·1	35	77	324	22	54	307
Dec.	6·6	20·2	1 09·4	34	89	388	25	47	326
1919									
Jan.	10·6	25·5	1 35·4	36	84	334	16	38	280
Feb.	7·6	23·0	1 05·0	38	94	440	17	41	271
Mar.	9·9	31·7	1 29·0	57	129	630	35	76	440

Summary of Results of Magnetic Observations at Meanook for Fiscal Year 1918-19

Month	Mean Monthly Values				
	D East		H	Z	I
1918	°	′	γ	γ	° ′
April	27	44·0	12936	60410	77 54·8
May		42·8	990	584	53·9
June		44·2	948	375	53·7
July		43·6	915	217	53·7
August		43·2	930	270	53·5
September		44·7	934	566	56·7
October		44·3	928	338	54·4
November		43·2	928	333	54·3
December		42·9	953	481	54·7
1919					
January		42·5	....	....	54·2
February		42·6	936	381	54·5
March		43·2	936	409	54·8

Daily and Monthly Ranges

Month	Declination		
	Mean Daily Range		Absolute monthly range
	From hourly readings	From max. and min.	
1918	′	′	° ′
April	15·0	57·2	2 43·5
May	16·7	38·9	2 35·4
June	17·0	40·3	3 21·8
July	17·7	34·3	1 53·9
August	18·4	56·4	3 26·0
September	16·3	61·0	3 19·5
October	9·3	52·0	2 52·5
November	10·3	47·6	3 19·3
December	11·0	46·1	3 12·3
1919			
January	9·4	43·7	3 06·6
February	9·3	50·8	2 53·5
March	11·5	59·3	2 53·9

Physics Branch

The work of this branch has been practically in abeyance during the past year, partly owing to the absence from the office of Mr. J. Patterson, M.A., who has been engaged with the Department of Invention and Research of the British Admiralty, and partly from the fact that owing to increased duties with the Forecast Branch, the Director has been unable to give time to atmospheric research work. Mr. Patterson will shortly be relieved from Admiralty work and steps are being taken to augment the Forecast staff, which through unexpected events has been temporarily crippled.

Seismological Observations

The seismographs at Toronto and Victoria have been kept in successful operation throughout the year and have yielded some very interesting seismograms. No change has been made in the adjustments of the instruments, the booms being kept at a period of 18 seconds.

Record was made of 134 quakes, which is 44% more than usual. Of these, 102 were less than 1mm. amplitude, 20 of a moderate character and 12 were large. The largest occurred on:

April	21st,	with	epicentre	in the San Jacinto Valley, Cal.
May	20th,	"	"	in Chili.
May	23rd,	"	"	in Alaska.
Aug.	15th,	"	"	south of the Philippine Islands.
Oct.	11th,	"	"	off the Island of Porto Rico.
Nov.	8th,	"	"	north of Japan.
Dec.	4th,	"	"	Chili.
Dec.	6th,	"	"	off the Coast of Vancouver Island.

The quake of August the 15th was followed by a tidal wave which swept the Malay Archipelago and the Islands of the Pacific. A tidal wave also followed the quake of October 11th, causing a large loss of life and property over the greater part of the Island of Porto Rico. During the Vancouver quake of December 6th, the powerful light on the Estevan lighthouse was temporarily put out of commission by the mercury being shaken out of the lens table so that the lens could not revolve until new mercury was supplied.

We continue to forward abstracts of all our observations to various seismological centres throughout the world, and copies of the principal disturbances to the chief Seismological Observatory of the British Association at Shide, Isle of Wight. We also publish the records in several journals, and on request furnish the Associated Press with information regarding the character of any large disturbance and the distance from Toronto to the epicentre as ascertained from the time of arrival of the various waves. The Toronto evening papers are sometimes furnished with copies of the disturbances.

I hope shortly to replace the present Milne instruments, which are considered obsolete, with the new type as adopted by the British Association at a large number of their stations; and also to equip the Magnetic Observatory at Meanook, Alta., with a similar type of instrument. The old Milne instruments fail in a great number of cases to register the preliminary waves of distant quakes. The study of these waves is of considerable importance at the present stage of seismological investigation, as they afford the means for increasing our knowledge of the structure and formation of the interior of the earth, and it is desirable that they be distinctly recorded. The new type of instrument fulfills these conditions.

Agricultural Meteorology

Statistical studies of wheat and oats in respect to the relation between the yields and the weather-changes have been carried on during the year. The Dominion Experimental Farms, through the co-operation of Dr. Shutt, have aided as before by maintaining special plots of wheat near the meteorological instruments. Upon these plots the growth of the straw and the occurrence of certain vegetative epochs have been noted for the years 1915, 1916, 1917 and 1918. A preliminary notice of the studies regarding wheat by Mr. A. J. Connor, based on the results from the Experimental Farms and from the statistics of Spring-wheat yields in Manitoba since 1890, was published by the Department of Trade and Commerce in the Monthly Bulletin of Agricultural Statistics for April, 1918. The correlations between the yield and the temperature and rainfall of each 30-day period after sowing were there tabulated. It was shown that the period from the 60th to the 90th day after sowing was the most important and that during that period moist cool weather with a low daily range of temperature is required for a large yield. Since the rainfall of the third period is related positively to the yield, and the minimum temperature and the range of temperature related negatively, the quotient $\frac{\text{Rain}}{\text{range x minimum}}$ was plotted against the yields; and certain equations which resulted, when finally solved, yielded the formula:

$$Y = \cdot 434 \left(m - \frac{r}{2} \right) \log. \frac{1000p}{rm'}$$

Where Y is the yield in bu. per acre; m, the minimum temperature averaged for the 3rd 30-days; p, the total precipitation for the same 30-days; r, the mean daily range for the same 30-days. m′ is (m − 40).

This formula was based on the statistics for the years 1890 to 1915, but the co-operation of the Dominion Bureau of Statistics during the year 1918 furnished us with the dates of sowing and appearance above ground and other epochs throughout the Dominion, and we are therefore able to apply this formula to the data of 1918 in Manitoba. The average date of sowing of wheat in southern Manitoba was the 8th of April. The third period therefore began about the 7th of June and lasted until the 7th of July. For the two stations Winnipeg and Minnedosa only, the mean minimum was 49·6, the range 25·3, and the precipitation 1·50. Substituting in the formula above we obtain the yield to be expected from the conditions obtaining during the period June 7th to July 7th as 12·7 bu. per acre. In the Bulletin for January 1919, the official figure for the yield of Spring-wheat in Manitoba in 1918 is given as 16·25 bu. per acre. Whether the inclusion of the data from the remaining 30 meteorological stations in southern Manitoba will greatly affect this result will be determined during the analysis of the data which is now being made.

Studies in the yields of oats have proven more disappointing, possibly because the statistics in the early years were not made very accurately. A comparison of the very good year 1915 with the poor year 1916, leads us to suppose that a very early sowing of oats is essential to a good yield in Ontario, while the subsequent growth of straw should proceed at a uniformly gradual rate. This last condition is favoured by rather cool weather and a moist soil, with no extreme variations from the normal even for very short periods.

Respectfully submitted.

R. F. Stupart,
Director.

Phenological Observations

The following report on the phenological observations of 1918 is presented by Mr. F. F. Payne, of the Central Office of the Meteorological Service.

In British Columbia vegetation made rapid progress during April, and plants flowering during that month were earlier than usual. During May, however, growth was somewhat retarded and the dates of flowering did not differ much from the average.

In Alberta and Saskatchewan the progress of vegetation was similar to that in the last mentioned province, but the dates of flowering were generally earlier than usual in Alberta and somewhat late in Saskatchewan.

The dates of flowering in Manitoba did not differ much from the average, but growth late in May was slow.

In Ontario the dates of flowering in April were quite early, but during the month of May vegetation was retarded and the dates were later than the average.

In Quebec and the Maritime Provinces vegetation made slow progress in the Spring, and the dates of flowering were generally later than usual.

The number of reports received from observers was forty-eight, which is slightly in excess of the number received in 1917. These include five from schools in Saskatchewan, kindly supplied by Mr. W. H. Magee, Inspector of Schools.

The phenochrons or mean dates for Nova Scotia, given in separate tables were deduced from a very large number of observations. These tables were kindly supplied by Dr. A. H. Mackay, Superintendent of Education, and credit is also due to his assistants for the marked care shewn in their preparation.

"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 and Lunenburg Counties..................	" "
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 inlands
V.	Halifax and Guysboro Counties.....	" "

VI.	(A) Cobequid Slope to S (B) Chignecto Slope to N.M	(a) Coast, (b) Inlands.
VII.	North'rland Sts. Slopes (to the north) .	(a) Coast, (b) Low inlands (c) High inlands
VIII.	Richmond and Cape Breton Counties	" "
IX.	Bras d'Or Slope (to the southwest)...	" "
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. H. Hicks, Agassiz, B.C.
Stanley R. S. Bayne, Alberni, B.C.
A. B. Taylor, Atlin, B.C.
A. C. Murray, Fort St. James, B.C.
Mrs. Hugh Hunter, Penticton, B.C.
John Strand, Quesnel, B.C.
Geo. W. Johnson, Summerland, B.C.
Mrs. C. F. Walker, Tzouhalem, B.C.
A. S. Barton, Victoria, B.C.
Mrs. W. L. Fulton, Halkirk, Alta.
M. Hammond, Lacombe, Alta.
Thos. B. Waite, Ranfurly, Alta.
Miss Olive Parker and Pupils, Calais School District, Sask.
William Brown, Dundurn, Sask.
L. B. Potter, Eastend, Sask.
Miss D. E. Roy and Pupils, Fielding, Sask.
R. H. Carter, Qu'Appelle, Sask.
Geo. Lang, Indian Head, Sask.
H. C. Grose, Lang, Sask.
T. C. Van Son, Lewiswyn, Sask.
E. Bean and Pupils, Maymont, Sask.
R. A. Sim, Noremac, Sask.
Miss E. M. O. Seaboyer, North Battleford, Sask.
Mrs. M. E. Brown, Rabbit Lake, Sask.
C. W. Bryden, Shellbrook, Sask.
Miss Olive G. Tinline, Scott, Sask.
Mrs. H. Graham and Pupils, Wanganui, Sask.
William Irvine, Almasippi, Man.
Allan Campbell, Brandon, Man.

C. I. Baragar, Elm Creek, Man.
Staff and Patients of Sanatorium, Ninette, Man.
Alf. J. S. Goodridge, Oak Bank, Man.
Jas D. Plaice, Rapid City, Man.
Rev. C. J. Young, Brighton, Ont.
Miss M. Moffitt and Pupils, Cape Croker, Ont.
W. E. McDonald, Lucknow, Ont.
Miss H. M. Meighen, Perth, Ont.
L. G. Morgan, Port Dover, Ont.
M. A. Thompson, Queensboro, Ont.
F. F. Payne, Toronto, Ont.
David McKenzie, Abitibi, Que.
M. Savard, Cap Rouge, Que.
Lennoxville Experimental Station, Lennoxville, Que.
Pascal Fortier, Spirit Lake, Que.
R. G. Mowatt, Dalhousie, N.B.
Wm. H. Moore, Scotch Lake, N.B.
Superintendent of Experimental Farm, Nappan, N.S.
Miss R. Waye, Charlottetown, P.E.I.

I. Phenological Observations, Canada, 1918

Year 1918

Date of the year corresponding to the last day of each month

January	31	July	212
February	59	August	243
March	90	September	273
April	120	October	304
May	151	November	334
June	181	December	365

When first seen

	Agassiz, B.C.	Alberni, B.C.	Atlin, B.C.	Fort St. James, B.C.	Princeton, B.C.	Quesnel, B.C.	Summerland, B.C.	Tzouhalem, B.C.	Victoria, B.C.	Halkirk, Alta.	Lacombe, Alta.
1. Alder (Alnus incana) ... Shedding pollen	143	88	123		92			88			
2. Canada Thistle (Cirsium arvense) ... Flowering	163	179					163		188		180
3. Trailing Arbutus (Epigæa repens) ... “											
4. Dandelion (Taraxacum officinale) ... “	104	29	159	152	115	114	111		82	146	124
5. Violet, Blue (Viola palmata cucullata) ... “	115	92	160	152	110	114		110			141
6. Violet, White (Viola blanda) ... “			160		123	120		62	69		148
7. Columbine (Aquilegia) ... “	131	140	170		136		125	152	133		161
8. Trees appear green ...	108	111	153		123	90	111	120	88	126	134
9. Red Clover (Trifolium pratense) ... Flowering	148	150			168	144	137	147	142		
10. White Clover (Trifolium repens) ... “	145	150			160	133	132	147	142		167
11. Wild Raspberry (Rubus strigosus) ... “	141	149	171			175					
12. Cultivated Currant (Ribes rubrum) ... “	116	113			121	170	115	115	89		
13. Wild Rose (Rosa) ... “	135	152	171		160	150	138	146	131	153	160
14. Trillium (Trillium) ... “	93	107						106	100		
15. Anemone (Anemone) ... “	122		128							94	99
16. Maple (Acer) ... “	121	112						110	104		
17. Strawberry Wild (Fragaria Virginiana) ... “	112	100	166	146	120	88	111	103	111	134	
18. Strawberry Wild (Fragaria Virginiana) Fruit ripe	149			180	159	193				182	179
19. Crocus, Cultivated (Crocus) ... Flowering	73	66						29	7		
20. Lilac (Syringa vulgaris) ... “	122	132				137	127	118	118		164
21. Apple (Pyrus malus) ... “	117	124			135		116	121	110		
22. Plum, Cultivated (Prunus domestica) ... “	107	117						110	78		
23. Cherry, Wild (Prunus) ... “	100	122				198		117	116	129	
24. Cherry, Cultivated (Prunus cerasus) ... “	100	112					110	111	111		
25. Buttercup (Ranunculus acris) ... “	138	129	146		85	100	80	110	83	114	116

When becoming common

	Agassiz, B.C.	Alberni, B.C.	Atlin, B.C.	Fort St. James, B.C.	Princeton, B.C.	Quesnel, B.C.	Summerland, B.C.	Tzouhalem, B.C.	Victoria, B.C.	Halkirk, Alta.	Lacombe, Alta.
1. Alder (Alnus incana) ... Shedding pollen	152										
2. Canada Thistle (Cirsium arvense) ... Flowering	173								215		
3. Trailing Arbutus (Epigæa repens) ... “								144			
4. Dandelion (Taraxacum officinale) ... “	113	112			120	136			103	150	126
5. Violet, Blue (Viola palmata cucullata) ... “	118				119			117	84	136	153
6. Violet, White (Viola blanda) ... “									84		
7. Columbine (Aquilegia) ... “	138	152			139				144		169
8. Trees appear green ...	116				133				111	156	156
9. Red Clover (Trifolium pratense) ... Flowering	157				178				155		
10. White Clover (Trifolium repens) ... “	152				168				152		
11. Wild Raspberry (Rubus strigosus) ... “	147					195					
12. Cultivated Currant (Ribes rubrum) ... “	121				130				102		
13. Wild Rose (Rosa) ... “	142				165					174	167
14. Trillium (Trillium) ... “	97	113							135		
15. Anemone (Anemone) ... “	130									100	106
16. Maple (Acer) ... “	126	118							117		
17. Strawberry Wild (Fragaria Virginiana) ... “	115	135							121	138	
18. Strawberry Wild (Fragaria Virginiana) Fruit ripe	155	166		199							186
19. Crocus, Cultivated (Crocus) ... Flowering	81							62	60		
20. Lilac (Syringa vulgaris) ... “	128	138				151			126	139	172
21. Apple (Pyrus malus) ... “	125	132			143				125		
22. Plum, Cultivated (Prunus domestica) ... “	114	119							102		
23. Cherry, Wild (Prunus) ... “	106									135	
24. Cherry, Cultivated (Prunus cerasus) ... “	114	121							120		
25. Buttercup (Ranunculus acris) ... “	142	150			95	115			105	124	121

							137				26. Yellow Pond Lilly (Nuphar advena)...... "											
131	152									161	27. Blue-eyed Grass (Sisyrinchium).. "	135									167	
	124		152	124		108	117	114			28. Saskatoon (Amalanchier Canadensis)..... "		146			131				128		
206					198				201	206	29. Golden Rod (Solidago)......... "	212	171				206				203	211
		112	7	115	83	77			95		30. Wild Geese									125	100	
		119	101	86	85			114	100	95	31. Wild Ducks					91					103	
58	42	120	88	76	76	74	63		110	91	32. Robins (Merula)	80				82						
59	70			75	78	61			100	88	33. Meadow Larks (Sturnella)	89				81					106	
76		118	88	77	96	61		109		80	34. Blue Birds (Sialia sialis)	84				84	140					
107		143			135						35. Flickers or Golden Woodpeckers (Colaptes auratus)	154										
				126				79			36. Song Sparrows (Melospiza fasciata)											
143	81	128	121	99	120	95	78				37. Swallows (Clivicola riparia)	159				129				125		
			86								38. Juncoes (Junco hyemalis)											
	135										39. Oriolles (Icterus galbula)											
			104								40. King Birds (Tyrannus tyrannus)											
141	114	136		128	176	124	95	104			41. Humming Birds (Trochilus colubris)	147				130						
86		130		96			73	60	94	105	42. Frogs Piping	92				99				61		107
90				90		74				88	43. Earth Worm Casts (frost out of ground)	96										
		158	132						110		44. Lakes Open											
			112	72		74					45. Rivers Open											
87	56		121	98	102	74		71	101	91	46. Ploughing	117	89			105				77	112	98
91	71		123	101	118	98		91	96	96	47. Sowing	100	92			106				100	99	100
168	176		213	182		157	150	160	196	196	48. Hay Cutting	183				186					198	206
201	227		259	231	259	201		201	210	222	49. Grain Cutting	213	246			234				215	212	237
102	110	145	130	110	134	107		40	120	123	50. Potato Planting	126	145			133				86	130	141

II. Phenological Observations, Canada, 1918

Year 1918

Date of the year corresponding to the last day of each month

January	31	July	212
February	59	August	243
March	90	September	273
April	120	October	304
May	151	November	334
June	181	December	365

	When first seen											When becoming common										
	Ranfurly, Alta.	Calais School District, Sask.	Dundurn, Sask.	Eastend, Sask.	Fielding, Sask.	Fort Qu'Appelle, Sask.	Indian Head, Sask.	Lang, Sask.	Lewiswyn, Sask.	Maymont, Sask.	Noremac, Sask.	Ranfurly, Alta.	Calais School District, Sask.	Dundurn, Sask.	Eastend, Sask.	Fielding, Sask.	Fort Qu'Appelle, Sask.	Indian Head, Sask.	Lang, Sask.	Lewiswyn, Sask.	Maymont, Sask.	Noremac, Sask.
1. Alder (Alnus incana)..............Shedding pollen																						
2. Canada Thistle (Cirsium arvense)........Flowering	156		191			177	161	191	213					211			191	166	182			
3. Trailing Arbutus (Epigæa repens)........ "																						
4. Dandelion (Taraxacum officinale)......... "	133	172	143			135	122	161	179	164		135		152			144	135	171			
5. Violet, Blue (Viola palmata cucullata).... "	128		124			117	105	161	124		120	130		132			121	110	169			121
6. Violet, White (Viola blanda)............. "	140		160			139	171	166	174			144		176			140	173				
7. Columbine (Aquilegia)......... "	170		174				183					176		181				188				
8. Trees appear green..............................	122		121	124		121	125	121	122		119	127		125				138				130
9. Red Clover (Trifolium pratense).........Flowering	177		145			172	171		184			181		154				174				
10. White Clover (Trifolium repens)......... "	144		145				173	171	176			150		181				175				
11. Wild Raspberry (Rubus strigosus)........ "	182		154			177	153	171	182			186		176			181	155				
12. Cultivated Currant (Ribes rubrum)...... "	134		143				140	186	103			138		152				142				
13. Wild Rose (Rosa)............. "	167	164	172		155	162	163	169	181	169		171		176		161	171	168	173			
14. Trillium (Trillium)............ "									183													
15. Anemone (Anemone)........... "	101		87	98		104	81	100	96		84	105		100			115	94				91
16. Maple (Acer)................. "	123		124	124			120		110		79	127		132				125				
17. Strawberry Wild (Fragaria Virginiana)............	132	121	135	132	145	127	132	167	165			134		151			135	135				
18. Strawberry Wild (Fragaria Virginiana)..Fruit ripe	183	167	176		173	152	175	186	181			186				182		178				
19. Crocus, Cultivated (Crocus)....Flowering	128						142			108		132						145				
20. Lilac (Syringa vulgaris)................. "	163		176				161					165		181				164				
21. Apple (Pyrus malus).................... "	138						140		154			144						143				
22. Plum, Cultivated (Prunus domestica)..... "	140						125					145						130				
23. Cherry, Wild (Prunus)......... "	137			144	130	126	130					140					130	133				
24. Cherry, Cultivated (Prunus cerasus)...... "	137											140										
25. Buttercup (Ranunculus acris)............ "	158		117			104	167		103	114		160		128			121	171				

163											26. Yellow Pond Lilly (Nuphar advena) .. "	168										
158		160			156	175	166	159		154	27. Blue-eyed Grass (Sisyrinchium) .. "	161		167				178	172			
137	124	144	132	126	125	124		174	180		28. Saskatoon (Amalanehier Canadensis) ..... "	138		150	135		130	129				
		212	183		191	214	191	183			29. Golden Rod (Solidago) .... "			224				222				
88		86			82	92	83	94		84	30. Wild Geese	94		110			87	100	100			
93		86	78		82	91	83	84		82	31. Wild Ducks	98		110	81		84	100	107			84
88		113	99	98	90	94	100	95			32. Robins (Merula)	91		118			96	102				
128		94	86		84	81	98	78		84	33. Meadow Larks (Sturnella)	132		105	93		96	85	102			89
	160	101	78		109	152	96		170		34. Blue Birds (Sialia sialis)			149	83							
102		106	103		89	96	121	100			35. Flickers or Golden Woodpeckers (Colaptes auratus)	104		121			100	105				
98		117	85		90	100	121	88			36. Song Sparrows (Melospiza fasciata)	102		124				102	135			
132		136	138		132	146	136	163			37. Swallows (Clivicola riparia)	138		157			135	149	152			
85	95		84		83	92	79				38. Juncoes (Junco hyemalis)	91			92		91	94	100			
152			145		144	134	152	165			39. Orioles (Icterus galbula)	158					150	136	152			
94	133	125	144		143	141	161	144			40. King Birds (Tyrannus tyrannus)	101		153			150	144	169			
157					151	166					41. Humming Birds (Trochilus colubris)							178				
102		86	100		99	95	86	87		81	42. Frogs Piping	105		101			106	97				86
130					91	100					43. Earth Worm Casts (frost out of ground)							105				
108		84			110	122	94				44. Lakes Open	114		95								
		84	87			121	87				45. Rivers Open											
127		86	105		92	94	86	94		105	46. Ploughing	130		105				100				130
100		94	111	100	97	85	93	101		100	47. Sowing	110		105				95				112
203		192	199		175	189		206		156	48. Hay Cutting	216		206				193				
242	231			232	226	232	232	242		240	49. Grain Cutting	248	234			235		235	253			217
		136	132		130	140	140	144		124	50. Potato Planting			140				144				144

III. Phenological Observations, Canada, 1918

When first seen											Year 1918	When becoming common										
North Battleford, Sask.	Rabbit Lake, Sask.	Shellbrook, Sask.	Scott, Sask.	Wanganui, Sask.	Almasippi, Man.	Brandon, Man.	Elm Creek, Man.	Ninette, Man.	Oak Bank, Man.	Rapid City, Man.	Date of the year corresponding to the last day of each month January......... 31 July............212 February........ 59 August..........243 March.......... 90 September......273 April...........120 October.........304 May............151 November......334 June............181 December.......365	North Battleford, Sask.	Rabbit Lake, Sask.	Shellbrook, Sask.	Scott, Sask.	Wanganui, Sask.	Almasippi, Man.	Brandon, Man.	Elm Creek, Man.	Ninette, Man.	Oak Bank, Man.	Rapid City, Man.
											1. Alder (Alnus incana)............. Shedding pollen											
										212	2. Canada Thistle (Cirsium arvense)........Flowering											212
											3. Trailing Arbutus (Epigæa repens)........ "											
137	160		134	151	132	121		123	139	128	4. Dandelion (Taraxacum officinale)........ "	143					134	137				131
			137		146	129			148	122	5. Violet Blue (Viola palmata cucullata) .... "						148					126
					146	151		127		131	6. Violet, White (Viola Blanda)............ "						148					134
			168					156			7. Columbine (Aquilegia)......... "											
	125		115		124	115		118		121	8. Trees appear green..............................		150									125
									198		9. Red Clover (Trifolium pratense)........Flowering											
											10. White Clover (Trifolium repens)......... "											
		165						185		189	11. Wild Raspberry (Rubus strigosus)........ "											192
131						144		177		154	12. Cultivated Currant (Ribes rubrum)...... "	143										161
159	168			169		169		165	172	167	13. Wild Rose (Rosa)............. "	166				175		175				171
						165		152			14. Trillium (Trillium)............ "											
101	101	100	101	103		92	97	87	97	97	15. Anemone (Anemone)........... "	105	112	105	104	125		96	105		105	100
			121			115		122			16. Maple (Acer)................... "				131			121				
127	124		130	138	146	151		125	153	144	17. Strawberry Wild (Fragaria Virginiana)............	143	150				148					147
171				172	181	178				177	18. Strawberry Wild (Fragaria Virginiana) ..Fruit ripe	178					183					
101						87		118			19. Crocus, Cultivated (Crocus)....Flowering	105										
			162			168		132			20. Lilac (Syringa vulgaris)................. "				171							
						138				150	21. Apple (Pyrus malus)..................... "											154
						136					22. Plum, Cultivated (Prunus domestica)...... "											
134					152	144		145		143	23. Cherry, Wild (Prunus)......... "	145					154					144
											24. Cherry, Cultivated (Prunus cerasus)...... "											
	125				127	112		85		108	25. Buttercup (Ranunculus acris)........... "		132				130					

											26. Yellow Pond Lilly (Nuphar advena)...... “											
158	160			165		154				160	27. Blue-eyed Grass (Sisyrinchium).. “	162	162			172						164
131	155	142		157	132	140			146	139	28. Saskatoon (Amalanchier Canadensis)..... “	143	160	147			134					141
193				207				213	229	223	29. Golden Rod (Solidago).......... “	199										227
99		90	86		77	89	77	80	113	84	30. Wild Geese..................................				105		102		105			92
	88	97	85			85	87	77		92	31. Wild Ducks..................................		100		105				105			94
92	98	100	104	116	93	84	82	87	103	92	32. Robins (Merula)................ “		106				100	100	110			96
90	95	101	104	94	120	87	84	86		93	33. Meadow Larks (Sturnella)................		110				123	100	105			95
	100			126							34. Blue Birds (Sialia sialis)..........................		110									
	92				100	83	86	89			35. Flickers or Golden Woodpeckers (Colaptes auratus)		110				102					
105		99						86			36. Song Sparrows (Melospiza fasciata)................											
				140		127		121		143	37. Swallows (Clivicola riparia)........................											144
88					145	90		79			38. Juncoes (Junco hyemalis)........................						147					
					145	140		122			39. Orioles (Icterus galbula)..........................						147					
100				158	146	95		124		145	40. King Birds (Tyrannus tyrannus)..................						147					145
						199		153			41. Humming Birds (Trochilus colubris)...............											
95		100	99	102	93	99	95	88	99	117	42. Frogs Piping..................................				105		100	103	110			120
					115	79	102				43. Earth Worm Casts (frost out of ground)...........						119		109			
		90					74	104			44. Lakes Open..................................											
	73		87			88	69				45. Rivers Open..................................								74			
95	99	95	94	90	93	86	93	81		87	46. Ploughing..................................	102	101		105		100		106			98
95	90	96	98	92	94	95	84	81		92	47. Sowing..................................	102			106		98		106			218
	196	207	192		203	184	201	209	192	211	48. Hay Cutting..................................		209		201		210		206			228
222		232	228	233	224	221	215	207	243	225	49. Grain Cutting..................................	229		235	238		226		222			108
	123	130	121		117	121	115	125	136	132	50. Potato Planting..................................		127	144	137		149					

IV. Phenological Observations, Canada, 1918

Year 1918

Date of the year corresponding to the last day of each month

January	31	July	212
February	59	August	243
March	90	September	273
April	120	October	304
May	151	November	334
June	181	December	365

When first seen

Species	Phenomenon	Brighton, Ont.	Cape Croker, Ont.	Lucknow, Ont.	Perth, Ont.	Port Dover, Ont.	Queensboro, Ont.	Toronto, Ont.	Abitibi, Que.	Cap Rouge, Que.	Lennoxville, Que.	Spirit Lake, Que.
1. Alder (Alnus incana)	Shedding pollen				110	110	95	105	137		104	
2. Canada Thistle (Cirsium arvense)	Flowering			198	189	168	193	201			206	
3. Trailing Arbutus (Epigæa repens)	"					120		110			140	
4. Dandelion (Taraxacum officinale)	"	119	120	121	122	98	117	107	154	136	128	
5. Violet, Blue (Viola palmata cucullata)	"	134	123		128	97	121	124	152		140	
6. Violet, White (Viola blanda)	"				128	94	125				123	
7. Columbine (Aquilegia)	"	151	148	151	140	161		145		154	129	
8. Trees appear green		136	135	130	126	134	127	135	150		130	146
9. Red Clover (Trifolium pratense)	Flowering		154	157	160	146	165	168			156	
10. White Clover (Trifolium repens)	"		155	156	159	149	165	162			160	
11. Wild Raspberry (Rubus strigosus)	"	178		156	158	148	161	163			181	
12. Cultivated Currant (Ribes rubrum)	"		135	137	131	158		136		138	167	
13. Wild Rose (Rosa)	"	164	160		160	160		169				
14. Trillium (Trillium)	"	127	119	125	125	140	127	123			135	
15. Anemone (Anemone)	"				153	91	159	139				
16. Maple (Acer)	"	132			117	123		92			138	
17. Strawberry Wild (Fragaria Virginiana)		134	123	131	128	128	125	135	154	136	139	
18. Strawberry Wild (Fragaria Virginiana)	Fruit ripe	171	165		160	163	157	163	198	169	160	
19. Crocus, Cultivated (Crocus)	Flowering	133			116	98	104	89		115	118	
20. Lilac (Syringa vulgaris)	"	140	149	142	140	146	142	143		150	141	
21. Apple (Pyrus malus)	"	140	146	138	138	136	138	141		151	140	
22. Plum, Cultivated (Prunus domestica)	"	134		139	128	124				140	133	
23. Cherry, Wild (Prunus)	"	138	137	130	139	117	140	135			135	
24. Cherry, Cultivated (Prunus cerasus)	"	140		136	138	125				145		
25. Buttercup (Ranunculus acris)	"	151	130		144	145	150	166			146	

When becoming common

Species	Brighton, Ont.	Cape Croker, Ont.	Lucknow, Ont.	Perth, Ont.	Port Dover, Ont.	Queensboro, Ont.	Toronto, Ont.	Abitibi, Que.	Cap Rouge, Que.	Lennoxville, Que.	Spirit Lake, Que.
1.				110		102	112				
2.			203	191		201	206				
3.							122				
4.	121	130	126	130		125	123				
5.	136	135	140	128	100	125	132				
6.			141	128		128					
7.	156	152	155	140		146	150				
8.	140	140		127		136					
9.		167	167	167		169	171				
10.		165	159	162		168	166				
11.			153	160		168	166				
12.			139	131			139				
13.	181	164		163	165		173				
14.	133		128	128	147	137	125				
15.				154	97	166					
16.				118	129		104				
17.	136	136	141	130	132	137	139				
18.	181		165	166	167	165	171				
19.				116	103	117	105				
20.	144	152	145	142	150	146	151				
21.	145	152	141	139		140	151				
22.	139		140	129							
23.	138	140	137	140		142	140				
24.	145		138	139			171				
25.	181	142		151	147	159					

141			167	190	160				166		26. Yellow Pond Lilly (Nuphar advena)...... “	151			167	191	167				
162			144	150		162					27. Blue-eyed Grass (Sisyrinchium).: “	166			154		146				
								145			28. Saskatoon (Amalanchier Canadensis)..... “										
		211	202	212	201	208			205		29. Golden Rod (Solidago)......... “			219	212		213	217			
80	97	77	89	63		74	113	86		111	30. Wild Geese..........	81	118		90		125				
79	98		84	78	93		106	99		111	31. Wild Ducks..........	100			84		111				
77	77	77	77	64	76	74	102	95	79	105	32. Robins (Merula).........	79	80		80		78	81			90
82	79	79	84	66	79	81		96	118	116	33. Meadow Larks (Sturnella).........	91			102		83	86			127
78	79	77	79	66	76	83		111	89		34. Blue Birds (Sialia sialis).........	79	80				78	89			105
109	87		84	87	90	73	126	108	125		35. Flickers or Golden Woodpeckers (Colaptes auratus)	110			103		93	95			132
80	85	77	78	102	79	109	123		80	108	36. Song Sparrows (Melospiza fasciata).........	82	91		80		110	87			89
96	117		90	122	116	103	104		120	144	37. Swallows (Clivicola riparia).........		123		130		124	124			125
100		88	85		109				65		38. Juncoes (Junco hyemalis).........	132					140	100			115
134	137	128	129	129	127	133			125		39. Orioles (Icterus galbula).........	136			131		127	135			135
132	136	129	133	147		134	123		116		40. King Birds (Tyrannus tyrannus).........	134	140		139		139	137			121
139		137	133	129	130	141		141	170		41. Humming Birds (Trochilus colubris).........				147		138				181
95	92	79	102	86	88	97	130	113	116	116	42. Frogs Piping.........	103	96	92	103		98	106			120
110	107		91	104	117	95	145		101		43. Earth Worm Casts (frost out of ground).........		111				126	100			120
106	111		112	62	92	91	133			121	44. Lakes Open.........						94				
77	80		91	66	80	78	121		93	102	45. Rivers Open.........						84				
105	93	92	105	84	108	92		117	105	143	46. Ploughing.........	121	105	95	113		126	100			
106	105	103	119	89		103		124	116	143	47. Sowing.........		119		126		127	117			120
180	179	183	200	165	195	191	222	200	184		48. Hay Cutting.........	185	186	189	200		205	197			
		210	200	201	207	214		238	224		49. Grain Cutting.........				220		224	222			
129	138		122	103	121	120		148			50. Potato Planting.........	135	146	142	140		138	130			

V. Phenological Observations, 1918

Date of the year corresponding to the last day of each month

January	31	July	212
February	59	August	243
March	90	September	273
April	120	October	304
May	151	November	334
June	181	December	365

When first seen				Year 1918		When becoming common			
Dalhousie, N.B.	Scotch Lake, N.B.	Nappan, N.S.	Charlottetown, P.E.I.			Dalhousie, N.B.	Scotch Lake, N.B.	Nappan, N.S.	Charlottetown, P.E.I.
124		108	74	1. Alder (Alnus incana)	Shedding pollen	127		120	81
156		152	224	2. Canada Thistle (Cirsium arvense)	Flowering	161		210	238
	121	103	118	3. Trailing Arbutus (Epigæa repens)	"			110	125
138	128	103	130	4. Dandelion (Taraxacum officinale)	"	139		135	144
143	129	126	134	5. Violet, Blue (Viola palmata cucullata)	"	143		132	144
132	124	129	132	6. Violet, White (Viola blanda)	"	143		140	150
	152	161	171	7. Columbine (Aquilegia)	"			170	182
140	135	130	125	8. Trees appear green		147		140	131
	166	128	170	9. Red Clover (Trifolium pratense)	Flowering			140	183
	164	130	170	10. White Clover (Trifolium repens)	"			152	152
	164	149	171	11. Wild Raspberry (Rubus strigosus)	"			121	
		140	154	12. Cultivated Currant (Ribes rubrum)	"			122	164
	165	165	182	13. Wild Rose (Rosa)	"			201	163
143	130	154	168	14. Trillium (Trillium)	"	147		166	180
	161			15. Anemone (Anemone)	"				
134	131	122	156	16. Maple (Acer)	"	139		128	163
133	127	124	134	17. Strawberry Wild (Fragaria Virginiana)	"	144		130	144
173	165	135	187	18. Strawberry Wild (Fragaria Virginiana)	Fruit ripe	180		166	196
137	123		106	19. Crocus, Cultivated (Crocus)	Flowering	145			118
	153	153	156	20. Lilac (Syringa vulgaris)	"			161	162
166	151	130	151	21. Apple (Pyrus malus)	"	173		140	158
	143	145	152	22. Plum, Cultivated (Prunus domestica)	"			153	161
	148	140	150	23. Cherry, Wild (Prunus)	"			150	157
		128	148	24. Cherry, Cultivated (Prunus cerasus)	"			151	156
166	148	132	154	25. Buttercup (Ranunculus acris)	"	170		140	168

	187	159	178	26. Yellow Pond Lilly (Nuphar advena) “			167	186
	153	155	169	27. Blue-eyed Grass (Sisyrinchium) “			162	181
				28. Saskatoon (Amalanchier Canadensis) “				
213	206	171	208	29. Golden Rod (Solidago) “	238		212	217
89	99	83	92	30. Wild Geese	102		121	99
92			92	31. Wild Ducks	100			99
103	90	44	88	32. Robins (Merula)	106	94	110	113
				33. Meadow Larks (Sturnella)				
	156	123	187	34. Blue Birds (Sialia sialis)			151	196
143	118	89	191	35. Flickers or Golden Woodpeckers (Colaptes auratus)	149		120	219
102	91	97	156	36. Song Sparrows (Melospiza fasciata)	107	94	121	164
138	117	116	170	37. Swallows (Clivicola riparia)	145		145	181
84	81	82	74	38. Juncoes (Junco hyemalis)	101	92	119	88
	140	154		39. Orioles (Icterus galbula)			165	
161	137	143	163	40. King Birds (Tyrannus tyrannus)	166		161	177
157	140	142	179	41. Humming Birds (Trochilus colubris)	163		211	186
116	112	110	114	42. Frogs Piping	127		118	121
126	128	102	113	43. Earth Worm Casts (frost out of ground)	137		112	120
	117	97	100	44. Lakes Open			99	119
119	105	103	100	45. Rivers Open			110	119
126	112	104	123	46. Ploughing	137		122	130
135	136	99	129	47. Sowing	143		150	144
207	205	201	201	48. Hay Cutting	211		210	212
246	236	232	231	49. Grain Cutting	253		248	273
135	136	119	137	50. Potato Planting	145		152	151

VI. Phenological Observations, Canada, 1918

Year, 1918

Date of the year corresponding to the last day of each month

January	31	July	212
February	59	August	243
March	90	September	273
April	120	October	304
May	151	November	334
June	181	December	365

When first seen

Species	I. Yarmouth and Digby Counties, N.S.	II. Shelburne, Queen's and Lunenburg Counties, N.S.	III. Annapolis and King's Counties, N.S.	IV. Hants and Colchester Counties, N.S.	V. Halifax and Guysboro Counties, N.S.	VIA. Cobequid Slope, (to the South) N.S.	VIB. Chignecto Slope,(to the N.West) N.S.	VII. Northumberland Sts. Slope, N.S.	VIII. Richmond and Cape Breton Counties, N.S.	IX. & X. Bras d'Or and Inverness Slope, N.S.	Average Dates.
1. Alder (Alnus incana, Wild)	109	105	106	108	113	115	114	116	118	126	113
2. Aspen (Populus tremuloides)	133	103	117	117	111	131	129	120	124	127	121
3. May Flower (Epigea repens, L.)	103	103	104	113	111	115	114	118	121	122	112
4. Field Horsetail (Equisetum arvense)	119	125	121	127	128	133	128	127	133	130	127
5. Blood Root (Sanguinaria Canadensis)				138	129			126	133	132	132
6. White Violet (Viola Blanda)	120	120	122	127	128	119	127	126	131	133	125
7. Blue Violet (Viola palmata, *cucullata*)	123	124	124	129	133	125	129	130	135	136	129
8. Hepatica (Hepatica triloba, etc.)	130		127		130			130	137	130	130
9. Red Maple (Acer rubrum)	128	126	127	127	133	140	133	128	131	140	131
10. Strawberry (Fragaria Virginiana)	123	124	124	129	133	126	129	136	133	135	129
11. Strawberry (Fragaria Virginiana)... Fruit ripe	156	157	155	161	164	165	164	161	159	172	161
12. Dandelion (Taraxacum officinale)	127	126	117	131	133	132	132	132	138	138	131
13. Adder's Tongue (Erythronium Americanum)	133	146	135	136	138	130	130	131	152		137
14. Gold Thread (Coptis trifolia)	130	129	138	132	133	134	135	135	140	137	134
15. Spring Beauty (Claytonia Caroliniana)			131	124	133	123	132	125	137	134	130
16. Ground Ivy (Nepeta Glechoma)	157	131	137	135	141	127	129	142	144	142	138
17. Indian Pear (Amelanchier Canadensis)	137	133	132	137	142	141	139	137	142	145	138
18. Indian Pear (Amelanchier Canadensis)... Fruit ripe			180					215			197
19. Wild Red Cherry (Prunus Pennsylvanica)	139	137	137	142	146	147	139	139	155	151	143
20. Wild Red Cherry (Prunus Pennsylvanica). Fruit ripe								230	240		235
21. Blackberry (Vaccinium Can. and Penn)	135	134	138	140	147	144	138	141	152	149	142
22. Blackberry (Vaccinium Can. and Penn)... Fruit ripe	192	176	178	211				214	211		197
23. Tall Buttercup (Ranunculus acris)	141	142	145	148	155	142	147	148	154	155	148
24. Creeping Buttercup (R. Repens)	148	145	153	155	163		163	155	167	164	157
25. Painted Trillium (Trill. erythrocarpum)	139	141	157	140	147	140	139	143	156		142

When becoming common

Species	Average Dates.	I. Yarmouth and Digby Counties, N.S.	II. Shelburne, Queen's and Lunenburg Counties, N.S.	III. Annapolis and King's Counties, N.S.	IV. Hants and Colchester Counties, N.S.	V. Halifax and Guysboro Counties, N.S.	VIA. Cobequid Slope, (to the South) N.S.	VIB. Chignecto Slope, (to the N. West) N.S.	VII. Northumberland Sts. Slope, N.S.	VIII. Richmond and Cape Breton Counties, N.S.	IX. & X. Bras d'Or and Inverness Slope, N.S.
1. Alder (Alnus incana, Wild)	119	116	114	113	115	119	111	121	122	126	130
2. Aspen (Populus tremuloides)	127	115	142	122	124	126	125	135	124	129	133
3. May Flower (Epigea repens, L.)	119	106	112	112	119	119	120	121	124	127	128
4. Field Horsetail (Equisetum arvense)	132	125	131	127	131	130	129	129	132	137	136
5. Blood Root (Sanguinaria Canadensis)	138			150	138	137			130	138	135
6. White Violet (Viola Blanda)	132	127	127	129	131	134	127	135	132	137	137
7. Blue Violet (Viola palmata, *cucullata*)	135	130	130	130	134	137	133	138	135	140	140
8. Hepatica (Hepatica triloba, etc.)	136	142	121	133		135			134	144	143
9. Red Maple (Acer rubrum)	136	132	131	132	134	138	140	137	134	136	142
10. Strawberry (Fragaria Virginiana)	136	133	132	130	136	139	135	136	136	139	142
11. Strawberry (Fragaria Virginiana)... Fruit ripe	172	170	169	166	172	172	174	171	171	179	175
12. Dandelion (Taraxacum officinale)	138	135	133	134	136	140	137	139	138	144	143
13. Adder's Tongue (Erythronium Americanum)	143	142	156	140	143	147	136	135	138	156	
14. Gold Thread (Coptis trifolia)	139	136	135	139	136	138	139	139	139	145	143
15. Spring Beauty (Claytonia Caroliniana)	136			138	129	136	132	136	131	148	138
16. Ground Ivy (Nepeta Glechoma)	143	164	133	140	141	142	133	138	146	148	143
17. Indian Pear (Amelanchier Canadensis)	143	142	139	137	140	145	146	142	141	147	146
18. Indian Pear (Amelanchier Canadensis)... Fruit ripe	200			180					220		
19. Wild Red Cherry (Prunus Pennsylvanica)	148	145	142	142	146	152	154	147	142	158	151
20. Wild Red Cherry (Prunus Pennsylvanica). Fruit ripe	240								237	244	
21. Blackberry (Vaccinium Can. and Penn)	148	145	140	143	147	143	148	143	146	167	157
22. Blackberry (Vaccinium Can. and Penn)... Fruit ripe	218		206		220				219	226	
23. Tall Buttercup (Ranunculus acris)	158	152	155	152	156	162	153	154	155	166	161
24. Creeping Buttercup (R. Repens)	158	145	153	160	163	166		168	128	170	167
25. Painted Trillium (Trill. erythrocarpum)	149	146	146	140	145	152	148	147	147	159	

144	138	141	143	147	150	141	141	158	130	143	26. Rhodora (Rhododendron Rhodora)	148	151	143	145	146	152	152	146	144	160	142
143	143	143	147	153	146	149	148	157	154	148	27. Pigeon Berry (Cornus Canadensis)	154	151	148	149	155	159	151	155	155	163	160
			190					176	168	178	28. Pigeon Berry (Cornus Canadensis) .... Fruit ripe	196		209		198					181	
139	138	146	145	148	147	145	143	155	150	146	29. Star Flower (Trientalis Americana)	152	145	144	150	148	153	154	151	147	161	156
144	144	147	150	154	150	151	150	158		150	30. Clintonia (Clintonia borealis)	157	152	150	155	155	158	160	159	155	168	
151		151	151	160	157	163	157	163	144	155	31. Marsh Calla (Calla palustris)	162	157	156	155	157	164	163	169	161	184	160
147	145	146	152	156	156	153	155	179	170	156	32. Lady's Slipper (Cypripedium acaule)	161	157	151	150	164	159	160	158	161	182	168
153	149	147	156	161	162	156	157	168	163	157	33. Blue-eyed Grass (Sisyrinchium angustifol.)	162	160	155	153	161	164	167	163	163	171	167
147	158	152	164	165	151	161	163	161	171	159	34. Twinflower (Linnæa borealis)	161	155	163	166	117	172		170	170	167	170
155	145	146	147	155	160	146	171	163	153	154	35. Pale Laurel (Kalmia glauca)	158	156	151	152	153	162	166	150	171	169	157
154	164	159	151	166		153	167	157	154	158	36. Lambkill (Kalmia angustifolia)	161	163	167	166	151	168		158		162	157
161	148	130	159	163	169	163	159	160	147	148	37. English Hawthorn (Cratægus oxyacantha)	164	169	155	155	164	166		170	164	168	
153	151	153	158	147		161	155	166	151	156	38. Scarlet fruited Thorn (Cratægus coccinea, etc.)	161	166	159	158	162	152		160	160	172	161
167	160	152	165	169	169	164	165	175	173	166	39. Blue Flag (Iris versicolor)	171	168	165	162	175	175		168	170	178	179
159	154	157	158	168	165	154	160	169	162	161	40. Ox-eye Daisy (Chrysanthemum Leucanth)	167	163	161	162	167	173	172	168	166	174	173
155	164	154	154	166		164	161	176	168	162	41. Yellow Pond Lily (Nuphar advena)	168	164	168	159	162	172		173	167	180	170
149	159	156	141	163	179	158	151	164	155	157	42. Raspberry (Rubus strigosus)	162	147	156	152	158	167	176	163	157	171	160
	205		193				193	221		203	43. Raspberry (Rubus strigosus) .... Fruit ripe	212		210		196				215	228	
161	163	169	171	171		171		191		171	44. Yellow Rattle (Rhinanthus Crista-galli)	177	165	170	172	171	180			174	208	
167	157	158	169	165	176	162	157	164	166	164	45. High Blackberry (Rubus villosus)	171	175	165	165	175	172	183	173	164	171	167
	236	241	240					239		239	46. High Blackberry (Rubus villosus) .... Fruit ripe	246		243	245	248					248	
161	163	165	154	160			169	176	170	165	47. Pitcher Plant (Sarracenia purpurea)	170	167	168	169		165			174	181	
166	166	167	146	175		171	155	185		166	48. Heal All (Brunella vulgaris)	176	174	172	173	180	175	181		166	190	
172	164	167	177	174	168	164	168	133		165	49. Common Wild Rose (Rosa lucida)	177	172	177	174	177	177	173	176	174	193	
158	160	162	163	165	166	169	167	176	176	166	50. Fall Dandelion (Leontodon autumnale)	172	167	163	170	172	169	175	177	173	181	
	168	176		172	175		172	167		172	51. Butter-and-Eggs (Linaria vulgaris)	176		173	180		178			177	170	
131	131	128	138	135	132	133	130	134	133	132	52. Trees appear green	142	142	140	136	144	144	143	144	138	146	143
141	137	139	139	146	155	144	141	151	151	144	53. Red currant (Ribes rubrum, cultivated)	150	143	142	144	142	152	172	150	145	153	156
	202							219		210	54. Red Currant (Ribes rubrum) .... Fruit ripe	220									220	

VI. Phenological Observations, Canada, 1918

Year 1918

Day of the year corresponding to the last day of each month.

Jan.	31	July	212
Feb.	59	Aug.	243
March	90	Sept.	273
April	120	Oct.	304
May	151	Nov.	334
June	181	Dec.	365

When first seen

	I. Yarmouth and Digby Counties, N.S.	II. Shelburne, Queen's and Lunenburg Counties, N.S.	III. Annapolis and King's Counties, N.S.	IV. Hants and Colchester Counties, N.S.	V. Halifax and Guysboro Counties, N.S.	VIA. Cobequid Slope, (to the South)] N.S.	VIB. Chignecto Slope,(to the N.West) N.S.	VII. Northumberland Sts. Slope, N.S.	VIII. Richmond and Cape Breton Counties, N.S.	IX. & X. Bras d'Or and Inverness Slope, N.S.	Average Dates.
55. Black Currant (R. nigrum cultivated)	144	145	141	141	149	162	143	143	149	153	147
56. Black Currant (R. nigrum) Fruit ripe									185		185
57. Cherry (Primus Cerasus)	139	141	136	146	153		147	141	160	153	146
58. Cherry (Primus Cerasus) Fruit ripe								214			214
59. Plum (Prunus domestica)	147	140	138	145	146	157	146	142	159	155	147
60. Apple (Pyrus Malus)	146	141	139	146	151	157	147	142	159	152	148
61. Lilac (Syringa vulgaris)	158	149	147	156	160	156	153	150	167	161	156
62. White Clover (Trifolium repens)	151	155	149	152	156	159	156	138	164	163	154
63. Red Clover (Trifolium pratense)	142	133	146	156	159	160	157	153	166	158	153
64. Timothy (Phleum pratense)	148	156	168		171		166	163	169	173	164
65. Potato (Solanum tuberosum)	173	176	179						193		180
66. Ploughing first of season	168	114	114	124	121	107	120	123	120	121	117
67. Sowing	125	123	126	132	129	128	128	133	134	133	129
68. Potato-planting	118	123	131	135	127	131	130	132	127	130	128
69. Sheep-shearing	128	116	127	134	142	137	136	130	125	118	129
70. Hay-cutting	197	186	201	205	193			217	216	214	204
71. Grain-cutting	243		240	246	237			240	248	239	242
72. Potato-digging	270		261	268	263			276	270	275	269
73a. Opening of rivers	94	89	100	98	105	107	116	91	106	96	99
73b. Opening of lakes	89	96	112	48	112	118	117	111	113	118	103
74a. Last snow to whiten ground	103	103	108	112	102	108	107	114	113	115	108
74b. Last snow to fly in air	106	109	120	112	103	108	107	115	112	126	122
75a. Last spring frost—hard	138	150	163	170	145	125	172	148	126	123	146
75b. Last spring frost—hoar	140	162	173	171	165	172		171	145	154	161
76a. Water in streams—high	296	116	93		103	113	112	130	174	118	112

When becoming common

	Average Dates.	I. Yarmouth and Digby Counties, N.S.	II. Shelburne, Queen's and Lunenburg Counties, N.S.	III. Annapolis and King's Counties, N.S.	IV. Hants and Colchester Counties, N.S.	V. Halifax and Guysboro Counties, N.S.	VIA. Cobequid Slope, (to the South) N.S.	VIB. Chignecto Slope,(to the N.West) N.S.	VII. Northumberland Sts. Slope, N.S.	VIII. Richmond and Cape Breton Counties, N.S.	IX. & X. Bras d'Or and Inverness Slope, N.S.
55. Black Currant (R. nigrum cultivated)	154	154	149	146	146	154	178	152	146	157	157
56. Black Currant (R. nigrum) Fruit ripe	190									190	
57. Cherry (Primus Cerasus)	154	143	145	139	149	157	180	153	146	165	158
58. Cherry (Primus Cerasus) Fruit ripe	218								218		
59. Plum (Prunus domestica)	155	156	144	143	148	156	163	156	147	169	168
60. Apple (Pyrus Malus)	157	154	147	146	152	158	162	152	148	167	160
61. Lilac (Syringa vulgaris)	161	167	155	152	161	162	155	157	156	171	171
62. White Clover (Trifolium repens)	163	158	159	157	160	163	168	163	160	171	169
63. Red Clover (Trifolium pratense)	162	151	156	154	166	166	162	165	162	172	171
64. Timothy (Phleum pratense)	168	156	160	170		173		171	169	174	
65. Potato (Solanum tuberosum)	188	176								260	
66. Ploughing first of season	125	119	122	125	127	128	116	130	129	129	132
67. Sowing	137	135	131	135	135	136	137	135	139	141	142
68. Potato-planting	140	128	131	138	167	137	137	143	142	136	140
69. Sheep-shearing	137	139	124	132	135	151	137	148	137	134	131
70. Hay-cutting	216	214	200	208		216			223	233	221
71. Grain-cutting	248		239	243	255	245			247	256	253
72. Potato-digging	277	300	273	267	270	271			287	276	282
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											
76a. Water in streams—high											

284				263			223			257	76b. Water in streams—low										
264	315	249	248	243			275	232	280	263	77a. First autumn frost—hoar										
308	251	282		332			281	293	279	290	77b. First autumn frost—hard										
301	307	296	307	387			308	297	291	302	78a. First snow to fly in air										
310	309	309	311	312			322	318	310	312	78b. First snow to whiten ground										
331	350		334	343			331	330		336	79a. Closing of lakes										
	357		335				326	352		342	79b. Closing of rivers										
95	91	89	96	87		97	91		103	94	81a. Wild ducks migrating, N										
			297	271			249		271	272	81b. Wild ducks migrating, S										
94	84	94	90	86	84	94	85		96	90	82a. Wild geese migrating, N										
327	328		333	318					276	316	82b. Wild geese migrating, S										
82	86	88	88	90	85	94	88	90	98	89	83. Song Sparrow (Melospiza fasciata) .... North										
87	81	82	76	84		83	86	87	95	85	84. Robin (Turdus migratorius) "										
74	90	84	93	89		86	90	93	97	88	85. Junco (Junco hiemalis) "										
136	132	126	132	134		134	130	129	121	130	86. Spotted Sandpiper (Actitis macularia) "										
149	106	126	133	119			122	118	125	125	87. Meadow Lark (Sturnella magna) "										
131	125	123	135	127	117	125	125	127	122	126	88. Kingfisher (Ceryle Alcyon) "										
128	137	126	138	132	129	128	129	134	125	136	89. Myrtle Warbler (Dendroeca coronata) "										
136	141	134	141	149	139	139	139	137	152	141	90. Yellow Warbler (D. æstiva) "										
121	149	118	128	113	92	126	123	128	137	123	91. White throated warbler (Zonotrichia alba) "										
142	148	142	142	144	156	151	149	150	150	147	92 Hummingbird (Trochilus colubris) "										
134	131	137	140	143	138	144	132	150	132	138	93 Kingbird (Tyrannus Carolinensis) "										
140		140	132	145	129	143	137	161	150	142	94. Bobolink (Dolychonyx orysivorus) "										
146	136	141	144	143	149	124	143	141	143	141	95. American Goldfinch (Spinis tristis) "										
151	107	126	171	140			154	142	157	143	96. American Redstart (Setophaga ruticilla) "										
109	149	142	155		149	154	145	155		145	97. Cedar Waxwing (Ampelis cedrorum) "										
131	139	132	130	135		149	133	123	120	132	98. Night Hawk (Chordeiles Virginianus) "										
99	105	100	114	114	117	113	112	115	121	111	99. First piping of frogs "										
110	111	110	124	119	118	122	119	122	126	118	100. First appearance, snakes "										

Mémoires de la Société Royale du Canada
SECTION I

SÉRIE III | MAI, 1919 | VOL. XIII

Pierre Ducalvet.

Par M. BENJAMIN SULTE, M.S.R.C.

(Lu à la réunion de mai 1919.)

Avec l'aide de nombreux documents copiés à Londres au cours des dernières années, nous sommes en position de voir les deux faces de l'histoire de 1775-1783, pour laquelle il n'existait jusqu'à présent que les écrits de Ducalvet visiblement outrés et faux sur plusieurs points, mais assez et même beaucoup trop bien reçus des écrivains qui ne cessent de s'en inspirer. Je donne donc l'éveil à qui de droit parce que l'étude de cette période est à reprendre en totalité depuis que nous avons sous la main une source de lumière abondante.

La biographie de Ducalvet est aussi à faire. Les éléments ou matériaux ne manquent pas. Il était Français, se disait protestant. Il commença sa carrière en Amérique par l'Acadie, dans le commissariat, et en 1760 on le voit à Québec marchand de fourrures pour l'exportation, ce qui suppose un certain capital actif. Il s'aboucha de suite avec les gens de Boston et d'ailleurs qui s'abattirent sur la colonie dès la première année de la possession britannique et se coalisèrent pour la joindre politiquement aux autres provinces anglaises avoisinantes. C'étaient les pires ennemis des Canadiens et du gouverneur Murray, mais celui-ci comprenait parfaitement leur dessein. J'ai publié ailleurs de ce que Murray nous raconte d'eux. Cette triste engeance fut la seule cause de toute ce qui se passa de déplorable parmi nous depuis 1765 à 1785, et ce qui en restait alors reparut par moment de 1790 à 1812. Le seul bloc fidèle à l'Angleterre a toujours été le cultivateur canadien, puis dans les villes, un certain nombre d'Écossais et d'Anglais.

Les troubles ou manœuvres politiques du Canada commencèrent dès 1764 par des adresses et pétitions que signaient des protestants nouvellement établis. Dans le style qui fut celui du livre de Ducalvet et précédant ce livre de vingt années, on se plaignait de n'être pas écouté par le gouverneur Murray, mais sans trop dire de quoi il était question. Ces hommes, presque tous engagés dans le commerce de détail, exprimaient leur désappointement sans préciser sur quel point on les trompait. L'administration de la colonie, affirmaient-ils, ne faisait pas ce qu'elle devait faire. Mais quoi ? Nous avons maintenant le secret de ces phrases nuageuses: les marchands voulaient être tout dans le pays, tandis que par leur nombre, leur valeur, leur nationalité douteuse ils n'étaient rien. Une vingtaine d'individus, arrivant on ne sait d'où, à la suite des troupes et traitant les Canadiens comme des domestiques, affichaient la prétention de conduire toutes les affaires; ce n'étaient que des politiciens[1] au sens bas du mot, qui voulaient unir le Canada à la Nouvelle-Angleterre, pour ensuite en arriver à la séparation d'avec la Grande-Bretagne. Murray comprenait ces désirs cachés.

Roubaud, un Français indigne, qui fréquentait ces étrangers, étant étranger lui-même, y puisa l'idée surprenante qu'il prête à Montcalm: la révolution américaine couvant à Boston dès 1758.

Le parti annexioniste, comme il est juste de l'appeler, se reconnut un chef dans la personne de Thomas Walker, agent ou marchand, ramasseur de pelleteries, fixé à Montréal. Un soir, des hommes déguisés (Anglais) envahirent sa maison et, dans la bagarre, il eut une oreille coupée. C'était un grand ami de Ducalvet. Quelque temps après, celui-ci fut attaqué à la porte de sa demeure et il y eut des coups de poing. On attribua ces actes aux militaires. Les Canadiens ne s'en mêlaient aucunement.

Ce fut bien pis en 1766 lorsque la loi dite du Timbre souleva le peuple de Boston contre le parlement de Londres. Les agitateurs se mirent à dénoncer tout l'entourage de Carleton qui avait succédé au général Murray, mais ce nouveau gouverneur ne céda en rien à leurs exigences perverses.

L'invasion de 1775 fut un moment de triomphe pour Walker et son groupe. Par contre, en 1776, le jeu se trouva renversé, et les conspirateurs passèrent à l'état de suspects, ce qui, en temps de guerre et de révolution, est assez incommode. J'ai publié les noms de ces hommes avec d'assez amples détails sur le compte de chacun d'eux. Sans leur présence au milieu de nous, la province eut vécu exempte de trouble et très peu mécontente des actes de certains fonctionnaires aux instincts dominateurs, mais contenus avec adresse et résolution par Carleton.

En 1777 et 1778, Ducalvet continua de pourvoir les Américains de provisions de bouche, comme il avait fait en 1775. Ce commerce clandestin et traître partait de la terre d'Yamaska—une seigneurie—qu'il avait achetée.

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[1] Politicien, terme bas, ceux qui font de la petite politique de comté.

Vers 1777, le trésor des troupes américaines étant vide, on cessa de payer ce fournisseur. Il écrivit pour obtenir un règlement de compte et dressa la facture de son dernier envoi, puis ces papiers furent introduits dans un bâton creux confiés à un habitant de Chambly qui faisait la contrebande vers le lac Champlain. L'homme s'aperçut, en arrivant à l'île aux Noix qu'il allait être pincé et il laissa choir le bâton dans les broussailles. On le fouilla vainement. Alors le capitaine des gardes lui dit: "Votre affaire est bien simple, c'est la corde au cou demain à Montréal . . . à moins que vous ne rendiez les papiers." Le bâton fut retrouvé.

L'habitant dit à Ducalvet que ce bâton était enfoncé dans un marais pour toujours, de sorte que les gardes n'avaient rien découvert sur sa personne. Ducalvet se crut sauvé. Les papiers sont aux archives d'Ottawa.

En même temps, des correspondances furent interceptées qui compromettaient une vingtaine d'individus. Le gouverneur Carleton partait. Le général Haldimand lui succédait (1778). Une razzia eut lieu dans les endroits de réunion et aux domiciles des conspirateurs: Hay, Cazeau, Jotard, Mesplet, Ducalvet, Laterrière, Pillon, Hamel, etc., etc., furent pris; Walker et Pélissier étaient en fuite.

Nous étions en guerre. Les étrangers, Ducalvet et autres, qui soutenaient la cause ennemie, auraient pu être envoyés à l'échafaud sans étonner personne. Haldimand se contenta de les coffrer. Tous les cris: "au tyran! . . . sans procès . . . voyez comment on traite les Canadiens . . ." sont des déclamations de révolutionnaires ou, si l'on veut, les invectives de dix hommes qui font plus de tapage que mille individus restés tranquilles. Il n'y a pas eu de terreur ni d'exaction sous Haldimand.

Ce général, né en Suisse (1732) était devenu sujet britannique et avait été gouverneur des Trois-Rivières en 1760. C'est alors qu'il rencontra pour la première fois et devina très bien la nature de Pierre-Antoine Roubaud alors de Saint-François-du-Lac. En 1767, Haldimand devint commandant militaire des Florides et général de brigade. Par la suite il fut employé ailleurs. Il arrivait à Québec, le 30 juin 1778, pour remplacer Carleton comme gouverneur général. De tous les brocards débités sur Haldimand, je ne connais qu'une source en cinq personnes: Ducalvet, Jotard, Mesplet, Cazeau, Laterrière, tous étrangers, tous "Américains" et tous parlant au nom des Canadiens pour masquer leur jeu.

"L'année 1778 est remarquable par l'arrivée du gouverneur Haldimand, un des plus cruels despotes qui nous soient venus d'outre-mer." Avec des variantes à l'infini, trente écrivains ont refait, répété et allongé cette phrase qui n'a d'autre origine que les diatribes de Ducalvet et compagnie. Ces écrivains canadiens étaient nés après le passage des étrangers difformateurs parmi nous; ils n'ont pas connu le temps de Haldimand par conséquent, mais les écrits perfides ont passé sous leurs yeux et ils n'avaient rien pour les contredire, c'est pourquoi ils ont répété et amplifié ces fausses accusations.

Je crois n'avoir écrit qu'une seule phrase (1875) sur Haldimand et encore est-elle contraire à la vérité historique. J'ai été trompé moi aussi par nos historiens qui avaient été trompés par Ducalvet. Nous sommes tous logés à la même enseigne et fort mal logés à cet égard. Il est temps de quitter si mauvaise compagnie. Mais comment faire comprendre aux Canadiens qu'ils sont dans l'erreur! Le moyen d'y parvenir consiste à indiquer l'origine du malentendu.

La guerre américaine étant terminée (1783) Haldimand libéra ses prisonniers et fit dire à Ducalvet de quitter la province. Celui-ci se dirigea vers Londres pour attaquer en justice ce gouverneur sous le chef de dommage à ses propriétés, puis il alla à Paris, d'où il retourna à Londres rapportant à son ami Roubaud (alors en Angleterre) que Lafayette écrivait au Congrès pour lui faire payer ses réclamations. En effet, un peu plus tard arriva une lettre de change en faveur de Ducalvet . . . que Roubaud s'empressa de signaler au ministre des colonies. Ah! Roubaud, quelle histoire que la sienne!

Roubaud, qui était dans de très mauvaises affaires en 1762, avait voulu se jeter dans les bras de Haldimand pour s'en faire un protecteur, mais celui-ci l'ayant repoussé parce qu'il le connaissait pour être une canaille, ne fut pas surpris lorsque, plus tard, Roubaud employa sa plume contre lui dans les gazettes de Londres où il avait trouvé de l'emploi pour ses talents. Ce Français, étranger au Canada, d'où il s'était fait chasser, s'était mis dans le journalisme de l'opposition. C'est lui qui a fabriqué en 1778, pour des fins politiques, la fameuse lettre de Montcalm sous la date de 1758.

Ducalvet arriva à Londres le 24 septembre 1783 et, comme il l'explique, se mit à l'œuvre sans retard. "Visites, sollicitations personnelles, protections étrangères(?), tout fut mis en usage pour extorquer une audience du ministre Lord North et en arracher au moins une lueur d'espérance de justice, mais rien ne fut capable de réveiller la dormante Seigneurie." Extorquer est vraiment bien le terme, quoique Ducalvet prenne ce mot dans le sens d'obtenir. Il poursuivait sa vengeance contre Haldimand. On lui ferma partout la porte au nez parce que derrière cette porte étaient les preuves écrites de sa trahison, et pour lui comme pour Walker et les autres de la même farine, l'ordre était de faire la sourde oreille. Il le dit naïvement.

Mettant le comble à ses audaces, Pierre Ducalvet publia à Londres, en juillet 1784, un *Appel à la justice*, de 320 bonnes pages, où il expose son cas sous forme de lettres aux ministres, même au roi, au peuple canadien et ensuite il entre dans l'examen du gouvernement de la colonie. Il y met de la verve, sans aller jamais à la cause première de ses mécomptes. A l'entendre, tout est malice quand il s'agit de sa personne et toujours avec la ritournelle: "Voyez comment on traite les Canadiens." Absolument convaincu que les autorités agissaient sur des rumeurs et ne possédaient aucune preuve contre lui, il s'en donne à son aise et cache par un adroit silence le fond de ses affaires, tant en ce qui concerne les Américains que ses chicanes avec les juges de paix de Montréal.

Roubaud ne reconnait pas de talent littéraire à Ducalvet. Je pense que ce dernier a écrit d'après son propre plan et canevas, mais que Roubaud lui a aidé dans la rédaction. Le style c'est l'homme. L'*Appel* est dans la manière de Roubaud. C'est déclamatoire aussi, parce que Jotard et Roubaud étaient de l'école des encyclopédistes dont les pamphlets préparaient avec des phrases tapageuses et des accents dramatiques la révolution de 1789 en France.

L'heure paraissait favorable pour lancer un pareil factum. Le ministère de lord North, qui avait nommé Haldimand au gouvernement du Canada, venait de tomber par suite du résultat de la guerre de l'indépendance américaine. Roubaud, scribe de l'opposition, espérait de beaux jours du changement de cabinet. Quant à Ducalvet, il était coulé dans l'esprit des whigs et des tories, mais croyait toujours que le bâton dénonciateur pourrissait dans un marécage de la rivière Chambly.

Le but évident du livre est que son auteur voulait créer par l'abondance de ses invectives un sentiment de haine contre Haldimand qui induirait le ministère, le parlement et toute la nation à condamner sans l'entendre celui qu'il dénonçait, mais le ministère avait en main les papiers de la trahison de Ducalvet et la preuve de la fausseté de ses allégations. Il fut averti de ne plus se présenter nulle part—c'est lui qui nous révèle ce fait et il s'en indigne grandement.

Dès le début du livre, Ducalvet prescrit au roi George et à ses ministres la ligne de conduite qu'ils doivent suivre. Ce procédé est au moins aussi étrange que de le voir se donner partout le rôle de défenseur des Canadiens . . . tout en disant qu'il craint fort de ne pas être soutenu par ceux-ci.

Sur certain point de loi soulevé en Angleterre contre le général Haldimand, ou plutôt l'administration militaire, Ducalvet eut gain de cause—affaire de propriétée occupée par les troupes et dommage aux marchandises. Le roi paya pour ses représentants dans l'armée.

Le docteur Laterrière associe au nom de Haldimand le mot "tyran" que Jotard, Mesplets et les autres captifs avaient adopté. En cela ils étaient logiques puisqu'ils se disaient victimes d'une tyrannie administrative, mais nos écrivains ont trop facilement endossé le terme et pas du tout compris la situation. Lorsque, la paix étant proclamée, Laterrière reparut à Québec, il fut autorisé à s'établir de nouveau là où il le voudrait. Il emploie le "tyran" dans la même phrase qui nous annonce cette nouvelle et ajoute de suite que "le pauvre M. Ducalvet avait fait relever le tyran et que l'humain Lord Dorchester revenait gouverner le Canada." Le changement de ministère ramenait Dorchester. Ducalvet n'avait pas été écouté une seule minute; on lui avait dit nettement de ne plus importuner les ministres. Haldimand ne fut ni disgracié ni relégué dans l'oubli. Sa gestion en Canada avait été juste, appropriée aux circonstances du temps, on lui en sut gré et il serait convenable d'expliquer en quoi il a joué le rôle odieux que lui prêtent les partisans de la cause américaine, tous étrangers au Canada et tous parlant avec un aplomb inconcevable au nom des Canadiens.

Le livre est insolent, pas grossier, rempli d'injures sans gros mots si l'on tient compte de l'emphase et de l'exagération du langage du temps. Les "beautés" de la littérature *ante* révolutionnaire se rencontrent tout le long de l'ouvrage. Il y a par place des pointes de colère, mais l'affectation d'une vertueuse candeur se fait sentir du commencement à la fin. Il termine parce que le cœur lui crève, c'est le mot qu'il emploie. Pathos, fausse rhétorique, hypocrisie, sentimentalité hors de propos, il entasse tout cela pour faire balle, mais cette grenaille s'éparpille, quand on connaît la vérité.

D'après Ducalvet, il y a eu contre lui complot, conspiration, rage, déchaînement et continuité de persécution de la part des autorités de la colonie et du corps des juges de paix, augmenté de la cour supérieure. Ceci, je n'en doute pas, le sujet en valait la peine, mais lui, en criant à l'injustice, il oublie de nous dire pourquoi on le visait ainsi, et il gonfle son cas personnel en disant qu'il parle au nom des Canadiens. Le tour n'a pas dû faire plaisir à ceux-ci et la ficelle est trop visible pour tromper même l'ignorance de nos jours. Cependant, vers 1830, on s'y laissa prendre bel et bien et l'on créa tout d'une pièce la légende Haldimand, que nous avons adoptée de confiance.

Les mensonges de ce livre, les insinuations venimeuses qui y sont répandues, le vague de toutes les affaires mentionnées, dénotent chez Ducalvet un fonds de naïveté que l'on ne soupçonnerait pas chez un homme de son type. Selon toute apparence et évidence il croyait que le ministère allait s'empresser de rendre jugement en sa faveur, après la simple lecture de ses lamentations et ne rien chercher à connaître de ce que pouvaient dire les personnages accusés. Hélas! trois fois hélas pour Ducalvet, le ministère savait ce que le livre ne disait pas ou cachait, ou dénaturait: il avait de plus les papiers secrets de Ducalvet, qui suffisaient pour le faire pendre sans procès. On lui signifia d'avoir à laisser le gouvernement tranquille, et ce singulier martyr disparut de Londres. Aux dernières nouvelles après cela, il était en France.

Les allusions méchantes reviennent continuellement sous sa plume, et comme il ne précise presque rien, on est sous l'impression que ses phrases nébuleuses cachent un monde d'horreurs. L'insinuation est l'arme favorite des pamphlétaires. Elle laisse à supposer des forfaits dont on ne veut pas fournir l'explication, mais que chacun comprend à sa façon. Les actes imaginaires de tyrannie qu'il attribue de cette manière à Haldimand et autres personnes sont encore en partie des énigmes, malgré tout ce que nous savons maintenant sur cette époque.

Garneau, III., 39, dit: "Le gouvernement s'enveloppait dans le mystère. Un voile épais couvrait tous ses actes et le rendait plus redoutable." Pourquoi le gouvernement aurait-il rendu public ce qu'il importait avant tout de tenir secret? Étions-nous sous un régime parlementaire? Même à Londres où il y avait deux chambres législatives, le roi se gardait bien de faire des révélations inopportunes. Et pourquoi le gouvernement, de ce fait, se rendait-il plus redoutable? Est-ce que les Canadiens, sous le régime français avaient été accoutumés à lire dans les papiers les intentions des gouverneurs? S'il y avait quelque chose de redoutable dans ces mesures de précaution, ce ne pouvait être que pour Walker et compagnie. Ce passage de Garneau peut être signé par Ducalvet, il vient de cette source.

"Le secret des correspondances privées était violé," ajoute Garneau. Encore le genre Ducalvet. On a intercepté une lettre de conspirateur et celui-ci proclame que l'on viole la correspondance privée! Ce qui est certain, c'est qu'en temps de guerre, cela se pratique partout en grand—mais vouloir nous persuader que tout le monde y passait, à d'autres!

Quand il en vient à mentionner Ducalvet, notre historien dit que cet homme était soupçonné d'avoir fait des fournitures aux Américains. Nous n'avons plus de soupçons—les preuves suffisent.

Garneau n'a pas vu que les écrits de Ducalvet dénoncent un faussaire partout où il parle de lui-même et que son but est de faire croire qu'il représente les Canadiens; il n'a pas compris que les insinuations, le vague manifestement voulu de tant de passages cachaient le traître, le coupable en un mot.

Que le général Haldimand prenant la conduite des affaires à un moment des plus critiques se soit montré moins doux que Murray et Carleton ses prédécesseurs, rien que de bien naturel, à cause du péril de la situation par les ennemis aux frontières et les traîtres au dedans du pays. La bande de Walker était plus agissante que jamais. Ce gouverneur, dit Garneau, "faisait sur de simples soupçons emprisonner les citoyens par centaines." Ceci est du pur Ducalvet. Garneau, à ce même endroit nous explique "sur le bruit d'une nouvelle invasion" que nous n'étions pas sur un lit de roses.

Les emprisonnements en masse dont parle Ducalvet se bornent à une quarantaine d'arrestations de gens comme lui qui n'étaient que des traîtres et sans exception des étrangers au pays. Ma foi! quand il y aurait eu dans le nombre quelques Canadiens, tant pis pour eux.

La fameuse question des corvées se réduit à peu de chose. Du temps des Français, les abus de cette nature exaspéraient le peuple de la campagne et avec raison. Haldimand, voulant ouvrir des routes pour faciliter la défense du pays, employa ce moyen, mais payant argent comptant et bon prix ce que le roi de France n'avait jamais payé—et de plus Haldimand fournissait les pelles et les pioches.

Si jamais les chercheurs découvrent que Haldimand a maltraité les Canadiens, qu'ils le fassent savoir—ce sera du nouveau, mais qu'ils ne prennent pas les hommes de la bande à laquelle appartenait Ducalvet pour des Canadiens ni des témoins respectables.

Haldimand fit construire les premiers canaux du Saint-Laurent, du lac Saint-Louis au Coteau et aux Cascades. C'étaient des ouvrages solides calculés pour les besoins militaires du moment et le commerce à toutes les époques. Il fit exécuter aussi diverses explorations pour connaître les ressources du pays. C'est alors que commencèrent "les bonnes années" ainsi appelées par suite de l'état prospère dans lequel se trouva la colonie jusqu'à la guerre de 1812.

Durant son séjour au Canada, ce gouverneur s'est signalé parmi les gens d'étude des deux langues qui travaillaient à former des bibliothèques, des cercle littéraires et tout ce qui se rattache à l'ordre intellectuel. Il n'est donc pas surprenant qu'il ait collectionné des pièces historiques de haute valeur qui forment cent brassées de manuscrits. Nous avons tout cela maintenant, mais nos historiens n'en ont rien connu. En réalité ils n'ont pris leurs inspirations que dans l'ouvrage de Ducalvet. Quiconque mettra au jour les renseignements des volumineux cahiers de Haldimand revélera la vraie histoire de l'époque en question et corrigera nombre d'erreurs qui passent à présent pour la seule croyance possible. En attendant, n'acceptons plus rien de ce qui a été imprimé sur Haldimand. Quand on l'aura étudié, ses fautes entreront en ligne avec le reste et nous y verrons clair, tandis qu'aujourd'hui, nous sommes dans les limbes.

Ici j'ouvre un autre horizon.

La partie politique du livre n'est pas à dédaigner. On pourrait en faire une brochure instructive en y mettant des notes pour éclairer certains passages. Les Canadiens qui se vouaient à cette branche d'étude et qui figurent dans l'Assemblée de 1792 n'ont pas manqué l'occasion d'en tirer parti, on le sait par les débats qu'ils soulevèrent, mais ils n'ont pas mêlé les plaintes personnelles du pamphlétaire à ces questions d'intérêt public.

Ducalvet ne devance guère les principes politiques de son temps— il en fronde les abus. Son exposition de l'état des choses est à méditer du moment où il ne se met pas en scène. Il s'insurge contre ce qui lui paraît exagéré ou déplacé et aborde des projets de réforme, très souvent bien conçus. On en faisait autant à Londres. Des coups d'épée dans l'eau. L'heure n'était pas arrivée de mettre à néant l'absolutisme, les privilèges, les vieilles pratiques, néanmoins, pour ce qui concerne le Canada, ces pages ont de la valeur. On devrait les réimprimer, le livre de Ducalvet est devenu si rare.

Page 247, il dit que le *Courrier de l'Europe* publié à Londres, numéro du 23 juin 1784, parle d'un projet qui consisterait à diviser le Canada, haut et bas, en deux gouvernements sous un gouverneur général. Ce n'est pas une idée de confédération, comme certaines personnes le croient. Le comité chargé d'étudier ce plan consistait en lord Grantham, président, le jeune William Pitt, lord Sydney, Jenkinson et Dundas. Ducalvet désapprouve cette division du territoire de la province de Québec. Il demande une législature dont la chambre haute serait nommée par les seigneurs et la chambre basse (page 209) par les cent vingt-cinq paroisses existantes, chacune d'elles élisant deux députés. Ce plan, ajoute-il, est du baron Mazères.

Il propose aussi (page 217) un corps législatif de quarante-six membres dont moitié choisi par la couronne et moitié élus par le peuple, avec honoraires de cinq cents piastres par tête.

Ou encore (pages 221-223) le rétablissement du Conseil Supérieur du temps des Français, pour la judicature.

La liberté de la presse (page 228) ce qui eut fort satisfait Jotard et Mesplet, les seuls journalistes du pays.

Qu'on permettre (pages 219-221) à l'évêque catholique de faire venir des prêtres de France selon le besoin.

Institution des collèges (page 229) pour l'instruction de la jeunesse.

Naturalisation des Canadiens (page 230) dans toute l'étendue de l'empire britannique.

Création d'un régiment de gens autres que des Canadiens (page 223-227) pour remplacer les troupes royales. Les Canadiens doivent rester sur leurs terres, mais il faudrait leur donner l'instruction du soldat—il ne dit pas comment.

Ces propositions peuvent attirer un moment notre curiosité, surtout en ce qui concerne les prêtres et la naturalisation.

Très certainement cet ouvrage n'a pas soulevé d'enthousiasme parmi nous lorsqu'il parut. Le silence qui semble l'avoir accueilli en dit long. C'est tout au plus si on y remarqua favorablement un passage sur la milice, qui a du bon, et qui fut plus tard utilisé. Mais le reste, le fatras des accusations, les appels à la justice, c'était trop bien compris pour créer des adhérents à la cause du pamphlétaire. Les dessous, que Ducalvet ne divulgue jamais, étaient connus généralement et ne pouvaient qu'attirer du mépris sur l'ensemble de l'œuvre.

Ducalvet a raison de relever avec les termes de la censure le chiffre des salaires payés aux principaux officiers du Canada: Mabane, chirurgien des troupes, 200 louis sterling; membre du conseil législatif, 100 l. s.; juge des plaidoyés communs, 500 l. s.; commissaire faisant fonction de juge en chef, 300 l. s.; juge de la cour des prérogatives, 100 l. s.; total 1,200 louis sterling ou $6,000. Ce qui aujourd'hui représente bien $20,000.

Toute cette partie du livre est à voir. Elle ne regarde et ne règle en rien la situation du pauvre Ducalvet, mais c'est un tableau des sottises du régime colonial du temps.

Il est vrai de dire que nous n'avions pas en 1780 les libertés politiques dont nous jouissons. C'était chose impossible. Ducalvet ne touche pas à cette question: il ne la connaît pas. Ce sont les hommes de notre temps qui ont soulevé cette plainte. L'Angleterre en 1780, était plus mal gouverné que le Canada. Les libertés politiques, les réformes que nous demandions en 1792, 1820, 1837 n'étaient pas introduites dans le Royaume-Uni.

Sous le régime français, nous n'avions aucune liberté politique. En 1780, nous étions mieux sous ce rapport, aussi Ducalvet ne critique point la constitution de la Grande-Bretagne, ni le système colonial. Il s'en prend aux personnes uniquement.

De nos jours, on a élargi le cercle où se débattait notre prétendu Canadien et on le suppose reprochant à l'Angleterre de nous avoir refusé des réformes qu'elle ne possédait pas elle-même et que nous n'avions nullement demandées. Avec les idées d'aujourd'hui on embrouille celles d'autrefois.

Les abus commis par le groupe de fonctionnaires envoyés ici de Londres suscitaient de l'opposition parmi les Canadiens et bon nombre d'Anglais vers 1830. C'est alors que les orateurs politiques et les journalistes se mirent à exploiter les dires de Ducalvet. Ils avaient beau jeu. Une, sinon deux générations entières avaient passé depuis 1780, la mémoire des événements se trouvait perdue. La correspondance officielle restait au secret. L'*Appel* se présenta comme une révélation—on en fit un Évangile et c'est encore notre Coran pour l'usage de tous les jours.

Notre devoir, en conscience, est d'examiner les pièces officielles du temps qui forment cent volumes de manuscrits et d'en extraire ce qui concerne, non seulement Ducalvet, mais toute la bande des agitateurs avec laquelle il était lié. Cette page d'histoire une fois mise au jour, on fera bon marché de ce qu'on a dit ou publié pour soutenir la cause véreuse de Ducalvet et, au lieu d'avoir des historiens aveuglés ou plutôt qui ne voient que par les lunettes de ce vilain brouillon, ou saura en fin de compte ce qui s'est passé il y a cent cinquante et cent quarante ans. Il faut mettre de côté pour toujours les écrits de nos historiens qui traitent de cette période. De nouvelles et grandes lumières sont là pour nous éclairer en tout point.

Louis Rouer de Villeray, Premier conseiller au Conseil Souverain de la Nouvelle-France.

Par M. PIERRE-GEORGES ROY, M.S.R.C.

(Lu à la réunion de mai 1919)

"Il vaudrait autant avoir mis dans le Conseil le Père supérieur des Jésuites et le Père ministre que les sieurs de Villeray et d'Auteuil."
Frontenac

La famille Rouer de Villeray était originaire d'Italie et appartenait à la maison de La Rovère, l'une des plus illustres et des plus anciennes de l'Europe, qui a donné deux papes à l'Eglise, des princes souverains à l'Italie, une infinité de cardinaux et d'évêques, des doges à la République de Gênes et des chevaliers des ordres les plus distingués de l'Europe.[1]

Divisé en plusieurs branches, établie en Piémont d'où elle sortait, à Gênes, à Venise, dans le Comtat-Venaissin, cette famille a passé aussi en France sous plusieurs noms: Rouvere, La Rouyer, Rouer. Quant à ce qui concerne ce dernier nom, il y avait dans le Languedoc des Rouer de Fourquevaux, venus de Lombardie, dont l'un, Raymond de Rouer, chevalier de l'Ordre du Roi, gouverneur de Narbonne, envoyé en ambassade vers le roi d'Espagne, commanda, vers 1562, comme capitoul, les armées du Roi contre des religionnaires, dans le Haut-Languedoc.[2]

Louis Rouer de Villeray, le premier de ce nom qui vint s'établir dans la Nouvelle-France, était né sur la paroisse de Notre-Dame-en-Grève, ville d'Amboise, évêché de Tours, en 1629, du mariage de Jacques Rouer de Villeray, valet de chambre de la Reine, et de Marie Perthuis.

Louis Rouer, qui arriva en Canada vers 1650, à l'âge de vingt-un ou vingt-deux ans, y vint très pauvre, dit M. Margry. Mais il s'était sans doute résolu à cet exil pour conquérir au loin ce que le sort lui avait refusé dans sa patrie et peut-être donné à des aînés. Ainsi faisaient les cadets de Normandie prenant pour devise ces mots: "Cherche qui n'a."

L'avocat Peronne Du Mesnil, qu'on ne peut guère croire car ses avancés sont des attaques furieuses et non prouvées contre les principaux habitants de la colonie, dit dans un de ses *Mémoires* au ministre

[1] *Dictionnaire de la noblesse; Voyage à la Louisiane et sur le continent de l'Amérique septentrionale, fait dans les années 1794 à 1798*, par B. D.

[2] P. Margry, *Les Rouer de Villeray*, p. 5.

Colbert, que M. de Villeray était arrivé dans la Nouvelle-France en 1651 comme valet du gouverneur de Lauzon qui "le prit en prison de la Rochelle où il estait detenu faute de payement de la somme de 71l. comme appert par le papier de la geolle du 10 juillet 1651."[1]

Le gouverneur de Frontenac, dans une de ses lettres, dit que M. de Villeray s'engagea comme soldat dans la garnison de Québec, en arrivant ici. M. J.-Edmond Roy semble croire que M. de Villeray agit plutôt comme secrétaire du gouverneur de Lauzon. Il a pu être en même temps soldat et secrétaire du gouverneur.

A part l'affirmation de M. de Frontenac, nous n'avons pas de preuve que M. de Villeray a été soldat dans la garnison de Québec. Mais il est certain qu'il fut secrétaire du gouverneur de Lauzon. Une concession de terrain à Québec en date du 15 mai 1656, accordée par le gouverneur de Lauzon à Charles Sevestre, lieutenant particulier civil et criminel en la juridiction de Québec, est signée "Lauzon" et plus bas "par Monseigneur, Rouer."[2] Ce Rouer ne peut être autre que notre M. Rouer de Villeray. Dans le contrat de mariage de M. Rouer de Villeray reçu deux années plus tard, le 9 février 1658, par le notaire Peuvret il est également qualifié de "secrétaire du gouverneur." Il ne peut donc y avoir de doute sur ce point.

Dans une colonie naissante les hommes instruits ne sont pas nombreux. Les autorités confient au même individu plusieurs charges à la fois. M. de Villeray, tout en servant de secrétaire à M. de Lauzon, exerça comme notaire à Québec. Ses lettres de nomination n'ont pas été conservées, mais il est certain qu'il exerça cette charge de 1654 à 1657.

Pareillement, nous voyons par la commission de M. Martin de Saint-Aignan comme juge-prévôt de la seigneurie de Beaupré du 7 novembre 1663, que M. de Villeray avait exercé cette charge: "Supplie Charles Aubert la Chesnaye, intéressé pour la plus considérable partie dans la seigneurie de Beaupré et isle d'Orléans, lisons-nous dans cette commission, disant que la dite terre et seigneurie est demeurée depuis un assez long tems sans juge, par la caducité du sieur Olivier Le Tardif, et la *démission du sieur Rouer de Villeray de sa commission de juge-prévôt en la dite terre . . . .* "[3]

A quelle date M. de Villeray fut-il nommé juge prévôt de la seigneurie de Beaupré ? Combien de temps garda-t-il cette charge ? Il nous est impossible de répondre à ces deux questions, mais rien

[1] *Bulletin des Recherches Historiques*, vol. XXI, p. 197.

[2] Pièces judiciaires, notariales, etc., etc., conservées aux Archives Judiciaires de Québec, première liasse, n° 33.

[3] *Édits et Ordonnances*, vol. III, p. 86.

n'empêchait M. de Villeray d'être en même temps secrétaire du gouverneur, notaire à Québec et juge prévôt sur la côte de Beaupré. Cette dernière charge était plutôt une sinécure, car les habitants n'étaient pas encore bien nombreux à cette époque dans la seigneurie de Beaupré.

Dès son arrivée à Québec en octobre 1651, le gouverneur de Lauzon plaçait l'administration de la justice sur un pied plus régulier. Un grand-senéchal fut mis à la tête de la justice ordinaire. Un lieutenant-général civil et criminel et un lieutenant particulier, assistés d'un procureur fiscal, furent chargés de rendre la justice sous l'autorité de ce grand-senéchal.[1]

Le premier grand-senéchal de la Nouvelle-France fut Jean de Lauzon, fils du gouverneur. Cette charge de grand-senéchal, au dire de M. de La Tour, était plutôt un titre d'honneur.[2]

Nicolas Le Vieux d'Hauteville et Louis-Théandre Chartier de Lotbinière occupèrent successivement la charge de lieutenant-général de la senéchaussée de Québec. Charles Sevestre exerçait dès 1656 la charge de lieutenant particulier de la senéchaussée.

Charles Sevestre étant décédé à Québec le 9 décembre 1657, M. d'Ailleboust, qui avait succédé au gouverneur de Lauzon, nomma M. de Villeray lieutenant particulier de la senéchaussée.

M. Sevestre occupait aussi la charge de commis du magasin des Cent-Associés à Québec. M. de Villeray lui succéda pareillement dans cet emploi. M. Sevestre avait tenu ses écritures d'une façon telle qu'après sa mort on eut beaucoup de difficultés à les comprendre. M. de Villeray, son successeur, qui avait épousé sa fille deux mois après sa mort, fut tenu responsable de ses erreurs ou de sa mauvaise gestion.

Le 5 septembre 1658, le gouverneur d'Argenson écrivait à M. de Morangé, conseiller ordinaire du Roi en ses Conseils et directeur de ses finances:

"La mort de M. Sevestre a obligé Monsieur d'Ailleboust d'en arrêter les comptes. J'ai ordonné qu'on mit la copie entre les mains de Monsieur Denis pour vous l'envoyer. Il (M. Sevestre) avait la charge de lieutenant particulier, laquelle, après sa mort, Monsieur d'Ailleboust a fait exercer par le sieur de Villeray sous votre bon plaisir. Je le trouve très capable et personne à s'en acquitter avec honneur et je ne fais nul doute que recevant cette gratification de votre compagnie il n'en aie une parfaite reconnaissance. C'est à lui que M. Denis avait fait opposition pour sa maison, mais je l'ai trouvée si fort

[1] Ferland, *Cours d'histoire du Canada*, vol. 1er, p. 402.

[2] *Mémoires sur la vie de Mgr de Laval.*

avancée qu'il aurait été néanmoins nécessaire de le dédommager, outre qu'elle n'est point du côté de la rade et qu'ainsi on peut dire qu'elle est plutôt contre la bienséance que contre la nécessité. Il n'en est pas de même d'une autre qui regardait la rade des vaisseaux et que j'ai ordonnée qui fut levée parce qu'elle empêche la batterie.

"Le sieur de Bécancour n'a pu s'empêcher de témoigner sa chaleur ordinaire sur la conservation du bâtiment du Sr de Villeray sur ce qu'il disait en avoir concession mais il a été bien étonné lorsque je lui ai dit que ce ne pouvait être qu'une surprise puisque si il est vrai que le bâtiment de Villeray nuise à la forteresse du magasin celle qu'il y bâtirait à la place causerait le même empêchement et que par là il découvrait seulement l'intérêt qui le faisait agir et nullement la pensée de la justice et de maintenir les droits de votre compagnie."[1]

M. d'Argenson, on le voit, avait une haute opinion de l'honnêteté et des capacités de M. de Villeray. Mais celui-ci avait des ennemis et ils réussirent à indisposer le gouverneur contre lui. La plupart des lettres de M. d'Argenson au ministre n'ont pas été conservées, mais c'est certainement sur ses plaintes que M. de Villeray fut obligé de traverser les mers pour aller s'expliquer auprès des autorités.

Dans un arrêt du roi signé à Paris le 13 mai 1659, au sujet de la traite des pelleteries, nous lisons: " . . . . et d'autant que Sa d. Majesté a été informée que le nommé Rouer de Villeray a été par voies et moyens illicites élu et nommé pour être du conseil de la dite traite, que d'ailleurs il est accusé de plusieurs crimes dont il doit se justifier auparavant que d'exercer aucune charge publique et qu'il doit représenter tous les comptes que défunt Sevestre son beau-père a rendus de la recette et dépense des droits du dit magasin avec les registres qu'il en a tenus et les autres pièces justificatives des d. comptes, Sa dite Majesté ordonne que pour y satisfaire et pour se purger des d. crimes le d. Rouer viendra en France par le retour des vaisseaux qui iront cette année au dit pays et cependant qu'il sera procédé au plus tôt à l'élection et nomination d'une autre personne pour assister au dit Conseil de la traite au lieu et place du d. Rouer par les habitants du dit pays qui seront assemblés à cette fin par l'ordre du sieur d'Argenson."[2]

Le 21 octobre 1659, le gouverneur d'Argenson écrivait au ministre: "Il y a un habitant d'ici appelé Villeray qui s'en va en France se justifier de quelque accusation que font Mrs de la Cie contre lui. Il a quelques qualités assez bonnes mais on ne peut avoir confiance en lui parcequ'il a été à trop de Messieurs: M. de Lauzon, M. de Charny

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[1] Archives du Canada, Correspondance générale, vol. 1er.

[2] Archives Provinciales de Québec, 1ère série, cahier 1er.

et M. d'Ailleboust, si bien qu'il voltige tantôt d'un côté et tantôt d'un autre."[1]

M. de Villeray partit à bord du vaisseau du capitaine Poulet qui prit la mer le 26 octobre 1659. Le Père Barthélemy Vimont, l'abbé de Queylus, M. de Bécancour, M. Chartier de Lotbinière et la plupart des marchands de Québec et de Montréal s'embarquèrent en même temps que M. de Villeray.[2]

M. de Villeray revint au pays au printemps de 1660. Ses explications avaient été trouvées si satisfaisantes qu'on lui remit sa charge dès son retour au pays. Le gouverneur d'Argenson, indignement trompé sur son compte, lui rendit aussi toute son estime.

Le 4 novembre 1660, M. d'Argenson écrivait au ministre: "On nous a donné bien des comptes à revoir cette année. Pour moi, ma pensée était de décharger le commis du magasin du compte rendu en 1657 de même que nous avions fait des autres, mais on a jugé dans le Conseil d'ici plus à propos de renvoyer ce compte sans l'arrêter, mais seulement avec quelques remarques. Cela ne laissera pas d'embarrasser le commis du magasin ou du moins ses héritiers desquels est le sieur de Villeray, lieutenant-particulier de ce Québec qui est un des meilleurs habitants de ce pays et un fort honnête homme. Il avait passé en France l'année passée et va encore y faire un tour. Il lui serait fâcheux d'être recherché après avoir payé par l'ordre de ceux qui avaient le pouvoir et vous voyez bien qu'il serait impossible à un commis de refuser un commandement du gouverneur particulièrement quand il y fait donner quelque approbation du Conseil. Ce n'est pas que j'en aie jamais voulu user de la sorte. J'ai toujours laissé une entière liberté au Conseil de disposer et de donner les ordres au commis de payer, mais seulement pour vous montrer la justice qu'il y a de décharger le commis, ce que je vous prie d'insinuer à ceux qui pourraient vous en parler."[3]

M. de Villeray s'embarqua pour la France, à Québec, le 5 novembre 1660, sur le vaisseau de Pointel.[4] Il revint au cours de l'été de 1661.

A l'automne de 1662, nouveau voyage en France. M. de Villeray s'embarqua le 20 septembre 1662, sur le vaisseau du sieur La Mothe, avec mademoiselle Mance, M. La Garenne, etc.[5]

D'après l'édit de créations du Conseil Souverain de la Nouvelle-France, du mois d'avril 1663, la nouvelle institution devait se com-

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[1] Archives Provinciales de Québec, 1ère série, cahier 1er.

[2] *Journal des Jésuites.*

[3] Archives Provinciales de Québec, 1ère série, cahier 1er.

[4] *Journal des Jésuites.*

[5] *Journal des Jésuites.*

poser du gouverneur de Mézy, de Mgr de Laval et de cinq autres personnes qu'ils devaient choisir conjointement et de concert.

Ces cinq personnes furent choisies le 18 septembre 1663. Le premier nom sur lequel s'arrêtèrent M. de Mézy et Mgr de Laval fut celui de M. de Villeray. Il fut choisi comme premier conseiller.

Dès la deuxième séance du Conseil Souverain, M. de Villeray fut chargé d'une mission délicate et peut-être dangereuse.

En 1660, les directeurs de la compagnie des Cent-Associés avaient envoyé à Québec l'avocat Peronne Du Mesnil en qualité de contrôleur général, d'intendant et de juge souverain. Pendant son séjour de près de quatre années ici, Peronne Du Mesnil se conduisit comme un véritable inquisiteur, accusant tous les hommes en place d'être des voleurs.

En septembre 1663, Peronne Du Mesnil apprenant que le Conseil Souverain, nouvellement organisé, avait l'intention de demander aux commis et receveurs des deniers de la Communauté de rendre leurs comptes pour les deux dernières années, fit forcer l'étude de M. Audouart, greffier de l'ancien Conseil, et enlever certains registres et pièces justificatives dont on avait besoin pour cette reddition de comptes.

Le 20 septembre 1663, le Conseil Souverain chargeait MM. de Villeray et Bourdon d'enlever ces registres et papiers à Peronne Du Mesnil, puis de les sceller et mettre sous bonne garde. Ils devaient aussi forcer Peronne Du Mesnil à quitter la maison qu'il habitait et qui appartenait à la colonie. Une escorte de soldats fut donnée à MM. de Villeray et Bourdon et ils s'acquittèrent de leur mission avec une fermeté qui ne plût pas au sieur Peronne Du Mesnil qui faisait le rodomont dans le pays depuis quarante mois. De là les accusations aussi mensongères que ridicules portées par cet avocat bavard contre M. de Villeray après son retour en France.[1]

Deux partis se formèrent bientôt dans le Conseil Souverain: celui de l'évêque, qui, obéissant à l'édit du roi, avait établi son séminaire et la dîme, et s'opposait avec fermeté à la vente des boissons enivrantes aux sauvages; et le parti de gouverneur, qui, se figurant que Mgr de Laval voulait empiéter sur ses attributions, essayait de se venger en favorisant la traite de l'eau-de-vie et en lui créant des embarras pour la dîme. M. de Villeray n'hésita pas à se déclarer en faveur de la dîme et contre la traite de l'eau-de-vie, c'est-à-dire pour son évêque contre le gouverneur de Mézy. De là la fureur de ce dernier

[1] *Le Mémoire* de Peronne Du Mesnil a été publié dans le *Bulletin des Recherches Historiques*, vol. XXI, pp. 166 et seq.

contre M. de Villeray et MM. d'Auteuil et Bourdon, procureur-général, qui avaient agi comme lui.

Le 13 février 1663, pendant que Mgr de Laval était au château, dans la salle ordinaire des séances du Conseil Souverain, M. d'Angoville, secrétaire de M. de Mézy, vint de la part de son maître lui donner lecture de l'avis de destitution de MM. de Villeray, d'Auteuil et Bourdon.

"Il ne les avait nommés, disait-il, qu'à la suggestion de l'évêque de Pétrée, dont ils étaient les créatures. Ils avaient voulu se rendre maîtres du Conseil, contre les intérêts du roi et du public, dans le but de favoriser des particuliers. Ils avaient formé et fomenté des cabales, contrairement à leur devoir et au serment de fidélité qu'ils avaient prêté au roi. On avait profité, ajoutait-il, de sa bonne foi et de son ignorance du pays pour le faire consentir à leur nomination. Il priait maintenant le prélat de se joindre à lui pour faire une assemblée du peuple, à l'effet de choisir d'autres officiers."

Mgr de Laval se contenta de faire remarquer que cette déclaration n'avait aucune valeur, puisqu'il ne lui avait pas donné son concours, ainsi que le voulait l'édit de création du Conseil Souverain.

"M. de Mézy, dit M. l'abbé Gosselin, alliait une foi profonde à de grands travers d'esprit. On lui fit entendre que ses actes arbitraires forceraient le clergé à lui interdire les sacrements de l'Église; de ce moment, sa conscience ne fut pas en repos."

Enfin, à la séance du Conseil Souverain, le 16 avril 1663, M. de Mézy rendit ses bonnes grâces à MM. de Villeray et Bourdon et il déclara comme nul et non avenu tout ce qu'il dit et écrit contre eux. La disgrâce de M. de Villeray avait duré deux mois.[1]

Cependant la colère de M. de Mézy contre M. de Villeray et les autres membres du Conseil Souverain qui partageaient ses opinions n'était calmée qu'en apparence. Elle n'attendait qu'une occasion favorable pour éclater de nouveau.

M. Charron avait été élu syndic des habitants en assemblée publique régulièrement convoquée par ordre du Conseil Souverain. M. Charron résigna bientôt. Une assemblée convoquée pour lui élire un successeur fut sans résultat. Une troisième assemblée, convoquée par le gouverneur seul et, par conséquent. irrégulière, nomma M. Lemire.

Certains conseillers, parmi lesquels MM. de Villeray et d'Auteuil, ayant protesté contre cette élection, M. de Mézy ne put se contenir

[1] Sur cet épisode on peut consulter M. l'abbé Gosselin, *Vie de Mgr de Laval*, tome 1, pp. 437 et seq. Tout l'événement est raconté de main de maître.

et il suspendit de leurs fonctions MM. de Villeray, d'Auteuil, de la Ferté et le procureur général Bourdon.

C'est au moment où M. de Mézy était le plus monté contre M. de Villeray que ce dernier traversa en France probablement pour ses affaires et peut-être aussi pour mettre le ministre au courant de ce qui se passait ici. Il s'embarqua le 30 août 1664 sur le vaisseau du sieur Le Gangneur.[1]

Vingt jours après le départ de M. de Villeray pour la France, le 19 septembre 1664, M. de Mézy se présentait au Conseil Souverain et déclarait que le roi lui avait donné le pouvoir et à Mgr de Laval de changer les conseillers au bout de l'an, qu'il en avait parlé plusieurs fois à l'évêque, mais qu'ils n'avaient pu s'entendre. Il annonçait également que M. de Villeray, en route pour la France, ne faisait plus partie, non plus, du Conseil Souverain.

Le 24 du même mois, M. de Mézy, de sa seule autorité, nommait les successeurs des conseillers destitués. "En tout cela, dit Garneau, le gouverneur violait l'édit royal, car s'il ne pouvait nommer les conseillers sans le consentement de l'évêque, il ne pouvait non plus se passer de ce consentement pour les destituer ou les suspendre."[2]

En France, M. de Villeray ne perdit pas son temps. Il vit le ministre et le fit voir par ses amis. Il écrivit même un mémoire que nos historiens ne semblent pas avoir connu et où il donne les raisons de la haine du gouverneur de Mézy contre lui. "La source du désordre, écrivait-il en cette occasion, procède de deux choses: l'une, de ce que l'édit du roi touchant l'érection du Conseil Souverain à Québec diminue la grande autorité des gouverneurs, et l'autre, l'avarice de M. de Mézy, qui lui a fait rechercher par force et par artifice une augmentation de 5,000 livres au-delà des précédents gouverneurs. Jugez où cela va, eu égard au pays et à sa pauvreté. J'ai fait tout le possible pour empêcher cette augmentation et que les intentions de Sa Majesté fussent suivies, et plus j'y ai fait mon devoir, plus il a eu occasion de m'en savoir mauvais gré, et pour cela il a mis tout en usage pour me perdre."[3]

M. de Villeray revint dans la Nouvelle-France pendant l'été de 1665. Il fit probalement la traversée sur le *Saint-Sébastien* qui amenait ici l'intendant Talon. Ce vaisseau, parti de Larochelle le 24 mai 1665, jeta l'ancre devant Québec le 12 septembre suivant. La traversée avait duré 117 jours! M. de Villeray apprit en arrivant, en même

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[1] *Journal des Jésuites.*

[2] *Histoire du Canada*, tome 1er.

[3] Bibliothèque Nationale, fonds Colbert, collection verte.

temps que sa destitution, la mort de celui qui en avait été la cause. M. de Mézy était en effet décédé à Québec, le 5 mai 1665.

Coïncidence curieuse! Dans le mémoire d'instructions remis à M. Talon avant son départ, le roi semblait insinuer que les Jésuites menaient tout le pays, y compris le gouverneur et l'évêque. Le roi disait à M. Talon de s'informer là-dessus. "Pour y parvenir il faudra qu'il voit le procureur général et le sieur Villeray, qui sont les deux principaux du Conseil Souverain établi à Québec, que l'on dit être entièrement dévoués aux dits Jésuites, desquels il tirera ce qu'ils en peuvent savoir sans néanmoins se découvrir de ses intentions."

Pendant ces cent dix-sept jours de traversée, M. Talon eut amplement le temps de questionner M. de Villeray sur les choses du pays. Celui-ci, qui habitait la Nouvelle-France depuis quatorze ans et qui avait été mêlé à tous les événements importants, lui donna, nous pouvons le croire, des renseignements qui mirent M. Talon absolument au fait de la situation du pays.

M. de Tracy, arrivé dans le pays le 30 juin 1665, se chargea de réparer l'injustice commise au détriment de M. de Villeray par l'irascible M. de Mézy. Le 6 décembre 1666, il faisait de nouvelles nominations au Conseil Souverain et M. de Villeray recevait la charge de premier conseiller.

Le 10 novembre 1668, le Conseil Souverain de la Nouvelle-France rendait son célèbre arrêt permettant à "tous les Français habitants de la Nouvelle-France de vendre et débiter toutes sortes de boissons aux sauvages qui en voudront acheter d'eux et traiter." Mgr de Laval et M. Le Gardeur de Tilly seuls refusèrent de signer cet arrêt. M. de Villeray, comme les autres membres du Conseil Souverain, apposa sa signature. C'était la première fois que M. de Villeray différait d'opinion avec Mgr de Laval sur le funeste commerce de l'eau-de-vie. Il dût regretter cette erreur. C'est l'intendant Talon qui avait décidé le Conseil Souverain à adopter cet arrêt.

"Certes, a écrit M. Chapais, Talon ne se rendait pas compte du fléau qu'il déchaînait. Il croyait, sans doute, servir encore le bien public en provoquant cette décision. Cependant quelles que pussent être ses intentions, il commettait un acte dont l'historien impartial ne saurait l'excuser. Il y a dans sa vie bien des pages glorieuses. Mais on voudrait pouvoir déchirer celle qu'il écrivit le 10 novembre 1668"[1] La même remarque s'applique à M. de Villeray. On voudrait pouvoir déchirer la triste page qu'il écrivit le 10 novembre 1668.

M. de Villeray avait été d'autant plus mal inspiré en suivant M. Talon sur cette question de l'eau-de-vie qu'en cette même année 1668

[1] *Jean Talon*, p. 245.

il avait été élu marguillier de l'église paroissiale de Québec qui était en même temps la cathédrale de Mgr de Laval. L'évêque de Québec, toutefois, ne lui garda pas rancune pour ce faux pas dans sa carrière jusque là sans reproche.

Le 14 janvier 1669, le gouverneur de Courcelle continuait M. de Villeray dans sa charge de conseiller au Conseil Souverain. Nous lisons dans le procès-verbal de l'assemblée du Conseil Souverain tenue ce jour-là: "En l'assemblée convoquée au château Saint-Louis de Québec par M. Daniel de Remy, chevalier, seigneur de Courcelle, gouverneur et lieutenant-général pour le Roi en la Nouvelle-France, où il présidait assisté de Messieurs Claude de Bouteroue, conseiller de Sa Majesté en ses conseils, intendant de la justice, police et finances de ce pays, et de Mgr François de Laval, évêque de Pétrée, nommé par le Roi premier évêque de ce pays lorsqu'il aura plu à notre Saint Père le Pape d'y en établir un, conseiller perpétuel au Conseil Souverain établi à Québec par l'édit du mois d'avril 1663; les sieurs de Villeray, de Gorribon, de Tilly, Damours, de la Tesserie, de Mouchy et Peuvret ayant été mandés, il leur a été déclaré qu'il a été fait choix de leurs personnes pour remplir les charges du dit Conseil, savoir les dits sieurs de Villeray, Gorribon, de Tilly, Damours et de la Tesserie pour être continués dans l'exercice des charges de conseillers, le dit sieur de Mouchy pour être établi en la charge de substitut du procureur général, et le dit sieur Peuvret pour être continué secrétaire et greffier."[1]

Le gouverneur de Courcelle n'était pas un ami de Mgr de Laval. Le 13 janvier 1670, il réorganisait le Conseil Souverain. M. de Villeray, que le gouverneur jugeait trop favorable à Mgr de Laval et à son clergé, fut remplacé comme conseiller par M. Dupont.

M. Patoulet, secrétaire de l'intendant Talon, écrivait au ministre Colbert le 25 janvier 1672, au sujet de l'exclusion de M. de Villeray: "M. de Courcelle en 1670 estima devoir congédier le conseil formé par M. de Tracy, lui et M. Talon, pour en exclure le sieur de Villeray, soupçonné par lui d'avoir de trop fortes liaisons avec M. l'évêque de Pétrée et les PP. Jésuites. Et comme il n'a peut-être pas fait réflexion que le roi ne lui a pas confié ce pouvoir-là, et que des habitants du pays ont dit que lorsque M. de Courcelle en sera parti ils protesteront de nullité contre les arrêts que le nouveau conseil qu'il a établi a rendus, je crois qu'il serait bon pour remédier à beaucoup de chicanes, qui pourraient naître de là, d'autoriser par un arrêt du Conseil de Sa Majesté le procédé de mon dit sieur de Courcelle, et cependant faire rentrer le dit sieur de Villeray, seul homme capable de judicature. M.

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[1] *Jugements et délibérations du Conseil Souverain de la Nouvelle-France*, vol. 1er, p. 539.

l'évêque de Pétrée et les PP. Jésuites se conformant en toutes choses aux instructions du roi il ne peut plus être suspect."[1]

Il tombait dans le lot de M. de Villeray de devenir la bête noire des gouverneurs de la Nouvelle-France. Tour à tour MM. de Mézy, d'Argenson et de Courcelle avaient eu des griefs contre lui. Mais le gouverneur de Frontenac devait être tout le temps de son administration un violent et presque toujours injuste adversaire de M. de Villeray.

Le 2 novembre 1672, M. de Frontenac écrivait au ministre Colbert: "Il ne me reste plus, Monseigneur, pour faire une aussi longue, et peut-être aussi ennuyeuse lettre, qu'à vous dire que Mrs. Paget et quantité d'autres principaux habitants de La Rochelle, qui sont créanciers de la communauté du Canada me présentèrent en passant une requête par laquelle ils me demandaient que j'eusse à les faire payer de ce qui leur était dû par les habitants de ce pays, prétendant qu'on y avait touché de grandes sommes sur les dix pour cent qu'on y lève, sans qu'ils eussent été payés de quoi que ce soit. Comme je n'étais pas en lieu de leur pouvoir rien répondre, je les remis quand je serais arrivé, et en ayant parlé depuis à M. Talon, il m'a dit qu'il ajusterait cela quand il serait en France.

"Cependant les habitants m'ont fait ici les mêmes plaintes, disant que le droit se levait toujours sans qu'ils se vissent acquittés de la moindre somme; qu'un nommé Villeray avait été depuis quelques années établi par M. Talon pour le recevoir, et qu'il n'y en avait pas un d'eux qui ne connut fortune d'être arrêté prisonnier, lorsqu'ils allaient à La Rochelle. Les marchands et le syndic des habitants me vinrent même trouver il y a quelques jours pour se plaindre que le dit Villeray voulait exiger un droit de cinq pour cent sur toutes les marchandises sèches qui avait été aboli il y a deux ans, sans néanmoins qu'il y eut eu pour rétablir aucune ordonnance publiée, qu'on leur avait demandé la déclaration de leur facture de cette année et même exigé le droit d'un capitaine d'un vaisseau qui est parti depuis huit ou dix jours pour les Îles, ce qui ne donnait pas un grand courage de continuer ce commerce. Ce sera à vous à régler, s'il vous plaît, toutes ces choses-là avec M. Talon qui, je crois, vous en rendra bon compte. Ils viennent de m'apporter leurs requêtes que je vous envoie sur les cottes G. L.

"L'on m'a donné avis que ce Villeray avait envie de vous demander la charge de procureur-général du Conseil Souverain, mais il passe ici pour un esprit fort brouillon et qui cherche à mettre la dé-

[1] Archives du Canada, Correspondance générale, vol. 3.

sunion partout, quoique d'ailleurs il ait de l'entendement et du savoir. C'est ce qui a obligé, il y a un an, de l'ôter du Conseil où il faisait la charge de conseiller. Il y a encore une autre raison plus forte, *c'est qu'il est entièrement dévoué aux Pères Jésuites, et l'on dit même ici communément qu'il est du nombre de ceux qui sans en porter l'habit ne laissent pas d'en avoir fait les vœux.*[1] C'est pourquoi j'ai cru qu'il était de mon devoir de vous en avertir afin que vous vissiez, en cas que l'on vous en parlât, si après avoir (eu) autant de peine *à ôter aux Pères Jésuites la connaissance et la direction des affaires de ce pays il serait à propos de leur ouvrir une porte pour y entrer indirectement.*"[2]

Le 13 novembre 1673, M. de Frontenac revenait à la charge auprès du ministre Colbert: "M. Paget et les autres qui m'avaient, comme je vous le marquai l'année passée, parlé des dettes que leur doit le pays, m'ont encore celle-ci envoyé une nouvelle requête pour être satisfaits; mais je leur mande qu'ils n'ont qu'à s'adresser à vous et que vous reglerez cela ou avec M. Talon ou avec celui dont le Roi fera choix, pour lui donner l'intendance de ce pays. Cependant comme un nommé Villeray duquel je me donnai l'honneur de vous parler dans mes dernières depêches et dont je vous dépeignais le caractère, était commis pour la levée du dix pour cent et que pendant cet hiver il m'a donné en deux ou trois rencontres des marques de son humeur brouillonne, intriguante et propre à mettre la division et le trouble partout, je crus en partant pour le voyage du lac Ontario, et prévoyant qu'il arriverait quelques vaisseaux avant mon retour, devoir remettre cette commission entre les mains d'une personne plus affectionnée pour le service et qui fut moins dépendante des Jésuites, dont il est un des principaux arc-boutants et duquel ils se servent dans toutes leurs machines. C'est pourquoi j'ai commis le sieur de Peiras qui a été autrefois secrétaire de M. de Courcelles et qui est un homme très capable, en bonne réputation et entre les mains de qui les deniers seront plus assurés qu'ils n'auraient été dans celles de l'autre. Et comme il avait déjà fait la recette de deux vaisseaux devant que j'eusse reçu vos premiers ordres qui ne sont arrives ici que le troisième septembre par navire du capitaine Poulet, et que je voyais que les gens de M. Talon à qui le dit Villeray avait à répondre, s'en retournaient en France, j'ai cru que vous ne trouveriez pas mauvais que je ne changeasse rien de ce que j'avais fait, avant que de savoir vos intentions, vous assurant que le sieur de Peiras rendra un bon et fidèle compte à l'intendant qui viendra en ce pays de tout ce qui aura passé par ses mains.

[1] Tous les mots en italiques en chiffres.

Archives du Canada, Correspondance générale, cahier 3.

"Si j'ai manqué en cela ça été en croyant bien faire et non pas manquer d'obéissance à vos ordres que je servirai toujours aveuglement."[1]

Le ministre Colbert, qui connaissait de longue date l'antipathie de M. de Frontenanc pour M. de Villeray, lui répondait le 17 mai 1674: "A l'égard du sieur de Villeray, Sa Majesté a toujours reconnu que c'estait celuy de tous les habitans de Canada qui estait le plus accommodé, et qui s'appliquait le plus au commerce, et mesme avait déjà des vaisseaux en mer qui avaient donné commencement au commerce avec les Isles de l'Amérique; et comme Sa Majesté vous a toujours fait connaistre qu'il n'y avait rien de plus important, et de plus nécessaire que ces sortes d'establissemens, aussy ceux qui s'y portent debvraient asseurement avoir le plus de part en vostre confidence, et en vos bonnes grâces, affin que par le favorable traitement qu'ils recevraient de vous, ils fussent convier à augmenter ce commerce, et que leur exemple excitât les autres à s'y porter; c'est asseurément l'ordre et la règle que vous debvez tenir, et quoy que vous trouviez quelques deffauts en ces sortes de gens, il faut les dissimuler, et les souffrir, parce que le bien qu'ils peuvent faire, excède infiniment le mal, et puisque la compagnie avait donné au d. Villeray la commission de recevoir les droits de dix pour cent vous ne pouviez pas et ne debviez pas donner cette recepte à un autre sous pretexte que le dit Villeray est attaché aux Jésuites.

"Sa Majesté veut de plus que le commis de la compagnie paye les 36,000 l, des charges extraordinaires du pais suivant l'estat de la compagnie sans que vous l'obligiez à payer davantage.

"Sa Majesté veut que vous teniez soigneusement la main à ce que les habitants se pourvoyent des armes, poudres, plomb et autres munitions qui leur seront nécessaires pour leur défense.

"Que le recensement de tous les habitans se fasse tous les ans avec grand soin, en sorte qu'il n'en soit obmis aucun.

"Que vous portiez tous les garçons et filles au mariage, aussy tost qu'ils viennent en aage.

"Que vous restablissiez le sieur de Villeray dans sa charge de premier Conseiller au Conseil Souverain, en cas qu'il ne l'ayt point encore esté."[2]

M. de Villeray ne devait pas être longtemps en dehors du Conseil Souverain. Au printemps de 1674, la compagnie des Indes Occidentales "bien informée que ce serait faire justice à M. de Villeray et en même temps procurer un bien à la Nouvelle-France de le rétablir dans

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[1] Archives du Canada, Correspondance générale, vol. 4.

[2] Archives du Canada, Ordres du Roi, série B, vol. 6.

la charge de premier conseiller au Conseil Souverain qu'il possédait ci-devant," le *nommait* au roi, ainsi qu'elle en avait le privilège par ses lettres patentes, pour continuer d'en exercer la fonction.

Le 18 mai 1674, le ministre Colbert informait M. de Frontenac de la nomination de M. de Villeray, mais il oubliait de joindre à sa lettre les provisions de sa Majesté. M. de Villeray fut tout de même installé dans son ancienne charge de premier conseiller, le 8 octobre 1674. Il est dit dans le procès-verbal de réception: "Le Conseil pour donner à Sa Majesté des marques de sa parfaite obéissance et de la promptitude avec laquelle il se porte à exécuter ses ordres sur la moindre connaissance qu'il peut avoir de ses volontés, a ordonné et ordonne que nonobstant le défaut de la présentation des provisions du dit sieur de Villeray . . . il sera reçu en une des charges de conseiller au dit Conseil sans lui donner de rang pour le présent. . .[1]"

Le gouverneur de Frontenac était présent à la séance en question et c'est lui qui dictait ces belles phrases . . . . pour la galerie.

Quelques semaines plus tard, le 14 novembre 1674, il écrivait à M. Colbert et tout en informant le ministre de ses procédés de bon prince à l'égard de M. de Villeray il lui servait un plat de sa façon:

"Vous me marquez que Sa Majesté pourvoit encore deux conseillers au Conseil Souverain pour composer le nombre de sept. Cependant Mr. de Bellinzani ne m'a envoyé que les provisions du Sr de Lotbinière et celles du Sr Dauteuil pour procureur-général, duquel vous ne me faisiez aucune mention. On les a reçus l'un et l'autre, mais l'oubli des provisions du sieur de Villeray que vous m'ordonnez par les derniers articles de votre dépêche, de rétablir en la première place de conseiller, a causé quelque difficulté au Conseil pour le remettre dans ce rang, parcequ'il ne représentait point ses provisions et quoi que j'aye fait toutes (sortes) d'instances, comme vous pourrez voir par le procès-verbal et l'arrêt que le Conseil a donné cotte A que je vous envoye, je n'ai pu obtenir qu'il fut reçu à la première place, mais seulement en celle de conseiller sans lui donner de rang et ce par provision en attendant qu'il représente ses provisions et que la volonté du Roi ou la vôtre, leur fut plus clairement connue.

"J'aurais néanmoins fort souhaité que le Conseil ne se fut pas arrêté à cette formalité dans l'appréhension que j'ai que vous ne me soupçonniez de ne pas avoir agi en cela comme je devrais et que ce ne soit un effet d'un reste de chagrin que j'aurais contre lui, puis que je vous assure que si je vous ai écrit ci-devant sur son sujet, dans les termes que j'ai fait, ce n'a été que par les connaissances que j'ai eues du caractère de son esprit; car, du reste, il n'y a homme en

[1] *Jugements et Délibérations du Conseil Souverain.*

Canada dont je dusse être plus satisfait, puisqu'il n'y a en a point qui ait eû tant de soumissions apparentes pour moi, ni qui ait pris plus de soin de rechercher mon amitié; mais j'ai toujours eu en vue de suivre exactement ce que vous m'aviez prescrit en partant, sur le sujet de *Mr l'évêque de Pétrée et des Pères Jésuites*[1], j'ai cru ne les devoir pas autoriser par leurs émissaires dont celui-ci est le principal et le plus dangereux comme vous pourrez aisément le vérifier par des personnes désintéressées qui vous instruiront de tout ce qu'il a fait, non seulement du temps de Mr de Courcelles, mais encore de celui de plusieurs autres gouverneurs qui l'avaient précédé. Pour moi, il ne m'avait jamais donné aucun sujet de plainte quand je vous en ai fait le portrait, mais je ne craindrai point de vous dire d'abord qu'il est venu en ce pays, il a pris parti dans la garnison, et a été soldat dans le fort, que la fortune qu'il y a fait ensuite est si médiocre que, s'il n'avait été les dernières années, facteur et commissionnaire d'un marchand de La Rochelle dont les affaires sont assez embrouillées, il n'y aurait jamais pu subsister; qu'il ne s'est jamais appliqué au commerce de la mer, publiant ici hautement que le temps et l'étude qu'il a donnés depuis dix ans aux choses du droit et de la jurisprudence, où je ne le crois pas encore fort habile, lui ont fait abandonner toutes sortes de trafics; que, bien loin d'avoir des vaisseaux sur la mer il n'a jamais eû une chaloupe sur cette rivière, comme en ont de simples habitants de Québec, et même qu'il n'a pas présentement un canot de bois pour traverser la rivière et qu'à l'égard du commerce avec les îles de l'Amérique, jamais il n'y a pensé ni travaillé. Mais il n'est pas étrange qu'on ait espéré pouvoir vous déguiser les choses sur des faits qu'on a cru qui ne se pourraient pas éclaicir de si loin, puisque, dans ceux dont on devrait présumer que je pourrais vous envoyer aisément la preuve, on m'a pas laissé de le faire.

"La copie que vous recevrez cotée B. de la commission que Mr Talon lui a donnée en son nom pour lever le dix pour cent, vous fera connaître que ce n'est point MM. de la Compagnie qui la lui avaient donnée et que je n'ai point eu dessein de choquer leurs droits en la donnant, comme j'avais fait, à un autre, puisque si leur nom eut paru, je n'aurais eu garde d'y rien changer; mais voyant tous les gens de Mr Talon s'en retourner en France, et ne croyant pas, comme je vous l'ai déjà marqué, les deniers en trop grande sûreté dans les mains d'une personne peu accomodée, je crus les devoir remettre dans celles d'un homme de bien et fidèle comme celui que j'avais choisi.

"Cependant, Monseigneur, aussitôt que jai reçu votre depêche j'ai rémis la commission à Mr de Villeray qui a fait, cette année, la

[1] Tous les mots soulignés en chiffres.

recette du dix pour cent, par où vous reconnaitrez ma prompte obéissance, et que je n'ai aucune peine à tout ce que vous m'ordonnerez.

"Comme il n'est pas content de l'arrêt qu'on a donné sur sa réception, il m'a demandé de lui permettre de passer en France où il ne manquera pas de vous alléguer l'injustice que Mr de Courcelles lui a faites de l'ôter du Conseil de son autorité et sans le consentement de Mr l'évêque, mais c'est à Mr de Courcelles à vous rendre compte des raisons qu'il a eues pour cela et que j'ignore. Tout ce qui est de ma connaissance est que le registre du Conseil, dont je vous envoye copie cotté C, porte que les cinq conseillers qui le composent, ont été établis du consentement mutuel de Mr de Courcelles et de Mr l'évêque; que l'acte de rétablissement du Conseil qui se fait tous les ans, aux premiers jours de l'année, est signé de Mr de Courcelle et de Mr de Bouteroue lors intendant et qu'il est spécialement marqué qu'il n'est point signé de Mr l'évêque parce qu'il était malade; que les gouverneurs précédents ont plusieurs fois changé de conseillers suivant les termes de l'édit de création qui porte qu'ils seront tous les ans changés ou continués; qu'il y a cinq ans que le Conseil subsiste dans le même état où il est, à la réserve de deux conseillers que j'y ai mis depuis que je suis gouverneur, par le retour en France d'un de ceux qui l'était et la mort d'un autre, que le sieur de Tilly y a toujours eu la première place, qui est un vieux gentilhomme de 60 ans et le seul peut-être de cette qualité qui se soit venu habiter en ce pays, dans les commencements de la colonie, qu'il y a apporté beaucoup de bien dont il a perdu une grande partie dans la guerre des Iroquois qui le pillèrent, qu'il se trouve présentement chargé de quinze enfants tous vivants, qu'il est apparenté de toutes les personnes les plus considérables du pays et que, dans le temps qu'il pourrait espérer quelques gratifications il est à la veille de recevoir une grande mortification, se voyant obligé de descendre d'un dégré et peut-être de sortir tout-à-fait du Conseil si vous n'avez la bonté de lui faire octroyer des provisions d'une des charges de conseiller, comme il m'a prié de vous le demander."[1]

Le 7 janvier 1675, le gouverneur de Frontenac renouvelait le Conseil Souverain. Après un discours pompeux où il déclarait qu'il avait trop bonne opinion des Conseillers pour s'imaginer qu'il y en eut aucun qui eut été capable de manquer à son devoir, à son serment, à sa conscience, à son prince et à lui-même, il nommait de nouveau MM. Le Gardeur de Tilly, Damours, Dupont, de Peiras et de Vitré. MM. de Villeray et de Lotbinière, tenant leur charge du roi, n'eurent pas besoin d'être nommés de nouveau. La chose était fort heureuse pour

[1] Archives du Canada, Correspondance générale, vol. 4.

M. de Villeray. Avec les sentiments qu'entretenait le gouverneur à son égard il est bien probable qu'il aurait été mis de côté.

En cette même année 1675, le Conseil Souverain fut presque entièrement transformé. Il fut assimilé aux compagnies supérieures du royaume. Les conseillers fixés au nombre de sept recevaient les mêmes privilèges, prérogatives, exemptions et autorités que les conseillers des cours souveraines de France. Au lieu d'être choisis chaque année par le gouverneur et l'évêque, les conseillers devaient à l'avenir être nommés à vie et par mandement direct du roi.

Anomalie assez curieuse, l'édit de réorganisation du Conseil Souverain est daté du 5 juin 1675 et les nominations des sept nouveaux conseillers avaient été faites par le roi cinq semaines plus tôt, le 26 avril 1675.

M. de Villeray fut maintenu dans sa charge de premier conseiller.

Le 16 novembre 1675, M. de Villeray achetait de René Robineau, seigneur de Bécancour, grand-voyer de la Nouvelle-France, le petit fief de Bécancour sur la Grande-Allée, à Québec. Ce fief d'un arpent de front sur dix de profondeur était borné par devant à la Grande-Allée, par derrière au fleuve Saint-Laurent, d'un côté aux représentants de feue Marie-Marguerite Le Gardeur, femme de feu Paul Godefroy, et de l'autre à un emplacement que M. de Villeray avait acquis des héritiers de feu Jean de Lauzon, grand sénéchal de la Nouvelle-France. M. Robineau avait eu la concession de ce fief de la compagnie de la Nouvelle-France, le 26 février 1657.

M. de Villeray paya son acquisition six cents livres comptant.[1]

Par son édit du 5 juin 1675, qui confirmait et réglait l'établissement du Conseil Souverain, le roi avait aussi ordonné que l'intendant comme président du Conseil devait demander les avis, recueillir les voix, prononcer les arrêts. En un mot, l'intendant devait avoir les mêmes fonctions que les premiers présidents des cours en France. Les deux premières places du Conseil devaient cependant appartenir au gouverneur et à l'évêque.

Le greffier du Conseil Souverain, d'après les ordres de l'intendant Duchesneau, dans les procès-verbaux des séances du Conseil, intitulait M. de Frontenac "chef du Conseil."

Au mois de janvier 1679, le gouverneur donna ordre au greffier du Conseil Souverain, M. Peuvret, de changer la formule employée jusqu'alors et de lui donner désormais le titre de chef et président du Conseil. M. Duchesneau s'opposa très énergiquement à ce changement.

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[1] Acte de vente devant Romain Becquet, notaire à Québec, le 16 novembre 1675.

Le 20 mars 1679, sur la proposition du procureur-général d'Auteuil, le Conseil Souverain délégua deux de ses membres, MM. de Villeray et de la Martinière, auprès de M. de Frontenac et de M. Duchesneau afin de les engager à laisser de côté leurs prétentions respectives jusqu'à ce que le roi eut décidé la question. L'intendant Duchesneau consentit bien volontiers à cet arrangement, mais le gouverneur ne voulut entendre aucun accommodement. Après de nombreux et longs pourparlers qui ne servirent qu'à monter davantage les esprits, le 27 mars 1679, M. de Frontenac se rendait au Conseil Souverain et déclara qu'il eut à le traiter désormais en la même manière et à lui donner les mêmes qualités qu'il plaisait à Sa Majesté de lui donner. Et il ordonna formellement au greffier Peuvret de le qualifier à l'avenir de chef et président du Conseil, soit sur son plumitif, soit sur le grand registre, dans toutes les intitulations qu'il y ferait des assemblées où il assisterait.

Du 27 mars au 3 juillet 1679, les séances se passèrent en discussion oiseuse, le gouverneur et l'intendant persistant l'un et l'autre dans leurs prétentions. La séance du 3 juillet 1679 fut très orageuse. M. Duchesneau consentit à se retirer du Conseil, mais il défendit au greffier de donner au gouverneur l'intitulation qu'il exigeait. Le gouverneur et l'intendant se contèrent leur fait devant tous les conseillers.

Ce fut le lendemain de cette séance orageuse que M. de Frontenac exila de Québec les conseillers de Villeray et de Tilly et le procureur-général d'Auteuil. M. de Villeray eut ordre de se retirer à l'île d'Orléans, dans la maison de M. Berthelot, M. de Tilly devait se rendre chez son beau-père, M. Juchereau de Saint-Denis, à Beauport, et M. d'Auteuil devait se retirer dans sa maison de Monceaux, à Beauport, en attendant de s'embarquer tous trois pour aller rendre compte de leur conduite au roi.

Le 5 juillet 1679, le Conseil Souverain se réunit à Monceaux, chez le procureur-général d'Auteuil. Deux conseillers, MM. Damours et de la Martinière, furent députés auprès du gouverneur pour lui demander de révoquer ses ordres au sujet de MM. de Villeray, de Tilly et d'Auteuil. M. de Frontenac ne voulut rien entendre.

Les choses traînèrent ainsi jusqu'au milieu d'octobre. Le 16 octobre 1679, le Conseil adopta une résolution priant le gouverneur et l'intendant de consentir à ce que ni l'un ni l'autre ne seraient nommés dans l'en tête des procès-verbaux du Conseil, mais que le greffier écrirait seulement: "le Conseil assemblée." Le gouverneur et l'intendant consentirent à cet expédient. Le gouverneur rappela même MM. de Villeray, de Tilly et d'Auteuil à Québec. Le Conseil se mit résolument à l'œuvre pour disposer des affaires qui s'étaient accumulées pendant cette longue querelle.

Le 10 novembre 1679, l'intendant Duchesneau entretenait longuement le ministre des prétentions de M. de Frontenac au sujet des *intitulations*, puis il ajoutait: "Depuis que le Conseil a eu la liberté de s'assembler, on a toujours travaillé à l'expédition des affaires qui ne se sont pas trouvées en grand nombre, par besoin que j'ai pris d'accommoder, autant qu'il m'a été possible, la plus grande partie des procès et de prévenir les différents qui pouvaient arriver; à quoi je puis dire, Monseigneur, que j'ai réussi à la satisfaction de tout le monde et que j'ai retenu les esprits dans le devoir qui avaient assez de dispositions de s'aigrir.

"L'union dans laquelle Mr le gouverneur a vu tous les officiers du Conseil pour ne point consentir qu'on donnât aucune atteinte à la déclaration du roi, l'a mis dans d'étranges emportemens contre eux; jusqu'à les traiter de séditieux et de rebelles, et il s'est efforcé de faire passer cette bonne intelligence pour une cabale, et c'est l'adresse dont il s'est toujours servi pour tâcher de décrier tout ce qu'on a fait pour le bien du pays et rendre suspects les plus honnêtes gens.

"Le sieur de Villeray, qui va par ordre de Mr le gouverneur, rendre compte de sa conduite à Sa Majesté, vous informera, Monseigneur, de toutes choses. Je suis obligé par la force de la vérité de vous dire, comme vous le reconnaîtrez, qu'il est homme capable. Il est d'ailleurs d'une probité connue, et fait honneur à la colonie par sa naissance noble et par ses autres bonnes qualités, quoiqu'il ne subsiste que par son grand ménage."[1]

M. de Villeray, qui était un lutteur peu ordinaire et qui était d'ailleurs accoutumé à la disgrâce des gouverneurs, s'embarqua pour la France à la fin de novembre 1679.[2] Là-bas, ses protecteurs ordinaires firent valoir sa cause auprès du ministre qui lui était déjà favorable et qui était passablement fatigué des ennuis que lui causait M. de Frontenac.

M. de Villeray revint dans la Nouvelle-France au mois d'octobre 1680. Il était porteur d'un ordre de Louis XIV à M. de Frontenac de le rétablir dans ses fonctions de conseiller. Il apportait aussi une lettre du roi fort sévère pour M. de Frontenac: "Tous les corps et presque tous les particuliers, écrivait le roi, se plaignent avec des circonstances si claires, que je ne puis douter de beaucoup de mauvais traitements, qui sont entièrement contraires à la modération que vous devez avoir. Vous avez voulu que dans les registres du Conseil

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[1] Archives du Canada, Correspondance générale, vol. 5.

[2] Entre le 21 et le 29.

Souverain, vous fussiez qualifié de chef et président de ce Conseil, ce qui est entièrement contraire à mon édit concernant cet établissement, en date du 5 juin 1675; et je suis d'autant plus surpris de cette prétention, que je suis assuré qu'il n'y a que vous dans mon royaume qui étant honoré du titre de gouverneur et lieutenant-général dans un pays, eut désiré d'être qualifié chef et président d'un Conseil pareil à celui du Canada. Je désire donc que vous abandonniez cette prétention mal fondée, et que vous vous contentiez du titre de gouverneur et mon lieutenant-général . . . . Au surplus, l'abus que vous avez fait de l'autorité que je vous ai commise, en exilant deux conseillers et le procureur-général pour une cause aussi légère que celle-là ne me plait guère, et n'était l'assurance précise que vos amis m'ont donnée que vous agiriez avec plus de modération à l'avenir, j'aurais pris la résolution de vous faire revenir."[1]

Le voyage forcé que M. de Villeray venait de faire en France avait été pour lui une occasion de dépenses considérables. L'intendant Duchesneau, témoin journalier des colères et des injustices de M. de Frontenac pour M. de Villeray, essaya de lui obtenir une gratification. Le 13 novembre 1680, il écrivait au ministre: "J'ai fait connaître au Conseil Souverain les intentions de Sa Majesté sur l'expédition des procès et pour empêcher que la chicane ne s'y introduisit afin que les procédures de justice ne divertissent point les habitants de leur travail et de leur commerce; je vois les officiers très disposés à les remplir.

"Je dois vous dire en cet endroit, Monseigneur, que le sieur de Villeray, premier conseiller, qui a l'honneur d'être connu de vous, et qui est sans contredit le plus habile et le plus capable de rendre service au Roi dans ce pays, mérite d'être distingué par quelques gratifications de Sa Majesté. Il a extrêmement souffert de son envoi en France, et comme il est fort honnête homme et de naissance, il subsiste honorablement du provenu de sa terre qu'il fait valoir avec une grande économie. Il a été obligé de l'abandonner longtemps. Il a perdu cette année une partie de ses provisions par le naufrage du navire *Saint-Joseph.* Ce qui fait qu'il a très grand besoin des bienfaits du Roi."[2]

M. de Frontenac était fidèle à ses amis. Qu'ils eussent tort ou raison, il les défendait avec une égale ardeur. Pareillement, lorsqu'il voulait leur obtenir des faveurs, il ne cessait d'importuner le ministre que quand il avait obtenu ce qu'il demandait. M. de Frontenac était aussi *fidèle* à ses ennemis en ce sens qu'il ne les *lâchait* que quand

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[1] Archives du Canada, Correspondance générale, vol. 5.

[2] Archives du Canada, Correspondance générale, vol. 5.

ils les avaient démoli. La lettre de blâme reçue du roi et apportée par M. de Villeray lui-même dût être assez difficile à digérer pour lui. Aussi il ne tarda guère à créer une nouvelle querelle à M. de Villeray. "Par l'article 25 de l'Édit de 1600, écrit Ignotus, il était défendu de prendre le titre d'écuyer à quiconque n'était point issu d'un ayeul et d'un père ayant porté les armes, ou servi le public en des charges honorables susceptibles de conférer un commencement de noblesse à sa postérité. Une déclaration du mois de janvier 1624 alla beaucoup plus loin. Elle interdit le titre d'écuyer et l'usage d'armoiries timbrées à tous ceux qui n'étaient point de race noble, et cela sous peine de deux mille livres d'amende. On voit par le *Journal des Audiences* que, le 13 août 1633, sur les conclusions du procureur-général, il fut défendu à ceux qui n'étaient pas gentilshommes de prendre la qualité d'écuyer et de timbrer leurs armes, sous une pénalité de quinze cents livres."[1]

L'édit de 1600 fournit l'occasion désirée par l'irascible gouverneur pour recommencer la guerre à M. de Villeray. Au mois de mars 1681, le Conseil Souverain était occupé au procès de Louis Bolduc, procureur du roi à la prévôté de Québec, accusé de malversations. M. de Villeray avait été chargé de procéder aux informations dans cette affaire. Bolduc était un des protégés du gouverneur. Plusieurs fois déjà il l'avait défendu auprès du ministre. Cette poursuite, on le comprend, donnait de l'humeur à M. de Frontenac.

Le 10 mars 1681, devant le Conseil Souverain, le gouverneur fit une énergique remontrance à M. de Villeray. *Les Jugements et délibérations du Conseil Souverain* nous ont conservé la teneur de cette remontrance: "Monsieur le gouverneur a dit que puisque la Cour était occupée à rechercher les abus que les officiers peuvent commettre dans l'administration de leurs charges, il était surpris que le procureur-général qui témoigne tant de chaleur pour en être éclairci en de certaines rencontres, demeure dans le silence dans d'autres et les dissimule quoiqu'il ne les puisse ignorer, que pour lui gouverneur il n'en peut pas faire de même parce qu'il manquerait à son devoir et que sa condescendance autoriserait la continuation des abus et servirait comme d'une espèce de titre à ceux qui les voudraient continuer, qu'ainsi il ne peut pas s'empêcher d'avertir la Compagnie de deux manquements notables qu'a fait le sieur de Villeray dans un exploit qui est tombé entre ses mains et qui est semblable à beaucoup d'autres à ce qu'il a appris donnés en conséquence de ses ordonnances sur le même sujet, le premier en ce que le dit exploit n'est point libellé et qu'il n'y est point dit contre qui le témoin doit être entendu quoique les formules

[1] *La Presse*, janvier 1903.

de l'ordonnance du Roi le porte expressément, et le second en ce que la qualité d'écuyer qui est donné au dit sieur de Villeray sans qu'il ait produit sur cela aucuns titres qui puissent faire voir qu'elle lui appartient, qu'il exhorte la Compagnie à donner ordre à ces abus afin que dorénavant les exploits soient libellés en la manière que l'ordonnance le désire, et que les témoins que l'on voudra entendre ne puissent être surpris, et que le dit sieur de Villeray ne puisse prendre des qualités qu'il n'ait prouvé lui appartenir, et se conformer mieux à l'arrêt du Conseil d'État du Roi donné le 29 mai dernier et registré dans la Compagnie le 24 octobre aussi dernier, par lequel le Roi défend aux Conseillers de prendre d'autres qualités que celles qu'il leur donne dans les lettres de provisions de leurs charges."[1]

Sept jours plus tard, le 17 mars, M. de Villeray soumettait au Conseil Souverain sa réponse à la remontrance de M. de Frontenac. Elle est trop longue pour être citée ici. Mais le premier conseiller répondait point par point à la remontrance du gouverneur.

Au sujet de l'exploit d'assignation, M. de Villeray déclarait que le manquement, s'il y en avait un, était le fait de l'huissier et non le sien. Quant au titre d'écuyer, M. de Villeray affirmait qu'il ne l'avait jamais pris dans aucun des actes et registres du Conseil, et que s'il s'en était servi ailleurs c'était dans le but de le confirmer à ses enfants en vertu de son droit. "D'ailleurs, ajoutait-il, il n'est pas venu en pensée au dit sieur de Villeray de produire ses titres tant parce qu'il ne lui a pas été connu qu'il fut d'aucune nécessité ni ayant eu aucune déclaration du Roi pour la recherche de la noblesse, ni personne préposée à cet effet qui ait paru en ce pays; que si quelques particuliers sous prétexte de la crainte de perdre les titres qu'ils ont, et de la difficulté de les recouvrer, ou autrement, ont eu la précaution d'en demander l'enregistrement au Conseil et qu'on ait bien voulu leur accorder cette grâce purement et simplement; il n'a pas cru que cela le dût obliger de faire enregistrer les siens. Par ces réponses et raisons le dit sieur de Villeray justifiant suffisamment qu'il n'y a eu aucun abus commis de sa part, ni contravention au dit arrêt du Conseil d'État; il a lieu d'espérer que Monsieur le Gouverneur qui a ainsi paru être prévenu contre lui, voulant bien laisser le Conseil dans la liberté entière d'opiner, il sera donné acte au dit sieur de Villeray de ses dits réponses, et ordonner qu'elles seront enrégistrées pour servir et valoir ce que de raison, et afin de faire connaître qu'il est en droit de prendre la dite qualité d'écuyer dans ses affaires particulières pour les raisons susdites, il a joint à la présente réponse, sans que cela

[1] *Jugements et Délibérations du Conseil Souverain*, vol. II, p. 478.

puisse tirer à conséquence, un inventaire des titres justificatifs de sa dite qualité, fait à Québec le quatorze mars 1681."

Le Conseil, après avoir entendu le procureur-général, déclara qu'il serait sursis à l'examen de la noblesse du sieur de Villeray jusqu'à ce qu'on eut connu les volontés de Sa Majesté sur la recherche des usurpateurs de noblesse au Canada.

La discussion, au Conseil, se prolongea encore pendant plusieurs séances au détriment des affaires du pays. M. de Frontenac, malgré les preuves de noblesse apportées par M. de Villeray, lui défendit de s'intituler écuyer, et, celui-ci, pour terminer cette chicane, s'en abstint.[1]

Frontenac, avec son flair ordinaire, jugeant que le roi le blâmerait d'avoir soulevé une si longue querelle et d'avoir fait perdre le temps du Conseil pour une si petite affaire, crut que le meilleur moyen de se tirer du mauvais pas où l'avait conduit son orgueil et sa haine contre de Villeray serait de l'attaquer sur un autre point. Dans sa lettre du 2 novembre 1681, au marquis de Seignelay, après s'être plaint amèrement du Conseil Souverain, il écrivait: "Si les sieurs de la Martinière et de Monceaux s'étaient contentés d'envoyer à la Cour leurs plaintes en particulier sur les prétendus mauvais traitements reçus de moi, et de prier M. Duchesneau de les appuyer, il y aurait moins à redire puisqu'il doit être libre à chaque particulier de se plaindre des violences qu'il croit qu'on lui fait et d'avertir Sa Majesté vu qu'il se persuaderait être contre son service mais de l'avoir voulu faire juridiquement, comme ils l'ont fait, c'est informer ouvertement contre un gouverneur, et de vouloir le soumettre à leur juridiction. Ce que je n'estime pas, Monsieur, que vous approuverez.

"C'est pourquoi je vous supplie très humblement d'avoir la bonté de m'en faire avoir raison, tant au regard des deux premiers, que du sieur de Villeray qui a toujours été regardé par ceux qui m'ont précédé dans ce gouvernement comme le premier mobile et le principal instrument de toutes les divisions qu'on y a fait naître, je ne le dis (pas), par aucun ressentiment contre lui, mais pour vous informer seulement de la vérité qu'il est aisé de justifier, tant par des arrêts du Conseil Souverain de Québec, où plusieurs gouverneurs ont été obligés à différentes reprises de lui ôter la charge de conseiller, que par arrêt du Conseil d'État de Sa Majesté au rapport de M. de Brienne par lequel il était déclaré incapable de posséder aucune charge en Canada. Mais l'appui qu'il a jusqu'à présent trouvé par le moyen de certaines

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[1] Sur toute cette chicane à propos du titre d'écuyer on peut consulter les *Jugements et Délibérations du Conseil Souverain*, vol. II, et une étude de Ignotus dans la *Presse* de janvier 1903.

gens qui ont grand intérêt de le protéger l'a non seulement garanti de toutes ces punitions mais en lui procurant des avantages et des gratifications à l'exclusion des personnes qui étaient ici le plus zélées pour le service du Roi lui ont encore augmenté son insolence avec l'envie de continuer ses mêmes intrigues et menées, et donné un méchant exemple à ceux qui auraient pu appréhender le péril qu'il devait y avoir à l'imiter."[1]

Dans ce même automne de 1681, M. de Villeray, qui avait d'importantes affaires à régler en France, demanda à M. de Frontenac la permission le s'embarquer sur un des vaisseaux qui partaient de Québec vers le 10 ou le 11 décembre.

M. de Frontenac, qui se doutait que le principal objet du voyage de M. de Villeray en France était de porter plainte contre lui au ministre et qui avait déjà fait l'expérience que les séjours du premier conseiller en France étaient désastreux pour lui, refusa d'accorder le congé demandé.

M. de Villeray qui n'était pas facile à désarçonner eut recours au Conseil Souverain. Le 8 novembre, il le requérait de députer deux de ses membres auprès du gouverneur pour le faire revenir sur son refus. MM. Dupont de Neuville et de Peiras, qui avaient la confiance du gouverneur, acceptèrent la tâche. Mais leur éloquence fut dépensée en pure perte. M. de Frontenac refusa péremptoirement de laisser partir M. de Villeray.[2]

Le 13 novembre 1681, avec son astuce ordinaire, le gouverneur donnait au ministre les raisons qui l'avaient engagé à empêcher M. de Villeray de passer en France: "Je n'avais point voulu, Monsieur, vous marquer dans la première lettre que je me suis donné l'honneur de vous écrire, il y a onze mois, que le procureur-général s'est avisé d'intenter un procès criminel contre le procureur du roi de la Prévôté de cette ville, parce qu'il n'est pas agréable à M. Duchesneau lequel l'a fait par le moyen de ceux de sa cabale, interdire de sa charge, sur la simple dénonciation d'un homme de Bayonne qui négocie ici et qu'on a fait évader et passer en France depuis deux mois, contre la défense que je lui en avait faite, parce qu'il eut ou qu'il ne pouvait

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[1] Archives du Canada, Correspondance générale, vol. 5.

[2] Dans son *Mémoire sur les mœurs, coutumes et religion des Sauvages de l'Amérique Septentrionale* (p. 131), Nicolas Perrot écrit qu'en 1681 M. de Villeray fut chargé par M. de Frontenac de publier, dans le pays des Outaouas, l'amnistie accordé aux coureurs de bois et qu'il fut en même temps établi commandant dans ces lieux. Il fait certainement erreur. D'abord M. de Villeray n'étant pas militaire n'aurait pas été nommé commandant aux Outaouas. Puis, M. de Frontenac, à tort ou à raison, avait trop de griefs contre M. de Villeray pour le charger d'une semblable mission.

prouver les choses qu'il avait avancées contre lui. Cependant le procureur général n'ayant par eu les preuves qu'il en espérait, a demandé qu'il fut informé de sa vie et de ses mœurs depuis 17 ans qu'il est en ce pays, quoi qu'il y en ait six qu'il a été reçu en la dite charge de procureur du Roi, sans aucune plainte ni opposition, et il a fait entendre soixante et dix témoins, sans avoir trouvé à ce qu'on dit, aucune matière d'assoeir une condamnation contre lui, ce qui est cause qu'après toutes les chicanes possibles qui ont été faites, pour allonger l'instruction de cette affaire, et nous restant un grand nombre de requêtes présentées par le procureur du Roi pour la faire juger leur dernière refuite a été de me faire demander par le rapporteur qui est le S' de Villeray, congé de passer en France d'où il n'y a qu'un an qu'il est revenu, ce qui m'a obligé à ne lui accorder, afin que cet officier put avoir plus tôt justice, laquelle il était, monsieur, résolu de vous aller demander, sur l'expression qu'il prétend qu'on lui a faites, si son procès ayant été jugé avant le départ des vaisseaux et qu'il eut pu en avoir toutes les pièces pour vous les porter."[1]

Dans une lettre de l'intendant Duchesneau au ministre de Seignelay datée du même jour (13 novembre 1681), nous entendons un autre son. M. Duchesneau fait la nomenclature de tous les abus de pouvoir commis par M. de Frontenac. Il insiste beaucoup sur l'injustice faite par le gouverneur à M. de Villeray en lui défendant de se qualifier d'écuyer, titre qui lui avait été reconnu par le Conseil d'État du Roi dans la première recherche de la noblesse.[2]

En 1682, le roi enlevait le gouvernement de la Nouvelle-France à M. de Frontenac. Les deux querelles ridicules faites à M. de Villeray en 1681 ne furent pas les causes immédiates de son rappel. Mais ces deux incidents joints à des douzaines d'autres firent certainement comprendre au roi que la position de M. de Frontenac n'était plus tenable.

M. de Villeray dût éprouver un singulier soulagement de se voir enfin débarrassé de son implacable ennemi. Pendant près de dix ans, M. de Frontenac ne lui avait laissé aucun répit. Une preuve que M. de Villeray n'était pas l'homme que M. de Frontenac dépeignait au ministre, c'est que ses successeurs immédiats MM. de la Barre et de Denonville, lui accordèrent toute leur confiance et n'eurent pas à s'en repentir. Leurs lettres au ministre en font foi.

Le 27 avril 1684, le gouverneur de la Barre et l'intendant de Meulles, sur la demande de M. de Villeray, accordaient à ses fils,

[1] Archives du Canada, Correspondance générale, vol. 5.

[2] O'Callaghan, *Documents relative to the history of the state of New York*, vol. *IX*, p. 156.

Augustin Rouer de la Cardonnière et Louis Rouer d'Artigny, une étendue de deux lieues de terre, "prés et bois, de front sur le fleuve Saint-Laurent, sur deux lieues de profondeur dans les terres, à prendre depuis une rivière qui est vis-à-vis les dites deux lieues, jusqu'à la dite Isle Verte, icelle même comprise . . . . Cette concession était faite aux sieurs de la Cardonnière et d'Artigny, à toujours, en toute propriété, en titre de fief et seigneurie haute, moyenne et basse justice.[1] C'est la seigneurie de L'Isle-Verte qui est devenue l'importante paroisse de L'Isle-Verte.

A l'automne de 1685, M. de Villeray passait encore en France.[2] Depuis son arrivée dans le pays il en était à son sixième ou septième voyage en France. La traversée entre Québec et les ports français duraient alors soixante, soixante-dix et même quelquefois quatre-vingt dix jours. Il fallait une dose de patience peu ordinaire pour faire le voyage si souvent dans d'aussi tristes conditions.

Le 13 novembre 1685, M. de Denonville faisait l'éloge de M. de Villeray au ministre. Il lui écrivait: "Le sieur de Villeray premier Conseiller du Conseil Souverain m'a prié de prendre la liberté de vous escrire à son sujet, il vous demande une grâce pour son fils aisné qu'il voudrait attacher auprès de luy et luy donner occasion d'estudier et se rendre capable de luy succéder.

"Je luy dois Monseigneur le temoignage de l'estime universelle qu'il s'est acquise d'homme integre et de juge incorruptible; il s'est toujours conduit dans un grand desinterressement: quand il paraistra Monseigneur que vous le distinguez je vous asseure que ce sera un moyen pour animer les autres a suivre son exemple.

"Il a une affaire en France qui luy est de conséquence cependant je l'ay retenu, n'ayant personne plus capable de me donner connaissance des affaires du Conseil Souverain, dans lesquelles il s'est toujours comporté en homme de bien, et qui ne se gouverne n'y par credit n'y par faveur, mais toujours dans l'estroite justice et dans les Regles du bien publicq. Je suis témoin de quelques endroits ou il s'est conduit avec fermeté et sagesse. Nostre Conseil Souverain vous rend compte Monseigneur de l'arrest qu'il a rendu à l'égard de l'affaire de Rageot ou il l'a demis de sa charge de greffier en attendant vos ordres. J'ay eu l'honneur de vous en escrire par le Retour des Navires du Roy. J'adjouteray seulement Monseigneur que je sçay seurement que l'on n'a cherché qu'a vexer ce pauvre malheureux chargé d'une grosse famille, c'est un homme de bien si il y en a un seul en ce pays il est reconnu tel dans tout le pays. On l'a ôté, Monseigneur, pour

[1] *Pièces et documents relatifs à la tenure seigneuriale*, p. 18.

[2] Lettre de M. Duchesneau au ministre, 28 septembre 1685.

mettre en sa place un homme qui meritera qu'on l'oste de son employ de Geolier si il continue de vivre comme il a fait par le passé. C'est le plus insolent et arrogant homme qui soit dans le pays, il a grande part a une insolence que son fils a fait devant l'église en publicq mettant l'Epée à la main dont il a frapé de plusieurs coups, le Sr. Chalons, cy-devant agent des anciens fermiers. Il est en fuitte, il y a un decret de prise de corps contre luy, son Père se vante de l'avoir élevé en bretteur. C'est un de nos libertins et faineants qu'il ne faudra pas épargner non plus que son Père qui dit hautement que son fils a tres bien fait."[1]

M. Gilles de Boyvinet, agent-général de la Compagnie du Canada, s'étant noyé dans la rade de Québec en revenant de France le 22 juillet 1686, l'intendant Bochart Champigny, après avoir pris l'avis du gouverneur de Denonville, donna une commission à M. de Villeray comme inspecteur ou contrôleur de cette compagnie.

M. Bochart Champigny écrivait au ministre le 16 novembre 1686:

"Le sieur de Boyvinet, qui revenait de France pour être agent de messieurs les intéressés, s'étant noyé à son arrivée en ce pays, M. de Meulles donna une commission au sieur de la Héronière qui était agent depuis un an pour continuer cet emploi. Ayant été revoqué par la procuration que ces messieurs avaient donnée au sieur Boyvinet, j'ai commis pour inspecteur le sieur Villeray, premier conseiller du Conseil Souverain de Québec, homme de probité, de l'avis de M. le marquis de Denonville. Ils ont travaillé ensemble jusqu'au 27 octobre dernier, que le dit sieur la Héronière s'avisa de refuser l'entrée du bureau au dit sieur de Villeray, ce qui lui donna lieu de me présenter requête, sur laquelle après les avoir entendus tous deux, et le sieur Blondel, contrôleur du bureau, et sur l'intelligence qui étaient entre les dits sieurs la Héronnière et Blondel, après m'avoir le dit sieur Blondel dit auparavant que le dit sieur la Héronnière faisait beaucoup de fripponneries, j'ordonnai que l'ordonnance de M. de Meulles serait exécutée et que toutes les lettres de change que le dit sieur la Héronnière tirerait sur la France seraient certifiées par le dit sieur Villeray, afin d'éviter toutes les friponneries qu'ils pourraient faire ensemble contraires au bien et à l'avantage de messieurs les intéressés qui ont grand intérêt d'avoir ici un agent honnête homme."[2]

Le 30 octobre 1686, M. de Villeray sollicitait l'agrément du Conseil Souverain pour passer en France. "Sur ce qui a été dit par M. Louis de Villeray, premier conseiller de ce Conseil, est-il dit au procès-verbal de cette séance, que dès l'année passée le besoin de ses affaires

[1] Archives du Canada, Correspondance générale, série C, vol. 7.

[2] Archives du Canada, Correspondance générale, vol. 8.

l'appelant en France, il n'avait pas cru devoir demander la permission d'y aller à cause que Monsieur de Meulles, ci-devant intendant, était absent pour son voyage de l'Acadie et que Monsieur le gouverneur lui fit connaître qu'il était à propos qu'il restât, mais que comme les avis qu'il a d'abondant reçus cette année lui font connaître qu'il n'était pas possible de s'en dispenser cette année sans en souffrir un très grand préjudice il en aurait conféré avec M. le Gouverneur et M. l'intendant qui avaient donné les mains à ce qu'il fit ce voyage, il requiert la Compagnie de vouloir aussi le faire et lui en donner la permission.[1] Le Conseil se rendit volontiers à la demande de M. de Villeray. Il s'embarqua dans les premiers jours de novembre et il revint dans l'été de 1687, juste pour constater que sa maison avait été incendiée pendant son absence. La perte était considérable pour lui car il n'était pas riche.

Le 9 septembre 1687, MM. de Denonville et Bochart Champigny écrivaient au ministre: "Nous devons vous dire que le pauvre M. Villeray, premier conseiller, à son retour de France, a trouvé sa maison brûlée. C'est un fort honnête homme qui travaille ici depuis longtemps et qui a bien besoin pour se remettre que vous ayez la bonté de lui continuer la gratification que vous lui avez donnée cette année."[2]

La mauvaise fortune poursuivait M. de Villeray. C'était la seconde fois qu'il voyait l'incendie détruire sa maison. En 1682, dans le grand incendie de la basse-ville de Québec, il avait également perdu sa maison et tout ce qu'elle contenait. Il est vrai qu'à cette époque Québec n'avait guère les moyens de se défendre contre le feu. Toutes les maisons étaient construites en bois et on avait aucune protection contre l'incendie.

En 1688, M. de Villeray remontrait au gouverneur de Denonville et à l'intendant Bochart Champigny que la concession qui avait été accordée à ses fils, MM. de la Cardonnière et d'Artigny en 1684, pouvait difficilement se partager et il leur demandait d'accorder au sieur d'Artigny seul cette concession et d'en accorder une autre au sieur de la Cardonnière. Le 24 avril 1688, MM. de Denonville et Bochart Champigny se rendaient à la demande de M. de Villeray et ils accordaient au sieur de la Cardonnière une nouvelle concession: "deux lieues de front sur le fleuve Saint-Laurent à prendre joignant et attenant à la concession du Bic appartenant au sieur de Vitré, conseiller au dit Conseil, en descendant le dit fleuve, et deux lieues de profondeur, ensemble la rivière dite de Rimouski et autres rivières et ruisseaux, si aucuns se trouvent dans la dite estendue, avec l'isle

[1] *Jugements et Délibérations du Conseil Souverain.* vol. I.

[2] Archives du Canada, Correspondance générale, vol. 9.

Saint-Barnabé, et les bastures, isles et islets qui se pourront rencontrer vis-à-vis les dites deux lieues jusqu'à la dite isle Saint-Barnabé, avec droit de fief, seigneurie et justice, haute moyenne et basse . . . ."[1]

La concession accordée à M. Rouer de la Cardonnière le 24 avril 1688, après avoir eu bien des vicissitudes et avoir changé plusieurs fois de propriétaires, est devenue l'importante ville de Rimouski.

Le 5 avril 1689, M. de Villeray réussissait à faire augmenter la concession qui avait été accordée à son fils d'Artigny en 1684 et en 1688. Ce jour-là, MM. de Denonville et Bochart Champigny concédaient à M. de Villeray pour le sieur d'Artigny, son fils, et à M. de la Chesnaye, "l'estendue de terre qui se peut rencontrer entre leurs dites concessions, avec deux lieues de profondeur, de laquelle étendue ils jouiront chacun moitié par moitié, sçavoir: le dit sieur d'Artigny, de celle qui joint la petite rivière Verte, et les islets et les bastures qui se peuvent rencontrer vis-à-vis, comme le dit sieur de la Chesnaye de l'autre moitié qui le joint à cause de sa dite concession, et pareillement les islets et battures qui se peuvent rencontrer vis-à-vis la dite moitié, lesquelles portions seront et demeureront dorénavant jointes, unies et incorporées à leurs dites concessions . . . ."[2]

En novembre 1689, M. de Frontenac revenait prendre le gouvernement de la Nouvelle-France. M. de Villeray ne dût pas le voir arriver sans une certaine appréhension. Pendant sa première administration M. de Frontenac ne lui avait été guère favorable. En serait-il de même sous le nouveau régime ? Mais, évidemment, M. de Frontenac n'avait pas été renvoyé dans la Nouvelle-France sans recevoir de sérieux avertissements du roi ou du ministre. On se rappelait encore à la cour la façon brutale dont il avait traité le Conseil Souverain et ses principaux officiers MM. de Villeray, d'Auteuil, etc., etc.

Le comte de Frontenac était un habile politique. Il changea complètement de tactique. Pendant son premier séjour dans le pays il manquait bien peu de séances du Conseil Souverain. Plus de trois mois s'étaient écoulés depuis son arrivée, et M. de Frontenac n'avait pas encore fait son apparition au Conseil. Cependant, l'intendant Bochart Champigny et le procureur-général d'Auteuil l'avaient invité plusieurs fois. Cette façon d'agir du gouverneur intriguait les conseillers qui pour la plupart siégeaient depuis plusieurs années et savaient avec quel intérêt il suivait autrefois les travaux du Conseil.

Le procureur-général d'Auteuil, fils de l'ancien procureur-général que Frontenac avait si maltraité autrefois, prit sur lui de se rendre au château Saint-Louis afin de savoir son intention. M. de Frontenac

[1] *Pièces et documents relatifs à la tenure seigneuriale*, p. 20.

[2] *Pièces et documents relatifs à la tenure seigneuriale*, p. 22.

répondit sèchement que le Conseil savait ce qu'il avait à faire; que, pour lui, il s'y rendrait, quand le service du roi l'y appellerait. Cette réponse embarrassa les conseillers. Le 20 février 1690, il fut décidé par le Conseil que MM. de Villeray, premier conseiller, Damours, Dupont et de Peiras se rendraient auprès de M. de Frontenac pour l'inviter à prendre sa place au Conseil.

Le 27 janvier 1690, la députation se présentait au château Saint-Louis. M. de Villeray, à titre de doyen, fit ce petit discours au gouverneur: "Nous venons de la part du conseil pour vous inviter d'y venir prendre votre place. Ce qui a empêché de le faire plus tôt, c'est la difficulté où la Compagnie s'est trouvée sur l'ordre qu'elle devait tenir à votre réception parceque jusqu'à présent nous n'avons rien de reglé pour la manière que l'on doit garder à celle de Messieurs les gouverneurs non plus qu'à celles de Messieurs les évêques et Messieurs les intendants. Et comme la Compagnie eût été bien aise, auparavant de savoir votre sentiment sur ce qui vous concerne afin de s'y conformer de tout son possible, elle en avait chargé Monsieur le procureur-général dans la pensée, Monsieur, que vous pourriez vous en ouvrir à lui. Et néanmoins il a rapporté à la compagnie que vous en ayant parlé, vous ne lui aviez fait autre réponse, sinon que le Conseil savait ce qu'il avait à faire et que vous y viendriez quand le service du Roi vous y appellerait, si bien que la Compagnie en nous chargeant de vous y prier de vouloir bien lui marquer le jour qu'il vous plaira de venir prendre votre place nous a encore recommandé de vous demander les vues que vous pourriez avoir sur la manière dont vous estimez y devoir être reçu, dans l'assurance que nous vous donnons qu'elle est dans le sentiment de vous rendre avec plaisir tout ce qu'elle vous doit."[1]

M. de Frontenac répondit assez rudement à M. de Villeray que c'était au Conseil Souverain de lui faire savoir de quelle manière il voulait le recevoir et qu'il verrait ensuite ce qu'il aurait à faire.

Les pourparlers entre M. de Frontenac et M. de Villeray agissant pour le Conseil Souverain se poursuivirent encore plusieurs jours. En fin diplomate qu'il était, M. de Frontenac se gardait bien de faire savoir aux conseillers le cérémonial qu'il exigeait pour son entrée au Conseil. De cette façon, il comptait, sans doute, qu'on lui offrirait plus que moins. Il serait trop long de rapporter ici les entrevues entre le gouverneur et le premier conseiller de Villeray.

Après cinq ou six entrevues entre M. de Frontenac et M. de Villeray, celui-ci, au nom des conseillers, suggéra que chaque fois que le gouverneur se rendrait au Conseil deux conseillers iraient le recevoir

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[1] *Jugements et Délibérations du Conseil Souverain.*

dans la salle des parties. S'il n'était pas satisfait de cette offre, le Conseil s'engageait à s'en rapporter à ce qu'il jugerait à propos "en telle façon que le dit sieur comte de Frontenac serait content." Cette fois, le vieux diplomate se déclara satisfait. Il voulut bien informer les conseillers qu'il se rendrait au Conseil après Pâques.

Il semble que pendant sa seconde administration M. de Frontenac n'ait eu aucun sujet de plainte contre M. de Villeray. Du moins, ses lettres ne font aucune mention de M. de Villeray. On a même le droit de supposer que les préventions du gouverneur étaient disparues puisque nous le voyons, le 3 août 1690, tenir sur les fonts baptismaux un petit-fils de M. de Villeray.

Le 4 novembre 1693, l'intendant Bochart Champigny prenait la peine d'informer le ministre qu'il était très satisfait de M. de Villeray:

"La bonne conduite et l'application des Srs de Villeray et Benac, agent et contrôleur de la ferme, me donnent lieu de vous en rendre tous les bons témoignages qu'il est possible de vous assurer que Mrs les fermiers généraux peuvent se reposer et prendre une entière confiance sur leurs soins et fidélité."[1]

M. de Lamothe-Cadillac dans un long mémoire de récrimination daté du 28 septembre 1694 et où il attaquait tous ceux qu'il n'aimait pas, disait de M. de Villeray: "N'est-ce pas encore une chose honteuse de voir M. de Villeray, le premier conseiller, tenir la boucherie dans sa maison et faire débiter la viande par son valet, et madame sa femme en recevoir l'argent? Prenez la peine de vous en informer, et vous ne trouverez personne qui ne rende ce témoignage. De quel avis peuvent donc être ces messieurs, sur l'article de la viande principalement, puisqu'ils sont eux-mêmes bouchers? Y a-til apparence qu'ils décident contre leurs propres intérêts . . . "[2]

M. de Lamothe-Cadillac en voulant nuire à M. de Villeray auprès du ministre rendrait hommage à son honnêteté et à son désintéressement. Quand tant d'autres autour de lui s'enrichissaient en quelques années, M. de Villeray qui avait rempli plusieurs charges où il aurait pu s'amasser un pécule était pauvre et était obligé de faire du commerce pour subsister, ses appointements de premier conseiller ne lui donnant pas suffisamment pour faire vivre sa famille.

Encore en 1694, M. Bochart Champigny se plaisait à louer les bons services de M. de Villeray. Le 24 octobre 1694, il écrivait au ministre: "Je continuerai à vous rendre de bons témoignages de la conduite de Mr de Villeray et de M. Benac, agent et contrôleur des

[1] Archives du Canada, Correspondance générale, vol. 12.

[2] Archives du Canada, Correspondance générale, vol. 13.

fermes en ce pays, dont l'application, la fidélité et l'axactitude m'engagent à vous dire qu'on ne saurait choisir deux meilleurs officiers ni plus honnêtes gens pour remplir ces emplois."[1]

Le 20 octobre 1699, l'intendant Bochart Champigny donnait au ministre des renseignements sur l'organisation religieuse et judiciaire de la Nouvelle-France. "La justice, écrivait-il, se rend dans une parfaite équité et avec autant de désinteressement, principalement au Conseil de Québec où la partialité et la prévention n'ont point d'entrée. Monsieur le gouverneur y occupe la première place, M. l'évêque la deuxième et son grand-vicaire en son absence qui est un sujet de mortification pour l'intendant à ce qui me semble. Il ne devrait pas être préféré y faisant les fonctions de premier président et y prononçant les arrêts. Il y a sept conseillers dont le plus ancien qui est le sieur de Villeray mérite une considération particulière aussi bien que le sieur d'Auteuil, procureur-général."[2]

"Dans l'hiver de 1700-1701, raconte l'annaliste du monastère des Ursulines, il y eut à Québec des maladies populaires qui firent d'étranges ravages. Le mal s'annonçait par un mauvais rhume, auquel se joignait une fièvre ardente accompagnée de fortes douleurs de côté, et il emportait les personnes en peu de jours. La contagion, qui avait commencé sur la fin de novembre, se répandit bientôt dans toute la ville, et il n'y eut pas de maison qui ne fut changée en hôpital. Toutes les communautés furent attaquées en même temps, et à peine en restait-il quelques unes debout pour soigner et assister les autres."[3]

La maladie sévit avec une violence extrême. M. de Villeray, qui était âgé de 71 ans, fut une des premières victimes de ce fléau d'un nouveau genre. Il succomba le 6 décembre 1700, et fut inhumé le lendemain dans la cathédrale.

Ceux qui, mettant leur conscience au-dessus de leur intérêt et de leur tranquillité, ne craignent pas de faire leur devoir, s'attirent d'ordinaire bien des ennuis et des tracas des ambitieux dont ils barrent le chemin et empêchent les menées. Il en fut ainsi de M. de Villeray. Toute sa vie il fut en butte au mauvais vouloir de ceux qui profitaient de leurs charges pour assouvir leur ambition et faire leur fortune. Mais à sa mort le sentiment fut unanime pour rendre justice à sa mémoire.

Dans un mémoire envoyé au ministre au sujet de celui qui devait le remplacer comme premier conseiller au Conseil Souverain, on trouve une note qui permet à la fois de savoir ce qu'était la charge de premier

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[1] Archives du Canada, Correspondance générale, vol. 12.

[2] Archives du Canada, Correspondance générale, vol. 17.

[3] *Les Ursulines de Québec*, tome II, p. 13.

conseiller et ce qu'on pensait de M. de Villeray. "Le sieur de Villeray, est-il dit dans ce mémoire, l'a exercée depuis la déclaration du roi de l'année 1675 avec beaucoup d'équité et d'honneur. Personne avant lui ne l'avait possédée, ce qui donne aujourd'hui lieu de douter, sous le bon plaisir de Sa Majesté, si cette place est unique et distincte des six autres, ou si l'ancien des six conseillers y doit monter de droit par succession. Le sieur de Villeray s'est toujours regardé dans sa place comme *primus inter pares*. Ça toujours été et c'est encore l'esprit dans lequel M. le gouverneur et M. l'intendant et tous les membres du Conseil, regardaient cette première place: changer cet ordre, ce serait les désoler tous." Plus loin, dans la même pièce il est dit "que la mémoire de M. de Villeray était respectée dans tout le pays."[1]

C'est toujours une consolation pour ceux qui font leur devoir malgré tous les obstacles de penser qu'après leur mort l'équilibre sera rétabli et qu'on leur rendra justice.

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[1] Archives de la marine, Personnel civil, Canada.

Un hydrographe du roi à Québec: Jean-Baptiste-Louis Franquelin

Par M. PIERRE-GEORGES ROY, M.S.R.C.

(Lu à la réunion de mai 1919)

Jean-Baptiste-Louis Franquelin était né entre 1651 et 1653 à Saint-Michel de Villebernin, paroisse de l'archevêché de Bourges, du mariage de Guillaume Franquelin et de Catherine Vitas.

Nous ne savons pas exactement en quelle année il passa dans la Nouvelle-France. Dans sa carte de l'Amérique Septentrionale datée de 1688, il écrit: "le tout fidèlement dressé conformément aux observations que l'auteur a faites lui-même pendant plus de 16 années . . ." Si l'on peut se fier à cette vague indication, Franquelin serait donc arrivé dans la Nouvelle-France en 1672, à l'âge de vingt-un ou vingt-deux ans.

De 1672 à 1678, toutefois, nous ne trouvons aucune mention de lui dans la correspondance des gouverneurs ou des intendants. En 1678, l'on voit, pour la première fois, son nom comme hydrographe au pied d'une carte pour servir à l'éclaircissement du papier terrier de la Nouvelle-France.

Trois ans plus tard, en 1681, on fait le recensement nominal de la Nouvelle-France et le recenseur nous apprend que Franquelin, âgé de 30 ans, non marié, habite avec Jean Juchereau de la Ferté à la basse-ville de Québec.[1]

En 1683, il envoie au ministre de Seignelay son *Plan géométrique de la basse-ville de Québec*, et joint à ce plan un petit exposé intitulé "Mémoire à Monseigneur le marquis de Seignelay pour l'augmentation de la basse-ville de Québec," dans lequel il dit: "L'augmentation de la basse-ville de Québek, qui est la capitale de la Nouvelle-France, estant ce qui se peut faire de plus avantageux dans le dit pays tant pour attirer de nouveaux habitans dans la dite ville et la rendre plus marchande, que pour la mettre en estat par l'abondance du peuple de résister aux efforts de ceux qui pourraient estre capables de faire des entreprises contre cette colonie la dite basse ville estant bornée d'un costé par une coste fort elevée, et de l'autre par le fleuve de Saint-Laurent, M. de Meulles, intendant de justice, police et finance de Canada, n'a trouvé qu'un moyen, mais très facile pour faire cette augmentation, qui est de prendre un espace qui se découvre à basse marée de deux cens toises de long d'un costé et de cent toises pour le

[1] Benjamin Sulte, *Histoire des Canadiens-Français*, vol. IV, p. 55.

retour qui rend (sic) au Sault-matelot et de quatre vingtz de large depuis la coste jusque à la dite basse marée, comme il se peut voir sur le plan cy joint, au bout duquel espace on bornerait la rivière par une digue ou muraille de la haulteur de douze pieds sur huit pieds d'épaisseur par en bas, qui se réduirait à trois pieds par le hault. Cette muraille arrestant la marée donnerait lieu aux habitans de prendre des places pour les bastir et la ville se trouverait par ce moyen augmentée de plus d'un tiers et se fortifierait beaucoup, puisque mesme au bout des dites deux cens toises il y aurait un éperon où on pourrait monter vingt pièces de canon. Cette dépense peut aller à trente mille livres. Si Sa Majesté veut l'entreprendre, elle aura toutes les places qu'elle réunira à son domaine: que si elle ne veut pas entrer dans cette proposition, mon dit sieur de Meulles s'oblige de faire la dite digue ou muraille à ses frais et dépens, s'il plaist à Monseigneur le Marquis de luy obtenir un arrest de concession de toutes les places vacantes et non basties contenues dans le dit pays, luy faire accorder dix milles livres par sa Majesté une fois payée et l'entrée franche au dit pays de trente tonneaux de vin et de quinze tonneaux d'eaux de vie pour les ouvriers."

Dans une lettre du gouverneur de la Barre au ministre de Seignelay du 4 novembre 1683, nous lisons: "J'ai envoyé un exprès à New-York, à Manatte et Orange et j'ay écrit à Boston, mon envoyé n'a rien fait parceque le sieur Dunken, nouveau gouverneur catholique, que le duc d'York y envoye, n'estait pas encore arrivé, et que mon homme l'a attendu deux mois avec assés de dépenses dont j'ai deschargé le Roy par les moyens les plus doux: Je luy ay écrit depuis peu par des Sauvages affidés dont je n'ay encore de réponse. Les Anglais de la Baye d'Hudson ont attiré cette année beaucoup de nos Sauvages du Nord, ce qui a fait qu'ils ne sont point venus en traitte à Montréal. Comme ils ont sçues que Dulut arrivait par des exprès qu'il les a envoyés en se jettant dans Missilimakinac, ils luy ont mandé qu'il vint visiter et qu'ils se joindraient à luy pour empêcher tous les autres d'y plus aller; si je bouche ce passage, comme je l'espère et qu'il est absolument nécessaire, les Anglais de cette Baye excitant les Sauvages contre nous et où le sr Dulut peut seul apporter le calme. Je prendrai des mesures avec seux de la Neuve-York qui me paraissaient fort contents de moy, mais qui voudraient un ordre du duc d'York pour me rendre mes déserteurs criminels. Je juge par l'état des affaires d'Europe qu'il est important de mesnager cette nation et je m'y attacherai fortement. Ce qui me vient présentement de ce côté mérite une explication entière et pour cela je vous envoie une relation séparée de ma despêche, laquelle avec la carte que je vous fais faire du pays vous donnera une parfaite connaissance de toutes choses et le moyen d'en entretenir Sa Majesté. Le garçon qui fait ces cartes est un nommé Franquelin aussi habile de la main qu'il y en ait en France, mais il est extrêmement pauvre et qui aurait besoin d'un peu de secours de la part de Sa Majesté comme un ingénieur. Il travaille à une carte très juste du pays que je vous envoyerai l'année prochaine en son nom, pendant que je le ferai subsister par quelques petits secours"[1]

Le marquis de Denonville, successeur de M. de la Barre au gouvernement de la Nouvelle-France, ne tarda pas, lui aussi, à se rendre compte des services que Franquelin pouvait rendre à la colonie. Le 13 novembre 1686, il écrivait au ministre: "Je croirais encore Monseigneur, qu'il serait d'une utilité fort grande au service du Roi d'avoir ici un maître pour montrer les premiers principes de la navigation. Je crois que l'on trouverait ici de bons sujets. Il y a ici un homme très capable d'enseigner nommé Franquelin, qui fait des cartes ici. Il sait bien de bonnes choses. Il serait très utile que vous eussiez la bonté de lui faire donner quelque subsistance. Il enseignerait à écrire, à dessiner, la navigation et l'arithmétique. Nos Canadiens ont assez de dispositions à être bons pilotes, en leur donnant le moyen d'apprendre."

M. de Denonville ajoutait: "Les Canadiens sont tous grands, bien faits et bien plantés sur leurs jambes, accoutumés dans les nécessités à vivre de peu, robustes et vigoureux, mais fort volontaires et légers, et portés aux débauches. Ils ont de l'esprit et de la vivacité."[2]

Le ministre se rendit à la suggestion de M. de Denonville et fit nommer Franquelin hydrographe du roi à Québec aux appointements de quatre cents livres par année.[3] Son brevet de nomination n'a pas été conservé mais nous croyons qu'il fut signé par le roi dans les premiers mois de 1687. On croit généralement que Franquelin fut nommé hydrographe en 1686. Comme la lettre M. de Denonville est datée du 13 novembre 1686 il est plutôt probable que la nomination eut lieu au printemps de 1687.

Dans un résumé de la correspondance officielle du Canada de 1687, on lit:

"Le Sr Franquelin remercie de l'emploi d'hydrographe qu'on lui a donné. Il représente qu'étant obligé d'avoir un logement qui lui

[1] Archives du Canada, Correspondance générale, vol. 6.

[2] Archives du Canada, Correspondance générale, vol. 8.

[3] L'hydrographie, écrit Mgr Gosselin, c'est l'étude de cette partie de la géographie qui concerne l'art de la navigation. (*L'instruction au Canada sous le régime français*, p. 332.)

coûte cent écus par an, pour avoir un grand lieu où il puisse donner des leçons et n'ayant que 400 livres d'appointements il aura peine à subsister mais cependant qu'il s'appliquera de son mieux à l'instruction des écoliers."[1]

Dans une lettre adressée à M. de Lamet, curé de Saint-Eustache de Paris, par le Père Chabaud, missionnaire, et datée de Kébec le 29 novembre 1688, nous voyons qu'à l'automne de 1688 Franquelin passa en France.

"Monsieur Franquelin, notre mathématicien, va à la cour; il emporte une carte considérable que vous pourrez voir chez M. de Segnelé."[2] C'est pendant le séjour en France de l'habile cartographe, en mars 1689, qu'il soumit au ministre deux mémoires qui prouvent que, dès cette époque, il était préoccupé de cette rivière de l'ouest à la recherche de laquelle notre Varenne de la Vérandrye devait, quelques années plus tard, consacrer sa vie.

Le premier mémoire de Franquelin était intitulé: "Mémoire pour informer Monseigneur de l'importance qu'il y a de tirer des lignes justes sur les limites des terres qui appartiennent au Roy dans la Nouvelle-France, planter des bornes, arborer les armes de Sa Majesté et en faire une carte bien fidelle."

"Il est important de faire attention, écrivait-il, que les étrangers se mettent insensiblement en possession de ce qui appartient au Roy, et si on les souffre plus longtemps la colonie et le commerce se détruiront. Un des moyens pour l'empêcher, est d'envoyer une personne qui puisse tirer des lignes justes et former des limites en plantant des bornes avec les armes de sa Majesté, comme Mon sr le marquis de Denonville et Mon sr de Champigny l'ont projetté.

"On pourrait faire mouler à Rochefort une douzaine ou deux de plaques de cuivre dans lesquelles les armes de sa Majesté seraient d'un costé et l'inscription qu'il plairait à Monseigneur d'ordonner de l'autre, ce qui se ferait à peu de frais.

"Il semblerait qu'il serait assez nécessaire de diviser ce grand terrain en provinces auxquelles on donnerait des limites et des noms français stables et permanens aussy bien qu'aux rivières et aux lieux particuliers, en abolissant tous les noms sauvages qui ne font que de

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[1] Archives des affaires étrangères, Amérique, tome II. Franquelin résidait à Québec dans une maison qui appartenait à Philippe Gaultier de Comporté, "size en la haute-ville, joignant d'un côté le clos des messieurs du Séminaire et de l'autre côté la rue qui va à l'Hôpital." Il payait cent trente cinq livres par année de loyer, (Bail de maison de Gaultier de Comporté à Franquelin, acte de Genaple, notaire à Québec, 13 novembre 1686.)

[2] Bibliothèque nationale, mss fr. Nouv. acq. n° 2610.

la confusion parce qu'ils changent très souvent et que chaque nation nomme les lieux et les rivières en sa langue, ce qui fait qu'une mesme chose a toujours divers noms.

"Ce travail non seulement rendrait les cartes plus intelligibles, mais confirmerait encore la possession des pais qui y seraient contenus.

"On pourrait faire des cartes particulières de ces provinces, en grand point, bien justes et bien fidelles avec des avertissemens qui marqueraient la qualité des terres, leur climat et leurs autres propriétez.

"Monsieur le marquis de Denonville et Monsieur de Champigny ont fait promettre au Sr Franquelin de commencer cet ouvrage à son retour en France parce qu'il est le seul dans ce pais qui ait acquis par son travail de plusieurs années les connaissances nécessaires pour y réussir.

"S'il plaist à Monseigneur de considérer l'utilité de cette entreprise, qui dans une si grande étendue de pais, ne peut estre que bien rude et bien pénible, il supplie très humblement Sa Grandeur de luy en faire expédier la commission en luy en accordant les mesmes appointemens qu'aux ingénieurs de Canada et luy continuant les siens parce qu'il faudra qu'il entretienne un dessinateur à Québec pour mettre ses ouvrages au net affin qu'il les puisse envoyer tous les ans."

Le second mémoire du même, présenté au ministre quelques semaines plus tard, portait pour titre: "Additions au mémoire que Franquelin, hydrographe du roy à Québec, a présenté à Monseigneur, touchant l'importance qu'il y a de planter des bornes, arborer les armes du Roy et tirer des lignes sur les limites des terres qui appartiennent à Sa Majesté dans la Nouvelle-France."

"On aurait peû, disait Franquelin dans ce nouveau mémoire, commencer cette entreprise du côté des colonies anglaises qui joignent le pays des Iroquois, sans que la conjoncture des affaires y pourra peut estre apporter quelques difficultez. Mais, comme il n'est pas moins important de faire la mesme oppération vers la baye du Nord, on peut y travailler du moins, avec autant d'utilité et mesme avec plus de fruit en voicy quatre raisons.

"La première que les Anglais n'ayant point encore pénétré dans les terres qui sont au couchant de cette baye, il serait à propos avant qu'ils y pénétrassent, d'en aller prendre possession, en y plantant des bornes et y arborant les armes de sa Majesté.

"La seconde, que l'on prendrait de bonnes et entières connaissances des lacs des Apsiniboels, des Christinaux et d'autres lacs d'où les Anglais tirent toutes les pelleteries qu'ils traitent au port Bourbon nommé par eux port Nelson.

"La troisième, que les nations de ce continent sont fort docilles et aiment beaucoup mieux les Français que les Anglais, et qu'ainsi il serait aysé de les détourner du port Nelson pour nous les attirer dans nos postes; et par conséquent profiter de ce commerce. Ce qui détruirait entièrement la traitte des dits Anglais et les contraindrait absolument d'abandonner avant qu'il fust trois ou quatre ans.

"La quatrième, que l'on pourrait sçavoir, s'il est vray comme les sauvages l'assure (sic) qu'il y a une grande rivière dans le lac des Assiniboels qui coule vers le nord ouest, par où ce même lac se décharge parce que si cela estait, on pourrait connaître s'il y a un passage dans le nord, à la mer de l'ouest, comme on l'a plusieurs fois tenté par mer, ou bien on examinerait si cette rivière est navigable et si elle a quelque bon havre à son embouchure, car pour lors il semblerait qu'il serait beaucoup plus avantageux qu'il n'y eust point de passage, à cause des étrangers qui auraient le mesme avantage que nous s'il y en avait un, outre que le commerce qu'on ferait par le moyen de cette rivière serait très utile et très profitable au pays, quoy qu'il s'y rencontrast des difficultez pour le transport des marchandises: parce que ces mesme difficultez donneraient lieu au peuple de faire les colonies pour faciliter les voitures, les quels se sentant attirez par l'espérance de quelque gain et par des sallaires reglez et asseurez s'avanceraient dans des terres qui demeureront encore longtems incultes sans cela."[1]

Le 1er mai 1689, Sa Majesté autorisait MM. de Denonville et Bochart Champigny à remplacer le sieur de Villeneuve, ingénieur du Roi dans la Nouvelle-France, par M. Franquelin, s'ils le croyaient capable."[2]

Quelques semaines plus tard, le 24 mai 1689, le roi ordonnait à MM. de Denonville et Bochart Champigny de donner à Franquelin, qui retournait dans la Nouvelle-France pour faire la carte des parties du nord de l'Amérique, tout le secours dont il aurait besoin.[3]

Franquelin était plutôt un cartographe qu'un ingénieur. Peut-être refusa-t-il la charge d'ingénieur que lui offrait le roi ? Une chose certaine c'est qu'il ne remplaça pas l'ingénieur Villeneuve puisque le 1er mars 1693, Jacques Levasseur de Neré était nommé ingénieur du Roi dans la Nouvelle-France "pour remplacer M. Villeneuve."

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[1] Nous empruntons les deux mémoires de Franquelin donnés ici à l'important ouvrage de M. Harrisse, *Notes pour servir à l'histoire, à la bibliographie et à la cartographie de la Nouvelle-France.*

[2] Richard, *Supplément au Rapport du Dr Brymner sur les Archives Canadiennes, 1899*, p. 274.

[3] Richard, *Supplément au Rapport du Dr Brymner sur les Archives Canadiennes, 1899*, p. 275.

L'attaque de Phipps contre Québec et les malheurs des temps empêchèrent Franquelin de travailler comme il l'aurait voulu à l'importante carte que le ministre lui avait ordonnée de lever.

A l'automne de 1692, Franquelin s'embarquait de nouveau pour la France. Il fit la traversée sur le navire l'*Envieux*. Il se rendait en France, à la demande et sur l'ordre du gouverneur de Frontenac.[1]

M. de Frontenac dit bien que c'est lui qui envoya Franquelin en France, mais il ne parle pas de la mission qu'il lui avait confiée.

Franquelin revint dans la Nouvelle-France dans l'été de 1694.

Dans un mémoire du Roi à MM. de Frontenac et Bochart Champigny non daté, mais de 1694, nous lisons: "Sa Majesté a bien voulu renvoyer le Sieur Franquelin pour servir en qualité d'hydrographe, il a donné un mémoire des choses qu'il propose de faire. Ils pourront y faire travailler dans un temps plus favorable, cependant Sa Majesté désire qu'ils s'appliquent à recueillir les observations qu'ils ont desja faites pour en informer Sa Majesté et particulièrement pour ce qui concerne la navigation du fleuve Saint-Laurent afin de faire rectifier les cartes qui en ont esté faites.

"Ils n'ont point satisfait suffisamment à ce qui leur a esté si précisement ordonné par Sa Majesté pour les lieux de l'entrée et du fleuve Laurent où les vaisseaux partis de France pourraient se rassembler si les vaisseaux ennemis estaient dans ce fleuve et y recevoir des avis de leur part de l'estat du pays."[2]

Franquelin se rembarqua pour la France à l'automne de 1694 ou dans le premier vaisseau qui fit le trajet de Québec en France au printemps ou à l'été de 1695. Il ne devait pas revenir dans la Nouvelle-France.

Nous avons peu de renseignements sur lui après son départ de la Nouvelle-France. Il semble, toutefois, qu'il fut employé sous les ordres du célèbre Vauban probablement en qualité de dessinateur.

Sur la fin de 1696, on avait songé en France à reprendre le projet de conquête de la Nouvelle-York conçu par M. de Callières en 1689. Le 16 janvier 1697, M. de Chevry, qui avait longtemps servi en France et en Acadie avec la réputation d'un bon officier d'infanterie, écrivait à M. de Lagny: "Je vous envoye, Monsieur, le sieur Franquelin, avec le brouillon du plan de la baie et de la ville de Boston, dont, malgré ses occupations pressées, il promet une copie régulière dans mardi prochain. Il a chez lui la carte des côtes depuis Pentagouet jusques à cette baie, et depuis cette baie jusques à Manhatte, et le plan de cette ville et de ses environs. Je vous supplie de l'écouter

[1] *Jugements du Conseil Souverain*, vol. III, p. 737.

[2] Archives du Canada, série B., vol. 171, folio 196.

afin qu'il nous tienne parole, car monsieur de Vauban ne lui laisse guère de temps. Si les bureaux venaient ici aujourd'hui, on pourrait toujours faire voir ce brouillon à Monsieur Phelipeaux et à monsieur de la Touche."[1]

Dans l'été de 1700, Louis Jolliet, qui avait succédé à M. Franquelin comme hydrographe du roi à Québec, décédait obscurément à l'île d'Anticosti ou sur la côte du Labrador. Quelques mois plus tard, le 18 mai 1701, Franquelin était de nouveau nommé hydrographe du roi à Québec,[2] mais ne se pressait pas de venir occuper son poste.

Le 5 octobre 1701, MM. de Callières et Bochart Champigny écrivaient au ministre: "Le sieur Franquelin à qui Sa Majesté a accordé la place de maître d'hydrographie, vacante par la mort du sieur Jolliet, ne doit pas venir cette année en ce pays, quoiqu'il en ait reçu les appointements. Comme les Jésuites ont continué cette école à Québec depuis la mort du sieur Jolliet et qu'ils en tiennent même une à Montréal dans l'espérance qu'ils pourraient avoir cette place, nous croyons, Mgr, qu'il y aurait de la justice qu'ils en reçussent les appointements pendant une année qu'ils ont enseigné."[3]

Franquelin ne s'embarqua pas pour Québec et il fut remplacé dans sa charge d'hydrographe par Jean Deshayes qui était dans la Nouvelle-France depuis 1685. Nous ne connaissons pas les raisons qui empêchèrent Franquelin de revenir dans la Nouvelle-France, mais nous avons le droit de présumer que les dettes qu'il avait été obligées de contracter ici pour faire subsister ses enfants et ceux du premier mariage de sa femme ne furent pas étrangères à sa décision de rester en France. Pendant tout le temps de son séjour ici, il ne recevait que quatre cents livres d'appointements par année et avait vécu misérablement.

Le 7 août 1691, la prévôté de Québec le condamnait à payer aux héritiers de feu Hugues Cocheran dit Floridor une somme de douze cent cinquante six livres, six sols, huit deniers.[4] Incapable de payer, harcelé par les huissiers qui faisaient des procédures comme pour augmenter à plaisir les frais, Franquelin fut obligé de s'adresser au Conseil Souverain afin d'obtenir un délai pour solder cette créance. Le 29 octobre 1691, le Conseil prenant en considération le départ prochain de Franquelin pour aller lever la carte des parties du nord de l'Amérique par ordre du roi, lui accordait surséance de dix-huit

[1] *Collection de manuscrits*, vol. II, p. 253.

[2] Richard, *Supplément au Rapport du Dr Brymner sur les Archives Canadiennes, 1899*, p. 340.

[3] Archives du Canada, Correspondance générale, vol. 19.

[4] Franquelin avait emprunté cette somme le 7 octobre 1688. (Obligation devant Gilles Rageot, notaire à Québec.)

mois pour solder sa dette à condition qu'il paierait l'intérêt sur le tout.[1] Mais les créanciers de Franquelin étaient légion. Il n'avait pas plutôt obtenu un léger délai d'un de ses créanciers, qu'un autre entrait en scène, le talonnant et lançant à ses trousses huissiers et procureurs, tous gens plutôt indifférents à la science . . . et aux savants. Le 21 juillet 1692, le Conseil Souverain prenant en pitié le malheureux hydrographe, lui accordait un même délai de dix-huit mois pour satisfaire ses créanciers généralement quelconques.[2]

Les requêtes présentées au Conseil Souverain par Franquelin pour être protégé contre ses créanciers n'ont malheureusement pas été conservées, mais le jugement du Conseil du 21 juillet 1692 prend la peine de noter que l'hydrographe du roi était tellement ennuyé par toutes ces procédures qu'il ne pouvait s'appliquer aux travaux si difficiles et si délicats qu'il avait entrepris.

Malgré toutes nos recherches, nous n'avons pu découvrir l'endroit ni la date de la mort de Franquelin. Tout ce que nous pouvons affirmer, c'est qu'il mourut en France entre 1712 et 1730.[3]

Il avait épousé à Québec, le 4 février 1683, Elisabeth Aubert, veuve de Bertrand Chesné. La veuve Chesné avait lors de son second mariage huit enfants vivants, et son mari l'avait laissé avec de nombreuses dettes. Ce mariage mal assorti fut, croyons-nous, la cause de tous les malheurs de Franquelin.

Quoiqu'il en soit, le 1er avril 1693, le ministre donnait instruction à l'intendant Bochart Champigny d'accorder passage à madame Franquelin et à ses huit enfants sur le vaisseau du roi pour aller rejoindre son mari en France.[4]

Elle s'embarqua à l'automne de 1693 avec quelques-uns de ses enfants sur le vaisseau du roi, *le Corossol*, qui périt corps et bien en faisant route pour la France.[5]

Du mariage de Jean-Baptiste-Louis Franquelin et de Elisabeth Chesné étaient nés:

1. Marie-Jeanne Franquelin née à Québec le 18 février 1686. Probablement périe dans le naufrage du *Corossol* en 1693.

2. Geneviève-Marguerite Franquelin née à Québec le 20 juillet 1688. Probablement périe dans le naufrage du *Corossol* en 1693.

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[1] *Jugements du Conseil Souverain de la Nouvelle-France*, vol. III, p. 580.

[2] *Jugements du Conseil Souverain*, vol. III, p. 669.

[3] Dans l'acte de mariage de sa fille Elisabeth, à Québec, le 24 octobre 1712, le père est dit "vivant." Dans l'acte de mariage de son autre fille, Marie-Anne, à Québec, le 13 octobre 1730, il est dit "défunt."

[4] Richard, *Supplément au Rapport du Dr Brymner sur les Archives Canadiennes, 1899*, p. 291.

[5] *Jugements du Conseil Souverain*, vol. III, p. 1008.

3. Marie-Anne Franquelin née à Québec le 11 septembre 1690. Mariée à Québec, le 13 octobre 1730, à Jacques Quesnel de Fonblanche, marchand bourgeois à Montréal.[1]

4. Elisabeth Franquelin née à Québec le 23 août 1691. Mariée à Québec, le 24 octobre 1712, à Joseph Lemieux, fils de Guillaume Lemieux et d'Élisabeth Langlois, de Notre-Dame de l'Assomption de Berthier. Madame Lemieux décéda à Berthier le 10 avril 1762.

5. Marie-Joseph Franquelin né à Québec le 7 avril 1693.[2] Cet enfant, au départ de sa mère pour la France, fut confié aux soins de Gervais Beaudoin. En 1725, un jeune Franquelin était cadet à bord du vaisseau du roi le *Chameau*. On voit par une lettre du roi à MM. de Vaudreuil et de Chazel du 29 mai 1725 qu'il leur envoyait une lettre par le jeune Franquelin. Le cadet Franquelin devait être Marie-Joseph Franquelin, fils de l'hydrographe Franquelin.

Il nous reste à donner la liste des cartes levées par Franquelin. Les ouvrages de MM. Harrisse, *Notes pour servir à l'histoire, à la bibliographie et à la cartographie de la Nouvelle-France;* Marcel, *Cartographie de la Nouvelle-France*, et J.-Edmond Roy: *Rapport sur les Archives de France relatives à l'histoire du Canada*, nous ont beaucoup aidé pour retracer les vingt cartes connues de Franquelin:

1. Carte du golfe et du fleuve St.-Laurent avec le Canada jusqu'aux lacs, 1678. Franquelin (Harrisse, n° 207; Roy, p. 286.)

2. Carte générale de la France septentrionale, contenant la découverte du pays des Ilinois faite par le sieur Jolliet, Joannes-Ludovicus Franquelin *pinxit*. "A Monseigneur Colbert, conseiller du Roy en son Conseil Royal, ministre et secrétaire d'État, commandeur et grand trésorier de Sa Majesté, par son très humble, très obéissant et très fidelle serviteur Duchesneau, intendant de la Nouvelle-France (1681). 1 m. x 0 m. 78.[3] (Harrisse, n° 214; Roy, p. 258.)

3. Carte contenant une partie du Canada et les terres qui s'estendent depuis 44 jusqu'à 61° de lattitude, et de longitude depuis 246 jusqu'à 297. Cette carte est une des quatre parties de la description générale du Canada et des terres qui s'estendent depuis 27 degréz jusqu'à 338 de long. A Québec en la Nouvelle-France, le 10 septembre 1681, par Jean-Louis Franquelin. 1 m. x 0 m. 68. (Harrisse, n° 216; Roy, p. 256.)

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[1] Contrat de mariage devant Barbel, notaire à Québec, le 13 mai 1730.

[2] Mgr Tanguay (*Dictionnaire généalogique*, vol. *1er*, p. *241*) dit Marie-Josephte mais c'est Marie-Joseph qu'il faut lire.

[3] L'Université Laval, de Québec, possède une très belle copie de cette carte.

4. Carte de la Nouvelle-France et des terres qui s'estendent depuis 44 jusqu'à 61 degréz de l'attitude. A Québec, par J(ean) L(ouis) F(rançois) F(ranquelin), 1681. 1 m. x 0 m. 68. (Harrisse, n° 217; Roy, p. 256.)

5. Partie de l'Amérique septentrio. depuis 27 jusques à 44 degréz de l'att. et depuis 269 degréz de longitude jusqu'à 300, prenant le premier méridien aux Iles Açores. A Québec en la Nouvelle-France, par Jean-Louis Franquelin, 1681. 1 m. x 0 m. 68. (Harrisse, n° 218; Roy, p. 256.)

6. Carte contenant une partye de l'Amérique septentrionale, depuis 27 jusqu'à 44 degréz de lat. A Québec, par Jean-Louis Franquelin, 1681. 1 m. x 0 m. 68. (Harrisse, n° 215; Roy, p. 256.)

7. Carte du fort St.-Louis de Québec par Jean-Baptiste-Louis Franquelin, 1683.[1] (Marcel, n° 14; Harrisse, n^os^ 220 et 347; Roy, p. 276.)

8. Plan géométrique de la basse-ville de Québec avec partie de la haute ville pour connaistre la disposition du lieu et faire voir l'augmentation qui s'en peut faire jusqu'à la basse marée, comme il se distingue aisément par ces aligmens tirez en petits points vides. Par Jean-Baptiste-Louis Franquelin, 1683. 0. 35 x 0.35. (Marcel, n° 13; Harrisse, n^os^ 221, 346; Roy, p. 276.)

9. Carte de la Louisiane ou des voyages du Sr de La Salle et des pays qu'il a découverts depuis la Nouvelle-France jusqu'au Golfe Mexique, les années 1679, 80, 81 et 82, par Jean-Baptiste-Louis Franquelin, l'an 1684.

L'original de cette carte conservé aux Archives de la Marine à Paris est maintenant perdu. Une copie fac-simile faite pour l'historien Francis Parkman se trouve dans la bibliothèque de l'université Harvard, à Cambridge, Mass., É.-U.[2]

10. Carte du grand fleuve St.-Laurent, dressée et dessignée sur les mémoires et observations que le Sr Jolliet a très exactement faites en barque et en canot en 46 voyages, pendant plusieurs années, par Jean Baptiste Louis Franquelin, 1685. (Harrisse, n° 229; Roy, p. 287.)

11. Amérique septentrionale comparée, corrigée et augmentée sur les journaux, mémoires et observations les plus justes qui en ont

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[1] Ceci n'est pas une carte, mais une perspective cavalière très finement dessinée, avec luxe de cartouches ingénieux. La lettre est particulièrement soignée. Dans le coin supérieur gauche se trouve ajoutée par une main étrangère, la date 25 bre 1683. (Note de J. E. R.)

[2] Une réduction de cette carte a été publiée au frontispice du volume LXIII de l'ouvrage de Reuben-Gold Thwaites, *The Jesuit Relations and allied Documents.*

été faites, en l'année 1685 et 1686, par plusieurs particuliers, par J. Baptiste-Louis Franquelin. G. du Roy. Dédiée à Monseigneur le marquis de Seignelay, par J.-Baptiste-Louis Franquelin, maistre d'idrographie pour le Roy à Québec. Carte coloriée aux armes de Seignelay, 1 m. 01 x 0 m. 93. (Roy, pp. 256 et 833.)

12. Carte géralle du Voyage que Monsr De Meulles, Intendant de la Justice, Police et Finances de la Nouvelle-France a fait (en Acadie) par ordre du Roy, et commencé le 9 Nov. (1685) et finy le 6e juillet 1686. (Roy, p. 553.)

13. Le lac Ontario avec les lieux circonvoisins et particulièrement les cinq nations iroquoises. L'année 1688. Coloriée. 0 m. 45 x 0 m. 31. (Harrisse, n° 239, Roy, p. 269.)

14. Carte de l'Amérique septentrionalle depuis le 25 jusqu'au 65e deg. de latt. et environ 140 et 235 deg. de longitude, contenant les pays de Canada ou Nouvelle-France, la Louisiane, la Floride, Virginie, Nelle Suède, Nelle York, Nelle Angleterre, Acadie, isle de Terreneuve, etc., le tout très fidellement dressé, conformément aux observations que l'auteur a faittes luy-même pendant plus de 16 années, par l'ordre des gouverneurs et intendants du pays. . . . En l'année 1688, par Jean-Baptiste-Louis Franquelin, hydrographe du Roy à Québec en Canada. Carte coloriée aux armes du Roi; dans un cartouche au bas de la carte: "Québec comme il se voit du côté de l'est."[1] 1 m. 60 x 1 m. 05. (Roy, pp. 257 et 834.)

15. Carte de la ville et des environs de Boston par Franquelin, 1693, vérifiée par le Sr de la Motte (Roy, pp. 296 et 830.)

16. Carte de l'Amérique septentrionale, entre 27 et 64 degréz de lattitude et environ 250 et 340 de longitude, où est compris les pays de la Nouvelle-France, Nouvelle-Angleterre, Virginie, Caroline, Floride, et tous les environs du grand fleuve Mississipi, etc. Le tout très correctement et très exactement dressé sur ce qu'en a vu l'auteur et sur les justes et fidels mémoires et relations qu'il a eu soin de recueillir depuis plus de douze années de gens experts. Par Jean-Baptiste-Louis Franquelin. Dessignée et écrite par F. de la Crois." Légendes historiques sur les différents établissements européens (8d). 4 sections, ds 0 m. 87 x 0 m. 49. (Harrisse, n° 223, Roy, p. 257.)

17. Carte de l'Amérique septentrionalle, entre les 25 et 65 degréz de lattitude et depuis environ les 240 jusqu'aux 340 de long. Contenant les pays de la Nelle-France, la Louisiane, Floride, Virginie, Nelle Yorke, Nelle Angleterre, Acadie, etc. Le tout très exactement

[1] Ce cartouche a été reproduit dans la carte de la Nouvelle-France de M. P.-M.-A. Genest.

dressé conformément aux observations que l'auteur en a faites luy même sur les lieux, et suivant les mémoires et relations qu'il a eu soin de recueillir pendant près de 17 années, de tous les voyageurs qui ont parcouru ces contrées qu'il a confrontés les uns avec les autres par l'ordre des gouverneurs et intendants, avant d'en dresser cette carte pour présenter en Cour, par Jean-Baptiste-Louis Franquelin. "Québec, vue du Nord-Ouest" (10 x 2) et "Québec, comme il se voit du côté de l'est" (10 x 3). 4 sections de 0 m. 78 x 0 m. 50 chacune. (Harrisse, n° 240; Roy, p. 258.)

18. Partie de l'Amérique septentrionalle, où est compris la Nouvelle-France, Nouvelle-Angleterre, N-Albanie et la N. York, la Pensilvanie, Virginie, Caroline, Floride, et la Louisiane, le Golfe Mexique et les îles qui bordent à l'Orient, etc. Par Jean-Baptiste-Louis Franquelin, géographe du Roy, 1699. "Vue de Québec" et repas indien (12-3) 2 m. 60 x 1 m. 72, en quatre sections de 0 m. 65 x 0 m. 43. (Harrisse, n° 258; Roy, p. 258.)

19. Carte du pays des Iroquois, par J(ean) B(aptiste) L(ouis) F(ranquelin), hydrographe du Roy, Coloriée, 0 m. 45 x 0 m. 32. (Harrisse, n° 213; Roy, p. 269.)

20. Carte généralle de la Nouvelle-France dans l'Amérique septentrionale où est encore compris la Nouvelle-Angleterre, la Nouvelle-York, la Nouvelle-Albanie, la Pensilvanie, la Virginie et la Floride. A Monseigneur, Monseigneur le comte de Pontchartrain, ministre et secrétaire d'état, par son très humble, très obéissant et très fidèle serviteur, Franquelin, 1708. "Résultat, dit l'auteur, de vingt années d'applications et de soins à parcourir le pais qu'elle contient." Aux armes de Pontchartrain. 0 m. 53 x 0 m. 44. (Harrisse, n° 248; Roy, p. 272.)

Jacques Cartier était-il noble?

Par REGIS ROY.

Présenté par B. SULTE, M.S.R.C.

(Lu à la réunion de mai 1919.)

Jacques Cartier, le découvreur du Canada, était-il noble ? L'était-il d'origine ? Avait-il atteint à cet état distingué durant sa vie par un anoblissement dû à ses services ou par l'acquisition de son domaine de Limoilou ? Ou bien, prenait-il rang tout simplement dans la bourgeoisie ? Des écrivains, des chercheurs ont écrit sur ce sujet, soutenant le pour, répliquant contre; cependant personne de ceux-là n'a apporté une pièce, un document, soit positif, soit négatif pour établir ou renverser la thèse proposée de chaque côté. Et pourtant, il devrait y avoir quelque chose d'assez défini dans ce qui a été publié jusqu'à ce jour, pour en arriver à une conclusion plus satisfaisante.

La question nous a été faite également, si le célèbre navigateur avait été anobli, parce que dans le premier volume de notre *Armorial du Canada-Français* M. E.-Z. Massicotte et moi, nous nous étions posés affirmativement en publiant les notes que nous avions trouvées au dictionnaire généalogique, etc., de M. le comte de Mailhiol. Cette demande avait une inflexion dubitative et nous a engagé à entreprendre une revue des ouvrages biographiques du grand Malouin, avec le résultat qui suit.

Il est reconnu que la noblesse s'acquérait de sept manières: par la naissance, par la possession d'un fief, par la chevalerie, par le service militaire, par la possession pendant une ou deux générations d'offices ou charges nobles, par l'obtention de lettres d'anoblissement et par les armoiries. C'était la noblesse de naissance ou de race, la noblesse inféodée, la noblesse de chevalerie, la noblesse militaire, la noblesse d'office, la noblesse par lettres et la noblesse par armoiries. (Loysel en ses Institutes coutumières—de Laroque.)

Ce sera donc sous l'un de ces titres qu'il faudra considérer le classement de notre illustre découvreur.

Cartier était-il de naissance noble ? Ses biographes se sont plutôt attachés à décrire ses voyages, sa vie à Saint-Mâlo. La reconstitution de sa généologie n'est qu'une œuvre de suppositions et de tâtonnants calculs de dates, car de l'aveu général de ces écrivains, les registres de l'état civil de Saint-Mâlo, commencés en 1454 sont très incomplets à venir jusqu'à l'année 1553.

"Les baptêmes ont d'énormes lacunes et manquent même totalement de 1472 à 1494; les mariages sont mentionnés à peu près sans texte, jusqu'en 1553; les actes de sépulture font entièrement défaut." (Jouons des Longrais, *Jacques Cartier*, Documents nouveaux, p. 9.)

"Plus on étudie cette question de la généalogie de Jacques Cartier, plus les difficultés s'amoncellent. Ne possédant que des actes imparfaits, l'écrivain se trouve très souvent réduit à des conjectures plus ou moins risquées." (Dr. Dionne, *Jacques Cartier*, 1889, Québec, p. 15.)

Mais alors, comment savoir si cette famille ayant autant de lacunes dans sa filiation appartenait à une caste spéciale? Si le champ d'action est défectueux aux archives civiles n'y en aurait-il pas un autre ailleurs pour y conduire des recherches avec plus de chances de succès. Sans avoir toute une lignée complète pour prouver le point qui nous intéresse, ne suffirait-il pas d'un document, d'un acte civil, dans d'autres archives, ceux du Parlement ou de la Chambre des Comptes, ou encore la présence bien constatée d'un représentant à l'occasion d'une des réformations ou recherches ordonnées par le roi pour la découverte des usurpateurs des titres de noblesse? Si les prétentions de ce personnage ne sont pas déboutées, n'est-ce pas assez alors pour en conclure qu'il était noble?

M. Jouons des Longrais connaissait l'Armorial et nobiliaire de Bretagne de M. Potier de Courcy puisqu'il le mentionne à la page 96 de son livre précité, lors du choix de priseurs nobles pour le partage des biens d'un Huchestel, de Saint-Mâlo, mais nous ne comprenons pas pourquoi il a passé sous silence ce qui suit, copié à la page 162 du premier tome de cet Armorial:

"Cartier, sieur du Hindret, paroisse de Saint-Coulomb, de la Boulaye, paroisse de Betton.

"Réformations et montres de 1478 à 1513, paroisses de Saint-Coulomb et de Saint-Lunaire, évêchés de Dol et de Saint-Mâlo.

"Robin, secrétaire du duc en 1444; Jacques, célèbre navigateur de Saint-Mâlo, découvrit le Canada en 1534. (Armorial de l'Arsenal.)

Plus loin à l'article Hindret, M. de Courcy ajoute:

"Hindray ou Hindret, sieur dudit lieu et de la Motte-Jehan, paroisse de Saint-Coulomb.

"Réformations et montres de 1478 à 1513, dite paroisse, évêché de Dol.

"(La branche aînée fondue dans Cartier.)"

Les historiens ont admis que Paramé dans les parages de Limoilou (dont Cartier fut sieur ou propriétaire) et de Saint-Coulomb, du côté de la seigneurie du Hindré ont été des pépinières de Cartier qui ont très bien pu venir à Saint-Mâlo comme le faisait de toute antiquité une foule d'immigrants des paroisses du diocèse, dont la parenté collatérale avec les habitants se perd dans la nuit des temps. (M. des Longrais, *Idem*, p. 10.)

Le savant Ogée rapporte en un article sur Saint-Coulomb: "En 1500 on voyait dans ce territoire les maisons de Bouais, du Cartier, de la Ville-Galbrun, du Vieux-Chatel, de la Fosse-Ingrand, etc."

L'auteur du *Nobiliaire et armorial de Bretagne*, n'a pas dû mettre par à peu près la composition de l'article Cartier ci-dessus, puisqu'il dit dans la préface de sa première édition: "On ne trouvera dans notre travail, tout de patience et d'érudition, rien de frivole, rien d'asservi à des intérêts actuels; nous n'avons pas voulu flatter les amours-propres, spéculer sur les vanités. . . . Notre but est plus élevé et consiste à présenter le tableau historique de la noblesse bretonne. Nous avons donc cru traiter avec le même soin les articles consacrés aux familles éteintes même depuis plusieurs siècles et ceux relatifs aux familles existantes."

Plus loin, il affirme qu'il n'a inclus dans son travail que des faits prouvés par des actes authentiques ou puisés à des sources toujours indiquées.

La première réformation ou recherche connue en Bretagne fut commencée en 1423 sous le règne du duc Jean V et continuée pendant plusieurs années dans les neuf évêchés.

Une nouvelle recherche eut lieu sous le duc François I en 1440 et se continua jusqu'en 1483 pour les évêchés de Rennes, Nantes, Saint-Mâlo et Dol.

La reine Anne, de par l'autorité de Louis XII, en ordonna une autre, en 1513, qui fut effectuée dans les évêchés de Rennes, Nantes, Saint-Malo, Vannes, Saint-Brieuc et Dol.

Le roi François I fit réformer de 1535 à 1543 les évêchés de Saint-Brieuc, Vannes, Cornouailles, Léon et Tréguier.

Dans ces recherches, réformations ou montres datant de 1423 à 1543—période où vivaient Jacques Cartier et ses ascendants—M. de Courcy a trouvé des notes sur notre Malouin, puisqu'il en parle. Ce gentilhomme qui imprime un ouvrage d'un caractère sérieux et important, mérite, il nous semble, la bonne confiance du public. Autrement, pourquoi aurait-il travaillé, pourquoi tant de recherches, un labeur aussi dur?

Parfois, lorsqu'il n'est pas certain d'une note, il l'avoue franchement, comme par exemple à l'article *Michel, évêché de Nantes.* (Nous citons ce nom parce qu'il nous intéresse) il remarque: "Nous ne savons si le sieur de Villebois, du nom de Michel, commissaire-général de la marine à Brest, en 1776, appartenait à la même famille."

Cet auteur nous avertit encore que les familles dont les noms se trouvent mentionnés dans les réformations de 1513 à 1543 et dans celle de 1668, ou qui ont justifié à cette dernière époque au moins de trois générations nobles sont comprises dans son recueil sous la qualification de nobles d'extraction. Les Cartier nommés par ce généalogiste sont des recherches de 1478 et de 1513 et ne sont pas rapportés comme déboutés de leurs prétentions. Donc . . .

Nous ignorons si l'article *Cartier* du livre de M. de Courcy a été réfuté ou déclaré erroné. En attendant cela nous voulons croire en lui, puisqu'il est Breton et qu'il a fait un ouvrage approfondi sur la noblesse de sa province.

Le 19 mai 1541, avant d'entreprendre son troisième voyage aux "terres-neuves" du Canada (c'est ainsi que les nouveaux pays découverts par Cartier étaient connus), celui-ci dicta son testament instituant héritières sa femme et sa sœur, donnant à celle-ci, sa maison de Saint-Malo et à la première son manoir et ses terres de Limoilou. Aux termes de ce document, Jacques Cartier s'intitule capitaine et maître-pilote du roi, sieur de Limoilou et bourgeois de Saint-Malo.

Quelques auteurs ont vu dans ce titre de sieur de Limoilou l'anoblissement de l'intrépide marin. Une telle opinion serait bien fondée si cette propriété eut été fief noble acheté d'un noble, mais il paraît que la terre de Limoilou était roturière et redevable d'un cens. Admettant ce cas, la roture de ses biens de Limoilou n'amoindrirait pas ses autres droits nobiliaires.

De quelle façon le Découvreur devint-il acquéreur de ce petit domaine? Quelques-uns ont cru à une libéralité de François I, et certes, elle eut été bien méritée; d'autres ont pensé à une acquisition toute personnelle de Jacques. Quoi qu'il en soit, il convient de noter que la première mention que l'on en ait date de 1541. Aussitôt rentré à Saint-Malo en 1534, Cartier présente à son auguste chef le rapport de ses découvertes et reçoit immédiatement une nouvelle commission pour une seconde expédition d'une plus grande durée. Jusqu'au temps de son premier voyage, Cartier à Saint-Malo, dans les actes civils que l'on a trouvés, n'est consigné que comme Maistre Cartier ou tout simplement de son nom, mais après 1535 on lui accorde publiquement les titres de capitaine et de maître-pilote du roi. Cela se poursuit jusqu'au 17 octobre 1540, quand le roi, par lettres patentes enregistrées au Parlement de Rouen (Dr. Dionne, *ibidem*, p. 99. Ne serait-ce pas à Rennes, plutôt, capitale de la Bretagne ?) constitua Jacques Cartier, capitaine-général et maître-pilote de tous les vaisseaux pour la nouvelle entreprise (troisième voyage).

"Comme marin, Cartier reçut de son souverain la plus haute marque de confiance qu'il pouvait obtenir. Le titre de capitaine-général était fort apprécié à cette époque, et on ne trouve dans les annales de la marine Française à venir aux dix-septième siècle que peu d'exemples d'une pareille munificence royale. (Dionne, *ibidem*, p. 190.)

Cet office anoblissait Cartier. Peu après l'émission des lettres royales du 17 octobre, c'est-à-dire le 13 novembre suivant, au baptême de la fille de noble homme Antoine de Saint Cyre, Cartier est premier parrain, et, l'officiant, dom Roland Columbel inscrit en son registre: *Noble homme mestre Jasques Cartier, lieutenant-général du roi, capitaine et maistre pilote dudit Sire en son entreprise de la découverte des terres du Canada.*

Voilà qui mérite considération, car on rencontre tout spécialement, exactement à ce moment à Saint-Malo, appliqué à notre héros le titre de *Noble homme!* Dom Columbel évidemment, ne parlait pas sans raison et l'on ne peut s'expliquer ce terme que comme un corollaire des lettres de François I du 17 octobre 1540.

Si le Découvreur avait déjà la noblesse comme le dit M. de Courcy, les lettres royales ne le rendaient pas plus noble, mais confirmaient plutôt cette dignité.

Dans la suite, à d'autres cérémonies pareilles, les prêtres accolent au nom de Cartier les qualificatifs de: *Sieur de Limoilou*, *noble homme*, *noble capitaine*, *Maistre*, *capitaine*, *monsieur*, parfois *Jacques Cartier* seulement, et, une fois en 1550 on place avant le nom des deux compères: *Honnestes gens*: Jacques Cartier et Robin Pestel. Ce qui a fait remarquer au regretté historien québècois qui cependant doutait à contre-cœur de la noblesse du Malouin: "Les curés ou personnages que l'on voit présider aux baptêmes de 1540 à 1557 ne paraissent pas souvent disposés à accorder au capitaine son titre de seigneur (de Limoilou.)" Le Dr. Dionne ignorait sans doute qu'à cette époque on n'imposait pas aux curés détenteurs des actes de l'état civil la même obligation qu'aux notaires; aussi les actes d'église n'étaient reçus dans toutes les preuves que comme justificatifs de filiation et jamais de qualité. Le terme d'*honnestes gens* quelques dix lignes plus haut a une résonnance très plébéienne, mais nous venons de la rencontrer sous la plume de M. de Denonville, gouverneur du Canada, à l'égard de membres d'une famille canadienne anoblie elle aussi.

L'on nous permettra la reproduction de ce passage de la lettre de M. de Denonville. On y verra mieux la nuance qu'il convient d'appliquer aux mots que *honnestes gens* comportaient alors.

Denonville au Ministre, 28 août 1687 (fragment): (Au retour de l'expédition contre les Iroquois) . . . "Vous avez donné une lieutenance à Longueuil qu'il a accepté avec plaisir; il est l'aîné de sept frères de la famille des Le Moyne que le roi a anoblie pour les services que feu leur père a rendus en ce pays. C'est une famille avec celle des LeBer, beau-frère dudit Le Moyne, dont je ne me saurais trop louer et qui mérite le plus d'être distinguée par la bonne conduite et la bonne éducation des enfants, qui sont tous *honnêtes gens!*" Ces deux mots signifiaient le plus souvent "conduite réglée, gens de bonne société, d'une classe marquante, gens de mérite." Nous les avons aujourd'hui dans un autre sens.

Les Longueuil étaient nobles et cependant le gouverneur ne leur faisait aucun compliment dérogatoire à cette qualité on les qualifiant d'honnêtes gens. Beaucoup de nobles n'étaient guère dignes de cette qualification.

Cartier, comme beaucoup d'autres Malouins, pouvait être bourgeois et faire le commerce maritime ou autre sans déchoir en caste, car les nobles bretons étaient fort privilégiés puisqu'ils ne dérogeaient par l'exercice d'aucun commerce.

Le domaine de Limoilou était situé sur la limite des paroisses de Paramé et de Saint-Coulomb, sur la route de Saint-Vincent. En faisant un léger détour vers le nord, on pouvait apercevoir une maison d'assez belle apparence, sans prétention architecturale. C'était le manoir de Limoilou clos dans une enceinte de pierre. Deux portes assez rapprochées, de formes très anciennes, en fermaient l'entrée. Ces portes sont encore connues dans le pays sous le nom de Portes-Cartier. Près de la plus grande, dans le haut du mur à gauche, on voit une pierre sculptée. Les deux parties du mur attenant à la grande porte ont été rebâties, car les marques du mortier y sont plus fraîches qu'ailleurs. M. Alfred Ramé (*Note sur le manoir de Cartier*, Paris, 1867) a dit que ce bloc sculpté représentait un écusson soutenu par deux anges . . . et que le champ de l'écu portait *uniquement un franc quartier.* Et l'on a dit: des armes parlantes!

Avec quelle certitude peut-on assurer que ces armoiries ont été celles de Cartier? On pourrait tout aussi bien avancer que ces armes ont appartenu à l'un des propriétaires successifs de ce manoir. Parce qu'il y a un franc quartier dedans ce serait une conclusion trop vite tirée et il est bon de se rappeler que durant l'espace de plus de trois cents ans la maison a changé de maître bien des fois et que à l'un d'eux se rattachent peut-être les armes attribuées à Cartier. La pierre gravée aux emblêmes héraldiques qui n'offre aux regards des curieux aujourd'hui: *uniquement qu'un franc quartier*, a subi les outrages du temps puisque l'on ne peut déterminer la composition du champ de l'écu et du quartier. Était-ce métal ou émail ? Indubitablement l'un ou l'autre, voire les deux. Un examen soigneux de nobiliaires de la vieille Bretagne, surtout des personnages domiciliés dans le diocèse de Saint-Malo, n'a donné qu'une armoirie ayant un franc quartier: celle des Martin, sieurs du Verger.

Nous avons une légende édifiée sur un quatrain mystique encadré au-dessus d'une porte d'entrée d'un ancien médecin et ensuite d'un marchand à Québec et ce n'est que dernièrement que M. Sulte nous a fait voir combien le point de départ du roman de M. Kirby est loin du vrai. Ceci soit dit en guise d'exemple; il n'en manque pas d'autres.

La seule pièce produite par M. des Longrais en infirmation de la noblesse de Cartier est à l'occasion du règlement d'une succession en 1557. Les intéressés convinrent de trois priseurs nobles, tous leurs parents. Et parce qu'ils n'avaient pas choisi les priseurs ordinaires de la ville, au nombre desquels était Cartier, M. des Longrais en a conclu que Cartier ne pouvait être noble! C'est alors que dans une note de renvoi l'écrivain mentionne l'armorial de M. de Courcy à l'égard des trois priseurs nobles. Et de Cartier qui figure ailleurs dans ce même ouvrage, pas un mot! Cela ne paraît pas juste. Nous avons exposé impartialement ce que nous avons trouvé.

Cartier était-il noble ? M. de Courcy dans son armorial et nobiliaire de Bretagne se pose pour l'affirmative. Ensuite viennent les lettres patentes du 17 octobre 1540 qui confèrent une noblesse d'office.

Les arguments émis contre la noblesse de Cartier manquent de force. Nous en attendons de plus probants pour nous convaincre que notre héros n'était pas homme de qualité.

Ménage et ses élèves,

Par HARRY ASHTON.

Présenté par MARIUS BARBEAU, M.S.R.C.

(Lu à la réunion de mai 1919.)

I

Victor Cousin écrit dans *La Jeunesse de Madame de Longueville*[1] en parlant de Madame de Sévigné: "Dans une correspondance manuscrite de Mme de La Fayette que j'ai pu parcourir, j'ai rencontré plus d'une allusion au temps où elle faisait pour ainsi dire ses études sous Ménage." Il ajoute en note: "Cette correspondance a été vendue à Sens en 1849, à la vente de M. Tarbé. J'ai pu l'examiner quelques heures. Elle se compose d'environ cent soixante-seize lettres inédites, et parcourt presque toute la vie de Mme de La Fayette. On y voit que Ménage se prit de passion pour ses belles écolières. Rebuté et découragé assez vite par Marie de Rabutin il se tourna vers la parente de celle-ci, Mlle de Lavergne, sans être plus heureux, mais sans être traité avec autant de négligence. Le commerce de Ménage avec Mlle de Lavergne dura même pendant qu'elle fut mariée au comte de La Fayette: il s'anima depuis son veuvage[2] et avec des vicissitudes de vivacité et de langueur, il subsista jusqu'à sa mort. Évidemment Mme de La Fayette coquetta un peu avec son maître de latin et d'italien, et pendant quelque temps les relations sont assez intimes sans être tendres. Sur la fin c'est une bonne et parfaite amitié. Plusieurs lettres montrent avec quel soin Mme de La Fayette avait étudié sous Ménage les poètes et les bons écrivains, anciens et modernes. Elle le consulte, et elle lui rappelle leurs discussions sur l'emploi de telle ou telle expression. Il est sans cesse question de leur ami commun Huet. . . . Quelques lignes sur Segrais. Je ne me souviens pas d'avoir rencontré une seule fois le nom de La Rochefoucauld. . . . D'ailleurs nous n'avons ici que les lettres ou plutôt les billets de Mme de La Fayette: il n'y en a pas un seul de Ménage. La plupart sont autographes, quelques-uns dictés et signés, tous parfaitement authentiques. M. Tarbé avait fait de cette corres-

[1] Paris (Didier) 3e édit. 1855, 8°, p. 23.

[2] Cousin croyait, comme tous ses contemporains, que M. de La Fayette mourut quelques années après son mariage.

pondance une copie qui s'est vendue avec les autographes. Le tout appartient aujourd'hui à M. Feuillet."

Quand nous disons que ces lettres n'étaient pas datées, on comprendra que Victor Cousin a fait un véritable tour de force pour en tirer toutes ces conclusions en quelques heures. Inutile de dire que les conclusions ainsi tirées au pied levé ne sont pas fort exactes.

M. le comte d'Haussonville est allé voir ces lettres avant de publier son livre sur Mme de La Fayette.[1] Il en tira un article pour *La Revue des Deux Mondes*.[2]

M. d'Haussonville utilisa ses "quelques heures" mieux que ne l'avait fait Cousin, mais lui non plus n'avait le temps—ou la patience—nécessaire pour déchiffrer les billets de l'élève et les brouillons de lettres du professeur.

Venant après ces deux éminents écrivains nous avons dû consacrer des mois au travail qu'ils accomplissaient en quelques heures. Les lettres, mises à notre disposition avec une amabilité charmante, par la famille de feu M. Feuillet de Conches, sont aujourd'hui presque toutes datées et classées.

Le premier résultat de ce travail est de prouver que la correspondance—à l'exception de quelques billets—est de Mme de La Fayette et non pas de Mlle de La Vergne. Elle commence l'année avant le mariage, est très suivie en 1655 (l'année du mariage) 1656, 1657, 1658, cesse après 1662, pour reprendre vers 1690. Nous ne croyons pas à une simple lacune dans cette collection, mais bien à une cessation de la correspondance. Les lettres de la seconde période parlent d'une reprise d'amitié. Victor Cousin fait remarquer que le nom de La Rochefoucauld ne se trouva pas dans ces lettres.[3] Nous croyons, sans pouvoir l'affirmer que la correspondance cessa pendant la période de l'amitié avec La Rochefoucauld pour reprendre longtemps après sa mort.

Sans être "pris de passion" pour son élève, selon l'expression de Cousin, le professeur a pu ressentir de la jalousie ou—ce qui est plus probable—l'élève a pu cesser de rechercher l'amitié de Ménage. Qu'elle recherchait cette amitié à une certaine époque ressortira de l'étude qui suit.

II

Ménage nous est trop connu. Nous l'avons vu au théâtre se quereller avec Trissotin et il reste dans notre souvenir sous le nom

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[1] Paris (Hachette), *Les grands écrivains français.*

[2] 1890.

[3] Il ne s'y trouve, en effet, qu'une fois.

de Vadius, pédant ridicule. On aura beau dire que Molière est moins sévère envers lui qu'il ne l'est envers Cotin, que, même si l'on admet que Vadius est un portrait fidèle et non pas une caricature, rien dans sa conduite en scène ne l'empêche d'être fort estimable—son pédantisme à part. On aura beau dire que Molière avait besoin de lui pour faire une scène et qu'il n'avait nullement l'intention de l'écraser à tout jamais sous le poids du ridicule. Vadius ne peut être réhabilité.

Car non seulement Ménage est pédant, mais il est galant. Voilà le comble de l'absurdité. Lui, auteur de troisième ordre, il ferait la cour à des célébrités littéraires telles que Mesdames de Sévigné et de La Fayette ?

Personne ne se demande si, *au 17^e siècle*, ces aimables personnes passaient pour des célébrités littéraires ? Cousin n'hésite pas à écrire, à propos de Madame de La Fayette "Ce n'est pas seulement une personne de beaucoup d'esprit et de beaucoup d'instruction, c'est un auteur. Il n'est pas surprenant qu'elle sût écrire, puis qu'elle en faisait profession—M^me de La Fayette est très supérieure assurément à M^lle de Scudéry, à M^me d'Aulnoy à M^me Lambert mais elle est de leur famille." Or, des personnes telles que Mesdames de Sevigné et de La Fayette ne pouvaient pas passer, de leurs temps, pour des célébrités littéraires. Leur sang leur permettait, peut-être, quelques incartades de conduite mais non pas celle-là. Le jugement de l'époque est formel à ce sujet. "Il n'y a rien de plus incommode" écrit M^lle de Scudéry, interprète fidèle des préjugés de ses contemporains, "que d'être bel esprit ou d'être traité comme l'étant, quand on a le cœur noble et quelque naissance. Car enfin, je pose pour indubitable que, dès qu'on se tire de la multitude par les lumières de son esprit et qu'on acquiert la réputation d'en avoir plus qu'un autre, et d'écrire assez bien en vers ou en prose pour pouvoir faire des livres on perd la moitié de sa noblesse, si on en a, et l'on n'est point ce qu'est un autre de la même maison et du même sang qui ne se mêlera point d'écrire."[1]

M^me de La Fayette se rendait bien compte qu'en publiant ses œuvres elle risquait de perdre "la moitié de sa noblesse" et c'est pourquoi elle ne les signait pas. L'idée paraît être assez répandue que ce n'était pourtant qu'un secret de polichinelle et que la société de l'époque savait pertinemment qu'elle en était l'auteur. La vérité en est tout autre. Elle se confia à ses amis intimes, mais à eux seuls. On verra par les lettres qui suivent que Ménage lui-même ne pouvait affirmer qu'elle fût l'auteur de la *Princesse de Clèves*.

[1] M^lle de Scudéry, *Le grand Cyrus*.

Loin d'annoncer à tout venant qu'elle écrivait des livres, M^{me} de La Fayette avait peur de passer pour un auteur de profession. Voilà pourquoi elle écrivit à Huet:

"Je vous avais bien donné un *Princesse de Montpensier* pour Araminte[1] mais je ne vous l'avais pas remis pour le lui donner comme une de mes œuvres. Elle croira que je suis un vrai auteur de profession de donner ainsi mes livres. Je vous prie, racommoder un peu ce que cette imagination pourrait avoir gâté a l'opinion que je souhaite qu'elle ait de moi."

Quand on lui vola un exemplaire de sa nouvelle, le danger était encore plus grand et elle écrivit aussitôt à Ménage:

"Cet honneste Ferrarois quy estoit a moy m'a desrobé une copie de la Princesse de Montpensier et l'a donnée à vingt personnes. Elle court le monde mais par bonheur ce n'est pas sous mon nom. Je vous conjure si vous entendés parler de faire bien comme si vous ne l'avies jamais veue et de nier qu'elle vienne de moy si par hasard on le disoit"

Elle a recours au même subterfuge quand paraît la *Princesse de Clèves,* mais cette fois elle fait le petit mensonge elle-même et ne peut pas s'empêcher de dire du bien de l'ouvrage. La lettre est adressée à Lescheraine, secrétaire de la duchesse de Savoie.

"Un petit livre qui a couru il y a quinze ans et ou il plut au public de me donner part a fait qu'on men donne encore a la P^{e} de Cleves: mais ie vous assure que ie ny en ay aucune et que M. de la Rochefoucald a qui on la voulu donner aussi y en a aussi peu que moy: il en fait tant de serments qu'il est impossible de ne pas le croire sur tout pour une chose qui peut estre avouee sans honte. Pour moy ie suis flattee que lon me soupçonne et ie croy que iavourois le livre si jestois assuree que l'autheur ne vint jamais me le redemander. Je le trouve tres agreable bien escrit sans estre extremement chatié plain de choses d'une délicatesse admirable et qu'il faut mesme relire plus dune fois et surtout ce que cy trouve cest une parfaite imitation du monde de la court et de la manière dont on y vit il ny a rien de romanesque et de grimpe aussi nest ce pas un Roman cest proprement des Mémoires et cestoit a ce que lon ma dit le tiltre du livre mais on la changé. Voila Monsieur mon jugement sur M^{e} de Cleves ie vous demande aussi le vostre on est partagé sur ce livre a se manger les uns en condamnent ce que les autres en admirent ainsi quoyque vous direz ne craignez point destre seul de vostre party."

Ménage lui-même, pas plus que Lescheraine, n'est dans les confidences de M^{me} de La Fayette, à en juger par ce brouillon de lettre trouvé dans la correspondance:

"Il y a cinq ou six ans que ie fis imprimer un livre de généalogies intitulé l'Histoire de Sablé. Ce livre doit être suivi d'un autre sur la mesme matière dans lequel au sujet de votre Princesse de Montpensier jay dit que c'estoit cette Princesse de Montpensier dont vous aviés escrite l'histoire avec toute sorte d'élégance et d'agrément et que cette histoire seroit incomparable si vous n'aviez point escrit celle de la Duchesse de Clèves qui lui est comparable. Je vous demande premierement Madame si vous voulez bien qu'on disse que vous avez fait des livres et je vous demande en segond lieu si vous avez fait cette Histoire de la Duchesse de Clèves comme je

[1] Sœur de Huet.

l'ay dit et comme jen suis persuadé car quelques uns disent que c'est Mr de la Rochefoucauld qui l'a faite et d'autres que c'est Mr de Segrais. Aiant l'honneur de vous connoistre depuis que vous estes née et aiant eu l'honneur de vous voir aussi longtems, aussi longtems et aussi particuliérement que jay fait il me seroit honteux d'avoir été mal informé de cette particularité et d'en avoir mal informé le public. Je vous supplie donc Madame de me faire savoir la vérité de la chose, etc.

Madame de La Fayette, qui est près de la mort, n'a aucune raison pour ne pas être franche avec son ami dévoué—mais elle n'ose pas encore l'être auprès du public. C'est pourquoi elle répond:—

"Vous pouves parler dans vostre histoire de Sablé des deux petites histoires dont vous me parlastes hier mais ie vous demande en grace de ne nommer personne ny pour lune ny pour lautre ie ne croy pas que les deux personnes que vous me nommés ayent nulle part qu'un peu de correction les personnes qui sont de vos amis n'advouent point y en avoir mais a vous que n'advoueroit-elle point (sic) ie suis dans un estat qui me conduit entièremt a songer a mon salut ie suis ravie de ce que vous me mandés de vos dispositions cela fortifiera les miennes, etc.

M^me de Sevigné fut encore moins un "auteur de profession." Elle n'a jamais rien publié.

Ménage, d'autre part, fut un écrivain connu, apprécié non seulement dans le cercle de ses amis mais en dehors de Paris, même en dehors de la France.

Mesdames de la Fayette et de Sévigné étaient probablement très flattées des attentions de l'illustre écrivain—jusqu'à être jalouse l'une de l'autre. Après un silence un peu trop long Ménage écrit à la Marquise ce qui lui vaut cette réponse. . . . "Pour moi, j'ai bien de l'avantage sur vous, car j'ai toujours continué à vous aimer, quoi que vous en ayez voulu dire, et vous ne me faites cette querelle d'allemand que pour vous donner tout entier à M^lle de la Vergne—Mais enfin, quoiqu'elle soit mille fois plus aimable que moi, vous avez eu honte de votre injustice et votre conscience vous a donné de si grands remords, que vous avez été contraint de vous partager plus également que vous n'avez fait d'abord. Je loue Dieu de ce bon sentiment et vous promets de m'accorder si bien avec cette aimable rivale que vous n'entendrez aucune plainte ni d'elle ni de moi, étant résolu en mon particulier d'être toute ma vie la plus véritable amie que vous ayez."

Malgré ses bonnes résolutions, l'amitié entre M^me de Sévigné et Ménage n'a pas été de longue durée en comparaison avec celle de M^me de la Fayette. Plus tard la Marquise ne prenait pas au sérieux les attentions de Ménage. Bussy-Rabutin raconte que Ménage se trouvait un jour chez elle au moment où elle allait sortir pour faire des emplettes. Sa demoiselle n'étant point en état de la suivre, elle dit à Ménage de monter dans son carrosse avec elle. Celui-ci, badinant en apparence mais au fond très fâché, lui dit qu'il lui était bien rude de voir qu'elle n'était pas contente des rigueurs qu'elle avait depuis si longtemps pour lui, mais qu'elle le méprisait encore au point de croire qu'on ne pouvait médire de lui et d'elle "Mettez-vous," dit-elle, "dans mon carrosse; si vous me fâchez je vous irai voir chez vous."

Mais cette attitude de la part de la Marquise n'empêchait pas M^me^ de la Fayette d'être jalouse à son tour et d'écrire à Ménage à plusieurs reprises pour lui reprocher de s'occuper trop de M^me^ de Sévigné.

"Il est vray qu'il sera fort honteux pour moy que vous acheviés l'oiseleur sans que ie m'en mesle et ie crains fort que pour me faire encore plus de honte vous ne cherchiés le secours de quelqu'autre. Si vous l'eussiés achevé il y a trois mois j'aurois cru que M^e^ de Montbazon vous auroit aidé mais présentement ie ne sçay à qui je m'en dois prendre si ce n'est à M^e^ de Sévigné. Elle vient d'arriver belle et fraiche—six mois d'absence luy auront donné pour vous la grâce de la nouveauté. . . . (Le 16 jan. 1657.)

"Je n'ay pas esté plus estonné d'aprendre que M^e^ de Mercœur estoit morte que d'aprendre que vous n'aves veu M^e^ de Sevigné qu'une seule fois depuis son retour. Il faut avouer qu'il y a de grandes révolutions dans l'empire amoureux. (Le 20 fév. 1657.)

Ménage avait une réputation de galanterie parmi ses contemporains. D'après Somaize il est "des plus galants d'Athènes (lisez Paris) et malgré qu'il ayt une mine judicieuse, un port grave et une grande doctrine on ne laisse pas de voir qu'il est né pour la galanterie." Et si les contemporains sont d'accord pour dire qu'il est galant, tous ceux qui se sont occupés depuis de M^me^ de la Fayette sont également d'avis qu'il était importun. Sur quels documents appuie-t-on cette accusation ? Est-ce sur le mot que Tallemant met dans la bouche de M^me^ de La Fayette; "Cet importun de Ménage viendra tantôt" ? Si la Comtesse dit cela, on peut lui accorder le bénéfice des circonstances atténuantes et ne pas prendre sa parole au sérieux, car, d'après Tallemant lui même, elle l'a dite "un jour qu'elle avait pris médecine." Et pourtant, même ces jours là, Ménage n'était pas toujours importun, car un billet qui est devant nous contient cette phrase à son adresse: "je prendray demain medecine venes me voir sur les trois ou quatre heures."

Faut-il accorder plus d'importance au quatrain trouvé dans les papiers du chanoine Favart à la bibliothèque de Reims ?

"Laissez là Comtesse et Marquise
Ménage, vous n'êtes pas fin.
Au lieu de gagner leur franchise
Vous y perdez votre latin."

Mais comment résister à la tentation de faire ce trait d'esprit quand on ne voit les choses que de loin ? Avait-on la prétention, en écrivant cette bagatelle, de fournir un document à la postérité ?

La vérité nous paraît tout autre. Il y a des preuves incontestables que les deux femmes faisaient de grands efforts pour retenir Ménage comme ami et sans aller jusqu'à dire que ce sont elles qui furent importunes, nous pouvons admettre qu'elles taquinaient le petit abbé pour avoir ses lettres et ses visites.

Mais il ne suffit pas d'affirmer, nous laisserons parler les documents.

"Je vous dis encore une fois que nous ne nous entendons point, et vous êtes bien heureux d'être eloquent, car sans cela tout ce que vous m'avez mandé ne vaudroit guere. Quoique cela soit merveilleusement bien arrange, je n'en suis pourtant pas effrayee et je sens ma conscience si nette de ce que vous me dites, que je ne perds pas espérance de vous faire connoître sa purete. C'est pourtant une chose impossible, si vous ne m'accordez une visite d'une demi-heure: et je ne comprends pas par quel motif vous me la refusez si opiniâtrement. Je vous conjure encore une fois de venir ici, et puisque vous ne voulez pas que ce soit aujourd'hui, je vous supplie que ce soit demain. Si vous n'y venez pas, peut-être ne me fermerez-vous pas votre porte, et je vous poursuivrai de si prês que vous serez contraint d'avouer que vous avez un peu de tort. . . . "[1]

Nous avons déjà vu que Ménage délaissa un peu M^me^ de Sévigné pour "importuner" de ses attentions M^lle^ de La Vergne. Voyons donc quel ton prend celle-ci pour éloigner d'elle le galant abbé:

"Ce jeudi au soir.

"J'aurois raison d'etre en colere de ce que vous me mandez que vous ne m'importunerez de votre amitie. Je ne crois pas vous avoir donne sujet de croire qu'elle m'importune. Je l'ai cultivée avec assez de soin pour que vous n'ayez pas cette pensee. Vous ne la pouvez avoir non plus de vos visites que j'ai toujours souhaitees et recues avec plaisir. Mais vous voulez etre en colere a quelque prix que ce soit. J'espere que le bon sens vous reviendra et que vous reviendrez a moi qui serai toujours disposee a vous recevoir fort volontier."

Il semblerait pourtant que M^me^ de la Fayette elle-même devait savoir mieux que personne si Ménage l'importunait. Or, la lettre que nous venons de citer est loin d'être une exception. Dans la correspondance que nous avons devant nous et qui s'étend longtemps après la mort de M. de la Fayette et même jusqu'à la mort de Ménage il y en a bien d'autres du même genre. Nous en détachons les passages suivants de lettres séparées parfois par des intervalles de plusieurs années:

"Je ne vous puis assez dire la joie que j'ai que vous ayez recu avec plaisir les asseurances que je vous ai donnees de mon amitie. Je mourais de peur que vous ne les receussiez avec une certaine froideur que je vous ai vue quelquefois pour des choses que je vous ai dites, et il n'y a rien de plus rude que de voir prendre avec cette froideur la des temoignages d'amitie que l'on donne sincerement, et du meilleur de son cœur. Vous aurez pu voir par ma seconde lettre que, quoique j'eusse lieu de me plaindre de ce que vous me faisiez pas reponse, ne sachant pas que vous etiez a la campagne, je n'ai pas laisse de vous ecrire une seconde fois, et j'aurais continue

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[1]Lettre de M^me^ de Sévigné à Ménage. Éd. Gr. Ecriv. T. Lp. 345.

a vous ecrire quand meme vous auriez eu la durete de ne pas me faire reponse. Ce que je vous dis la vous doit persuader que je suis bien eloignee d'avoir pour vous l'indifference dont vous m'accusez. Je vous asseure que je n'en aurai jamais pour vous, et que vous trouverez toujours en moi l'amitie que vous en pouvez attendre.

"Il y a lomtemps (sic) que je ne vous ay vue il fait beau venes un peu jusques ici. Jay aussi bien grand besoin de vostre secours ou du moins de vos advis.

". . . je suis persuadee que la seule envie de ne pas continuer un commerce qui vous parait ennuyeux par les longs voyages que ie fais dans la province vous a fait manquer a mescrire ie vous dis en amie que cela est le plus vilain du monde et qu'il y va de votre honneur reparer cela par quatre lettres toutes les semaine au lieu de deux que vous m'avez ecrites ie vous en tiens quite pourtant a une pendant un voyage que je vais faire a Limoges qui sera assez long."

M^me^ de la Fayette emploie tous les moyens pour retenir Ménage jusqu'à se servir de sa mauvaise santé pour regagner sa sympathie:

"Je n'espère pas de deviner qui est Chloé mais j'espère d'estre bien tost en estat que vous l'aimerés moins que moy car je croy que je vais estre malade i'ay eu un accès de fievre cette nuit assés considérable."

Simple artifice littéraire pour amener la nouvelle de son indisposition? Non pas! L'idée revient à plusieurs reprises dans la correspondance.

"Quoy que vous fassies pr persuader la pesanteur de mes fers vous auries peine à en venir bout (sic) après les avoir portés si lontemps l'on croira que vous faittes comme ceux qui descrient les mtres quils ont servis quoy quils ne se soient pas mal trouvés ches eux enfin vous ne voules pas rentrer ailleurs quelque offres que lon vous fasse ie vous asseure que si nous sommes un mois ensembles à Fresnes vous rentreres à mon service. Surtout si je puis avoir une maladie qui vous fasse pitié iay toujours remarqué que la fievre mestoit tres bonne auprès de vous en attendant que ie me retrouve en estat de vous commander ie vous prie de m'envoyer une lettre pour M. de Novion . . " Etc.

Elle persiste à écrire même quand Ménage ne répond pas. La place nous manquerait pour citer toutes les lettres où elle réclame une continuation de la correspondance.

Les preuves abondent et il nous semble juste de compter l'importunité de Ménage parmi ces légendes mal fondées qui pullulent dans l'histoire littéraire et qui continueront à avoir cours tant que l'on se contentera de répéter ce qu'a dit un prédécesseur au lieu d'aller aux documents eux-mêmes.

Voici, selons nous, sous quel aspect dut se présenter la réalité: Madame de Sévigné était alors une dame comme les autres et non pas encore l'épistolière renommée que nous connaissons. Madame de La Fayette n'est que M^lle^ de La Vergne, elle sera bientôt la femme isolée et malade d'un obscur soldat, et beaucoup plus tard seulement l'auteur de cette *Princesse de Clèves* qui fait date dans l'histoire de la littérature. Ménage, de son côté, n'est pas pour elles l'abbé pédant et ridicule que nous voyons aujourd'hui à travers le Vadius de Molière.

C'est un professeur qui, au début de son enseignement, amuse les deux jeunes femmes par ses galanteries dans le goût du temps, qui aime à tirer de sa mémoire remarquable une foule de connaissances et d'anecdotes intéressantes; c'est de plus un bon causeur, qui fait honneur à deux dames, ses élèves, en les fréquentant et en faisant rejaillir sur elles un peu de son savoir et de sa renommée. Les élèves ont pu exagérer la valeur du Maître—soit. Elles lui étaient bien supérieures et devaient toutes les deux rester célèbres alors que le petit abbé allait se perdre sous le fatras de son érudition et le ridicule de ses galanteries. C'est vrai. Mais il ne faut pas tourner, nous non plus, les pages de l'histoire qui furent celées à tous les trois, et pour bien comprendre ce qui se passait entre eux, il faudrait essayer de voir comme eux et oublier les jugements postérieurs.

Cependant, si nous n'admettons pas volontiers que Ménage fut importun par son amitié, nous savons qu'il avait besoin parfois d'être rappelé à l'ordre à cause de sa galanterie. Mais ici encore on a exagéré. C'est friser le ridicule que d'examiner sérieusement, comme on l'a fait, la nature exacte de cette galanterie et d'analyser les sentiments qui ont pu exister entre le maître et ses élèves.

La connaissance que nous avons de la vie et des habitudes des poètes romantiques nous pousse à chercher leurs passions et leurs "ulcères" dans leurs œuvres qui sont trop souvent, en effet, des confidences. De plus, une certaine critique se plaît autour de nous à exploiter les "fonds de tiroir" et à faire dire parfois aux vieux papiers beaucoup plus qu'ils ne disent en réalité. Il faut ici abandonner, oublier ces méthodes. Nous nous trouvons en face de gens qui n'ont pas coutume de dissimuler leurs amours sous le couvert de l'amitié; n'essayons pas de bâtir une intrigue quand l'histoire nous met en présence d'un professeur, plus galant dans ses lettres que dans sa conversation, et d'une élève naturellement froide et douée d'une "divine raison." Aucun mystère ne se cache là-dessous. Les galanteries épistolaires ne tirent généralement pas à conséquence; tout ce que l'on peut dire dans le cas présent c'est que les badinages de Ménage ont pu flatter la jeune M^{lle} de La Vergne. Il est agréable d'entendre son savoir, sa beauté, même sa froideur et sa cruauté, chantés en vers et en plusieurs langues par un homme aussi en vue que Ménage, mais de temps à autre les billets galants détonnaient un peu, trouvaient l'élève occupée à des pensées plus sérieuses. Alors on faisait sentir à l'abbé qu'il est des moments où la galanterie, admise comme un jeu, peut être déplacée: "Il n'y a rien de plus galant que vostre billet," écrit M^{me} de La Fayette "si la pensee de faire vostre examen de consience (sic) vous inspire de telles choses, je doute que la contrition soit forte. Je vous asseure que je fais tout le cas de votre amitie qu'elle merite que l'on en fasse et je crois tout dire en disant cela. Adieu jusques a tantost je ne vous promets qu'une heure de conversation, car il faut retrancher de ses divertissements ces jours icy."

Dans un autre billet, elle dit à Ménage: ". . . . vos lettres sont bien galantes. Savez-vous que vous y parlez de . . . et de victime? Ces mots la font peur a nous autres qui sortons si fraichement de la semaine sainte."

"Je niray point a Chaliot parcequil ne fait pas asses beau et que ie me veux reposer mais scavés vous bien que vous ne me verrés plus si vostre amitié augmente si fort vous scavés bien quelles bornes iy ay mises vostre lettre est si douce que si vous men escrivés souvent de pareilles ie vous gronderois bien fort prenes bien garde que nous ne nous brouillions en vérité ie ne croy pas aux anchetements mais je croy aux tournements de cervelle."

Chacun de son côté a prévu le mauvais usage qu'on pourrait faire de cette correspondance et l'interprétation fâcheuse que l'on ferait de leur amitié. Aussi au moment de son mariage M^me^ de La Fayette réclama, semble-t-il, ses lettres et Ménage, pour sa part, répondit aux calomniateurs par une ballade. Nous la citons tout au long, car elle montre bien les sentiments qui unissaient les deux personnes; elle fait voir aussi que Ménage ne se faisait pas d'illusion sur la nature de ces sentiments. Pour un pédant galant et ridicule, l'envoi de cette ballade renferme une pointe d'esprit malicieux que les biographes ont peut-être négligée à tort."

POUR MADEMOISELLE DE LA VERGNE.

BALADE.

Rien n'est si beau que la jeune Doris
Son port hautain n'est pas d'une mortelle.
Ses doux regards; ses amoureux souris;
Ses traits divins sa grace naturelle;
De son beau teint la fraischeur éternelle;
De son beau sein la blancheur immortelle;
Et ses beaux yeux plus brillants que le jour,
Sur mille cœurs exercent leur puissance,
Ie l'aime aussi de toute mon amour,
Mais honni soit qui mal y pense.

I'aime d'amour ses aimables écrits;
Ses doux accents, qui charment Philomèle;
Et son esprit, délices des esprits;
Et sa vertu des vertus le modèle;
I'aime son cœur et constant et fidelle,
Qui des vieux temps la bonté renouvelle;
Chose si rare en l'empire d'amour;
Et de ses mœurs l'adorable innocence;
Chose si rare aux Beautés de la Cour,
Mais honni soit qui mal y pense.

Elle qui fait de mon amour le prix;
Qui voit ma flame et si pure et si belle;
Qui voit mon cœur si saintement épris;
Qui reconnoist la grandeur de mon Zèle
L'honore aussi d'une absence cruelle,
Ronge mon cœur, comme un cruel vautour;
Sa belle main, consolant ma souffrance
Par ses écrits me promet son retour,
Mais honni soit qui mal y pense.

Envoy.

Jeunes Blondins, qui soupirez pour elle,
Et qui souffrez ses rigoureux mépris;
Pour estre aimez, comme moy, de la Belle
Il faudroit estre amans à cheveux gris,
Et ne l'aimer que d'amour fraternelle.
De vous alors on diroit dans Paris:
Elle a pour eux beaucoup de bienveillance;
Comme Ménalque ils sont ses favoris,
Mais honni soit qui mal y pense.

III

M. le Comte d'Haussonville entrevoyait l'innocence de Ménage, mais il n'allait pas assez loin dans la voie des réparations.

Nous n'oserons pas dire que Ménage ait été "exploité," mais il a payé cher le bonheur d'avoir Mme de la Fayette pour correspondante et il a payé de fort bonne grâce.

Il la tient au courant de ce qui se passe à Paris:

"Vous mobligerés tres fort de mescrire les nouvelles tous les ordinaires ie vous donneray des miennes toutes les sepmaines ie m'en vais a Vichy la sepmaine quy vient mes maux mont donné un peu de relasche depuis huit ou dix jours."

Dans d'autres lettres, elle charge Ménage d'écrire les nouvelles à M. de La Fayette, étant assurée qu'il remplira ce devoir mieux qu'elle et elle le prie de copier sa lettre et de la lui envoyer, car elle est à Fresnes.

Il doit lui envoyer les livres aussitôt parus—les romans de Mlle de Scudéry surtout ne doivent pas traîner dans son "cabinet."

(août 1654) . . . "Ce n'est pas une sottise de grande conséquence que davoir pris un Cirus pour lautre mais c'en est une de ne me lavoir pas envoyé si tost que vous me lavies mandé car vous scaures que cest voler sur lautel que de retarder un plaisir a une pauvre campagnarde comme moy. . . ." (17 sept. 1655) " . . . Puis que le second tome de Clelie est acheve ie vous conjure demploier vostre credit et ma considération si elle est de quelque chose auprès de Mlle de Scudery pour obtenir ce second tome vous luy pouves asseurer qu'en lenvoyant en Auvergne cest comme si elle lenvoyait dans les estats du grand cham de tartarie et quil y est aussi incogneu et aussi caché hormis moy qui que ce soit au monde ne le lira et pour plus grande asseurance cest que si elle veut ie vous le renvoiray. . . ."

(24 sept. 1655) "Vous me promettes bien des choses de me promettre la Clelie les œuvres de Sarasin, et le livre de Mr. Costar ie vous prie mandes moy dans quel temps ie pouray avoir tout cela afin que mon impatience ait un terme ou elle se puisse arester. . . ."

Parfois Ménage se met en colère—d'après M^me^ de la Fayette toujours—mais elle le lui pardonne et pour prouver combien son pardon est complet, elle lui demande de lui envoyer en Auvergne tel livre dont elle a besoin.

Il veille sur les nombreux procès de M. de la Fayette qui partage avec ses contemporains la douce manie de faire des procès à tort et à travers pour le seul plaisir, dirait-on, de se créer des soucis. Les plus longues lettres de M^me^ de la Fayette, traitent de ce sujet.

"Il se faut bien" écrit-elle en juillet 1657 "que mon mal de teste mait quitté de foy (de bonne foy?) il me prend tres souvent et ie ne pretends pas quil madonne (m'abandonne) jamais tout a fait vous scaves que cest la maladie des beaux esprits et ainsi il faut que jy sois sujette tant que ie seray bel esprit et aparament si tant est que ie le sois ie le seray toujours ie croy pourtant que lon se desfait quelques fois du bel esprit par exemple ie nay plus dans la teste que les exploits les arest les productions ie n'ecrits presque que pour mes affaires ie ne lis que des papiers de chicane . . . asseurement j'ai fort (mes affaires) dans la teste et comme vous voyes ie vous en parle asses souvent . . ." Etc.

Il fait des commissions:

(1 oct. 1654) " . . . ie n'ay point eu de lettres de M^e^ de Sévigné depuis qu'elle est partie de Paris ie crains qu'on ne perde ches elle les paquets que iy adresse de sorte que ie vous envoye cette lettre et vous prie de la luy faire tenir le plus tost qu'il se poura ie vous prie aussi d'aller ches quelque bon graveur voir des emprintes de cachets quils soient jolis et dan choisir trois ou quatres que vous me ferez graver sur de largent et après quils seront faits vous les garderes jusques a ce que je vous prie de me les envoier adieu il faut que ce soit des chiffres nimporte de quelle lettre."

Il lui cherche une maison à Paris:

" . . . Je croy bien que ie ne serai pas logée comme une reine pour mille ou douze (cents) francs par an et ie ne le prétends pas aussi mais comme nos affaires sont tournees a nous tenir lomtemps a Paris cela fait que ie ne veux pas une maison de si grand prix qui si ie ne le devois tenir que six mois joublié a vous dire en vous parlant dune maison que ie ne la voulois que pour Noel ne pouvant aller a Paris qu'a la fin de decembre . . ."

Mais il ne trouve qu'une moitié de maison, ce que lui vaut la réponse suivante:

" . . . ie scay a peu pres ce que cest que la moettié du logis de Mr. des Fenestreaux cela serait trop petit pour nous si ie ne prends que la moettié dune maison ie veux au moins que cela soit la moettié dune belle maison et celle la ne lest pas a mon gré . . ."

Cela vous apprendra, M. l'Abbé Ménage, d'offrir à Madame la Comtesse la première moitié de maison venue! Ménage ne se froisse pas pour si peu et nous le retrouvons plus tard très occupé de son rôle de précepteur. Il continue son enseignement du latin en lui envoyant des lettres latines—des cours par correspondance au 17e siècle! Mais quel professeur de nos jours oserait écrire à son élève "*Mea carissima Laverna*" comme le fait Ménage?

Vers cette époque aussi il veille sur l'impression d'un roman de son élève *La princesse de Montpensier.* Peut être a-t-il poussé l'obligeance jusqu'à la collaboration si le billet suivant fait allusion à la *Princesse de Montpensier.*

(Fin mars 1662) " . . . J'admire tous les reproches que vous faittes a vostre memoire elle a acoutumé de vous servir si a point nommé que vous deves luy pardonner ses premieres fautes ie mestois bien aperceue que vous avies rompu vostre serment mais ie voulois vous en espargner le scrupule ie ne vous envoie point cette petite histoire quy ne vaut pas la peine que vous la rescrivies bon soir vous ne vous plaindres pas de ma negligence a vous faire responce j'admire le manifeste de Mr. Fouquet."

"Je croyais avoir de vos nouvelles aujourdhuy et de celles de la P. de M . . . ie voudrois bien voir demain matin la première feuille si elle est tirée . . ."

"J'ai bien envie de vous voir et bien envie de voir mes œuvres sortant de la presse si vous voules venir demain ceans a une heure ou deux ie seray avec vous jusques a trois et demye ie vous donne le bon soir."

Mais ce pauvre Ménage ne lit pas bien les épreuves et son manque de soin lui attire le petit billet suivant:

"Je nay pris que deux exemplaires et ie renvoye les autres puis que vous les trouves mal reliés i'en ay marqué un avec un petit papier il y a une faute espouvantable a la 58me page quy oste tout le sens mais cela est sans remede voules vous venir demain disner et estudier avec moy mandes moy demain matin si vous y viendrés."

Ménage continue, même en 1662, à exercer ses fonctions de professeur, mais elles ne l'empêchent pas de soumettre à son élève ses propres œuvres et Mme de la Fayette fait preuve dans ses critiques d'un goût littéraire qui lui fait honneur.

Il est tout naturel qu'il accepte ces critiques de bonne grâce puisqu'il les provoque, mais l'on se demande comment il a pu supporter la logique féminine de la Comtesse.

"Je ne trouve pas estrange" lui ecrit-elle le 12 septembre 1656 "que vous mescrivies avec precipitation quand il est dix heures du soir mais ie trouve estrange que vous attendies si tard a mescrire et il me semble que quand on a envie descrire aux gens lon saist prendre son temps en sorte que lon ne soit pas pressé de finir sa lettre pour moy ien use ainsi et ie *commence toujours mes lettres par celles des personnes que jayme le mieux en sorte que qui verroit lordre que ie tiens a escrire mes lettres verrait le rang que mes amis tiennent dans mon cœur* a en juger par la vous auries sujet destre content car ie commence tres souvent mes lettres par la vostre.

A en juger par là, Ménage dut être fort content de la lettre suivante (2 novembre 1657):

"Je ne vous escrivis mardy comme a mon ordinaire parce qu'au milieu de mes despeches ie me trouve si mal que Mme de Sevigné et vous *que javois gardés pour les derniers* demeurastes sans que ie vous pusse dire un mot. . . ."

Et pourtant, après avoir fait des commissions, envoyé des livres, donné des leçons, trotté pour les procès, débité des nouvelles de la cour et de la ville pendant quarante ans, le fidèle Ménage demande à lui être vraiment utile.

"Vous connaissez mon cœur 'lui ecrit-il' car vous le possédez il y a plus de quarante ans. Vous savez qu'il est parfaitement reconnaissant et aussi Madame vous ne pouvez pas douter que je n'aye toute la reconnaissance imaginable de toutes les amitiés que vous me faites tous les jours dans vos belles et éloquentes lettres. Mais Madame vous y faites trop valoir la longue durée de l'amitié, et l'admiration que j'ay pour vous. C'est a vous, Madame, à qui est dû le merite de cette longue durée. Il n'est rien si aisé que d'aimer d'estimer et d'admirer toujours la plus aimable, la plus estimable et la plus admirable personne du monde. Je le dis, Madame, comme je le pense de quelque côté que je tourne les yeux je ne voy personne de votre sexe qui vous soit comparable et c'est de vous qu'on peut dire véritablement—

"La nature la fit et puis rompit le moulle."

"Mais, Madame, ne pourray-je jamais vous témoigner mon amitié, mon estime et mon admiration que par des paroles—ne seray je jamais assez heureux pour vous être de quelque usage je souhaitte avec la plus grande passion du monde de pouvoir vous rendre quelque service considérable et je vous supplie de croire, Madame, qu'il n'est rien au monde que je ne fasse pour votre service . . ." Etc.

Heureusement pour sa réputation de femme de cœur—M^me^ de la Fayette n'était pas aussi injuste que les critiques modernes. Elle savait fort bien que la dette était de son côté et qu'un ami tel que Ménage n'était pas à mépriser.

"Sur la fin c'est une bonne et sainte amitié" écrivit Victor Cousin. Il est à regretter qu'il n'ait pas décrit tout au long, dans un des volumes de sa série sur les dames du 17^e^ siècle, une amitié dont il appréciait si bien le caractère. La Comtesse a beau être froide, sèche, raisonneuse, l'abbé a beau être pédant, ennuyeux, et absurde, nul ne pourrait parcourir leurs lettres après la reprise d'amitié sans être touché par les souffrances de l'une et par la fidélité de l'autre. Victor Cousin, que nous avons déjà cité, fait remarquer que dans la collection Feuillet de Conches il n'y avait que des lettres ou plutôt des billets de M^me^ de la Fayette (était-il exigeant ce monsieur là ? Qu'appelle-t-il donc une lettre ?) et qu'il n'y en avait pas un seul de Ménage. La liasse contenait, quand elle est arrivée jusqu'à moi, non pas des lettres de Ménage, il est vrai, mais bien des brouillons de lettres. Son écriture est difficile, parfois impossible, à déchiffrer; il se répète, biffe, laisse des phrases inachevées, griffonne des citations, mais on peut bien voir la tenue de sa lettre et nous allons donner pour la première fois, croyons-nous, des lettres de Ménage avec les réponses de la Comtesse.

Les premières sont d'une date proche de la reprise d'amitié dont parle M^me^ de la Fayette.

Lettre de Ménage (1691).

"Madame:

"Je me réjouis de votre meilleure santé et je vous en souhaite une parfaite. Si vous trouvez les lettres latines que je vous ay écrites vous me les envoiyres donc s'il vous plaist elles me serviront à travailler à votre portrait.

"Telle que nostre siecle aujourdhuy vous regarde
Merveille incomparable de toute qualité
Telle je fais dessein de vous confier en garde
Aux fastes éternels de la postérité.

"Mr. l'Abbé Ferrare est a la campagne. Quand il sera icy de retour ie l'exorteray fortement a se reconcilier à Me de Tot. . . . Je vous diray cependant confidamment que ce Mr l'Abbé est gouverné par son tailleur qui est un Bourgeois de Paris de la fille duquel il est amoureux et que cette fille est sa domestique et qu'il la fait manger sa table (sic.) et que ce tailleur est si puissant sur son esprit qu'il lui a fait vendre sa charge de Consee du Parlement de Rouen dix sept mille livres qu'il avait acheté cinquante et qu'il lui a donné une partie de ces dix sept milles livres: et qu'on dit à Rouen que le Tailleur de Mr. L'Abbé Ferrare le dépouille au lieu de l'habiller. Je diray à M. Perrault ce que vous m'avez écrit de lui dont il aura bien de la joye. De votre côté, Madame, vous direz aussi s'il vous plait a M. Leger ce que je vous ay prié de lui dire. Un Conee du Parlement de Dijon m'a donné une douzaine de pots de moyeux de Dijon. Je vous en envoye une demie-douzaine que je vous prie d'avoir agréable. Je pense que vous savez que des moyeux de Dijon sont des prunes confites admirables. Mr de Benserade sera enfin taillé au premier jour. J'ay esté prié par ces Messieurs les Beaux esprits qui s'assemblent tous les jours chez moy de vous supplier de vouloir prononcer sur une question de langue soutenue dans le mémoire que vous trouverez dans ce pacquet. Adieu ma divine Madame, honorez moy toujours de votre bienveillance ie vous en conjure et songez quelque fois je vous prié combien il y a que je suis sans variation avec toute la tendresse possible et toute la passion imaginable etc.

"P.S. Vous pouvez bien croire Madame que je serois ravi de loger à vous: car outre le plaisir que j'aurois dans votre conversation j'auray lavantage de vous pouvoir servir dans vos études et je ne souhaite rien tant que de vous pouvoir être de quelque usage. Mais Madame comme il y a 35 ans que je loge avec Mr. Parfait je ne saurois quitter son logis qu'il ne le quitte lui mesme. Selon toutes les apparences il le quittera à Pasques et en ce tans la si vous me feriez la proposition que vous me faites aujourdhuy je l'accepterois avec la plus grande joye. Et si vous vouliez me prendre en pension ie vous donnerois mille écus de pension pour moy et pour mes quatre domestiques."

Réponse de Mme de La Fayette.

"Ce 2 octobre 1691.

"Vous m'appelés *ma divine Madame* mon cher monsieur. Je suis une maigre divinité vous me faites trembler de me parler de faire mon portrait vostre amour propre et le mien pattiroit ce me semble beaucoup vous ne pouriez me peindre que telle que jay este car pour telle que je suis il ny aurait pas moyen dy penser et il ny a plus personne en vie qui mait vue jeune. Lon ne pouroit croire ce que vous diries de moy et en me voyant on le croiroit encore moins ie vous prie laissons la cet ouvrage le temps a trop detruit les materiaux jay encore de la taille des dents et des cheveux mais je vous asseure que je suis une fort vieille femme. Ma santé n'empire pas Dieu mercy je me trouve mesme un peu mieux aujourdhuy que je ne fesois ces jours passés j'avois desja un peu ouy parler du tailleur de Mr l'Abbé Ferrare il me semble que cest un des articles de la noise je feray votre court a merveille a Mr. Leger Faittes la mienne à Mr. l'abbé Berault adieu mon cher Monsieur je suis en vérité bien sensible a l'amitié que vous me tesmoignez cette reprise a de l'air de la nouveauté je vous remercie bien de vos moyeux c'est ma confiture favorite parcequ'elle a un peu d'aigreur.

La C. de La Fayette.

"P.S. Quand jestois jeune et que vous me guidies j'aurois dit ce me semble qu'*erreurs* au pluriel est plus beau en vers qu'*erreur* mais que dans l'endroit que vous me marques je trouve *plein d'erreur* meilleur que *plein d'erreurs* je ne scay pas si je dis bien je voudrois bien scavoir qui sont les gens de l'autre monde qui me prennent pour un bon juge."

Mme de La Fayette a perdu La Rochefoucauld, son mari, ses amis l'un après l'autre, et elle n'hésite pas à faire savoir à Ménage combien elle apprécie son amitié.

"Quoy que vous me diffandiés de vous escrire je veux neanmoins vous dire combien je suis véritablement touchée de vostre amitié je la reconnois telle que je l'ay veue autre fois elle m'est chere par son propre prix elle m'est chere parcqu'elle m'est unique presentemt le temps et la vieilesse m'ont osté tous mes amis jugés a quel point la vivacité que vous me tesmoignés me touche sansiblemt il faut que je vous dise l'estat ou je suis je suis premieremt une divinité mortelle et à un exces qui ne se peut concevoir jay des obstructions dans les entrailles des vapeurs tristes qui ne se peuvent représenter je n'ay plus du tout despoir(?) ny d'esprit, ny de force je ne puis lire ny m'appliquer la plus petite chose du monde m'afflige une mouche me paroist un elephant voyla mon estat ordinaire depuis quinze jours jay eu plusieurs fois la fievre et mon poulx n'est point remis a son naturel jay un grand rhume dans la teste et mes vapeurs qui n'estoient que périodiques sont devenues continuelles apres que jay mangé quoique je mange tres peu je suis cinq à six heures à n'en pouvoir plus, plus incommodee qu'aucune femme grosse ce que jay de bon c'est que je ne dors pas mal et le peu que je mange je le mange sans degoust pour machever de peindre jay une faiblesse dans les jambes et dans les cuisses qui mest venue tout d'un coup en sorte que je ne scaurois presque me lever qu avec du secours et je suis d'une maigreur estonnante voyla Monsieur l'estat de cette personne que vous aves tant célebrée voyla ce que le temps scay faire je ne croy pas pouvoir vivre longtemps en cet estat ma vie est trop desaggreable pour en craindre la fin je me soumets sans peine à la volonté de Dieu c'est le tout puissant et de tous costes il faut enfin venir à luy lon ma assuree que vous songiés fort serieusement a vostre salut et jen ay bien de la joye ce fut par vous que j'apris la defaite des Turcs.

La C. de La Fayette."

La Comtesse insiste un peu trop sur ses maux—soit; mais elle sait qu'elle s'adresse à une âme compatissante:

"Je vous apprend avec plaisir," ecrit-elle "quand je me porte mieux, quand je suis plus mal je ne scaurois m'empescher encore de vous le dire, c'est un soulagement pour moy que de me plaindre avec quelqu'un qui je suis assurée qui prend part à mes maux . . ." etc.

Toutes les lettres de cette époque donnent des détails sur sa santé toujours languissante et elles respirent toutes une tristesse résignée qui va droit au cœur.

"Je vous trouve d'une vivacité pour moy qui toute malade que je suis me redonne les idées de notre jeune temps ou je n'estois pas malade. Je le suis devenue bien considerablement depuis le dernier jour que je parlay a votre homme. . . . J'iray devant vous dans l'autre monde et tant que je seray en celuy cy je seray sansiblement touchée de l'amitie que vous me temoignés.

La C. de La Fayette."

Ménage ne se fatigue pas de ces lettres pathologiques. Il y répond fidèlement—toujours pédant, toujours galant—mais quel brave cœur! Ne posséder que les brouillons de ces lettres est peut-être un avantage, car le premier jet fait mieux voir le cœur de l'homme que ne pouvait le faire la rédaction définitive.

Vendredy matin.

Il y a trop longtemps que je ne vous ay mandé de mes nouvelles il m'en ennuyes ma santé est toujours dune langueur a faire pitié je dors tres mal je manges de meme je suis aussy d'une maigreur aussy excessive que la grossesse dont jestois lorsque nous allasmes en Anjou je suis toujours triste chagrine inquiette scachant tres bien que je nay aucun sujet de tristesse de chagrin ny d'inquietude je me desapprouve continuellement. C'est un estat assée rude aussy ne crois je pas y pouvoir subsister et je vous assure que je ne me croid pas plus en droit que vous de faire un bail de six ans je suis faschee que vous deslogiez premieremt parceque ce vous est une tres grande payne et de plus c'est que je connoissois vostre logemt et que mon imagination scavoit ou vous prendre vous avez autrefois conduit mes lectures du temps que je lisois pour apprendre quelques choses presentent je ne lis point et je ne veux rien scavoir mais souvent je fais lire pour m'amuser et pour m'endormir indiquez moy quelq livres il fault qu'ils soient de narration un livre de raisonnement emportant mon pauvre esprit des la premiere periode la faiblesse de mon esprit et de mon corps est une chose surprenante Adieu mon cher Monsieur nostre amithié ne finira jamais que quand nous finirons.

La C. de La Fayette."

Et Ménage de la consoler: (La lettre suivante n'est pas une réponse à la précédente, mais elle est de la même année.)

"Ce n'est que par respect que iavois cessé de vous escrire et pour ne vous pas fatiguer de mes lettres. Aujourdhuy, Madame, vous m'ordonnez de continuer de vous escrire et je vous obéis avec la plus grande joye du monde. Vous pouvez bien croire M^{e}, que celle que j'ay de votre guerison n'est pas moindre. Et vous en jugerez sil vous plaist par tant de larmes que j'ai versées au sujet de votre maladie et les larmes et cette joye ont fait connoistre la vérité de ce mot de David *Qui seme dans les larmes moissonne dans la joye.* Je ne doute point que dans peu votre guérison ne soit suivie de votre embonpoint cependant, M^{e}, assez de vous affliger de votre maigreur. Il y a une épigramme dans l'Anthologie, c'est ainsi qu'on appelle le Recueil des Epigrammes grecque (sic) ou l'auteur de cette épigramme console une dame qui avoit beaucoup de maigreur en lui disant qu'il était ravi de la voir ainsi maigre parcequ'il en estoit plus pres de son cœur. Je ne vous diray pas la mesme chose: car je suis fasché de la diminution de votre embonpoint. Mais je prens M^{e}, la liberté de vous dire que vous estes trop affligée de votre maigreur. Et un de vos amis me disoit avant hier que votre tristesse n'avoit pas peu contribué à votre maladie. La santé est la mere de la joye mais elle en est aussi la fille. Je veux dire, M^{e}. que comme la santé cause la joye la joye cause aussi la santé . ." etc.

Elle regrette son indifférence—cause peut-être de la lacune dans cette correspondance.

"Je puis vous assurer que votre affaire est tres bien recommandée à Monsieur Rybier(?) Une niepce de Monsieur Pascal tres digne niepce de son oncle lui a recommandé et luy a envoyé le billet par ou je la priois de recommander cette affaire à Monsieur Rybier(?) je m'etois bien doute qu'elle le lui envoyeroit je l'avois ecrit dans cette pensee j'y avois marqué tout ce que je dois a votre amitié depuis tand d'années et l'interet sansible que je prends a ce qui vous regarde. Je parlois de la justice de votre cause enfin j'y avois mis tout ce que j'avois cru de meilleur. Helas que ne ferois je point pour votre service que n'avez vous point fait pour le mien. Combien de pas vous ai je couste sans compter les larmes que je vous ai coustées aussi mais une reconnoissance a mon age n'est pas d'un grand prix ma santé est un peu meilleur qu'elle n'a este je suis toute a vous.

La C. de La Fayette."

Quand la Comtesse écrivait ainsi, il ne lui restait que deux ans à vivre et Ménage, malgré les prédictions de son amie, allait partir avant elle. Toute la liasse de ses dernières lettres serait à citer si la place le permettait. . . . La dernière, écrite une année avant sa mort, rend justice à Ménage:

"Samedi.

"J'avois ouy dire quelque chose du dessein de Me Hanequin mais je ne le croyois pas veritable comme vous me le mandes que je vous suis obligée de vos soins que l'on est sotte quand on est jeune on n'est obligée de rien et l'on ne connoist pas le pris d'un ami comme vous il couste cher pour devenir raisonnable il en couste la jeunesse vous me feres un tres grand plaisir de me mander ce que vous apprendries il y a des espèces de nouvelles dont je suis instruite mais il y en a d'autres dont je ne le suis point du tout ma santé fut assez bonne hier cela ne conclud pas quelles soit bonne aujourdhui ce qui me reste de vie se passera languissante un jour meilleure que l'autre je cours ma cinquante neuvieme année c'est beaucoup que d'estre encore en vie apres tous les maux que j'ai eu adieu mon cher monsieur je suis toute a vous bien veritablement et vous avez raison d'etre content de mon amitié.

La C. de La Fayette."

Les biographes se trompent quand ils nous représentent la comtesse comme une "intellectuelle" dominée par la raison, incapable d'écouter son cœur. Ils se trompent encore plus lourdement quand ils la représentent en païenne—ou tout au moins en femme irréligieuse. Elle a toujours observé avec exactitude les devoirs de son Église et dans ces dernières lettres, elle s'occupe non seulement de son propre salut, mais aussi de celui de son ami. Ils sont morts tous les deux en bons chrétiens et en bons catholiques.

Quant à Ménage, on ne pouvait essayer de le réhabiliter comme auteur. Comme homme il gagne par la fréquentation et plus je travaille sur cette correspondance, plus je pense que le mot que Mme de La Fayette appliquait à Montaigne "J'aurais aimé à l'avoir pour voisin," s'appliquerait avec justice à Ménage. C'était un bon voisin et un ami fidèle. Il s'en faut de beaucoup que l'on puisse en dire autant de tous les écrivains qui ont passé à la postérité.

La vente de la poule noire

(Anecdote canadienne[1])

Par JULES TREMBLAY.

Présenté par MARIUS BARBEAU, M.S.R.C.

(Lu à la réunion de mai, 1919.)

Pitro Miray venait d'avoir vingt ans. Personne du village, même les plus ankylosés, ne pouvait imaginer avec une prévoyance aussi parfaite, les moyens que Pitro découvrait chaque jour de ne pas avoir de travail utile à préparer, et encore moins à faire. Sa paresse était un vœu, sa fainéantise un parti pris. Déjà il avait traversé la crise de ses années scolaires sans apprendre à lire, et il avait fait sa première communion à seize ans, par charité. Les villageois, le disant lunatique, l'abandonnaient à sa douce folie, et le laissaient occupé à son désœuvrement.

Pourtant, Pitro ne manquait pas de talents. Il était maître ouvrier dans l'art de fabriquer les pièges à prendre les oiseaux et les petits animaux à fourrure; il savait mieux que tous métamorphoser en flageolets et sifflets les roseaux bordant la rivière et les tiges nouvelles coupées dans les bois.

Par les grandes chaleurs de l'été, il se vautrait dans l'herbe à dinde, à l'ombre du haut mur dégringolant la pente du chemin de rang, et permettait aux heures de couler sans rompre la monotonie somnolente de sa béatitude.

L'hiver venu, Pitro se collait au poêle et passait les jours à *gosser* des bouts de cèdre et de bois blanc qui devenaient des cages, des appeaux, des trébuchets. Cela le consolait d'avoir puisé de l'eau et fendu des bûches.

Le soir arrivé, s'il y avait veillée chez un voisin, il s'y rendait sans invitation et se plaçait le plus près possible de la chaleur. Mais il ne dansait pas. C'était trop fatiguant. Il se contentait de faire *affiler* les autres et de les faire danser en sifflant dans ses deux mains bombées, ce qui l'avait fait surnommer la *pétaque*, sous prétexte que son sifflement ressemblait à celui d'une ocarina. Pitro chantait, aussi, et chantait des complaintes et des ballades à faire rêver les jeunesses trop

[1] Anecdote basée sur une croyance ancienne répandue en certains milieux des "Cantons de l'Est" et de la Nouvelle-Angleterre.

tendres. Il avait entre autres pièces de son répertoire une *fameuse* renommée:

Catin, Catin, belleu Catin,
Queu fé-tu-u dans ton hardin!
—He tuille dé fleurs
De mille couleurs,
Pour mon sa-arviteur;
C'é pour z-y en fére in présent
T-à mon-on fidè-èle amant.

Pitro avait une raison secrète d'aller en veillée. Il aimait les contes, les belles histoires, surtout les contes de fées et de loups-garous, qu'il écoutait les yeux grands, la bouche béante. Un soir, le vieux Salvaye raconta comment s'était vendue de son temps la *Poule Noire*. Il avait été lui-même, naturellement, le héros de l'aventure, et la Poule Noire lui avait rapporté trois mille piastres et neuf francs. Malheureusement, il avait un jour oublié les engagements pris avec le Diable, et avait fait un signe de croix pour détourner le tonnerre. Du coup sa richesse avait été engloutie avec la grande maison dans le fond du Richelieu, et depuis lors Satan et lui ne se parlaient plus.

Voilà au moins une histoire qui faisait plaisir à Pitro. Il devait y avoir du vrai dans ce récit, puisque le père Salvaye était de tous les villageois le moins menteur. Pitro se promit bien à l'occasion d'essayer un peu, *voir*, d'acquérir sans effort trop coûteux assez d'argent en une fois pour continuer impunément à ne rien faire, et pour se payer, enfin, de grasses godailles au nez des habitants incrédules. Pitro rêva toute la nuit. Certains traits, cependant, étaient restés obscurs. Il relança donc le conteur aux bâtiments, et fit préciser les détails incompris. Décidément les vertus de la Poule Noire méritaient mieux qu'une attention passagère. Pour une fois dans sa vie il décida de travailler quelques heures afin—il en était intimement certain—de ne plus avoir à besogner du tout par la suite.

Les beaux jours étant revenus avec l'herbe et le soleil, il ne songea pas à retourner dormir dans le champ d'herbe à dinde, mais se prit d'une amitié profonde pour le père Salvaye. Il ne le quittait plus, le suivait dans les prés, faisait à son intention mille et un petits objets, et finissant toujours par lui demander des explications sur la désormais obsédante Poule Noire. Salvaye comprenait bien le jeu de Miray, mais faisait le finaud, ne laissait rien transpirer au dehors. Il mit un comble à l'émotion de Pitro en lui avouant une fois qu'il avait chez lui, au *grigner*, un gros livre dans lequel tout était expliqué. Ce livre était *Le Grand Albert*, un traité de magie blanche et noire indispensable à quiconque voulait tenter des relations avec les démons. Jusqu'ici Pitro avait été simplement idiot. Il devint crétin et de plus hypocrite. Il amenait toujours la conversation sur les Poules Noires passées et futures, et damnait à bon escient tous les chrétiens assez mécréants pour donner leur âme au Malin en échange d'un peu d'argent. Lorsqu'il se fut à son avis suffisamment bourré le crâne des choses indispensables au succès de son entreprise, il attendit son jour. Il avait dans l'intervalle visité toutes les basses-cours du village, et savait à quoi s'en tenir sur la population des poulaillers et sur la façon d'y avoir accès.

Des écoliers le surprirent, certain jour de congé, au milieu de l'érablière, en train de se livrer, tout seul, à un exercice qu'ils ne comprenaient pas. Pitro tenait de la main gauche une poule morte, la faisait tournoyer au-dessus de sa tête en prononçant et scandant des paroles inintelligibles, et la lançait par-dessus son épaule gauche à une distance phénoménale. Il regardait tomber puis allait ramasser la poulaille, revenait à son poste, et recommençait. Parfois il interrompait un mouvement en marche, corrigeait la flexion du bras ou la suspension en ligne bien verticale de la poule:

—*Non, cé pas çâ.*

Il reprenait alors le mouvement, sans fatigue, accordant un soin méticuleux au moindre geste, étudiant chaque courbe du coude et du poignet, débutant avec lenteur, puis accélérant jusqu'au presto vertigineux, sitôt qu'il croyait avoir enfin surpris le tour exigé. Les enfants coururent au village raconter ce qu'ils avaient vu et entendu, mais personne ne voulut les croire, sauf Salvaye, qui pour sa part en savait long sur ce mystère.

Septembre arriva. Les jours et les nuits conservaient encore une bonne chaleur. Le vendredi où la lune nouvelle était annoncée dans l'almanach, il faisait un temps superbe. Toute la journée Pitro fut nerveux. Il se promenait le long de la rivière, allait s'accouder sur le petit pont, pèlerinait dans la Savane, ne pouvait pas rester en place. Ses préoccupations n'empêchèrent pas l'heure de faire son chemin, et l'angélus était sonné depuis longtemps lorsque Pitro prit la route du souper, en repassant dans sa mémoire les aspects divers de son projet. Il lui fallait voler une poule, absolument noire—la crête exceptée s'entend—chez une veuve dont le mari était mort depuis au moins sept ans; cette veuve devait habiter une maison où il n'y avait pas un seul homme, pas même un enfant du sexe masculin. Ces conditions préliminaires étaient péremptoires. Certes, il y avait bien quelques veuves dans la paroisse, mais la Catherine avait sept garçons; la Méré en avait cinq; la Gritte avait ses quatre frères, et la jeune Pitoune avait son oncle. Restait la mère Dègle, entre la Savane et le champ d'herbe à dinde. Pitro connaissait le poulailler de cette vieille chipie; il savait bien qu'il s'y trouvait bonne quantité de poules noires; mais depuis quand la veuve était *asseulée*, c'était une autre affaire. A huit heures, Pitro passait là, faisant mine de flâner. La veuve tricotait sur le seuil. Le moment était bien choisi.

—*Coudon, la mère, y-a-ti longtemps qu'vot' mari é mort?*

—*Quoi's'ça peut t'fére, écornifleux?*

—*Bin, c'é l'vieux Dimont, comm' ça, qui voudré l'sa'ouèr.*

—*Qu gui diras qu'ça fé sept ans, pi qui attendra 'coré sept ans avant qu'je l'marise.*

—*Fâchez-vous don' pas, la mère.*

Sans écouter le flot verbeux qui le menaçait, Pitro s'en alla en murmurant:

—*Batèche, ça c'é bon.*

Pitro fut dans la Savane et s'y cacha. Ce grand marais, aux crêtes de *mock* digitées dans tous les sens, avait des sentiers et des appontements de fortune que seul Pitro connaissait. Il vit peu à peu des lumières s'éteindre aux fenêtres, et lorsqu'il crut le moment arrivé d'exécuter son œuvre longuement préméditée, il sortit de sa cachette, passant avec sûreté les buttes de terre noire entourées d'eau huileuse, et se trouva à la lisière des sapinages, à deux arpents du poulailler de la mère Dègle. La clôture de perches enjambée, Pitro rampa, rampa vers son but, où il arriva sans avoir donné l'éveil. Une fois devant le volet, il sortit de sa poche un cylindre de feuillard muni d'un fond et d'un couvercle percé de petits trous et d'une porte roulant sur charnières. C'était sa lanterne sourde. Dans une autre poche il trouva un bout de chandelle de suif, qu'il planta dans sa bobèche. Il battit le briquet sur du tondre et alluma, ayant bien soin de fermer sa lanterne. Il était prêt. Avec la lame de son couteau, il fit jouer le toquet de la porte de côté—l'autre étant fermée par un lourd cadenas—et il entra dans le poulailler. Un rayon de la lanterne tomba sur le *jouquoué*, et Pitro aperçut dans la demi-lumière une masse de plumes noires, d'un noir luisant, formant boule après les picorages d'une journée bien remplie. La chandelle éteinte d'un souffle, le voleur saisit la boule de plumes. Il y eut un gloussement effrayé, mais Pitro serra la volaille sous son veston, et partit comme il était venu. Il rentrait dans la Savane au moment où trois ou quatre ombres se dessinaient sur la route, tout près. Pitro eut peur. Quelqu'un le héla:

—*C'é-t-y toé, Pitro?*

—*Oué.*

—Ous' tu vas?

—J'sarche anne mine d'or.

—Tu ouéras pas clair, Pitro. Yé trop târd.

Pitro continua sa marche, sans voir que les ombres se glissaient en tapinois derrière lui. Arrivé au centre de la Savane, il se trouva près d'une mare où les vieilles femmes et les enfants avaient accoutumé de voir des fées danser, par les soirs de brume. Quatre sentiers étroits se croisaient sur un ilôt de mock durci et couvert de mousse. La mare était cernée par un soulèvement d'argile affleurant à travers la terre noire, et l'on pouvait contourner à pied sec l'étendue conquise par les grenouilles. Partout ailleurs il y avait des trous de vase, bordés de champignons, de plantes aquatiques, de bois pourri. Des aulnes poussaient en bouquets. Ailleurs, c'étaient des cèdres, des saules, des sapins rabougris. Dans l'air se répandait l'odeur forte du *petit thé.* De ce carrefour, Pitro pouvait voir assez bien le firmament. Assis sur une grosse souche d'arsin, il attendit, regardant tourner le Charriot, regrettant maintenant de le voir pivoter, ayant peur de tenter l'aventure épouvantante de Minuit. Mais à la fin, jugeant l'heure arrivée d'après la position des étoiles, il se leva tout droit, se tourna vers les quatre points cardinaux en prenant la Polaire comme point de direction, puis adressa un charabia ésotérique à Son Infernale Majesté Satan, scandant chaque syllabe avec chaque demi-tour du Nord à l'Ouest, de l'Ouest au Sud, du Sud à l'Est, puis de l'Est au Nord.

Pitro avait appris par cœur les incantations obligées, mais sa mémoire, sans doute, lui faisait défaut, et comme pour lui les paroles mystérieuses n'avaient aucun sens humain, il les dénaturait d'une façon qui pouvait déconcerter le Diable lui-même, et tous les sous-diables dont le métier est d'acheter au croisement des sentiers paludéens, à minuit, par les vendredi soirs de la lune nouvelle, des poules noires volées dans l'obscurité chez une veuve dont le mari est mort depuis sept ans.

—Saudit! Mârdi! Bacatèche de sincibor vlimeux! Roi du fer, veux-tu ma Poule Noère?

Quatre fois la question étrange sonna sur les aulnaies, passa sur la mare croupissante, au milieu du silence lugubre et rempli de ténèbres; quatre fois elle fut jetée, à chaque arrêt de Pitro, vers l'un des points cardinaux. Au quatrième appel, et sans attendre la réponse, Pitro tordit le coup à sa volaille, prit la carcasse dans la main gauche, la fit trois fois tourner au-dessus de sa tête, et finalement la lança aussi loin derrière lui que ses forces le lui permettaient. Deux secondes après un choc lourd retendit dans la mare. Au même moment, comme par l'effet prestigieux des paroles cabalistiques prononcées, les ouaouarons, les grenouilles, les crapauds, les couleuvres dans la mare et les trous d'eau, les chouettes, les hiboux et nocturnes de toute espèce sur les rameaux et les hautes souches, réveillés de leur quiétude, se mirent à siffler, à hululer, à crier. Ce fut un tintamarre étourdissant. Des ailes battirent. Des frôlements touchèrent les joncs, des formes glissèrent en agitant les nénuphars, rampèrent autour de Pitro, fou de terreur. Le mouvement de la gent palustre, surprise par la chute insolite d'un corps étranger dans son refuge, fit dégager des bulles d'air phosphorescentes; il s'éleva des vapeurs fantômatiques qui, aux yeux de Pitro, prirent des aspects terrifiants, des contours infernaux. Il ne douta pas le moins du monde que le Diable allait lui apparaître, et il se prostra sur le sol, face dans la boue, mais conservant quand même assez de sang-froid pour poser la question d'usage:

—*Es-tu là, Satin?*

Pas de réponse, mais des meuglements, des rugissements, des hurlements.

—*Es-tu là, Satin?*

Une voix caverneuse se fit entendre:

—*Oui, batèche, j'su lâ. Quoï's'tu veux?*

Deux autres voix caverneuses répétèrent alternativement la réponse. Pitro n'osait pas lever les yeux, tremblait de tous ses membres. Il était bien certain que le Diable d'Enfer en personne était là, tout près, à portée de main, qu'il lui soufflait dans le cou son haleine chaude et soufrée. Il eut bien envie de faire un signe de croix, comme disait l'avoir fait le père Salvaye, pour rompre le sortilège émouvant, mais la curiosité, surtout l'âpreté au gain mal acquis, l'emporta sur la peur, et Pitro balbutia, la voix trémulante:

—*M'sieu l' Yâbe, j'veux fére in marché.*

A cette phrase protocolaire, la première voix caverneuse répondit:

—*Pourquoé, in marché?*

—*Pour êt' riche.*

—*Quoï's'tu dannes?*

—*M-m-mon âme.*

—*Quand?*

—*Dans . . . dix ans.*

—*Cé correc'! Signe!*

Mais Pitro pria le Diable d'attendre un peu, lui demanda le temps de se remettre. Il voulait bien signer avec le sang de la Poule Noire et le sien mêlés le parchemin en peau de bouc que Satan avait dans sa poche, rédigé tout exprès pour l'occasion, mais il avait trop souleur pour le moment. Pendant tout le dialogue, le répondant avait employé, pour donner plus de force à ses répliques, un vocabulaire de *sacres* jusqu'alors inconnus aux oreilles pourtant exercées de Pitro, et le malheureux ne doutait plus qu'il fût en présence réelle de l'auteur célèbre de tous les sacres, de tous les jurons, de tous les blasphèmes. Il en ressentait même une admiration profonde à l'endroit du sacreur émérite qui lui faisait l'honneur d'une visite noctambulaire. Pitro retrouva cependant courage, en suivant l'exemple de son interlocuteur, en faisant de son mieux pour se rendre digne des largesses futures qui lui seraient dévolues de par la vertu de la Poule Noire. Il se leva sur un coude, et perçut devant lui des silhouettes vagues, étranges, noires, qui sur le bord de la mare gesticulaient et semblaient se tordre en proie à quelque sabbat vengeur. Il cherchait des yeux le Diable-Maître, toutefois, et se comptait trompé de ne pas voir le manteau de feu, les pieds fourchus, les cornes luisantes, le bonnet rouge à longue plume, et la grande fourche de fer chauffé à blanc que le *Grand Albert* lui avait promis, lors de la lecture par le père Salvaye. Mais il se dit que sans doute il allait tout voir en se tournant et en se redressant. Il tenta un effort dans ce sens, et aussitôt une violente poussée le rejeta sur le sol, pendant que la voix d'outre-terre lui criait dans les oreilles, avec des jurements effroyables:

—*Comment's' tu veux, pour ton âme?*

Pitro reconnut qu'il avait affaire à un diable sérieux, cette fois; mais peu au courant du marché et de la valeur du numéraire, il s'écria en tremblant plus fort:

—*J'veux cent piasses.*

—*Cent piasses, cent piasses, j'vâ t'danner cent coups de pieds.*

Et les coups se mirent effectivement à pleuvoir au bruit de rires sonores, pendant qu'un objet informe et humide, lancé des bords de la mare, tombait sur Pitro. Ce dernier, hurlant de douleur, voulut fuir, mais une main solide le tenait au collet et le recourbait sur le sol; des bruits de pas résonnaient sur la terre ou flochaient dans les flaques. Pitro crut sa dernière heure arrivée, crut qu'il allait payer, par la douleur de son séant, toute la paresse qu'il avait employée sa vie durant à rester dessus, et perdit un moment connaissance. Il demeura longtemps étendu, n'osant pas remuer, bien qu'il ne sentît sur lui aucun attouchement. Enfin, dans l'aube naissante, il risqua un regard, vit devant lui quelque chose de noir et de visqueux. Il allongea craintivement la main, sentit des plumes sous ses doigts. Enhardi, il se hissa sur un genou. La terre était piétinée partout. Des trous se dessinaient dans le mock. Il ramena ses regards sur ses mains, reconnut l'oiseau, le retourna, et le rejetant coléreusement dans la mare, s'écria:

—J'sava bin, itou, qu'y'ava teuq'chose. C'te damnée poul' là, c't'in coq.

Et il s'en alla, sans voir des traces fraîches de pas. En cheminant vers la demeure de sa vieille tante, il aperçut Salvaye et plusieurs autres villageois riant et dansant, l'interpellant:

—Pitro, as-tu vendu la Poule Noère?

—Pitro, t'as dé cornes.

—Pitro, tu sens l'soufre.

—Pitro, té pâ créquin.

Et les hommes vociféraient, ne pouvant se retenir. Pitro resta un mois sans se montrer, subissant en silence les reproches de sa tante, qui avait passé la nuit à l'attendre en pleurant. Le dimanche, il entrait après tout le monde à l'église, et sortait piteusement le premier, dès l'*Ite Missa Est.* Il s'apprivoisa tout de même, et revint chez les habitants siffler les danses, mais sitôt qu'on parlait en sa présence des mines d'or, des contes de fées, ou du *Grand Albert*, il baissait la tête. Quelqu'un lui demandant un soir s'il avait déjà vendu la Poule Noire, Pitro, maussade, pensa tout haut:

—C't'égal, si ç'ava pâs été in coq!

Carmel, une légende de la tribu des Cris.

Par le juge L.-A. PRUD'HOMME, M.S.R.C.

(Lu à la réunion de mai 1919)

Il y a longtemps de cela. Sur les bords de la Rivière-du-Cygne, près d'une forêt giboyeuse, s'était fixé un groupe de Cris.

C'était là qu'était née "L'oiseau bleu, à la bouche ouverte, en quête de nourriture." Les traiteurs visitaient souvent cet endroit, et y recueillaient une abondante moisson de fourrures. L'un d'eux, découragé d'un tel nom—qui s'allongeait en prenant l'allure d'une phrase, on ne sait comment ni pourquoi—suggéra à ses parents de lui substituer celui de Carmel.

Ce qu'il convient de retenir, c'est que, depuis lors, elle ne fut plus connue que sous le nom de Carmel.

Elle était remarquable par sa grande beauté, la majesté de son port, et l'élégance de sa démarche. Elle venait d'atteindre ses dix-sept printemps. Douce et dévouée envers ses parents, elle était encore plus remarquable par sa modestie et la pureté de son âme, que par la distinction de ses traits. Elle savait préparer le pémican, broder des mocassins, orner de dessins les peaux de la tente, corroyer le cuir et guérir nombre de maladie avec des essences extraites de fleurs et de racines. Pour se distraire de ses travaux, elle s'élançait parfois sur le dos d'un coursier, et cramponnée à sa crinière, sa longue chevelure flottant au gré de la brise, elle chevauchait des heures durant près du rivage du Cygne. Parmi les braves de sa tribu qui désiraient posséder Carmel se trouvait "L'oiseau gai."

Il avait hérité de l'esprit d'aventure de son père et comptait plusieurs actes de prouesse à son crédit. Trappeur habile, la forêt n'avait pas de secrets pour lui. Il se flattait de posséder les plus beaux chevaux de sa tribu. Jamais son âme émue n'avait connu un amour sincère, un attachement sérieux pour une femme.

De fait, il semblait comme ses ancêtres, ne considérer la femme que comme un être inférieur, digne de mépris.

A ses jeunes compagnons qui lui demandaient s'il ne songeait à prendre une compagne, il avait l'habitude de répondre "L'Oiseau n'est gai, que lorsqu'il est libre."

Il affectait stoïquement d'être insensible aux manières engageantes et aux regards langoureux des belles de sa bourgade.

Il eut bientôt fait de reconnaître que cette affectation dédaigneuse n'était qu'apparente et que la cuirasse dont il voulait envelopper son cœur, ne pouvait le protéger contre les traits de cupidon. Un soir que penché sur son aviron, il remontait la rivière du Cygne, il apperçut Carmel qui, sur le rivage, apprêtait quelques poissons. Cette apparition soudaine, fit naître aussitôt en son âme, un sentiment étrange jusqu'alors inconnu. Son image le suivit partout. Il s'en ouvrit à la jeune fille avec cette franchise naïve des peuples primitifs. Surprise de cet aveu, Carmel voulut s'enfuir.

Il la retint, la suppliant de l'épouser, lui jurant un amour éternel et lui promettant, si elle le voulait, d'être son esclave.

Carmel ne put se contraindre et lui déclara que son arrogance si bien connue des siens indiquait un mari despote et orgueilleux, que bref elle n'avait que du mépris pour lui.

"L'oiseau gai," blessé au plus intime de son être, résolut quand même d'avoir raison d'elle et de la posséder. Nous verrons bien, lui dit-il, en la quittant, qui l'emportera.

Dès le lendemain, il se rendit à la tente de son père, attacha à un arbre un superbe coursier et s'éloigna.

Lorsque Carmel à son réveil aperçut le cheval de "L'oiseau Gai" elle sentit son cœur défaillir.

C'est qu'elle ne comprenait que trop, ce que signifiait ce présent fatal, d'après les coutumes des Cris. C'était le prix offert pour la main de Carmel. Elle savait également que cette bête serait une terrible tentation pour son père qui se flattait d'être un élégant cavalier. Elle se rappelait ce qui venait d'arriver à sa cousine Komita. Son père revenait de la chasse, après plusieurs jours d'absence, sans avoir pu abattre un seul gibier. Sa famille était dans la détresse. Un jeune guerrier vint déposer à la porte de sa tente, un sac de farine. Le lendemain, le père affamé, faisait préparer de la galette et sa fille était livrée pour la vie à ce guerrier qu'elle n'aimait pas.

Carmel éprouvait une répugnance invincible pour "L'oiseau Gai." Elle tremblait d'effroi en le voyant. De plus, elle aimait tendrement Koto, un jeune Assiniboine, sans fortune, sans ostentation, mais doux et honnête. Il n'était son aîné que de deux ans. Ils avaient vécu dans la même bourgade depuis leur bas âge. L'affection réciproque déposée dès lors au fond de leur cœur, avait grandi comme les arbres de la forêt témoins de leurs confidences intimes.

Carmel comprimant les battements de son cœur, alla se blottir près de la tente, pour épier les sentiments de son père.

En effet, elle le vit bientôt, promener ses regards sur le fringant cheval, qui se cabrait violemment sous la longe qui le retenait captif. Le Sauvage savança rapidement, caressa l'animal, le considéra longtemps et tout à coup, saisissant une bride, il détacha le cheval et s'élança triomphant à travers la prairie.

Le sort en était jeté et elle devenait dès lors d'après une loi séculaire des Cris, l'épouse de l'Oiseau Gai.

Carmel demeura impassible comme le marbre, drapée dans sa douleur. Soudain, tournant ses yeux et ses mains suppliantes vers le soleil levant comme pour le prendre à témoin de son serment, elle s'écria avec des sanglots dans la voix:

Namawikatch—Iyiniwi Manito—Namawikatch.

Jamais! Dieu des Cris! Jamais.

Tout près de la tente, triste et abattu se tenait Koto qui avait tout vu et tout compris. Étendant la main vers Carmel "Adieu" lui dit-il. Namawikatch (Jamais) lui répondit-elle et se croyant abandonnée de Koto, elle se précipita dans sa tente.

Koto en s'éloignant, accablé sous le poid de sa douleur, se demandait cependant avec angoise, "Que veut-elle dire par ce mot 'Jamais'." Est-ce à moi qu'il s'adresse, parce que je n'ai pu donner à son père un aussi beau cheval que L'Oiseau Gai, ou est-ce à ce dernier parce qu'elle refuse de le suivre. Puis secouant la tête avec désespoir. Non! c'est bien fini, se dit-il en lui-même. D'après la loi inexorable des Cris, elle appartient à L'Oiseau Gai.

Du moins je ne veux pas que mon rival se moque de ma tristesse et insulte à ma misère. Je partirai pour la Rivière la Paix; je traverserai les Montagnes de Roche, s'il le faut pour tromper ma douleur et oublier jusqu'au nom de Carmel.

Le lendemain L'Oiseau Gai se présenta à la tente de Carmel pour l'amener comme son épouse. Carmel n'y était plus. Il la chercha en vain dans tous les environs; tous ses efforts furent inutiles.

Pendant ce temps-là, le père de Carmel chevauchait partout dans la prairie, tout fier de sa monture et n'était pas encore de retour. Carmel avait profité des ombres de la nuit, pour se glisser à travers la forêt et consulter un fort en Médecine. Ce dernier était un vieillard solitaire considéré par les membres de sa tribu comme un être dangereux. Carmel lui raconta ses peines et lui demanda de lui dire ce qui devait lui arriver.

Le vieillard alla cueillir quelques fleurs, les examina soigneusement et après un moment de silence, il lui dit: Carmel tu vas entreprendre un long voyage. Un ami volera à ton secours, mais vois-tu cette fleur rayée de jaune: elle contient un poison violent. Si ta peine devient trop amère, ou si ton ennemi te suit de près, fais bouillir la racine de cette fleur; bois ce breuvage saturé de sucre de cette plante et tu cesseras de souffrir."

L'Oiseau Gai en apprenant la fuite de Carmel, avait juré de se venger de cet affront et d'en demander compte à son beau-père. D'ailleurs il espérait bien que Carmel serait bientôt de retour et il résolut de l'enlever de force. Une fois entre ses mains il l'emporterait sur son cheval, jusqu'au bord de la rivière et menacerait de l'ensevelir dans les flots, si elle ne consentait désormais à vivre avec lui. S'il ne pouvait gagner son affection, il pouvait du moins, croyait-il, dompter sa volonté.

Koto entendit L'Oiseau Gai annoncer à sa belle-mère, l'œil étincellant de colère, qu'il reviendrait le soir même chercher Carmel. Il résolut de monter la garde ce soir-là, et de résister en face à L'Oiseau Gai. Dès que les étoiles commencèrent à scintiller au firmament, il vit Carmel déboucher de la forêt, et l'œil au guet s'avancer avec précaution de sa tente où bientôt elle disparut.

A minuit L'Oiseau Gai monté sur un cheval noir, se rendit à la tente de Carmel. Comme une panthère qui cherche à se jeter sur sa proie, il se précipita vers la porte, souleva la peau d'orignal qui en fermait l'entrée et puis il écouta quelques instants.

Tibikak (ce soir) s'écria-t-il.

Aussitôt il entendit une voix mâle lui répondre. *Wabang.* (Demain) et se retournant il aperçut l'ombre de Koto qui se dressait devant lui. L'Oiseau Gai, tremblant de rage, porta la main au couteau suspendu à sa ceinture. Rapide comme la biche poursuivie par le chasseur, Carmel se précipita entre les deux rivaux et s'écria "Jamais" et regardant en face L'Oiseau Gai, elle lui dit "ni ce soir, ni demain—jamais." L'Oiseau Gai voulut de nouveau s'élancer sur l'Assiniboine qui les nerfs tendus l'attendait fièrement. Carmel de nouveau se jeta entre les deux et offrant sa poitrine à ses coups "Frappe-moi si tu le veux, chien."

L'Oiseau Gai décontenancé, baissa la tête, sauta sur son cheval, partit en jetant ce défi à Koto. Wabang (demain).

Carmel et Koto se regardèrent quelques instants en silence et étendant ses bras, Koto voulut la saisir. Carmel le repoussa de la main. Elle lui rappela que d'après une loi sacrée dans sa nation, le présent accepté par son père la constituait l'épouse légale de L'Oiseau Gai. Puis elle ajouta en poussant un profond soupir: "Qui osera briser mes chaînes" et à l'instant elle entra dans sa tente.

Koto ne comprit pas le sens de ses paroles. C'était une invite à braver L'Oiseau Gai et par un coup d'audace à faire fléchir la rigueur de la loi. Koto crut que Carmel lui adressait un adieu suprême et que ses dernières paroles exprimaient le désespoir de son âme. Il demeura quelque temps les yeux fixés sur la porte de la tente où celle qu'il aimait depuis son enfance était disparue et comme quelqu'un qui a jeté un dernier regard sur une tombe qui s'est fermée pour toujours, il s'éloigna à pas lents. Dès que l'aube matinale eut dissipé les ténèbres de la nuit, alors que les fleurs sauvages tremblent encore sous la buée de l'aurore, Koto partit pour la Rivière La Paix.

Il espérait dans le silence du désert trouver un soulagement au naufrage de son amour. Nul ne sait ce que devint Koto depuis lors.

Le lendemain, L'Oiseau Gai apprit le départ de Koto et se présenta de nouveau pour obtenir son épouse. Sa mère l'attendait à la porte et lui représenta que sa fille était malade. Il la repoussa dédaigneusement et entrant dans la tente, il voulut saisir Carmel. Celle-ci s'enfuit en criant "Namawikatch" (Jamais.) L'Oiseau Gai était décidé cette fois, d'en finir et il voulut l'enlever de force. En ce moment, la mère saisit le fusil de son mari et le mettant en joue, elle menaça le ravisseur de le tuer s'il ne s'éloignait à l'instant.

L'Oiseau Gai craignant pour sa vie, s'enfuit, poursuivi par la mère qui lui répétait que s'il revenait jamais, elle le tuerait sur l'heure, heureuse de mourir ensuite elle-même, pour assurer le bonheur de sa fille.

Carmel épuisée par l'émotion se jeta fièvreuse sur sa couche. Sa mère se pencha sur elle en sanglotant et lui dit: "J'ai juré par le Manitou des Cris que jamais je ne te sacrifierai à cet homme que tu hais. Nous allons nous éloigner dans une terre lointaine et vivre en paix loin de L'Oiseau Gai."

Quelques heures après cette scène, le père de Carmel arrivait avec son superbe coursier. Sa femme lui raconta ce qui s'était passé pendant son absence. Son cœur balança quelque temps entre l'amour pour son enfant et le respect des traditions de ses ancêtres. L'amour paternel finit par l'emporter.

Lorsque L'Oiseau Gai vint pour le sommer de remplir son contrat et de lui livrer sa fille, il lui représenta l'état pitoyable de Carmel, qui préférait mourir que de l'épouser; il le supplia de reprendre son cheval et lui offrit en outre d'autres présents pour l'apaiser. L'Oiseau Gai demeura quelque temps rêveur et tout à coup se tournant vers Carmel: "Tu ne mérites pas, dit-il, que je t'aime. Vas retrouver ton chien Assiniboine. Mon cheval vaut mieux que toi" et il repartit amenant son cheval en affectant un sourire de mépris. Le marché était rompu et Carmel était libre. Dès que Carmel put supporter les fatigues du voyage, ils partirent tous trois pour la Saskatchewan, car le père se considérait comme déshonoré parmi les siens de la rivière du Cygne.

Les parents de Carmel espéraient qu'une fois rassurée contre L'Oiseau Gai (ironie des noms) elle reprendrait sa gaieté habituelle. C'est qu'ils ignoraient l'affection profondé qu'elle portait à Koto. A mesure qu'elle s'éloignait de la bourgade natale, elle sentait sombrer l'espérance de le revoir. Le long de la route, elle receuillit les fleurs jaunes que lui avait fait connaître le fort en Médecine de la rivière du Cygne.

Un soir qu'ils étaient campés au pied d'une colline, elle se leva pendant la nuit avec précaution pour ne pas éveiller ses parents. Elle ranima la flamme du foyer, y jeta quelques branches sèches et fit bouillir les fleurs jaunes. Elle versa le liquide dans une corne de buffle et gravit la colline.

Je verrai bientôt dit-elle la fin de mes maux et d'un trait, elle en but le contenu.

Pourquoi donc se dit-elle, suis-je si malheureuse? et tout à coup elle se rappella qu'un jour un missionnaire lui montrant un crucifix, lui avait expliqué que le Grand Esprit, avait tellement aimé tous les hommes, qu'il avait donné sa vie pour eux, au milieu de cruelles souffrances.

Puisque le Grand Esprit est mort pour moi, avant mon dernier soupir, je lui donne tout mon amour.

Ramassant deux branches d'arbres, elle les lia ensemble en forme de croix et les plantant en terre—"Reçois, dit-elle, O Grand Esprit, cette marque de mon affection."

Quelques instants après, le poison se mit à accomplir son œuvre fatale. Elle sentit qu'il lui déchirait les entrailles et ne put retenir des cris de douleur qui éveillèrent ses parents. Ils furent bientôt à ses côtés. Elle leur raconta tout ce qu'elle venait de faire et leur demanda comme dernière faveur, de la déposer après sa mort auprès de cette croix. Carmel s'éteignit bientôt et ses parents accomplirent ses dernières volontés. C'est là que depuis, repose de son dernier sommeil, la vierge de la rivière du Cygne. Sur la ligne du Pacifique Canadien du Nord, à quelques milles de Humbold, près de ce monticule on a donné le nom de Carmel à une gare, en souvenir de cet événement tragique.

L'effort littéraire du Canada Français.

Par FERNAND RINFRET.

Présenté par MARIUS BARBEAU, M.S.R.C.

(Lu à la réunion de mai 1919.)

I

Le moment est-il bien choisi pour traiter de littérature canadienne-française? Nous le croyons; et il y a dans cette question plus qu'un souci, ou si l'on veut, une tentative d'art.

Il faut s'inspirer des circonstances graves où nous nous trouvons, de l'heure présente. Nous sortons d'une guerre où les grandes puissances d'Europe se sont heurtées, les unes pour asservir, les autres pour sauvegarder les droits des petites minorités.

Et ne vous semble-t-il pas, que, par certains côtés, notre sort à nous se rattache singulièrement à celui de ces petits peuples désireux de vivre au grand air, en la pureté d'un ciel libre et clair? Ne sommes-nous pas, dans le domaine intellectuel, comme une lointaine province, gardant, jusque dans l'éloignement d'histoire et le loyalisme du nouveau régime accepté, le souvenir ému de la patrie absente?

Notre liberté spirituelle, ce souvenir qui persiste en nous comme le son du cristal "longtemps après qu'il a vibré," ce sont nos institutions, notre code, nos traditions, notre langue. Il ne saurait être indifférent de rappeler comme les Canadiens-français ont conservé jalousement un héritage qui leur a demandé parfois bien des larmes et bien des luttes.

La France nous a envoyé récemment quelques-uns de ses plus nobles enfants; et ce fut une fierté pour nous que de pouvoir, après cent cinquante ans de séparation définitive, leur souhaiter la bienvenue dans une langue restée commune et que ces trois demi-siècles n'avaient pu entamer; dans cette langue, la plus belle d'entre toutes, fluide et claire dans sa solidité même et dont on ne sait plus si elle est un ruisseau qui coule ou un marbre éternel figé dans la grâce; langue que nous aimons pour les efforts mêmes, pour les patientes et inlassables études qu'elle nécessite. Soldats de cette autre guerre patiente des années, nous l'avons portée comme un drapeau vivant, le plus noble et le plus pur trésor de notre héritage national.

Or il est un patient ouvrier de cette guerre, qui a lutté contre l'apathie, l'indifférence, parfois même la raillerie; qui avec des moyens presque toujours modestes, mais avec une intention et un courage souvent admirables a su réaliser ce rêve de faire servir la langue à des œuvres durables. . . . Ce phénomène étonnant entre tous, c'est le littérateur canadien.

La première question qu'on se pose, quand on traite de littérature canadienne-française est assez bizarre et inattendue. On commence d'abord par se demander: "Avons-nous vraiment une littérature?"

Ne souriez pas: on a, à maintes reprises, consacré des colonnes de journaux et de revues à résoudre ce grave problème. Et c'est une première anomalie, au sujet de nos auteurs canadiens, que quand on veut parler d'eux on ait d'abord à se demander s'ils existent. Mais, c'est une incertitude qui ne manque pas de consolation. L'ardeur même que l'on met à la discussion serait assurément une preuve d'existence, si l'on se donnait la peine de refaire la formule de Descartes. Nous en parlons; donc elle existe. Ceux qui en doutent confondent le désir de la perfection avec la réalité de l'objet.

Une littérature, nous apprend le dictionnaire—et c'est un excellent guide, simple, ennemi des arguties et des sophismes,—une littérature, c'est tout bonnement "l'ensemble des productions des écrivains d'une nation." Voilà le point de départ. Quel que soit le caractère de ce "tout," sa valeur, sa forme et la nature de son groupement, c'est déjà une littérature du fait qu'elle existe. Et on ne nous contestera pas que nous ayons, dans le Canada français, rempli surabondamment les conditions de cette définition essentielle.

Le public n'a qu'une idée vague du nombre d'ouvrages qui ont été et qui sont encore publiés dans notre province. Ceux qui consultent les catalogues de nos rares bibliothèques ou que leur position met en contact avec les publications courantes savent que les livres canadiens-français sont aussi abondants que variés.

Bon nombre de ces ouvrages n'ont qu'une valeur bien relative. Mais il y a, dans cet amas poudreux de livres que si rarement vient remuer le pieux attouchement d'un chercheur, toute une lignée d'œuvres à laquelle nous ne saurions refuser le nom de littérature.

Marivaux parlait jadis de ces prédicateurs qui prêchaient contre la vanité avec la vanité de bien prêcher: ce serait un travers égal que de s'attarder à une critique littéraire tendant à démontrer que son objet n'existe pas. Ce fut pourtant le thême favori de plusieurs de nos jeunes écrivains: ils établissaient souvent, par leur propre talent, la fausseté d'une thèse qu'ils soutenaient, ma foi! très littérairement. Notre littérature existe donc de fait, sinon de grand mérite: on ne saurait le contester.

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Il faudrait en écrire largement l'histoire. On pourrait calquer ce travail sur le fameux "Manuel" que Brunetière a consacré à la littérature française et qui comprend à la fois l'histoire des tendances générales et la classification biographique des écrivains.

L'histoire de notre littérature—qu'on peut et qu'on doit diviser en plusieurs périodes,—commence rationnellement en 1760.

M. l'abbé Roy a écrit judicieusement à ce sujet: "L'histoire de notre littérature nationale commence après la cession du Canada à l'Angleterre. Les livres qui ont été faits avant cette date sont l'œuvre de Français de France qui, pour la plupart, sont retournés dans leur pays; et ces livres ont tous été publiés en France. Après la cession, les Canadiens sont abandonnés à eux-mêmes, et ils doivent donc travailler eux-mêmes à leur fortune économique et littéraire."

Quant à la détermination des périodes, elle n'est pas rigoureuse. Elle est une méthode conventionnelle d'analyse, dont on peut tirer d'excellents renseignements sans qu'elle nous lie irrécusablement. Négligeant pour ma part les divisions complexes, je me contenterai de diviser notre littérature en trois périodes.

La première, datant de la cession, nous conduirait jusque vers 1830: elle n'offre rien de très saillant. Il faut la retenir comme époque de formation: les colons canadiens-français restés au pays après la défaite s'essaient à commencer une nouvelle vie économique et intellectuelle.

Avec Michel Bibaud, commencerait une plus ample période. Ce nom ne vous dit rien sans doute: et cependant par l'importance relative de ses œuvres et leur valeur comparative, il ouvre une nouvelle époque littéraire au Canada français.

Après les hésitations de la période de formation, voici venir enfin des œuvres de poésie ou d'histoire, qui sont vraiment des œuvres "achevées," ce qui les distingue de tout ce qui a précédé.

Nous avons, dans le domaine poétique: Bibaud, Garneau, Crémazie (qui domine l'époque): puis plus tard, mais dans la même tradition, les Fréchette, les Chapman, les Lemay, les Poisson et autres, qui se rattachent directement à cette même filiation, tandis qu'ils n'ont rien de commun avec nos jeunes poètes contemporains; l'histoire fournit à notre nomenclature les noms plus saillants de Garneau, Ferland, Gérin-Lajoie, Casgrain, auxquels on peut joindre parmi les contemporains ceux de Sulte, de David, de DeCelles, de Gagnon, de Dionne; nous avons des publicistes comme Ètienne Parent, Royal Dansereau; parmi les conteurs et les romanciers, on ne saurait oublier Chauveau, de Gaspé, Gérin-Lajoie, de Boucherville, Marmette, Faucher de Saint-Maurice, Arthur Buies, Lusignan, Routhier; parmi les orateurs

Cartier, Chapleau, Mercier, Laurier que ses grands discours français placent dans cette période.

Ce qui distingue généralement nos littérateurs de cette période, ce qui les différencie de nos jeunes contemporains, c'est le caractère vraiment national de leur inspiration. Non seulement dans le domaine de l'histoire où le sujet de lui-même s'impose, mais dans tous les domaines—poésie ou roman—c'est le Canada français qu'on chante.

Que l'on relise Gérin-Lajoie glorifiant un de nos défricheurs; ou de Gaspé et les "Anciens-Canadiens"; ou cet ouvrage délicieusement absurde qu'on appelle "Une de perdue, deux de retrouvées"; qu'on ouvre Crémazie et qu'on voie mourir son vieux soldat, à Carillon, dans les plis du drapeau; qu'on chante avec Fréchette la légende de notre peuple; qu'on ressuscite le souvenir exquis de Lusignan, disant les délicates émotions de notre vie de famille; qu'on se grise aux flots mousseux de l'esprit de Buies (en voilà un autre qu'il ne faudra jamais oublier) en tous les auteurs de ce temps chante véritablement l'âme de la patrie canadienne!

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Une nouvelle perturbation littéraire est préparée et se produit à l'époque de l'École Littéraire, avec ses Charbonneau, ses Gill, ses Nelligan, et les autres jeunes poètes de la génération les Lozeau, les Paul Morin, les Chopin, les Gonzalve Desaulniers.

On ne saurait nommer tous nos poètes; la poésie est la forme la plus usuelle de notre effort littéraire. Il vaut mieux les confondre tous en la tendance nouvelle qu'ils expriment et qu'ils ont apportée à notre littérature d'aujourd'hui. Ils ont cessé de s'inspirer directement du terroir, pour devenir plus humains dans le sens absolu du mot; ils ont subi plus directement l'influence de la littérature moderne de France.

Également, nos romanciers comme le Dr. Choquette, nos critiques comme M. l'abbé Roy, nos économistes comme M. Léon Gérin, nos jeunes orateurs comme M. Edouard Montpetit ou M. Athanase David, nos auteurs dramatiques comme M. Louvigny de Montigny, nos prosateurs comme M. Marcel Dugas ou M. Léon Lorrain, nos journalistes comme M. Olivar Asselin, tous écrivent avec une teinte moderne qui les distingue absolument de nos aînés.

Nos historiens eux-mêmes ont adopté la formule moderne. Il suffit à ce sujet de consulter la documentation précise et riche de M. Hector Garneau, qui continue en la rajeunissant par les méthodes les plus nouvelles l'œuvre de son grand-père.

Notre littérature actuelle, dans son ensemble, a gagné en forme, en perfection plus grande de style, ce qu'elle a perdu en expression de notre vie propre et de notre nationalité. Elle affecte même une sorte de répulsion pour les sujets du terroir, qui ne forment plus que rarement les thèmes de nos poèmes ou de nos livres: à ce point de vue, elle marque une réaction sur la période précédente.

Si l'on veut suivre la progression de notre mouvement littéraire, il est intéressant de rapprocher des vers de quelques-uns de nos poètes, à différentes époques.

Voici d'abord quelques vers d'un petit poème d'Octave Crémazie. Vous en observerez la forme un peu archaïque, vieux siècle, l'inspiration vraiment canadienne:

Il est sous le soleil un sol unique au monde,
Où le ciel a versé ses dons les plus brillants,
Où, répandant ses biens, la nature féconde
A ses vastes forêts mêle ses lacs géants. . . .

Heureux qui le connaît, plus heureux qui l'habite,
Et ne quittant jamais pour chercher d'autres cieux
Les rives du grand fleuve où le bonheur l'invite,
Sait vivre et sait mourir où dorment ses aïeux!

Chez Fréchette, le vers est plus ample, plus facile, plus nuancé: il se rapproche moins du vieux siècle que de l'époque romantique française. Mais l'inspiration demeure très locale, comme en font foi d'ailleurs tous ses recueils et en particulier sa "Légende." Voyez par exemple ces vers par où il salue l'Amérique, et qui rappellent Musset:

Quand, le front couronné de tes arbres géants,
Tu sortis vierge encor, du sein des océans,
Fraîche, et le front baigné de lueurs éclatantes;
Quand, secouant leurs flots de lianes flottantes,
Tes grands bois ténébreux, tout plein d'oiseaux chanteurs
Imprégnèrent les vents de leur âcres senteurs. . . .
. . . Amérique! au contact de ta jeune beauté,
On sentit reverdir la vieille humanité!

J'en pourrais citer bien davantage. Ces quelques vers donnent une idée assez exacte de la manière de Fréchette: romantique dans la forme (il a beaucoup pratiqué Hugo, surtout dans la *Légende* et la *Voix d'un Exilé*), il reste cependant très canadien de fond: et à ce point de vue se rapproche de Crémazie.

Mais si nous passons au jeunes, c'est autre chose. Voyez par contre la forme subtile, plus riche, fort soignée et l'inspiration toute humaine, "délocalisée," si je puis dire, de ce sonnet de Nelligan. Cela s'appelle "Le Vaisseau d'Or" et je n'en cite que les deux quatrains:

Ce fut un grand Vaisseau taillé dans l'or massif:
Ses mâts touchaient l'azur, sur des mers inconnues:
La Cyprine d'amour, cheveux épars, chairs nues,
S'étalait à sa proue, au soleil excessif.

Mais il vint une nuit frapper le grand écueil
Dans l'Océan trompeur où chantait la Sirène,
Et le naufrage horrible inclina sa carène
Au profondeurs du Gouffre, immuable cercueil.

Nous avons plus moderne encore. Si nous ouvrons par exemple le *Paon d'Émail* de M. Paul Morin, nous trouvons des vers exquis, d'une facture patiemment ciselée et d'une recherche délicieusement excessive. De plus en plus, l'inspiration s'éloigne de nous pour errer dans les villes orientales et le pays des chimères. M. Morin nous définit lui-même sa manière, avec une richesse verbale des plus notoires, dans les tercets suivants:

—Et de ma plume où tremble une goutte d'émail,
Comme en ce manuscrit clos d'un riche fermail
Où ton pinceau mêla la chimère à la guivre.

A la gloire du Paon, sphinx orgueilleux et pur,
Je veux entrelacer, aux pages de mon livre,
A la cursive d'or l'onciale d'azur.

On voit comme tout cela est loin de Crémazie et de sa simplicité; comme tout cela nous éloigne aussi du terroir. Si je n'avais peur de lasser votre attention, je vous montrerais que nous sommes allés jusqu'au décadent. Voyez ces vers fort curieux de M. Guy Delahaye:

Coups d'ailes que donne le métal
A la prière de ceux qui pleurent,
Les bourdons frappant d'un son brutal

Les airs se brisant comme un crystal;
Puis, tel le souffle de ceux qui meurent
Pures de la pureté d'antan,

Les ondulations en montant,
Se raidissent, retombent, s'effleurent,
Et bientôt s'endorment en chantant.

On pourrait recommencer l'expérience avec nos prosateurs en rapprochant par exemple ceux de la deuxième période, Garneau ou

Buies, de M. Marcel Dugas, un jeune contemporain, de forme ultra-moderne et d'une inspiration tourmentée, purement humaine. Mais il me faut conclure.

Donc il conviendrait, selon ses tendances générales, de diviser en trois époques dominantes notre histoire littéraire:

1. La période des débuts et de vagissements, au lendemain de la conquête; période héroïque mais peu fructueuse;

2. La période qui va de Bibaud à la génération précédente: période où l'on cultive vraiment un idéal canadien et qui nous vaut, parmi tant d'autres: Garneau, Crémazie et Fréchette;

3. Et la période contemporaine, avec son idéal généralisé et son souci plus grand de la forme.

II.

Mais mon but n'est pas seulement de tracer rapidement une histoire littéraire. Je voudrais surtout étudier le problème dans son essence même. J'ai dit que notre littérature existe de fait, sinon de grand mérite.

Voulez-vous que nous cherchions maintenant quels sont les obstacles qui s'opposent chez nous à un développement littéraire plus intense? La question est assurément intéressante: elle nous éloigne de l'histoire pour nous amener à la psychologie de notre littérature, si le mot n'a rien de trop pédantesque. Quelles causes influent sur notre développement, sont de nature à le retarder et à le rendre plus difficile? Tentons d'en signaler quelques-unes.

Et c'est d'abord, inévitable, la comparaison mal comprise avec l'œuvre française.

Crémazie l'avait bien entrevu: Nous sommes, écrivait-il avec quelque énergie, des "colons littéraires" plus encore que des colons territoriaux. Nos littérateurs doivent subir la comparaison de l'œuvre venue de France, mieux écrite, plus intéressante, et conséquemment plus lue que la nôtre. Sur ce point nous n'avons qu'à nous incliner. Nous ne songerions pas à proposer qu'on ignore Victor Hugo ou Sully-Prudhomme en faveur de nos modestes poètes. Il faut seulement demander au public d'apporter à la lecture des nôtres une mentalité réflexe, qui tienne compte des circonstances où leur œuvre est produite: œuvre jeune, qui compte à peine une centaine d'années de tradition, quand l'œuvre française repose sur cinq siècles du passé le plus riche, le plus substantiel, le plus laborieux.

Lisons sans relâche les œuvres françaises. Elles sont le meilleur de notre formation, elles nous sont essentielles; mais nous ne devons pas en tirer le mépris de nos propres efforts: qu'elles nous apprennent aux uns à mieux faire, aux autres à mieux juger, à tous à discerner la part de valeur de chaque œuvre, ce que je serais tenté d'appeler la "relativité du mérite."

L'œuvre française devra rester l'inspiration de nos écrivains, mais non pas le point de comparaison. Les nôtres, s'ils ont la fierté de parler la langue illustrée par tant de génies, ont la tâche parfois ardue de la parler après eux et d'avoir à la dégager du danger toujours menaçant de l'anglicisme et des imperfections qui résultent de l'exil intellectuel où nous vivons. Il faut leur en tenir compte.

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Il y a cette autre difficulté que nos écrivains ne sont "jamais" des professionnels! L'auteur canadien est, par la force des circonstances, dans l'impossibilité radicale de vivre du produit de sa plume. Il est ainsi, nécessairement, un simple amateur, consacrant *ses loisirs* à la littérature, mais dépensant le plus long sinon le meilleur de son temps, à une autre occupation (droit, journalisme, fonctionarisme) qui lui permette de vivre. C'est moins le talent qui manque, que les occasions de le développer.

Que voulez-vous que fasse notre auteur canadien, même s'il a comme le dit Joachim du Bellay "l'aile bien empennée", quand il apporte à son travail, une imagination fatiguée, un cerveau trituré de labeur, une âme striée par les besognes quotidiennes ?

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Et puis, il y a le public. Si l'on relit les pages que consacrent nos vieux auteurs au public de leur temps, on est porté à croire de prime abord à un grand progrès; mais il faut se garder de l'optimisme. Notre public affiche encore, en général, une apathie pour la littérature qui devient dogmatique quand il s'agit de l'œuvre canadienne. Dans un pays jeune comme le nôtre, cela est normal. Les énergies sont sollicitées par une occupation dominante, qui laisse peu de place au souci littéraire et artistique; nos hommes de professions eux-mêmes sont, la plupart du temps, absorbés totalement par le droit ou la médecine.

Ceux qui trouvent le temps de lire ou d'étudier en marge de leur travail quotidien, sont ceux que leur tempérament destinait à écrire eux-mêmes, s'ils eussent vécu en un autre milieu. D'où il suit que la classe des lettrés est restreinte. Si l'on ajoute à cela que la plupart de ces derniers s'en tiennent exclusivement aux œuvres françaises, on voit d'ici ce qui reste pour l'auteur canadien.

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Autre difficulté: les mauvais procédés de notre critique littéraire. Sur ce point nous avons gagné sur la génération d'hier. Nous avons vu disparaître, pour le plus grand bien de notre littérature, ces mesquines accusations et ces fouilles dignes d'archéologues, par lesquelles les auteurs du temps tentaient de se démontrer qu'ils n'étaient que des plagiaires.

Mais notre critique est restée encore dans une bonne mesure, sujette aux extrêmes: ou elle est une réclame, ou elle est un éreintement. La critique réfléchie, qui s'essaie à discerner le vrai de l'adulation et de la dérision, est encore à créer chez nous, du moins dans l'usage courant. Il ne faut ni aduler, ni bafouer. Entre ceux qui louent les œuvres sans mesure et ceux qui les méprisent sans raison, devra se glisser une école de critique modérée et sage, s'essayant à démêler la promesse du défaut, le neuf et le sincère du postiche, le bois verdissant du bois mort, selon le conseil évangélique.

Une telle critique aurait aussi l'avantage d'influer sur le public, de diriger son goût, de souligner des mérites qui ont pu, qui ont dû lui échapper. On notera du reste comme tout cela s'enchaîne:

Vous améliorez la critique; vous agissez peu à peu sur le public dont vous combattez l'apathie; vous tendez ainsi à faire meilleure la part de l'écrivain; et vous rendez moins désastreuse la comparaison avec l'œuvre extérieure. . . . Mais cela est naturellement plus long à établir qu'à raconter.

Certes on peut aider au mouvement par des moyens artificiels: concours, bourses, et autres procédés académiques. Ils ont tous leur mérite: mais il ne faut pas l'exagérer. Ils ont le désavantage de n'agir que sur un petit groupe et c'est l'ensemble de la population qu'il faudrait remuer. Il faut agir sur tous, résolûment.

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Et cela nous amène naturellement à la vaste question de l'instruction—que je ne veux pas traiter ici—mais qu'il m'est impossible de ne pas mentionner.

Il nous faut une formation collégiale plus forte, plus complète, plus ouverte, plus répandue. N'ayons pas peur de généraliser l'instruction; c'est comme si l'on forçait tous les poumons intellectuels à s'emplir d'air et à respirer plus largement. Avec une instruction plus générale et mieux comprise notre mouvement littéraire s'accentuera nécessairement. Le public en sera plus avide, et moins de nos talents resteront incultes.

On connaît ce poême de Rostand sur un rayon de lumière, allumant dans l'atmosphère d'une chambre sombre une bande où vibrent des grains et des atomes. Il y en a, dit le poète, partout dans l'obscurité; mais, comme la gloire, le rayon qui passe n'en dore que quelques-uns.

L'instruction de même. Ils sont là dans la nuit de l'ignorance et de la médiocrité tous ces cerveaux qui ne demandent qu'à penser et à produire. Faisons donc large et profond ce rayon qui, les baignant au passage, leur saura donner à tous la vie de la science et de la lumière!

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A cette question de l'instruction se rattache celle des bibliothèques, qui est corrollaire. Elles sont trop peu nombreuses chez nous. Passez aux États-Unis. Vous verrez qu'il n'y a pas une petite ville qui n'ait sa bibliothèque à elle. On a établi un système roulant de livres par lequel on déplace les volumes d'un endroit à l'autre. Je n'ose vous rappeler que nous avons refusé à Montréal, il y a quelques années, l'offre du millionnaire Carnegie.

Depuis, nous nous sommes ressaisis. A l'excellente bibliothèque Fraser s'est ajoutée Saint Sulpice d'abord, puis la bibliothèque de la ville de Montréal. Cette dernière toutefois est plus remarquable par la belle ordonnance de ses salles que par le nombre de ses volumes.

Il faut répandre le goût du livre" la meilleure munition, nous dit Montaigne, que l'on ait trouvée pour l'humain voyage." C'est la lecture qui continue l'éducation collégiale: ce rayon dont nous voulions tout-à-l'heure baigner les cerveaux avides, il faut le renouveler sans cesse par le contact habituel des génies.

Il faudrait aussi que l'on répande le livre dans nos campagnes, il est à peu près inconnu. Il faut combattre avec énergie ce mal bien canadien, né d'une conception pusillanime de la morale et d'une paresse intellectuelle routinière: la *peur* du livre.

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Mais pour que s'améliore notre situation littéraire, il faut surtout compter sur le temps et nous armer de patience. Il est une loi économique qui a sa répercussion, non seulement sur la littérature, mais sur les arts en général. N'oublions pas, en effet, que l'épanouissement des arts ou de la littérature, comme tout autre résultat social, obéit à une loi progressive dont nous pouvons peut-être accélérer le mouvement, mais qu'il nous est impossible d'éviter complètement.

Où que nous regardions, dans l'histoire des nations, nous voyons que les peuples artistes ont été d'abord des peuples riches. L'art est né, au sein des peuples, de la richesse; voilà ce que nous ont appris les siècles. Or nous ne sommes riches ni en ressources actuelles, ni en population; nous sommes en voie de le devenir, tout simplement.

Logiquement, notre développement artistique devra suivre, non précéder ou même accompagner notre développement économique. L'artiste, le littérateur, vit de la surabondance, du superflu du travail de la population. C'est le plus noble et le plus élevé des parasites; mais dégagé de l'obligation personnelle d'ajouter au travail économique de la collectivité, il est un luxe et le dernier des luxes que s'offre une nation. Il le lui rend bien d'ailleurs, quand comme la France, le pays devient un centre d'intellectualité, et que ses œuvres répandues par le monde développent elles-mêmes une nouvelle source de richesse.

Mais dans un pays jeune comme le nôtre, le mouvement des activités est avant tout vers la production économique, toujours intense. C'est un courant qui entraîne tout; et le littérateur qui, dans ce débordement et cette poussée matérielle, veut s'attarder quand même à méditer et à penser, est forcément comme un ilot désert battu par les flots qui passent. Que le pays devienne riche: l'art et la pensée suivront. C'est la loi de l'histoire!

Nos banquiers, nos commerçants, nos spéculateurs travaillent aussi pour l'art, comme Sedaine, sans le savoir; et je lègue à nos écrivains d'aujourd'hui cette pensée de revanche—hélas! toute subjective—contre les mépris trop crus ou l'indifférence trop vive qui les blessent.

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L'instruction généralisée; la création de bibliothèques; et le développement de la richesse: voilà des motifs d'espoir, des moyens d'action que nous offre l'avenir.

Il en est un autre par lequel je voudrais terminer cette courte étude, et c'est: le contact plus intime avec la France. Tout ce que nous faisons pour nous rapprocher de la France peut avoir une action directe sur notre développement littéraire. Il faut applaudir au projet d'envoyer quelques-uns de nos meilleurs talents parfaire leurs études en France, projet dont on a saisi notre législature et auquel elle devrait donner suite à la prochaine session. Il faut applaudir à des institutions comme le conservatoire Lassalle où l'on apprend aux jeunes Canadiens à bien parler leur langue, à en articuler chaque syllabe avec une minutie pleine d'affection.

Et l'on voudrait, malgré la concurrence, voir se multiplier ici les journaux et les revues de France: ils s'abattront sur nous comme de blancs papillons, les ailes toutes chargées du pollen fécondant de la pensée d'outre-mer. Et l'on voudrait aussi voir s'établir chez nous un excellent théâtre français; pourvu qu'il soit fondé sur des bases solides et destiné à éduquer le public tout en l'amusant. Il faut désirer également un développement plus étroit des relations commerciales entre les deux pays; c'est ce que nous promettait récemment la visite de M. Pellerin de la Touche. Le produit français est objet d'art: qu'il passe dans nos habitudes et il aura sur nous une influence indiscutable. Il faut applaudir enfin à des sociétés comme l'Alliance française par où se retrouve un coin de France au Canada.

Nous avons jalousement sauvé de la conquête l'usage précieux de notre langue; et nous l'avons conservée dans la lutte, au mépris parfois de certains avantages matériels. Je ne sais s'il est réservé au Canada, dans un lointain avenir, de parler une langue nouvelle qui lui soit propre, comme le français lui-même est né des civilisations mixtes qui l'ont préparé. Mais à l'heure actuelle, la langue française est restée la meilleure sauvegarde de notre nationalité, de notre intégralité.

Nous n'avons jamais eu tant de raisons d'aimer la France. Il faut avoir mis le pied sur le sol de France, durant la guerre; il faut avoir vu les poilus de l'armée dans la boue héroïque des tranchées et sur les grandes routes dévastées de la patrie; avoir vu tant de ruines vengées par tant de gloire; Arras en poudre et Amiens déserte; Paris impassible et fière dans la gravité de son deuil; Verdun inexpugnable . . . il faut avoir vu également, dans les champs menacés, le labeur incessant des femmes françaises, demandant à la terre d'enfanter dans la douleur et de nourrir quand même—pour comprendre toute la beauté et toute la grandeur de l'héroïsme français!

Mais la France fut plus que l'héroïne infatigable et sans cesse renouvelée; elle fut véritablement le cerveau de la guerre. C'est elle qui *pensa* la victoire de la Marne, la première digue opposée au torrent prussien; c'est elle qui *pensa* la victoire de l'Yser, dans les marais du Nord; c'est elle qui *pensa* la résistance de Verdun où un million de soldats allemands vinrent se briser. . . . Et quand, à la suite de ces glorieuses résistances, les Alliés en commun voulurent organiser l'offensive de la victoire, c'est au cerveau de la France qu'ils demandèrent d'en dresser le plan.

Cerveau de la guerre, cerveau du monde, la France peut et doit rester notre inspiratrice dans le domaine de l'intellectualité.

Ah! sans doute, il nous est permis à nous aussi de situer en l'avenir le rêve de toutes les indépendances. Un jour viendra, lointain, où notre jeune pays formera à son tour un foyer générateur. Mais en attendant restons fidèles à notre rôle; continuons d'être, par delà les mers, la sentinelle éveillée et joyeuse de la pensée française en Amérique.

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SECTION II

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Presidential Address—Satire and Humour

By Maurice Hutton, M.A., LL.D., F.R.S.C.

(Read May Meeting, 1919)

Having had occasion recently to make a paper for a Centenary of Lowell, I have been led to consider the point of view of Lowell as humourist and satirist, but also the wider question of the point of view of humourists and satirists generally; whence this separate paper.

The peculiarity of the humour and satire of Lowell lay in this, I think: that, though he represented literature and the universities to his country men, he yet set himself to reach the governing masses, the masses who did not belong to the universities or literature, and to be understanded of the people; or again to put the same thing is a way more interesting and piquant, though he was satirist and humourist, of first rate excellence, yet, unlike the majority of humourists and satirists he chose the side of reform and championed the faiths of Reformers and Idealists, the "New Faiths"; or I might as well put it more broadly and say he championed just "Faith," for Faith after all is broadly the quality of reformers; he championed "Faith" and "Reform" against all those forces of conservatism which have generally included for reasons not very obscure, the humourists' irony and the satirists' wit.

Plato, who has often photographed by casual anticipation the smaller and quainter ironies of our world's life, has an *obiter dictum* on this theme; himself a humourist and no one can tell just how often a humourist, he has the right to be heard.

Advocating emancipation for women, publicity and public service for them "Glaucon" he made Socrates say "Glaucon, my superlative friend let us ask the wits and humourists to forego for once their usual line: not to make fun of all this novel and reforming feminism for its incongruities: not to jest unceasingly about the ladies who wear uniforms and ride a-horse back"—as who should say who drive motor cars and ride bicycles.

"Of course it is funny to see them, passing funny; but so were our naked races funny even to us once, to see; and they are a scandal still to the barbarian." (And so they still are after twenty centuries in spite of Plato.) "Let us ask the wits and humourists not to scoff but to believe and to be converted to the newer, truer Faith, that nothing can be ridiculous which is useful."

There it lies, you perceive, the doctrine; ancient, simple, true, I apprehend; that wits, satirists and humourists are usually men of little faith; that they are obsessed by usage and conformity to usage; that having eyes only for the incongruous and grotesque, they find the grotesque and incongruous more often than not, in the crude Faith of the Reformer; in the zeal without discretion of the Idealist; it is only natural; the humourist does not take himself seriously; it is the first condition indeed of humour; he cannot then take other men seriously; and how at any rate can he take seriously those most serious moods of humanity which are called Faith and Idealism? If he took conscience, etc., very seriously, the first result would surely be—as we have all seen with our humourist friends when they "get religion"—an immediate falling off of wit and humour; one would decrease as the other increased; it happened conspicuously to that great and delightful humourist, Lewis Carroll, when he grew older and more sober and more serious; he exchanged the lifegiving priceless nonsense of Alice for the painful moralizing of Sylvia and Bruno. So again if Dickens had been more of a moralist and less of a humourist, he could not have delighted in painting the brutality of Squeers and Mrs. Gamp and the humbug of Pecksniff and the folly of Micawber; he would have been instead depressed by the contrast between human nature, as it was in these grotesque creatures and what it might be and is in the saints; but if the wit and humour in a man do not decrease with age as they decreased with Lewis Carroll, why then they increase and at the expense of Faith; and with them comes an ever keener disgust for all Faith's foibles, an ever keener gusto in launching shafts against demagogism, hysteria, sciolism and the other grotesque garbs in which too often Faith is fain to masquerade; and after that it is but a step to a warfare against all enthusiasm; that dubious quality, that debatable land, enthusiasm; a reproach to our eighteenth century ancestors, the condition of all virtue to the nineteenth century. The wit and humourist, the satirist and cynic seem at last to be but one man with four names, and to have little more definite to say to us than—after Talleyrand I think—"Surtout point de zèle."

This is the temperament broadly of the humourists from Aristophanes down to Hookham Field his translator, down to Gibbon and Canning (with his 'needy knife-grinder') down to the Saturday reviewers; I think there was a touch of it on this side of the Atlantic in Hawthorne; he writes somewhere: "The time was come for me now to return to the merchants of Boston, and to the other old fogies, who in this general flux and intangibility of affairs still kept a death-like grip on a few plain truths, which had not been in vogue since yesterday morning."

But it was not the temperament of Plato or Lowell; Lowell seems an exception, with Praed perhaps originality as a companion—but a companion of very imperfect sympathy—for if Praed began life as a reformer he soon passed over, as was to be expected of a wit, to the Conservatives.

I am trying to find other companions for Plato and Lowell, but it is not easy; one indeed there is, the prince or princess of wits, humourists and satirists, Jane Austen; but then is she really parallel with Lowell? She had no opportunity in her cloistered Hampshire life of meeting radicals and idealists; she expended her satire, therefore, on the people she saw and met, and they were all conservatives and conventionalists.

Perhaps a more promising parallel is Dickens; but then Dickens was a satirist, not of types and temperaments, not of reformers and idealists, or of conservatives and realists, but a satirist of individual eccentricity; he painted gigantic and side-splitting posters, extravagant caricatures of the monthly nurse, of his own sanguine happy-go-lucky father, of the professional humbug with the good bedside manner, of the rascally private school master; but these broad farces are not photographs of temperament; and only two, out of the four illustrations I have chosen, can, even by a stretch be described as satires at the expense of conservatism, at the expense of existing institutions and established doctrines.

The author of the Biglow Papers was wit, satirist and humourist, yet he expended his wit on the Conservatives and Realists not on the idealists of his day; and few seem to belong to his class; and Dickens to belong only partially.

I take a living author for comparison; even Mr. H. G. Wells, that prophet as he seems to America, that most popular in America of all satirists and humourists, even Mr. Wells—who certainly does not count himself a conservative—cannot compete with Lowell in this regard. There is humour and satire in Peter and Joan both at the expense of idealists and reformers; and also in other passages—at the expense of Tories and Conventionalists; but if intrinsically the figures of Miss Phoebe Stubland and Lady Charlotte Sydenham be fair targets for his shafts, yet the satire and humour directed at Miss Phoebe the reformer is infinitely more entertaining, more piquant, better worth reading and writing, if only because the target is so much newer and brighter coloured, so much less fly-blown and dinted by previous archers.

It occurred to me that this perhaps was a mere personal judgment, born of my own twist towards the wicked Lady Charlotte and the conservatives, so I asked a young and clever graduate of the University of Toronto; he told me that he on the contrary read with greater zest the satire at the expense of Lady Charlotte, "because he hated and abhorred her; while Miss Phoebe, tho' silly, was a good soul."

I agree with him about the two ladies, of course; but not otherwise. Lady Charlotte is just a fool, and a heartless fool, and does not at this time of day repay study, but Miss Phoebe is an ass; and there are so many asses of her kind about and they bray so loudly and are so strong and willing, so patient and hard-working, that the world must take them seriously or they will take it; I don't think on mature reflection that I need be ashamed of enjoying the satire at Miss Phoebe more than the satire at Lady Charlotte; satire is not needed, is gratuitous, at the expense of moral deformity such as Lady Charlotte's, but satire and humour are discharging their regular task, their appointed work, their life long rôle and métier, when they fall upon the incongruities of poor dear silly Miss Phoebe.

It reminds me of the old anecdote about Lord Lytton: he took into dinner an emancipated lady, some Miss Phoebe; "Lord Lytton," said Miss Phoebe, "how can you be a Tory? all fools are Tories." "True, Madam," said Lord Lytton, "but—all asses are Radicals." Let Miss Phoebe then be written down an ass; and, oh, that she be written down an ass pretty quickly, or no one knows what price the world will not have to pay for the knowledge that Miss Phoebe is an ass, and that the mares-nests and crazes and delusions of Faith and Reform are as perversive and pervasive, as the instincts themselves to Faith and Reform are essential to good life.

Then what is the métier and rôle of humour and satire? and how does it cover both Plato, Lowell, Miss Austen, Dickens and Wells, and also Aristophanes, Gibbon, Canning, Frere, the Saturday reviewers, and again the same Wells ("old Wells re-opened")

I take it the distinction between the two schools of humour and satire is pretty fine at first sight and slender; humour is mockery at the incongruous; and the incongruous takes two forms broadly which may be so defined—though in reality they are very different—as to seem alike; there is the incongruity between our theories and our practice, our ideals and our actions; and there is also the incongruity between our ideals and theories on the one hand and the actualities, possibilities and facts of life on the other; has not the difference almost disappeared in this definition, the difference between Plato and Aristophanes great though it be? Plato and Lowell satirise the incongruity of our actions in the light of our principles; Aristophanes the incongruity of our principles in the light of the facts and laws of life; it almost looks as if each humourist had the same incongruity in view only that they started from opposite points of view and chose the opposite of the two targets for their respective shafts; one was mocking our faithless lives, our disloyalty to principle; and the other our high-falutin principles, our disregard of facts and life and common sense.

But there is nevertheless here a real difference; Lowell is—like my academic friend who hates Lady Charlotte—satirising moral deformities, faithlessness to conscience; Aristophanes—like a true Greek, a true intellectual—is interested rather in the intellect than in morals even when he is scoffing at us, and he is satirising our unbalanced ambitions, our soaring ideals that are like balloons cut adrift from earth altogether, that take their occupant up to altitudes, the air of which no man can breath; as that balloonist is a failure, so these idealists are failures. Their hearts are all right, like Miss Phoebe's, but their heads are as silly as hers. Imperfect, impossible ideals are her foible; low life, coarse action is the offence—the sin rather—of the Lady Charlotte; Lowell is satirising sin but Aristophanes philosophy.

Perhaps I am labouring the point unnecessarily. Why not quote what certain of our own humourists have said? The bulk of the humour of Mr. Stephen Leacock, if I recollect aright, is at the expense of foolish idealists, of Mr. William Jennings Bryan and Miss J. Adams, not at the expense of Germany, or, if at the expense of Germany, still at the expense of idealist Germany, the Germany of method and system, with six little birds on each tree-branch singing in harmony or unison, not the Germany of brutal violence and cynical hypocrisy. Impossible ideals, not betrayed and denied ideals move Mr. Leacock's intellectual mirth. It is more profitable because more difficult to find other contemporary humourists of the opposite school, the school of Plato and Lowell. A critic in New York, after my paper on Lowell, observed that the same reasons which made Lowell interesting, endeared Bernard Shaw to him; Shaw satirizes not the pacifists and cranks, not the Sidney Webbs and Massinghams and Gardiners, not the nation with a capital N, but the great public, the conventionalists, the nation with a small "n." I suppose that is true though it is at first sight rather paradoxical (and all the more Shavian) that it should be so; at first sight one would expect an intellectual—and Mr. Shaw is nothing if not intellectual, much more intellectual, his friends say, and he himself has said, than Shakespeare—one would expect an intellectual to be rather indifferent to the moral inconsistencies and hypocricies of the great leviathan, to the vulgar common place eternal insincerities of raw human nature, and to be interested only in the false theories of other intellectuals; but after all there are two schools of intellectuals, as there are two of satirists and humourists, there are the "intellectuals" of the old world, men like Aristotle, who take a seriously scientific view of the world, and build on the past, on fact and history, and are thereby deeply prejudiced against reform ideals; for were the reforms practicable they would have been secured already in that illimitable past which has already tried all permutations and combinations of circumstances and institutions, which seemed to promise improvement, and has adopted already all which really brought improvement; unrealised ideals are now presumably—Aristotle suggests—Wills o' the wisp, misleading fires. The great flaws of life—slavery, infanticide, abortion, prostitution—though they be to the Jews a stumbling block and to the Christians a horror—I am not exactly quoting Aristotle you perceive but only Aristotelians—remain as permanent flaws—just as Ireland remains a running sore but not a mortal disease in the British body politic—simply because they have always been. These are the conservative intellectuals; they accept permanent flaws as a part of the laws of life. But Mr. Shaw has always been a liberal intellectual; he has always been idealist rather than scientific; he has, for example, a violent feud with the doctors and the vivisectionists; though he be an intellectual he is even in a greater degree a humanitarian; "Androcles and the Lion" is not a scoff at the early Christian idealist; but rather a sympathetic picture of him as compared with the unchristian ruffians of the world of all ages. "Blanco Posnet" and "the Devil's disciple" are not caricatures of impracticable visionaries but pictures of rough and foul-mouthed honesty, of unconscious Christianity in fact, which because it is rough and foul-mouthed is quite misunderstood by the smug conventional so-called Christianity of the Sunday school; the only objection to these entertaining and spirited dramas is obviously that they are a little too obvious and unintellectual; if a reader knows already from his reading of the Gospels that the Sunday schools are not infallible exponents of Christianity, that the publican and the harlot have already been entered in the race for the Kingdom by a Higher Authority than the Sunday school, against the righteous who need no repentance, well, such a reader says "agreed" before the race starts and the intellectual interest of the drama disappears, though the moral interest undoubtedly remains. But there remains also the semi-paradox that an intellectual dramatist is maintaining interest only by his moral appeal. "Androcles" is much better than "Blanco Posnet" for this reason: it retains an intellectual as well as a moral interest; is the ideal of the early Christian really impracticable? "Suppose" Mr. Shaw is here suggesting—"suppose we really try Christianity for the first time in the world as a real working system." Androcles remains his best, or one of his best, dramas; there is nothing intellectually cheap about it, as about Blanco and the Devil's Disciple; but what again the intellectual interest may be in "Widowers Houses" I cannot discover; nor even much moral interest for that matter; it appears to be a misanthropic picture of human nature, so wholly and unrelievedly bad, especially the feminine variety of it, that no hope remains for man, and interest disappears, except in the sense that Swift, the other Irish misanthrope, may still have an interest for some readers. Ireland is full of misanthropy; its inhabitants apparently enjoy despair; but despair is fatal to all interest, moral and intellectual, in the works it produces, except for Irish readers who love despair and negation and insoluble problems for their own sakes and would feel quite downhearted if a problem were solved.

I need not run through the catalogue of Mr. Shaw's plays; some, like "Mrs. Warren's Profession," are quite edifying, but intellectually even cheaper than Blanco Posnet; others are sheer fun and delightful farces, like Pygmalion; the humour whereof is abundant but does not come under either of the heads with which I am concerned.

Something reminds me of a stroke of satire from Mr. Goldwin Smith which does fall under these heads; under the Plato, Lowell, Shaw head—" 'Give me liberty, or give me death,' said Patrick Henry, and bought another slave." The interest in that sharp lunge at Irish rhetoric, is moral obviously, and not intellectual. But Mr. Goldwin Smith's epigrams were not always at the expense of common human insincerity; there is another epigram hardly relevant here for it is not humourous or satiric, but not less characteristic of its author, at the expense of one of the most popular humanitarian ideals, universal education; it means, said Mr. Goldwin Smith, "Sensibility without bread." I quote it only to illustrate the point that Mr. Smith coined epigrams on each side against common human nature, and against the idealists; in the vein of Plato and in the vein of Aristophanes; as an intellectual who was also idealistic and humanitarian, he could appreciate in turn each school of humour and satire; but as a moralist and Puritan at heart I think, he probably found greater pleasure or more food for reflection in the moral humourists than in the intellectual, in the school of Plato, Lowell and Shaw and the like, than in Aristophanes, Canning, Frere, Gilbert and the rest. But after all, the two schools are not mutually exclusive; there are humourists hovering between them, the connecting link; when Fielding satirises Square, is it the false pedantic ideal he satirises or the faithless betrayal of the false ideal? Or each alike? The two sides of humour the two species of incongruity, seem to have met and mixed in the humourous picture of Square.

The Revolt Against Reason; a Contribution to the History of Thought

By G. S. BRETT, M.A. (Oxon.), F.R.S.C.

(Read May Meeting, 1919)

I

There is a curious passage in the history of Descartes' mind which deserves to be studied for the light it throws on the development of thought at that critical point. The passage in question relates to the notion that animals are machines, a very natural and sensible idea if rightly understood; since Huxley has taken it under his protection we need not labour the point but give a brief account of Descartes' own views and then indicate the real importance which belongs to the topic.

It had been customary from the time of Aristotle to distinguish three senses of the word soul and three grades of being, namely, plants, animals, men. Since Descartes proposed to confine the term soul to the Reason, the question whether animals have souls can only be taken to mean, have animals a rational soul? As Descartes had also declared the human body to be a machine, and everyone agreed that man was a rational animal, the most elementary logic could show that an animal was wholly what man was in part, to wit a body and therefore a machine. So far the point is clear, but Descartes was not quite sure what his own statements meant. At first he was content to treat animals as machines; he was at that time fresh from the pursuit of physiology and also very much inclined to regard machinery as the true type of self-explanatory causation. In his eagerness to be rid of all occult causes he was ready to disregard some obvious facts. At this period he could see no distinction between a sound organism and a perfect clock. But as time went on these impulses grew weaker. The force of analogy began to assert itself. He hinted at the possibility of a different principle, the instinct. While he began by speaking of animals as mere machines he ended with the much more moderate statement that it was not possible to prove they could think. In the interval between his earliest and his latest views he grants that these organisms may have sensations and a kind of consciousness which does not amount to thought. In general his position is that Reason in the proper sense is peculiar to the human mind. In human life there are many actions that do not come into consciousness; they are reflex activities which the organism carries out without the intervention of mind. These are operations of our animal nature, our bodies as machines. The human and the animal world overlap at this point. Instead of saying with the Scholastics, that the vegetative and sensitive souls are merged in the rational soul as the higher form, Descartes regards the human body as an animal organism united with a rational soul. Animals can then be regarded as bodies only, and this is the point Descartes never wholly abandons. If he goes so far as to suppose that some obscure sensations accompany the operations of the body, it is because his idea of body develops into the idea of an organism which acts as if it had psychic qualities.

Fundamentally then we may regard this much disputed proposition, animals are automatic, *i.e.*, self-contained machines, as merely a forcible way of eliminating animism from physiology. But apart from the mere statement of the view there is the question of its historical place and significance. It is not a question of animal psychology at all, for it is concerned neither with animals nor with psychology, except in that wide sense in which the human being can be called simply an animal. Even the disciples of Descartes saw that the consequences were important and there can be no doubt that Henry More hit the mark when he said that the whole idea arose from the prejudice against giving animals a claim to immortality. There can be no doubt, too, that this was not all. Descartes disliked the sentimental attitude toward animals; he rightly thought the popular ideas about their powers, were gross exaggerations; he lived in close enough contact with the beliefs about human souls taking up their abode in animal bodies to feel the immense advantage of a more scientific view of the matter. Yet even here he blundered, for his sharp distinction between soul and body made it more than ever possible to regard the body as a place occupied by a soul, and so reduced the possible objections against its dwelling in all and every kind of body. Descartes in fact lost his way, believing as he did that moral qualities belonged only to men and that no one could prove animals to be reflective moral beings. Proofs might indeed be wanting but statements were abundant. Apart from Pliny who counted religion among the moral virtues of elephants and endorsed the ancient idea that those animals lifted up their trunks in prayer, Lactantius had been generous enough to ascribe morality, without religion, to animals. Omitting Porphyry, whose influence had waned many centuries before, and the queer stories which supplied the place of earnest enquiry for the whole period of the middle ages, we find Rorarius (1554) maintaining that animals have reason and make a better use of it than man. In the same year Gomez Pereira, in a book called Antoniana Margarita, upheld a similar position, the source of which can easily be traced to the Stoic idea of instinct, that natural faculty in all created things which operates undisturbed when the reason does not interfere with its promptings. Thus for a century before Descartes there had been a distinct tendency to dispute the primacy of man even in the moral sphere. It was argued that if man was made in the likeness of God but had defaced that likeness by his arbitrary choice of evil and his fall from grace, the animals having no such freedom of will preserved what Cicero had called their uncorrupted nature; they are either created evil or not evil at all.

The tide of opinion was turning against man. The reason for this is to be sought in the whole change which came over the dream of human perfectibility. The end and aim of knowledge had for long been put in the world above, its significance had not been of this world. Hobbes, the contemporary of Descartes, following in the steps of Macchiavelli and of Bacon, states abruptly the opposite point of view; for these men knowledge was power, the peculiar power of the human being by which he could devise more cunningly than other animals, by which he could secure advantages for himself and satisfy desire. The intellect that invented gunpowder was not amenable to the old definitions; it was a new variety and these writers believed in adapting their definitions to the facts. The curious enquirer could find in Hobbes the curt remark that speech enables a man to utter what he does not think, that it leads him to deceive and so "by discourse man is not made better, but more powerful." He might go further back still and produce from Paracelsus some bold statements that could only have escaped notice through being regarded as utter insanity. The discovery of America gave trouble, and some dispute arose as to the origin of the American Indians. The authorities boldly ruled in 1512 that they have descended from Adam and Eve. In 1520 Paracelsus declared that there had been another Adam, as if there could have been two first men! He delivered himself further as follows: "It cannot be proved that the men who inhabit the hidden countries are descended from Adam; but it is credible that they were born there after the deluge; and perhaps they have no souls. In speech they are like parrots and have no souls unless God be pleased to join them in the bonds of matrimony with those who have souls." We are left in no doubt about the intention of Paracelsus to write a new account of the origin of man, for he says explicitly that Moses wrote theologically and according to the faith but was not acquainted with natural science. Further, in 1616 Vanini suggested that man was originally a quadruped. Vanini was burned. In 1665 Peyrère talked about Pre-Adamites, and in the same year a work was published anonymously in English which seems to be the beginning of the history of the word *Anthropologie* in the English language. In this book Anthropology is divided into Psychology and Anatomy, and the writer announces that "of the former we shall in a distracted rehearsal deliver our collections." In 1677 Matthew Hale discussed the primitive origin of man and from that time onwards a series of works on comparative anatomy, on pygmies, and on other allied topics prepared the way for the appearance in 1735 of Linné's Systema Naturæ where we find man treated zoologically.

These few dates and titles show how the teaching of Descartes about animals comes midway in the development of a large theme. The focus of interest was man and the question at issue was not so much the scientific analysis of animal behaviour as the adjustment of man, now declared to be in part a machine, in relation to animals. The issue of the discussion was finally that which Descartes vaguely indicated, namely that as body man belongs to the animal kingdom, as mind he belonged to another realm. While Descartes confused the subject by treating this other realm as sometimes merely psychological, sometimes ambiguously spiritual, the sequel shows that it was possible to advance from his position to a general theory of man divided into physiology and psychology.

Whatever may be said of previous suggestions, it was the work of Descartes to give wider significance to the question of automatism. His followers and defenders saw this aspect of the problem and the consequent ventilation of his views brought to light many interesting points. Ignatius Gaston Pardies (Discours de la Connaissance des Bêtes, 1672), and a certain A. Dilly, author of a work on the soul of animals published at Amsterdam, 1691, were the chief writers concerned. Dilly argued that the growth of the embryo precedes consciousness, that movements easily become automatic, that somnambulists act unconsciously, that speech and the playing of instruments are systems of movements which depend solely on the nature and disposition of the organs. Pardies argued that it was simpler to explain the lamb's fear of the wolf through some automatic principle than to suppose the animal first learned to think the wolf could harm it. The theologians were attacked in flank by the assertion that it was more creditable to the Divine Wisdom to create an organism that automatically preserved itself than to complicate matters by adding consciousness. Regius declared that the education of animals was achieved by repetition of acts which produced new dispositions of the brain substance and so caused a regular flow of spirits to certain muscles. The same writer fell back on the early physiology of the emotions and explained the love of the animals by the temperature of the blood; the presence of the agreeable object causes physiological changes affecting the heart, while danger produces movement through affecting the spleen and the gall. Pardies further quoted the irrational fears of human beings, as for example the effect of a mouse on the feelings of a woman. In short, the whole movement, though curious in its focus and interests, produced a considerable amount of able writing which is closely akin in its results to the good and bad points of the later attempts to show how far consciousness is an epiphenomenon. Pardies clearly was not far from the views on emotions afterwards made popular by the Lange-James theory.

II

The importance of a scientific theory must be measured in different ways. We may, for example, think primarily of the changes visible in the details of scientific thought and progress; or we may diverge toward the hopes and fears, the latent desires and professed aims which are affected by each new explanation of life. This interaction of scientific thought and public opinion deserves to be studied closely; for it shows that they are organic one to another, and never more so than to-day. The science that neither affects, nor is affected by, the ultimate beliefs and most secret aspirations of mankind is dead; so dead that it can hardly be discovered anywhere in the annals of thought; for what history preserves is what, in its time and day, occupied the minds and busied the tongues of the people. This does not mean that popularity is the test of rightness; nor does it endorse a pragmatistic doctrine by saying that a theory becomes true when it is most widely believed; but in every age or generation the great truths are the nurture by which that age brings its culture to maturity, and the gradual assimilation of those truths is the unobserved and unintended process by which every generation achieves its growth and development.

The keynote of the late seventeeth century was dualism; a dualism was created by leaving untouched the traditional view of Reason while new emphasis was laid on the body and its functions. The increased weight of learning turned the scales in favour of experimental knowledge, till finally intellect and "pure reason" were deemed of no account; thus the eighteenth century passed over from the equilibrium of dualism to a thoroughgoing scepticism. There is no possibility of mistaking the accents of Hume or Voltaire or LaMettrie, or even Cabanis. Hume disputes the power of reason to do anything but calculate; Voltaire is unwearied in the slaughter of all things that are transcendent and too high for us so that we cannot attain unto them; La Mettrie looks for salvation in efficient causes and developes the Cartesian formula into the notorious phrase "man the machine"; Cabanis meditated on the heads that were severed by the guillotine from their bodies, and noted in the opening and closing of the eyes a proof of the fact that bodily movement may be independent of will. The famous phrase created by Cabanis when he declared that "the brain secretes thought as the liver secretes bile," was in essence only the formula of a scientific method; it became in fact a bitter reproach as it gradually took on the character of a materialistic dogma.

Such was the general drift of thought. What was its total meaning? Perhaps the truest estimate would be given by saying that men passed from dislike of the superhuman to glorification of the human, and thence slipped by imperceptible degrees to a lower level where the merely human became itself extraordinary. In a maze of complicated machinery all sense of simplicity vanished; reality could not be seen through the mist of representative ideas; benevolence could not be conceived as even possible in a world of self-seeking tempered only by hypocrisy; law, order, and government became inexplicable absurdities in view of the fact that the world, never very intelligible, was now openly regarded as having no intelligence to give its procedure significance. Paley might argue to infinity about the watch that resembled the universe and testified to intelligent workmanship, but for the average man the results were negative; neither the world nor the watch mattered, for space and time were both alike meaningless.

Speaking very generally one may safely assert that the Cartesian doctrine of "animal-machines" affected the eighteenth century deeply. The results may be summed up as follows: Firstly, there is a direct line of development from the Cartesian formulæ to the epoch-making work done at the close of the century on reflex action; before the nineteenth century was more than a year old every man of intelligence might know that a large part of his organism was wholly beyond the reach of his will or his intelligent control. Parallel with this physiological progress there goes a steady development of psychological theory toward a practical acknowledgment that man is wholly made by circumstances; his mind is the accumulated mass of his ideas, the alluvial deposit of a lifetime. Lastly, morals and politics caught the contagion; the moral standards became less and less distinguishable from the bald record of customs, and made little headway against the growing conviction that "what is, is right"; political theory, having abandoned Filmer and the fantastic habit of beginning from Melchisedec, passed from a natural man (whom Nature frankly disowned) to a still more blatant type also called "natural," but in every sense a manufactured article.

It has occurred to many people at different times that the most comprehensive question we can ask to-day is based upon the historical evolution which I have thus suggested rather than traced. That question might be put in this form: What place has reason in modern life; or again we might ask: Is democracy naturally allied with the philosophy which calls itself irrationalism? From answering that question man may be absolved; he is not only a little lower than the angels, but also a little less reliable than the minor prophets. But something may be done toward analysing the situation, and for this our earlier study gives us guidance since it indicates where and how the influences may be found at work.

In the first place, modern physiology and biology have tended to emphasise the original doctrine of Descartes; we are largely automatic in the sense that our life comprises tropisms, reflexes, hereditary tendencies, habits, brain-paths or even hereditary memories; we virtuously get up steam, but the permanent way is laid and we are but rolling stock; a Huxley arises to defend in essence the Cartesian automatism and complete the condemnation of reason by making consciousness a by-product or epiphenomenon.

To the sciences of the body must be added the science of mind. The great French anatomist, Bichat, bequeathed a part of his doctrine to Schopenhauer and from the original stock sprang the first doctrine of the Unconscious, a strange growth half physiology and half Buddhism. The great English doctor, Hartley, inspired the work of Charcot, and so indirectly produced that school of psychology which is to-day one of the brightest ornaments of French learning. From this school we have learned much about the nature and meaning of consciousness, to which must now be added as much of Freud's work as seems to the individual good. However much we leave unappropriated, there must inevitably remain enough to leaven the whole lump. The gradual but sure removal of one belief after another had, before 1860, created a profound sense of despair in some, of hope in others. The physiologists of 1860 were conscious of their aims; they were not only advancing the science of membranes and tissues; they were also emancipating the human race from the superstitions which had established themselves as eternal truths under the titles, "Soul," "Freedom," "Immortality," or "God." The materialism made in Germany, no less than its predecessor the German metaphysics, became for a time the fashion. Its subtle but widespread influence was curiously reinforced by the sudden irruption of evolutionism into the arena of human thought. Man could now be exhibited as physiologically a machine, and genetically a monkey. The soul which Descartes never openly repudiated but kept in splendid isolation as a fragment of the Divine lodged in an animal organism, now seemed threatened with final extinction. Theology took up arms for a lost cause and numberless essays or books were produced under titles which were all variations of one topic—science and the faith. These have hardly yet faded from the memory of living men; eminent divines and famous politicians joined in that historic struggle and witnessed to at least one thing—the importance of scientific thought in questions of public morality and social progress.

I have called this a lost cause for one particular reason: the opponents of science ignored the question of method and challenged the facts. On that ground they were destined to inevitable defeat. This in time became evident and a more fruitful line of thought emerged as soon as it was possible to see that the analytic method of science was not identical with the historical method as applied to social and political movements. Then a new school of thought arose which concerned itself less with traditional beliefs than with the foundations of belief, and broke away from the whole mechanical school by making science the instrument rather than the arbiter of human purposes. There, to a large extent, human thought stands to-day. Science is regarded as a vast organisation of means, but the ends which it serves are not created by it; they arise in a world of desires and purposes which neither physics nor chemistry nor even psychology can so much as pretend to resolve into atoms or "mind-stuff."

The deliverance from mechanism to which Bergson has perhaps given the most widely influential expression, leaves us in a precarious position. There can be little doubt that this deliverance has been mistaken for a proclamation of lawlessness. For science the unit is always a strictly definable ultimate regulated by the laws of the system to which it belongs; this is an indispensable requisite of strictly scientific method. But the individual creature is not such a unit, or at least cannot be known sufficiently to be recognized as such. It has accordingly seemed justifiable to speak of a creative element in individual activities, a creative synthesis or a creative evolution as the case requires. If we go from the individual to the group or the society a further difficulty arises; for there may be laws of groups that are not laws of individuals, and laws of social progress which, like calculations of probability, are true of the whole without being true of any one part. To the formulation of these laws a great deal has been contributed by the study of primitive man; we have learned to see how the individual is dependent on relatively permanent factors such as the customs of the tribe; and in this way many have been led to formulate individual action as a function of imitation, since the individual copies and repeats the pattern of life set before him. Thus once more the automatic appears, for imitation is psychologically automatic in character and has no connection with fully rational conduct.

In so far as a democracy professes to let everyone count for one and to give weight to every expression of opinion, it becomes vitally important to know what actually lies behind every purpose or opinion. It is at present rather the fashion to emphasise spontaneity, to decry logic, and to put an exaggerated value on expression for its own sake. In this way the distrust of reason is shown; with it goes a distrust of education as distinct from manual training; and finally a distrust of law, whether natural or political, as something invented by the superior person to bind with fictitious chains the unenlightened. Philosophy did not cause the recent war, nor has it caused the subsequent anarchy; but it must of necessity be an active power in war and revolution and peace, because men love to justify their actions and the justification becomes the philosophical creed in which the spirit of action is embodied. Marxism, syndicalism, Bolshevism, and the other modern developments are all rooted in a scheme of ideas which is as truly a philosophy as Platonism, Hegelianism, or the new realism. This we must sooner or later face, and first of all we must be clear about our original question—is life essentially rational or irrational?

Lord Lovel and Lady Nancy; a Traditional Ballad

BY W. J. WINTEMBERG

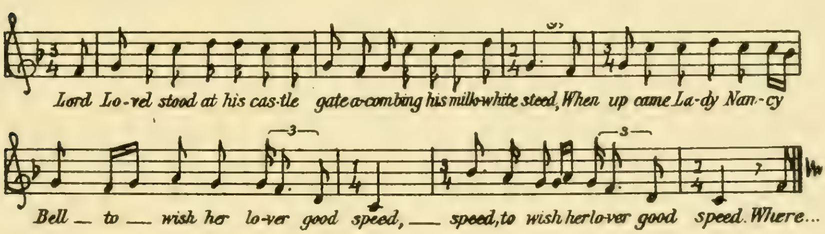
Presented by LAWRENCE J. BURPEE, F.R.S.C.

Read May Meeting, 1919

Although in the United States the collection of folk ballads has been carried on for some time, the Canadian field has until recently been neglected. That there is abundant material in Canada has been shown by Mr. C. M. Barbeau's large collections from both French and English-speaking Canadians.

So far only one version of "Lord Lovel," a traditional ballad handed down orally in Great Britain, probably for several centuries, has been recorded in Canada. It was recited to us by Mrs. Katherine H. Wintemberg, who learned it from an old woman, when a child, near Nenagh, Grey county, Ontario.

a THE CANADIAN VERSION[1]



Lord Lovel stood at his castle-gate
A-combing his milk-white steed,
When up came Lady Nancy Bell
To wish her lover good speed, speed,
To wish her lover good speed.

"Where are you going, Lord Lovel?" she said,
"Where are you going?" said she,
"I'm going away, Lady Nancy Bell,
Strange countries for to see, see,
Strange countries for to see."

"When will you be back, Lord Lovel?" she said,
"When will you be back?" said she.
"In a year or two or three, at the most,
I'll return to my fair Nancy, cy,
I'll return to my fair Nancy."

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[1] The melody was recorded and transcribed by C. M. Barbeau.

He had not gone but a year and a day,
Strange countries for to see,
When anguishing thoughts came into his mind,
Lady Nancy Bell he would see, see,
Lady Nancy Bell he would see.

He rode and he rode on his milk-white steed
Till he came to London town,
And there he saw the church-steeple top,
And the people all mourning round, round,
And the people all mourning round.

"Oh, what is the matter?" Lord Lovel he said,
"Oh, what is the matter?" said he.
"A lord's lady is dead," a woman replied,
"And some call her Nancy, cy,
And some call her Nancy."

He ordered her grave to be opened wide,
The shroud to be turned down,
And there he kissed her clay-cold lips,
Till the tears came trickling down, down,
Till the tears came trickling down.

Lady Nancy died, as it might be, to-night;
Lord Lovel died as to-morrow.
Lady Nancy died of pure, pure grief;
Lord Lovel died of sorrow, sorrow,
Lord Lovel died of sorrow.

Lord Lovel was laid in St. Bernard's church;
Lady Nancy was laid in the choir.
And out of her bosom there grew a red rose;
And out of her lover a brier, brier,
And out of her lover a brier.

They grew and grew to the church-steeple top,
Where they could grow no higher;
And there entwined in a true lover's knot,
For all true lovers to admire, mire,
For all true lovers to admire.

b English and American Variants

With the exception of a few minor differences, it is substantially the same as version *H*[1] of Francis Child's monumental collection of *English and Scottish Popular Ballads*.[2] Child's sources for his variant *H* are a London broadside in Dixon's *Ancient Poems*[3] and Davidson's *Universal Melodist* (I, 148).

The most marked differences between our variant and that of Child's are to be found in 5 and 9. Child's fifth stanza:

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[1] Part III, p. 211.

[2] Published in five volumes of two parts each, Boston, 1882–1898.

[3] *Ancient Poems, Ballads and Songs of the Peasantry of England*, p. 78, Percy Society, Vol. XIX.

"So he rode and he rode, on his milk-white steed,
Till he came to London town,
And there he heard St. Pancras bells,
And the people all mourning round."

In the ninth stanza, Lady Nancy—not Lord Lovel—is laid in the church, and he "was laid in the choir."

Several versions of Child's variant *H* have been independently recorded in the United States. Three are given by Phillips Barry, in his "Traditional Ballads in New England,"[1] which differ but slightly from *H*, the third being a mere fragment. "St. Pancras bells" become "St. Patrick's bells" in Barry's *A*, stanza 5, line 3. The first lines of stanza 9, are entirely different:

"They buried them both in St. Patrick's churchyard,
In a grave that was close by the spire."

In Barry's *A* 2, stanza 1, line 1, Lord Lovel "stood by his garden gate," instead of the usual "castle gate."

H. M. Belden[2] has published two variants (*a* and *b*)[3] in his "Old Country Ballads in Missouri." Compared with ours, Belden's versions offer some differences. Lord Lovel replies to Lady Nancy:[4]

"I'm going to travel this wide world round,
Strange countries for to see."

Stanza 5, the second last line:

"But when he came to his native city
He found the people mourning round."

Stanza 8:

"Lady Nancy she died as it were to-day,
Lord Lovel he died to-morrow;
Lady Nancy was laid in St. Peter's churchyard,
Lord Lovel was laid in the choir."

Stanza 9, the first lines of which do not occur in any other recorded version:

"And there they laid for many a year,
And there they laid, these two" . . . .

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[1] *The Journal of American Folk-Lore*, Vol. XVIII, 1905, pp. 291–293.

[2] *Ibid.*, Vol. XIX, 1906, pp. 284–285.

[3] Belden's *B* does not differ much from Barry's *A*.

[4] Stanza 2, lines 3 and 4.

In a variant[1] from the Southern Appalachians, Lord Lovel[2] (as in Barry's *A* 2)

> ". . . . was at his gate side
> A-currying his milk-white steed."

It includes a stanza that may have been borrowed from some other ballad:

> "Go dig my grave," Lord Lovel he said;
> "Go dig my grave," says he.
> "For I have no longer in this world to stay,
> For the loss of my Lady Nancy."

Child gives nine other variants of "Lord Lovel,"[3] in which many important divergences from our version may be noticed.

In variant *A*, apparently the earliest printed record,[4] the name of Lord Lovel's lady love is "Ouncebell." The name "Ounceville" occurs in *C*, "Oonzabel" in *E*, "Isabell" in *G*, and "Anzibell" in *J*. These are mere perversions of the same original name.

The name "Lovel" also undergoes some modifications in spelling. Thus, in *C*, it is "Travell," and in *G*, "Revel." In *B*, a variant from Scotland, the name naturally becomes "*Lavel.*"

From other variants we learn that the Nancy Bell of our version was more than a mere Lady—she was a king's daughter.

The lines, in two of Child's variants:

> "Dey down, dey down, dey down dery down,
> I wish Lord Lovill good speed!"

and

> "Hey down, hey down, hey derry, hey down!" etc.,

are also to be noticed.[5]

The stanza of variant *B*, in which the grief-stricken lover cries,

> "O hast thou died, Fair Nancybelle,
> O hast thou died for me!
> O hast thou died Fair Nancybelle!
> Then I will die for thee,"

does not occur in any other known ballad of the Lord Lovel type.

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[1] *English Folk Songs from the Southern Appalachians*, comprising 122 songs and ballads and 323 tunes. Collected by Olive Dame Campbell and Cecil J. Sharp. (New York and London, 1917.)

[2] This variant lacks stanza 8, and the last two stanzas.

[3] Part III, pp. 207–212, and IV, p. 512.

[4] From the "Percy Papers, communicated by the Rev. P. Parsons of Wye from singing; May 22, 1770, and April 19, 1775." (Child, Part III, p. 209.)

[5] Variant *A*, Stanza 4, line 3, and Stanzas 2 and 4, line 3 of Variant *E*.

In variant *E* (stanza 8, lines 3–4) Lord Lovel,

> ". . . . drawing forth his rapier bright,
> Through his own heart did it run."

This, Child thinks, "should, perhaps, be considered as taken from 'Lord Thomas and Fair Annet,' since in no other copy of 'Lord Lovel' and in none of 'Fair Margaret and Sweet William' does the hero die by his own hand."[1]

Now turning again to our version, let us notice a few of the more interesting features. As in most ballads of the "Lord Lovel" set, it opens with Lord Lovel

> "A-combing[2] his milk-white steed,"[3]

a rather menial occupation for a courtly knight. This may suggest a plebian origin for the ballad, but it may also be due to the influence of its long enshrinement in the memory of the common people. In Child's *F*, Lord Lovel is represented as "*mounting* his milk-white steed." In all but one version (Child's *D*) the steed is of this color. Milk-white steeds are a commonplace idea in ballads.[4] Sometimes also they are "berry-brown," or "dapple-grey," but seldom black.

In our version Lord Lovel's motive for leaving Lady Nancy Bell is "Strange countries for to see"; and it is the same in all other variants of Child's *H* and also in *D*. In Child's *B* he is

> ". . . . going to merry England,
> To win your love aff me."

In *J*, also, he is

> ". . . . going unto England,
> And there a fair lady to see."

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[1] Part III, p. 204.

[2] More literally "a-currying," in the lines from the Appalachian ballad, quoted above.

[3] *Cf.* stanza 1 of Child's variant *D* of "Child Maurice":

> "Gill Morice stood in stable-door,
> With red gold shined his weed;
> A bonnie boy him behind,
> Dressing a milk-white steed."

(Part IV, p. 268). See also

> "Childe Waters in his stable stoode,
> And stroaket his milke-white steed,"

(Child, "Child Waters," *A*, stanza 1, ll. 1–2; III, p. 85); and

> "Lord Thomas stands in his stable-door,
> Seeing his steeds kaimd down,"

(*F*, stanza 1, ll. 1–2, p. 93).

[4] Child, Part II, pp. 339–340.

His destination is "London toun" in *A* and G, and in *E* he

". . . . must needs be gone,
To visit the king of fair Scotland."

In the third stanza Lord Lovel promises to return "In a year or two or three at the most." This is also the time limit in all other versions of Child's *H*. In variant *F* he is to return "before six months are past," in *A* he is to be gone two years, in *G* and *J* three years, and in *B*, *C*, and *D* seven years. In all versions but *F* he returns before the expiration of the time to find that his lady-love has died of grief during his absence, and he also dies the following day; "an easily conceived tragedy," as Henderson says, "if it but seldom happens."[1]

The coming back or reappearance of a lover to find that his beloved has died occurs in other European folk-songs and ballads (principally German, Scandinavian and French). The theme has been so thoroughly discussed by Child in his introduction to "Lord Lovel"[2] and also more briefly by the Countess Martinengo-Cesaresco in her *Essays in the Study of Folk-Songs*[3] that I will merely refer to it here.

We now come to the most interesting part of the ballad, the burial of the two lovers, and, as Child says, "the beautiful fancy of plants springing from the graves . . . and signifying by the intertwining of stems or leaves, or in other analogous ways, that an earthly passion has not been extinguished by death."[4]

c. Analysis of the theme of the intertwining shrubs.

The underlying idea of the ending in Child's *A*, *B*, *E*, *F*, and *I* is the same as in our version. The main theme, however, is not confined to ballads of the Lord Lovel type, for it also occurs in "Earl Brand," "The Douglas Tragedy," "Barbara Allen," "Fair Janet," "Lord Thomas and Fair Annet,"."Fair Margaret and Sweet William," "Lady Alice" and "Prince Robert."

In all these there is quite a diversity in the places of burial. The lovers most often are buried in the church choir (or *quire*), and

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[1] Henderson, T. F., *The Ballad in Literature*, (Cambridge University Press, 1912), pp. 38–39.

[2] Part III, pp. 204–206. Other parallels are cited in Part IV, p. 512; VI, p. 510; VIII, p. 471; IX, p. 225, and X, p. 294.

[3] (London and New York, n. d., *Everyman's Library*), pp. 37–38.

[4] Part I, p. 96.

The theme has also been discussed in *Mélusine*, IV, 60, 85, and 142, and V, 39.

sometimes in the higher or lower chancel, in the high chapel, by the church door, and "in the east" and "in the west" of the church. Often, too, they are buried "beyond Kirk wa'," in the churchyard, in the "cold" churchyard, sometimes one in one churchyard and the other in another, but rarely beside each other. In one ballad the lover is "laid in the mire." In many of the ballads the names of the churches are given: St. Bernard's—as in our version,—St. Pancras, St. Peter's, St. Patrick's, St. John's, and Marie's, Lady Mary's, or St. Mary's. It might be of interest to note that most of the ballads in which the name is given as "Marie's church" are from Scotland. These may have been influenced by "The Douglas Tragedy," which was supposed by Sir Walter Scott to be founded in some actual event.[1]

The plants springing from the graves, in all these ballads, are the rose or the brier, and the birch. The roses are most frequently described as red or blood red. Lily-white roses occur in only two variants[2] and a green one in another,[3] which last must refer to the color of the bush. They usually spring from the grave itself, sometimes from the heart or breast of one of the lovers, and grow to the "church-steeple top," or to the top of the church, where, in most instances, they twine together "in a true lovers' knot."[4]

Several ballads have an additional stanza describing the subsequent destruction of the plants. In one of these (Child's *A*), it is:

"An old wowman coming by that way,
And a blessing she did crave,
To cut off a bunch of that true lover's not
And bury them both in one grave."

In "Fair Margaret and Sweet William" we find a different form:

"Then came the clerk of the parish,
As you the truth shall hear,
And by misfortune cut them down,
Or they had now been there."[5]

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[1] Scott, in a note to "The Douglas Tragedy," says "the chapel of St. Mary, whose vestiges may still be traced upon the lake, to which it has given name, is said to have been the burial place of Lord William and Fair Margaret," the hero and heroine in the tragedy. (*Minstrelsy of the Scottish Border*, Vol. III, pp. 244–245.)

[2] Child's "Lord Lovel" *E*, stanza 9; also in a version of "Barbara Allen," in the *Journal of American Folk-Lore*, XXVIII, p. 145.

[3] "Lady Marget" (9), *ibid.*, p. 155.

[4] In Child's "Lord Lovel" *I*, stanza 17,

"The tops of them grew far sundry,
But the roots of them grew neer."

[5] Percy's *Reliques*.

The concluding verse in Child's variant *A* of "Lady Alice":

> "The priest of the parish he chanced to pass,
> And he severed those roses in twain;
> Sure never were seen such true lovers before,
> Nor e'er will there be again,"

is similar.

The ending in "The Douglas Tragedy,"

> "But bye and rade the Black Douglas,
> And wow but he was rough!
> For he pull'd up the bonny brier,
> And flang'd in St. Mary's loch,"[1]

as Scott says, far surpasses the others.

In a variant of "Fair Janet" given by Child (VIII, 466) the final verse reads:

> "Till by there came an ill French Lord,
> An ill death may he die!
> For he pu'd up the bonnie brier,
> . . . ."

See also the concluding verse of "Giles Collins," in Child VI, p. 515.

In English and Scottish ballads the sympathetic plants, as we have seen, are mainly the rose or the brier, and the birch. In continental ballads, reference is made to many more trees, shrubs or plants; but there does not seem to be a single instance of the British rose and brier or brier and birch. The folk-poet preferred the trees and flowers of his home land, in some cases because they were sacred or symbolical of purity.

Let us study the diffusion of this folk-lore theme with reference to the various plants growing from the lovers' graves. We find occurrences where: (1) there are two kinds of trees; (2) the trees or plants are of the same kind; (3) the trees or plants do not spring from the graves but are planted; or (4) a single tree or plant is mentioned.

(1) The rose does not occur as often as one would expect, in most instances being one of two trees springing from the graves. In a Breton folk-song, a tree grows from the lover's grave and a rose from the maiden's.[2]

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[1] Scott, *op. cit.*, p. 245.

[2] Child (VIII, 443) citing Luzel (Paris, 1890). *Cf.* also the ballad "Le Plongeur," in *Mélusine*, III, 453–454.

In a Swedish ballad, Rosea Lilla and her lover, a duke, are buried south and north, in a churchyard, and a rosebush growing from the grave of Rosea Lilla covers the grave with its leaves. The lover is then laid in her grave, and a linden springs from it.[1] A Bulgarian song speaks of a youth growing up as a rose-tree and the maid as a grape vine.[2] In another song from the same source it is a rose and vine. In two Croatian songs, it is also a grape-vine and a rose; the youth (in one of them) is buried behind the church and the maid before.[3] In a Servian song, a red rosebush growing from one grave twines around a green fir rising from the other.[4] A rose and a lily, in a Slovenian song, issues from the graves of two lovers, buried east and west (of a church?) and mingle their growth.[5] In a Galician song a rose and a sage plant spring from one grave and a rosemary from the other; the flowers interlace.[6] According to a Turkish tale, Sora Chenim goes down into the grave of Taji Pascha, which opens to receive her. The "black heathen" orders one of his slaves to kill and bury him between the two lovers. Taji Pascha grows up as a poplar, Sora Chenim as a rosebush, and the "black heathen" as a thorn.[7] The plants are roses and canes in "Dom Diniz," a Portuguese song,[8] and in another, "The Princess Pèlerine," roses and pines.[9]

In countries where it flourished, especially in Greece, the cypress frequently appears in folk-songs. In one case, the lovers embrace, fall dead; a cypress and a lemon-tree spring from their graves.[10] It is a cypress and an apple-tree, in another.[11] In a song from the Peloponnesus, the lover becomes a reed, the girl becomes a cypress, and

"The reed to kiss doth bend his head, he bends to kiss the cypress."[12]

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[1] Child (I, 96) citing Arwidsson (Stockholm, 1834–42).

[2] *Ibid.*, (VI, 498) citing Miladnov, (Agram, 1861, and Sophia, 1891). Also G. Meyer, in *Mélusine*, IV, 87.

[3] *Ibid.*, (VI, 498) citing Kurelac, (Agram, 1871).

[4] *Ibid.*, (I, 97) citing Talvj (Leipzig, 1853). Also Dyer, *The Folk-Lore of Plants*, p. 12, citing what is probably the same song; and Grimm, *Teutonic Mythology* (Stallybrass trans.), Vol. II, p. 827, citing Vuk, I, No. 137.

[5] *Ibid.*, (II, 490) citing Stùr, (Prague, 1853).

[6] Karlowicz, J., Les deux arbres entrelacés, *Mélusine*, Paris (1890–91), Vol. V, 42.

[7] Child (X, 285–6), quoting Radloff. (St. Petersburg, 1885–86).

[8] *Ibid.*, (I, 97) citing Veiga. (Lisbon, 1870.)

[9] Puymaigre, Theodore, Comte de, *Choix de vieux Chants portugais*, (Paris, 1881), pp. 16–17, citing Almeida-Garrett.

[10] Child (I, 97, 200; IV, 498) citing Chasiotis and Sakellarios (Athens, 1866, 1868).

[11] *Ibid.*, (I, 97) citing Sakellarios.

[12] Garnett, Lucy M. J., *Greek Folk-Poesy* (Guildford, 1896), Vol. I, p. 148.

A mother, in another Greek song, poisons her son's wife and he kills himself,

"And there where buried they the youth, grew up a tall green cypress;
And there where buried they the maid, a reed grew, tall and slender.
The pliant reed doth bend its head, and kisses it the cypress.
Then when the *skyla* mother saw, whose jealousy had slain them—
'Ah see! [said she] the unhappy ones, see those who loved so fondly!
If they, when living, never kissed, dead, they may kiss each other!' "[1]

Child (I, 97) cites other Greek songs in which cypresses and reeds spring from graves. In one of these the reeds and trees bend toward one another "and kiss whenever a strong breeze blows."[2]

In the Portuguese ballad of "Count Nello," the king, who had forbidden the marriage of the count and the Infanta, orders the count to be beheaded. The count is buried near the porch of the church and the Infanta at the foot of the altar. From one springs a cypress, from the other an orange-tree, and their branches join and kiss. The king has the trees cut down, noble blood flows from the cypress, from the orange-tree blood royal, and from one flies forth a dove, from the other a wood-pigeon. They perch before the king at his table, and he cries, "Ill luck upon their fondness, ill luck upon their love! Neither in life nor in death have I been able to divide them."[3]

The cypress in Russian ballads is also one of the trees. In one, Vasily, the lover, is laid on the right and Sophia on the left (of the church ?), and from their graves grow a golden willow and a cypress. The trees are destroyed by the hostile mother.[4]

The same kind of trees occur in a different Russian song; and in another, it is a silver willow and a cypress.[5]

In a Neapolitan-Albanian ballad, a youth is killed and the beloved girl dies. Both are covered up with stones; from the youth comes up a cypress, and from the damsel a vine, which clasps the cypress.[6] This also occurs in another song of the same people, "but inappropriately, as Liebrecht has remarked, fidelity in love being wanting in this case."[7]

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[1] Garnett, *op. cit.*, p. 160.

[2] Child (III, 206).

[3] Puymaigre, *op. cit.*, pp. 47–48; and Countess Martinengo-Cesaresco *op. cit.* Child (I, 97) cites Almeida-Garrett (Lisbon, 1863), Braga (Coimbra, 1867), and Hartung (Leipzig, 1877).

[4] Child (IV, 498) citing Bezsonof (Moscow, 1861–4).

[5] *Ibid.*, (II, 489) citing Hilferding (St. Petersburg, 1873).

[6] *Ibid.*, (I, 94, 97) citing de Rada.

[7] *Ibid.*, (I, 97) citing Camarda.

In a Roumanian ballad a fir and a vine grow from the graves and meet over the church.[1] From the youth, according to a Servian text, grows a pine and from the maid a grape-vine.[2] The vine twines around the pine, in a Servian song.[3]

In Bulgaria, a song mentions a poplar growing from the girl's grave and a pine from her lover's.[4]

Several instances are to be found in Portuguese songs: in "Dom Doardos," it is an olive and pine trees;[5] in "A Ermida no Mar," it is a clove-tree and a pine; in "Filha Maria," it is a tree and pines;[6] in another song, a clump of pine trees grows over the grave of the knight and reeds on the grave of the princess. Though cut down, these plants grow again and are heard sighing in the night.[7]

It is a green maple and white birch, in a Russian song, the maple springing from the man who is buried under the church and the white birch from the woman buried under the belfry.[8] In the following Little-Russian ballads: (1) a maple growing from the man's grave and a white birch from the woman's mingle their leaves;[9] (2) the lovers are buried apart and a green plane tree grows from his grave and two birches from hers (but the branches do not interlace);[10] (3) the lover is buried on one side of the church and the maiden on the other. On his grave grows a rosemary, on hers a lily, and they both grow so high that they meet over the roof of the church. The girl's mother cuts them down, and the lover, speaking from the grave, upbraids her with the words: "Wicked mother, thou wouldst not let us *live* together; let us rest together;"[11] (4) the lovers are buried apart in the church, and the same kinds of shrub grow from their graves.[12]

A rosemary and a white flower are spoken of in a Croatian song.[13]

The lovers, according to a Hungarian ballad, are buried, one before the altar and the other behind. White and red lilies grow

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[1] Child (I, 97) citing Alecsandri (Bucharest, 1886–7); Stanley (Hertford, 1856), and Murray (London, 1859).

[2] *Ibid.*, (VI, 498) citing Vuk (Berlin, 1854).

[3] *Ibid.*, citing Krasic (Pantchevo, 1880).

[4] *Ibid.*, (VIII, 443) citing *Collection of the Bulgarian Ministry of Instruction.*

[5] *Ibid.*, (I, 97) citing Braga (Porto, 1869), also Hartung.

[6] *Ibid.*, (I, 97).

[7] *Ibid.*, citing Almeida-Garrett.

[8] *Ibid.*, (IV, 498) citing Trudy (St. Petersburg, 1872–77).

[9] *Ibid.*, (II, 490) citing Golovatsky.

[10] Karlowicz in *Mélusine*, V, 40, citing Kolberg (Cracow, 1882–1889).

[11] Child (II, 489), citing Golovatzky. See also Karlowicz, *op. cit.*, 40.

[12] *Ibid.*, (VIII, 443) citing Holovatzky.

[13] *Ibid.*, (VI, 498) citing Kurelac.

from their tombs; and the mother (or father) of one of the lovers wants to destroy the plants.[1]

In the French song of "Les deux amoureux," lavender and a tree grow from the graves.[2]

In the song "Le due tombe," from Piedmont, one of the lovers is buried in the church and one outside. A pomegranate springing from the man's grave and an almond-tree from the girl's grow large enough to shade three cities.[3] In version *D* of the same song, an almond-tree grows from the man's grave and a jessamine from the maid's.

In a Russian song, from the cossack's grave issues a thorn, and an elder from that of the maid. The cossack's mother goes to pull up the thorn and cries, "Lo! this is no thorn; it is my son!" The girl's mother goes to pluck the elder and exclaims, "Lo! this is no elder; it is my daughter!" both mothers being inimical.[4]

From the grave mound of a girl, in an ancient Romansch ballad, grows a camomile plant, from that of her lover a plant of musk, and the plants twine together and embrace.[5]

(2) Often the same kind of tree springs from each grave. Thus, in the Gaelic tale, the lovers Deirdre and Naois, are buried on either side of a loch; fir shoots grow from their graves and unite in a knot above the loch. Twice these shoots are cut down by the king's order, but each time they grow again; the king's wife then intercedes and the third time they are allowed to unite in peace.[6]

An old Cornish tradition (cited by Folkard) describes how "Iseult, unable to endure the loss of her betrothed . . . died broken-hearted, and was buried in the same church; . . . by order of the king, their graves were placed far asunder. But soon from the grave of Tristan came forth a branch of ivy, and from the tomb of Iseult there issued another branch. Both gradually grew upwards, until at last the lovers, represented by the clinging ivy, were again united beneath the vaulted roof of the sanctuary."[7]

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[1] Child (I, 98) citing Aigner.

[2] *Ibid.*, (VIII, 443) citing Daymard (Cahors, 1889).

[3] *Ibid.*, (VI, 498, Version *A*) citing Nigra (Turin, 1888). Also "Fior di Tomba" (No. 19, in the same collection) in which there is only one grave, large enough to contain the maid's parents, her lover and herself; see also the fragments *E*, *F*.

[4] *Ibid.*, (IV, 498) citing Trudy.

[5] Martinengo-Cesaresco, *op. cit.*, pp. 38–39.

[6] Jacobs, Joseph, *Celtic Fairy Tales* (New York and London, n. d.), p. 91. The original of this story is given in the *Transactions of the Gaelic Society of Inverness*, XIII, p. 257. The translation, which is Jacobs' source, appeared in the *Celtic Magazine*, XIII, p. 69, *et seq.*

[7] Folkard, Richard, Jr., *Plant Lore* (London, 1884), p. 389.

In the Breton ballad, "The Lord Nann and the Fairy" two oaks rise from the tomb of a man and his wife the night after their burial.[1]

Two Swedish ballads speak of a linden growing from each of two graves, made east and west of the church; the trees meet over the church roof.[2]

Two rose-bushes spring from the graves, in a Danish song.[3] In others, the plants are lilies, and, in one instance, they interlock over the roof of the church.[4]

In a Norwegian ballad, the lovers are buried north and south of the church, and lilies grow from their graves, over the roof.[5]

In three variants of the German song "Der Ritter und die Maid," the lovers are buried in one grave; three pinks spring from this grave, three lilies from another, and two lilies from a third.[6]

In a Spanish ballad, two olive trees (*olivera y oliverá*) come from the grave, and join when grown tall.[7]

Two pines spring from a grave, in a Portuguese ballad.[8]

In a Servian song, the two intertwining trees are pines.[9]

Karlowicz cites a Little-Russian ballad in which plane trees grow from the graves.[10]

In "Mem and Zin," a Kurdish poem of 1652–53, two rose bushes grow on the graves of two lovers, the branches of which intertwine.[11]

Haxthausen gives an outline of an Armenian poem in which the fire of passion glows so intensely within two reunited lovers that at last it bursts into flames and they are burnt to ashes, which are collected by some friendly hand and buried in one grave, from which at length spring up and blossom two rose bushes with their branches inclining toward one another and seeking to unite, "but a thorny branch,[12] growing up between them, separates them forever."[13]

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[1] Taylor, Tom, *Ballads and Songs of Brittany*, (translated from the *Barsaz Briez* of Vicomte H. de Villemarqué (Paris, 1867), (London and New York, n.d.). Also cited by Child (II, p. 379, 489).

[2] Child (I, 96) citing Arwidsson (Stockholm, 1834–42), and Wigström.

[3] *Ibid.*, (I, 96) citing *Danske Viser.*

[4] *Ibid.*, (I, 96 and VIII, 443) citing Kristensen.

[5] *Ibid.*, (I. 96) citing Landstad (Christiana, 1853).

[6] *Ibid.*, (I, 97—Nicolai and Kretzschmer—, I, 96–97—Uhland, Simrock, Erk, Hoffman and Richter).

[7] *Ibid.*, (II, 489), citing Milá.

[8] *Ibid.*, (VI, 498) citing Romero (Lisbon, 1883).

[9] *Ibid.*, (II, 489) citing Karadshitch.

[10] Karlowicz in *Mélusine*, IV, 88, citing *Zbior wiado.* (Cracow, 1877.)

[11] Child (I, 98) citing *Bulletin de la classe des Sciences historiques . . . de St. Pétersbourg.*

[12] Difference of creed.

[13] Haxthausen, Baron von, *Transcaucasia* (London, 1854), p. 351.

In a Kirghiz story, quoted by Bronevsky,[1] from the graves of two lovers, spring two willows "which mingle their branches as if in an embrace."

In a Chinese legend, King Kang had a secretary named Hanpang, whose beautiful wife he coveted. He threw Hanpang into prison, and his wife threw herself from a high terrace. Disregarding the wishes expressed in a letter discovered in her bosom after her death, the king had her interred in a grave separated from her husband. The same night two cedars sprang from the graves, and in ten days had grown tall and vigorous, while their branches and roots interlaced. The cedars were henceforth called "The trees of faithful love."[2]

In several ballads and romances, the kind of trees or plants is not specified. An Icelandic ballad and an Icelandic saga, for instance, mention two trees which spring from the bodies of Tristan and Isolde—buried on opposite sides of a church—and meet over the church roof.[3]

According to a Hungarian ballad, the lovers throw themselves into a deep lake, plants rise above the water and intertwine. The bodies are brought up by divers and buried in the church where the marvel occurs again.[4]

A mother, in a White-Russian song, in attempting to poison her son's wife, poisons her son also. They are buried separately, one in the church, one in the graveyard. Trees from their graves join their tops.[5]

A Ruthenian song differs from the last only in this: the two lovers are buried on different sides of the church; and the mother while trying to cut down the plants, which meet over the church, is turned into a pillar.[6]

An Afghan song tells how two trees spring from the remains of the lovers Audan and Doorkhaunee who have been buried at some distance from each other, and the branches mingle over the tombs.[7]

(3) We will now consider instances where the two trees or shrubs have been planted on the graves. In the German romances of Tristan,

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[1] Cited by W. R. S. Ralston, *Russian Folk-Tales* (London, 1873), p. 232, *note*.

[2] Gubernatis, A. de, *La Mythologie des Plantes*, II, p. 53, from Schlegel's *Uranographie chinoise*, p. 679.

[3] Child (I, 98) citing several authors (from 1854 to 1885).

[4] *Ibid.*, (I. 98) citing Aigner, *op. cit.*

[5] *Ibid.*, (X, 295) citing different authors.

[6] *Ibid.*, (VI, 498) citing Hermann.

[7] Elphinstone, Hon. Mountstuart, *An Account of the Kingdom of Caubul* (Second edition, London, 1819), Vol. I, p. 297.

King Mark plants a grape-vine over Tristan and a rose over Isolde,[1] and their roots grow down into the hearts of the lovers and the stems twine together.[2]

Brewer (*Dictionary of Phrase and Fable, sub voce* "Ysolde"), says that the lovers were buried in one grave and the rose-bush and the vine which were planted on it "intermingled their branches as they grew up that no man could separate them."

In a Servian ballad, a rose is planted on the grave of the maiden and a vine on the man's, and these embrace as if they were the lovers.[3]

A thorn and an olive, according to a Norman ballad, are planted over the graves, the thorn embraces the olive,[4] and the wood of these trees is used to build a church.

In a version of "Le due Tombe," an Italian song, a pomegranate is planted on the man's grave and a hazel on the other.[5] According to another version of the same song, an almond tree, planted on the girl's grave, is cut down.

The Wends have a song in which a maiden, before killing herself after the death of her lover, orders two grape vines to be planted on their graves. The vines intertwine.[6]

Child, citing some Russian songs in which the trees appear to have been planted, is not altogether clear. For instance, he says "laburnum[7] over Basil and cypress over Sophia, which intertwine." The others cited in the same note may also have been planted.[8]

In a White-Russian song the lover is buried in the church and the maid in the ditch. A plane and a linden are planted on their graves, the plane pierces the wall of the church and embraces the linden.[9] A green oak and a white birch are planted on the graves of two lovers who have been buried one in and the other near the church. The trees touch.[10]

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[1] Ulrich von Thürheim, vv. 3546–50, and Heinrich von Freiberg, vv. 6819–41 (in von der Hagen's edition of Gottfried of Strasbourg's *Tristan*), according to Child (I, p. 98), wrongly make the king plant the rose over Tristan and the vine over Isolde.

[2] Child (I, 98) citing Eilhart von Oberge (Strasbourg and London, 1877), Büsching and von der Hagen (Berlin, 1809).

[3] *Ibid.*, (II, 489) citing Karadschitsch (Berlin, 1854).

[4] Puymaigre, *op. cit.*, p. 189, citing Beaurepaire (Avranches and Paris, 1856).

[5] Child (VI, 493) citing Nigra.

[6] *Ibid.*, (I, 97) citing Haupt and Schmaler (Grimma, 1841, 1843).

[7] Corrected to silver willow in Part IV, p. 498.

[8] Child (II, 489) citing Hilferding, (St. Petersburg, 1873).

[9] Karlowicz, *op. cit.*, 39, citing a MS.

[10] *Ibid.*, citing *Zbior wiado.* etc. (Cracow, 1889).

In a German song a young man feigns death and when his love approaches he springs up and kisses her. "She falls dead with fright, and he declares that since she has died for him he will die for her. So they are buried severally at one and the other side of the church, and two lily stocks are planted, which embrace 'like two real married people.' "[1]

A white and a red tulip are planted on the graves of the lovers, in the Hungarian song of the "Two Princes." Their souls pass into the tulips.[2]

The Irish-Gaelic story of Naisi and Deirdre may be cited here, although the trees were not really planted. King Conor causes the lovers to be buried far apart, but for some days the graves are found open in the morning and the lovers together. The king orders stakes of yew to be driven through the bodies, so that they are kept asunder. Yew trees grow from the stakes, and so high as to embrace each other over the cathedral of Armagh.[3]

(4) Sometimes a single tree or plant springs from the lovers' graves. A few of these, especially lilies, may appear as a sign of innocence and purity, of which Hartland cites a number of instances.[4]

We find an example in Rusticien de Puise's prose romance of Tristan. A green brier issues from Tristan's tomb, mounts to the roof of the chapel, then descends and enters Isolde's tomb. King Mark causes it to be cut down three times, but the next morning it is as flourishing as ever.[5]

In another mediæval romance, we are told that King Mark lays the lovers within a chapel above which he sets a statue of Ysonde, and from Sir Tristan's grave grows an eglantine which twines about the statue. As in the French prose romance, the plant is cut down three times, but it grows again and ever winds about the image.[6]

Child cites a Middle High-German poem, from a manuscript of the end of the fourteenth century, in which a vine is said to have risen from the common grave of Pyramus and Thisbe and descends into it again.[7]

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[1] Child (Part II, p. 506) citing Schröer (Vienna, 1869).

[2] *Ibid.*, (I, 98) citing Aigner.

[3] Gaidoz, H., Le Suicide, *Mélusine*, IV, 12, citing *Transactions of the Gaelic Society of Dublin*, I, 133, 1808.

[4] *The Legend of Perseus* (London, 1894), Vol. I, p. 199.

[5] Scott's *Minstrelsy, op. cit.*, p. 128.

[6] Cox, George W., and Jones, E. H., *Popular Romances of the Middle Ages* (London, 1871), p. 267.

[7] Child (II, 490) citing Köhler.

In a Breton ballad, a *fleur-de-lis* springs from a common tomb even after it is plucked.[1]

According to the Italian song "Il Castello d'Oviglio," a single pomegranate springs from the grave, at the maid's feet.[2]

In German ballads, the plants often are lilies. A maid is buried in the churchyard; her knightly lover under a gallows, and from his grave grows a lily bearing the inscription: "Both are together in heaven."[3]

Finally, the English ballad of "Giles Collins" says:

> "A lily grew out from Giles Collin's grave
> Which touched Lady Annie's breast." [4]

Conclusion

I have shown that the geographical distribution of the main theme is very wide, that it is found among many different nationalities, and that it occurs not only in the folk-ballads but also in the tales of the people.

It is difficult and even impossible to determine whether the concept of the sympathetic plants originated in one or several definite centres from which it spread by diffusion through Europe and parts of Asia. But even if it did originate in several centres it would still probably require centuries for its general distribution in any one area. Those examples in which the lovers are buried in a church or churchyard, being confined to Europe where christianity more generally prevailed, might be grouped together as having a common origin. And the others without church or churchyard, possibly all originating among non-christian people, such as the Afghans, Kurds, Kirghiz, etc., would form another group.

The theme appears very old and was perhaps old when it was incorporated into the different romances of Tristan and Isolde.[5] It occurs in Kurdestan in the sixteenth century and it may have been an old and well-known theme, even then, in that part of the world.

Possibly the theme in most of the ballads of the Celtic, Teutonic, Scandinavian and Latin races, is derived from these early Tristan romances. Sir Walter Scott suggests that the verses in English and

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[1] Child (I, 97) citing Luzel.

[2] *Ibid.*, (VI, 498) citing Ferraro (Turin and Florence, 1875).

[3] *Ibid.*, (I, 97) citing *Wunderhorn* (Berlin, 1857), and Mittler (1855 and 1865).

[4] *Ibid.*, VI, p. 515, Stanza 5, lines 3 and 4.

[5] The metrical one composed by Gottfried of Strasbourg has been definitely assigned to the end of the twelfth century.

Scottish ballads embodying this theme are probably so derived,[1] but Child thinks this is a somewhat hasty assumption, and that the question as to the priority of romances or ballads is an open one.[2] We can be reasonably certain, that these romances, in their turn, were founded on earlier oral traditions.

The idea underlying all these examples seems to be that the trees or plants are, as Hartland thinks, "merely the lovers transformed."[3] It may also be due to "the old superstition of the soul embodying itself in a tree above the grave,"[4] just as, in a Ukrainian song, the rose above a young man's grave is regarded as his soul.[5] Classical mythology is full of such transformations of human beings into plants; take, for instance, the story of Narcissus.

As to the ballad of "Lord Lovel" itself, independent of the theme, we do not know when it originated, or whether the original one was founded on any actual event or not. The earliest copy, "Lady Ouncebell," known to exist, was "communicated by singing" in the year 1770, and it may easily be several centuries older. Our version may be derived more directly from an early broadside, now lost. It is of interest to note in this connection that most of the "Lord Lovel" ballads collected in the United States are of the same type as Child's *H* and our version. Probably they were transmitted to America through the medium of broadsides rather than through oral transmission.

[1] *Minstrelsy*, Vol. II, p. 128.

[2] Part I, p. 98.

[3] Hartland, *op. cit.*, p. 198.

[4] Henderson, *op. cit.*, p. 35.

[5] Puymaigre, *op. cit.*, p. 189, citing Chodzko, p. 30.

The Overland Journey of the Argonauts of 1862

By JUDGE F. W. HOWAY, LL.B., F.R.S.C.

(Read May Meeting, 1919)

The earliest recorded emigration across the prairies to the region west of the Rocky Mountains occurred in 1841, and according to Sir George Simpson, who met them near Edmonton, consisted of twenty-three families. Thirteen years later another party, known as the Sinclair party, numbering sixty-five persons—men, women, and children—followed in their tracks to the Columbia. In this paper an attempt will be made to trace and describe the journey in 1862 of the third immigrant party across the continent through British North America; but the first of such immigrants whose object was to reach a home in British territory. For this purpose liberty has been kindly granted by Mrs. Caroline L. McMicking, of Victoria, to use the original diaries of her late husband, Mr. Robert B. McMicking, and his brother, Thomas R. McMicking. These little books contain the day by day account of the incidents of the whole journey from Queenston, Canada West to Quesnel, British Columbia.

The Grand Trunk Pacific Railway follows, in a general way, the route taken by this party from Winnipeg to Fort George, and covers the distance in three days. We, who travel in luxury at this speed, find it difficult to visualize the slow and steady "grind" of twenty or twenty-five miles a day, the innumerable delays, the constant crossing and re-crossing of rivers and creeks—ferrying, fording, or bridging—the footsoreness, the uncertainties, the wearisomeness, the disappointments and dangers, and the dwarfing sense of man's insignificance that the surrounding vastness impressed upon these pioneers in their four months' crawl across the prairies and the Rocky Mountains. All things are ready-made for the pioneer *de luxe* of to-day; the pioneer of 1862 had to make them for himself.

In 1861 Cariboo had yielded about $2,700,000. Tales of easily-gotten wealth rolled from West to East, and as they rolled they not only increased, but all the asperities vanished leaving with the hearer only a clear vision of gold to be picked up in Cariboo "by the bucket-ful," as one old-timer used to phrase it. But El Dorado was far distant from Canada West. To reach it by the usual route meant a journey to New York, thence by water to Aspinwall, across the isthmus to Panama, by ship to San Francisco, and on to Victoria, thence by river steamer to Yale, and by stage four hundred miles to

Cariboo. Considering the delay and expense of such a voyage, some twenty-four adventurous young spirits of Queenston and the vicinity, lured by the "yellow root of evil," determined to make the Northwest Passage by land.

Setting out from Queenston on April 23rd, 1862, the first link of the journey was to St. Paul, then a busy little town and rapidly growing, but giving no indication of its future greatness. Their route was by rail and boat to Milwaukee, and thence by rail and river steamer to St. Paul. Here the party transferred to Burbank's stages for Georgetown on the Red River, distant about three hundred and twenty miles in the same general northwesterly direction now traversed by the main line of the Great Northern Railway. The stages travelled fifty or sixty miles a day. Georgetown was at that time the head of navigation on Red River. It had been promised them that the steamer *International* would be ready on May 10th to leave Georgetown on her maiden voyage to Fort Garry. The party had consequently timed their movements to arrive at Georgetown on May 9th, only to find the *International* quite unfinished. After eleven days of watchful (but not patient) waiting it was announced that the steamer would sail on May 20th.

During this enforced delay every stage-coach had brought to Georgetown other adventurers bound for golden Cariboo to swell the waiting list, and when the *International* cast off her lines she carried the original party of twenty-four, now grown to one hundred and fifty or more. Unfortunately the steamer was found ill-suited for the river; though drawing only forty-two inches of water, yet her length, one hundred and fifty feet, rendered her extremely difficult to handle in the tortuous stream. In consequence the trip occupied seven days. Accidents seemed to haunt the *International*. It appeared to be impossible to keep her in the channel. Scarcely had she covered two miles the first day when she ran into the brush that lined the banks, tearing off both her funnels. The following day the engine broke down, and the vessel was run ashore for repairs. The next day, while backing in order to turn a sharp bend, she struck the bank and damaged her wheel. Another day she broke her rudder and ran ashore.

Her Majesty's birthday occurred while the *International* was still in the land of the free. The diary thus succinctly describes the day's celebration: "At twelve o'clock noon, hoisted the stars and stripes; twelve-fifteen hoisted the Union Jack, and immediately after fired a salute and immediately after sang 'God Save the Queen.'" Two days later Fort Garry was reached. Hargrave speaking of that event says: "The great bulk of the passengers consisted of about 160 Canadians, who had come with the intention of pioneering an overland route across the continent to Cariboo."

From May 26th till June 2nd the emigrants were encamped in the vicinity of Fort Garry, little dreaming that the unearned increment of the land would in thirty years far exceed the total golden harvest of Cariboo. This period was spent in obtaining horses, cattle, and Red River carts for the journey as far as Edmonton, beyond which point the alleged cart trail did not extend. Red River carts have been mentioned by all visitors to that settlement. They are only another instance of man's ability to fabricate serviceable instruments, if compelled by necessity, out of any materials at hand. The Promyschlenski navigated Bering Sea in crazy vessels of green wood fastened with thongs of deer hide in default of nails to secure the planks properly; the pioneers traversed the broad prairies in just as primitive contrivances; for these Red River carts contained not a particle of metal, being composed entirely of wood and hide.

During this interval the travellers had full opportunity to discuss with the Hudson's Bay Company's officials the best mode and route of travel. They had the benefit of the advice of Governor Dallas; Mr. McTavish, the Governor of the settlement; Mr. Christie in charge at Edmonton; Bishop Tache, and, especially, of Timoleon Love and John Whiteford, the guide. The two last named had made the journey frequently and knew the region from experience.

This delay was moreover really necessary for the success of the undertaking. Had everything been ready it would nevertheless have been the part of wisdom to have delayed so as to obtain the advantage of the growth of the grass on the prairies. In truth the emigrants in their eagerness to reach El Dorado had set out three or four weeks too early.

Like all early travellers the party must have a guide. The orthodox guide in western history deserts his post just at the crucial point when his services are most required. Every care was, therefore, taken in the selection. On Bishop Tache's recommendation the choice fell upon Charles Rochette, a French half-breed, who for $100 agreed to conduct the emigrants to St. Ann's, a missionary settlement a few miles west of Edmonton.

The provisions for the journey were purchased at Fort Garry. They were primitive indeed—flour and pemmican. The flour was manufactured at the settlement, and though good and wholesome, was, of course, somewhat dark and coarse; it cost $3.90 for one hundred and twelve pounds. As to pemmican, it is of various degrees of unattractiveness. The ordinary type, which our travellers obtained, was simply a compound of buffalo meat and grease. Its manufacture is thus described by Milton and Cheadle: "The meat having been dried in the sun or over a fire in thin flakes, is placed in a dressed buffalo skin and pounded with a flail until it is reduced to small fragments and powder. The fat of the animal is at the same time melted down. The pounded meat is then put into bags of buffalo hide, and the boiling grease poured on to it. The mass is well stirred and mixed together, and on cooling becomes as solid as linseed cake." The experience of our emigrants agrees with that of these authors, that though at first decidedly unpalatable, tasting remarkably like a mixture of chips and tallow, yet after a time they became quite partial to it. For this staff of life on the prairies the party paid six cents a pound.

All preparations having been completed the travellers set out stragglingly for White Horse Plains, some twenty-five miles from Fort Garry, the appointed rendez-vous. With the usual optimism of amateurs they had fixed upon the high basis of one ox and cart carrying a load of eight hundred pounds for every two men; experience soon showed that six hundred pounds would have been sufficient. On well-travelled level roads the load was not at all excessive; but it was demonstratively too heavy over rough and hilly roads and especially towards the close of a long day's drive.

Though both Mr. R. B. McMicking's diary and that of his brother are silent upon the point, yet from other sources and particularly from Hargrave's Red River it appears clear that at Fort Garry that strange person, made famous by Milton and Cheadle, "Mr. O'B." (Mr. Felix O'Byrne) attached himself, like a bur, to the emigrants, though not to the Queenston section. It seems that no tale of Manitoba or the West, in the early sixties, can be told without a reference to this peculiar person. Our practical emigrants soon discovered that he was an utterly useless and helpless appendage, and at Fort Carlton on the North Saskatchewan they left the reverend, but not revered, gentleman to shift for himself. Hargrave states that he officiated as chaplain of the section to which he had attached himself. However that may be, those who have read Milton and Cheadle's story and, laughing over his impracticable conduct, may have thought that these authors had invented the character, will readily believe that energetic young men such as composed this party would not sit quietly under the spiritual ministrations of so spiritless a creature.

Gradually the numerous sections that constituted the expedition gathered at Long Lake, where the real formation for the overland journey was to be accomplished. The diary, under date of June 5th, 1862, says: "Rained this morning heavy: are holding a meeting for the purpose of appointing a captain, a committee, and forming general rules for our protection while on our journey. Captain T. R. McMicking (who was in command of those from Queenston) was elected captain over the whole party to Cariboo by unanimous vote of the party." The committee consisted of thirteen members, fairly representative of the constituent bodies. The total enrollment at Long Lake was: Queenston, 24; St. Thomas, 21; Huntingdon, Que., 19; Ottawa, 8; Toronto, 7; Montreal, 7; Ogdensburg, N.Y., 7; Red River, 7; Acton, 6; Whitby, 6; Waterloo, 6; Scarborough, 5; London, 5; Goderich, 5; Chatham, 3; total, 136. This was quite in accordance with American precedent. When the movement towards Oregon was at its zenith, it was the custom of the emigrants to delay their final organization in some cases even for a week or ten days after the journey commenced. Probably this was to enable the people "to find themselves" in their new surroundings.

And now the ninety-seven carts and one hundred and ten animals that carried the emigrants and their Lares and Penates set out from Long Lake, leaving behind them all real civilized life, not to meet it again until two thousand miles with all their dangers happed by land and water should have been slowly and painfully traversed, and then in totally new conditions and amid strange surroundings. We can see the long procession; and the picture is the clearer because of its variance from the familiar scene of emigrants on the way to Oregon. The stately "prairie schooner" is replaced by these little Red River carts, creaking and groaning at every move. Women and children were counted by the dozens—yea, by the hundreds—in the advance to Oregon; but in this company, not one woman nor one child, with the single exception of Mrs. Schubert and her family, who joined it at Fort Garry. Old men were totally missing here, though quite common in the Oregon movement. In truth the Oregon advance was one of real colonization; but this was essentially for a temporary purpose. The road was so indifferent that a guide was necessary to keep the travellers upon the right path; while, in the Oregon immigration, the miscalled Oregon Trail was a broad gash cut upon the bosom of the prairie so deep and clean that it is scarce an exaggeration to say that a blind man could not lose it. Considering that the Hudson's Bay Company and its predecessors had been trading in this region for nearly one hundred years the absence of roads may seem strange; but we have only to remind ourselves that their trade was carried on almost entirely by water communication.

The company on the march and in close order extended over half a mile. Each of the constituent parties kept together, taking the lead in rotation, thus giving to each impartially the opportunity to obtain game and also the use of the road before the soft places had been churned up and rendered difficult to cross. If in the day's march any accident happened the unfortunate cart simply turned aside and fell in at the rear after the repairs had been effected, rejoining its special party at camping time.

At the outset the day's travel consisted of a forenoon and an afternoon drive; the former from five o'clock till noon, the latter from two o'clock till six o'clock, subject, of course, to alteration if suitable camping sites were, or were not, found. Experience soon showed that better results could be obtained by dividing the day's journey of ten hours into three parts. It being the period of long daylight on the greater part of the journey to Edmonton, the camp was alive at 2.30 each morning, and the whole company in motion by the advent of day. After driving for about three hours a halt of two hours was made for breakfast; about eight o'clock the journey was resumed until noon, when a halt of two hours was made for dinner; and about two o'clock the final afternoon drive began, extending until five or six o'clock. In this way, with far less exertion, twenty-five miles a day were easily covered.

Each night the camping place was selected with an eye to the vital questions of wood and water. Preliminary symptoms of the uneasiness amongst the Indians, which culminated during the summer in the uprising in Minnesota, were already apparent. This restive spirit had for some years been growing more pronounced. Hind records that, in 1859, between the Assiniboine and the Saskatchewan he found the Indians determined to establish a toll of tobacco and tea for passing through their lands . Warned by the officers of the Hudson's Bay Company, our emigrants were constantly on the alert against Indian depredations. For protection at night the carts were drawn up in the form of a triangle, within which the horses and cattle were secured. The tents were set up outside the triangle, and a close watch kept by sentries—two on each side—during the hours of darkness. This vigilance, doubtless, contributed largely to their freedom from thefts and other annoyances.

The first two hundred miles, from Fort Garry to Fort Ellice at the confluence of the Assiniboine and the Qu'appelle, was along a road well-marked and way-worn. Crossing the Assiniboine at the Prairie Portage, as they called Portage la Prairie, the emigrants followed the chord of the arc almost due west. Just after leaving that portage the diary records: "Crossed a number of sloughs and some fine creeks . . . were bare-legged a good part of the way." Soon, however, they lost this thoughtful care and waded the creeks and water holes without hesitation or preparation. The diary notes the abundance of game, especially of ducks, on the small lakes and the splendid fish in the swift waters of the Little Saskatchewan.

On June 14th they reached the Assiniboine again and from the top of "a bad stony hill" looked down upon its beautiful valley and that of the Qu'appelle. To reach Fort Ellice the Assiniboine must be crossed. As the only means was a small scow that "carried one ox and cart at a time" it can readily be believed that the transfer occupied from 11 a.m. till 5 p.m. This post, once of considerable importance, stood, a lone habitation, crowning the summit of a small hill, at whose feet flowed a little stream called Beaver Creek. Its trade had gradually disappeared; the only justification for its continued existence was that, being situate on the borders of the great buffalo plains, it was in a position to supply pemmican and dried meat for the use of the brigades and the northern posts. Mr. McKay, the postmaster, is described as "an obliging gentleman who kept a prudent eye to business and a sharp look out after the bawbies."

The following day being Sunday the emigrants, according to their custom, rested. They attended divine service by the Rev. James Settee, the Indian missionary, who took as his text: Song of Solomon, chap. v., 9–10. This gentleman was a native, of Swamp Cree blood. He had arrived in the vicinity in 1859. Upon hearing of his arrival the Indians sent to ascertain whether the "great praying father" had sent plenty of rum; if so they would all become followers of the white man's "good manitou." When the reply came that not only had no rum been sent, but that they were expected to cease bartering buffalo meat for rum, the natives, much incensed, sent further word that "if the great praying father did not intend to send any rum the sooner he took his praying man from Qu'appelle Lakes the better."

Monday morning was spent in repairing the carts and harness in preparation for the long journey to Fort Carlton, on the North Saskatchewan. At the very outset, in descending the hill to the Qu'appelle River, an accident happened. The diary gives the vaguest outline: "Had a bad hill to go down; was very slippery; had been raining all day. An ox ran away belonging to Mr. Morrow, of Montreal. Morrow fell and the cart wheel passed over his head, doing him considerable injury." Dr. Stevenson, who was of the party, attended the injured man, and two days later Morrow and his companions overtook the main body. That very morning the guide, who had been showing premonitory symptoms of dissatisfaction, "borrowed a double barrelled shotgun and ammunition with the intention of going hunting and has not been seen since. We are under the impression that he has deserted us." For a considerable time the company refused to believe in this treachery; but on June 20th, the diary continues, "The guide has not yet been seen." Nor was he ever afterwards seen by them.

From the beginning of their journey Sunday had been carefully observed as a day of rest. Usually a religious service was held, Mr. Fortune, Mr. Robinson, or some other person conducting the meeting. Nothing but stern necessity ever induced the emigrants to break that rule. The entry of June 22nd, says: "Were driven for the first time to the necessity of washing on Sunday."

Eight days after leaving Fort Ellice, during which interval they had lost their way owing to the desertion of the guide and had travelled over very bad roads filled with deep ruts, through a hilly, marshy country abounding in small alkaline lakes, they arrived at the abandoned fort in the Touchwood Hills, a distance of three hundred and eighty-seven miles from Fort Garry. The pools and lakes afforded food and shelter to myriads of geese and ducks, teal, cranes, and bitterns. Our travellers found in them a delightful change from the regular diet of pemmican. Up to June 21st only one ox had been killed for food. As they approached the Touchwood Hills their road passed through a beautiful undulating country of great fertility, plentifully besprinkled with lakes, and covered with a profusion of wild flowers.

Six days later, June 30th, they reached the South branch of the Saskatchewan. The matter of fact recitals of the diary are well exemplified by the entry of this event. Modern travellers would fill a page with what occupies less than a paragraph. "Found the South Saskatchewan a muddy river, about two hundred yards in width. Cross in a ferry boat; about six carts and baggage at a load; swim the animals; all got over at 5.15. Went up the bank and on about a mile and camped at 6 p.m. for the night. A man by the name of Kelso of the Acton party while driving cattle into the river fell in, rose and went down the third time, and was picked off the bottom by a man named Strachan; when brought ashore, life for a while was very uncertain."

About noon on the next day, July 1st, having good roads and driving quickly they crossed the eighteen miles that separate the two branches and reached the North Saskatchewan at Fort Carlton.

This post was about five hundred miles from Fort Garry; seven hundred miles yet lay between them and the great barrier range of the Rocky Mountains. Carlton was of the usual type of trading post: a few wooden buildings within a palisaded enclosure. The facilities for crossing were so meagre that it was almost midnight before the whole company were safely upon the northern bank of the river. No time was lost at Carlton. Having purchased some buffalo meat, the first that they had tasted, the travellers were again in motion by seven o'clock on the following morning.

From this point to Fort Pitt the route was along the north side of the North Saskatchewan. The appearance of the country had changed; it was more hilly and broken. The temperature, especially at night, was much cooler. It became quite difficult for their untrained eyes to keep the trail, which was to be *sensed* rather than seen. The Thickwood Hills were passed on July 3rd, and the Lumpy Hills, July 4th. On that day immense fields of wild strawberries were met. The diary's downright entry runs: "Had strawberries and cream for supper"; but imagination readily draws the picture.

The next day they crossed some particularly bad sloughs. One, a veritable Slough of Despond, as it would seem from the diary's scant remarks, took an hour to cross and was so deep that the animals had almost to swim. A great quantity of the supplies were wetted. But as a recompense they came once more upon good roads and a beautiful region abounding in the most luscious wild strawberries. In a lake beside which they camped and which they supposed to be Pike Lake they caught fine pike. Wolves now appeared in large numbers; at a distance of a hundred yards from the camp they sat and howled through the summer night. Very little wood was to be obtained for the camp fires and the *bois du bison* was neither plentiful nor suitable for illumination. Fording sloughs and creeks, now struggling in the rain along rough, miry roads, and again traversing rich prairie, with the wolves on the flank, just out of rifle range by day and out of eyesight by night they reached on July 8th the North Saskatchewan once more, and on the following day arrived at Fort Pitt.

This fort, on the north bank of the river, about midway between Carlton and Edmonton, was a small establishment and was at that time in charge of Mr. Chantelaine. Like Fort Ellice its principal business was in obtaining supplies of pemmican and dried meat; the buffalo were never far from Fort Pitt. Here an Iroquois named Mitchelle was secured to guide them to Edmonton. Two so-called trails to that fort existed, one on each side of the river. Milton and Cheadle, who passed over in the next spring, chose the northern route; but our emigrants, following the guide's advice, determined to take that on the south side, as being both better and shorter. Having spent the day in making small purchases and in discussing their future movements they once more crossed the North Saskatchewan. The bateau, or row boat as the diary names it, was large enough to carry five or six carts. The animals as usual swam the river.

The next morning the whole camp was in motion at three o'clock. The trail was very rough and scarcely perceptible. "We find the guide very useful," says the diary, "sometimes we could not see any track at all." Antelope were seen, but though given chase none were obtained. A very large wolf, which had boldly ventured into the camp to pilfer, was shot by Mr. Fannin. Up to this time the weather had been generally fine, but now the deluge. From July 11th to July 21st it rained almost constantly. The diary gives a melancholy picture of sodden ground, brimming streams, and soaking clothing. The numerous tributaries feeding the Saskatchewan became so swollen that the regular fording places were quite impassable. During three consecutive days eight bridges from forty to one hundred feet in length were constructed. Any stream less than four feet deep was waded. On one occasion the waters having spread over an adjacent plain the party were obliged to wade waist-deep for more than half a mile. Question arose whether this were really the *Overland Route*, but Mr. Fannin jocularly remarked that it was at least three feet over land wherever he had tried it.

In one of the lulls of the tempest intense fog settled down and they were compelled to encamp at 4 a.m. after only an hour's travel, "the guide not being able to keep the trail." After breakfast "the guide went in search of the tracks, which had been very dim from Fort Pitt; in fact, most of the way, none at all." After five hours' search the trail was found and the journey westward resumed; and drenched by day and chilled by night stolidly they marched along. One Sunday during this trying time Mr. Robinson preached upon Acts xxviii, 15: "He thanked God and took courage," certainly, as the diary has it, "very appropriate for the occasion." The country, generally speaking, was rolling, dotted with groves of birch and aspen and interspersed with occasional bits of prairie which had the appearance of great fertility.

At last about eight o'clock on the evening of July 21st, they, in the words of the diary, "popped out of the bush on the river banks opposite Edmonton, without knowing how close they were to it. It is a splendid looking spot on a level flat. The weather cleared up and looked more like fine weather. The people at the fort were overjoyed on seeing the arrival on the opposite shore, but in consequence of the high water in the river the boats were all taken afloat down the river and they had nothing to cross with; but two men managed to cross in a box." So utterly fagged and travel-worn were they that they rested for a whole week. This interval was occupied in crossing the North Saskatchewan for the third time, in arranging the route of the remainder of the journey, and in exchanging oxen and Red River carts for horses and pack-saddles. After consultation with many of the Hudson's Bay Company's employees the emigrants fixed upon the route via Jasper House and Tête Jaune Cache as being the most direct to Cariboo. They were fortunate in finding an experienced guide, André Cardinal, who had already made twenty-nine trips to Jasper House and had also been frequently from Jasper House to Tête Jaune Cache.

The diary mentions that they saw "great quantity of coal on the banks of the Saskatchewan." There appeared to the diarist to be several parallel beds ranging from two feet to six feet in thickness interstratified with a kind of red clay. He dwells upon the fertility of the soil and states that Mr. Brazeau, the officer in charge, showed them a field which had for thirty years continuously produced fine crops of wheat without the application of any fertilizer. During their sojourn they delighted the inhabitants, then numbering only about thirty families, with a series of concerts in which all the latest 'hits' from Canada were enjoyed by crowded houses. The Rev. Mr. Woolsey, the Methodist missionary, was a frequent visitor at their camp. On Sunday, July 27th, they attended divine service twice, at the fort and at the camp. The diary carefully preserves the text on each occasion. When they had secured all the available horses at Edmonton the emigrants visited the settlement of St. Albans, ten miles from the fort, where after much difficulty they purchased the remainder.

Finally on July 29th the party, now reduced to about one hundred and twenty-five persons, for some of them remained at Edmonton, set out on the last portion of the voyage. Instead of a straggling line of creaking carts, the expedition now consisted of some one hundred and fifty pack animals each loaded with from 150 to 250 pounds, including 56 pounds of flour for each person. A few cattle were driven along for food. All heavy bulky articles had been abandoned and our travellers under the tuition of the guide had mastered that supreme test of western frontier life, the art of loading a pack-horse and of 'casting the diamond hitch.' Three days travel over a rough road, through swamps and brush, and across rain-swollen rivers brought them to the Catholic mission on the shores of Lake St. Ann, fifty miles from Edmonton, where the good Father Lacombe reigned supreme. From this point the road, if such it could be called, led through a succession of swamps, hills and streams, and forests so dense that at times it was necessary to keep men ahead to chop out the brush and fallen timber. In the vicinity of the Pembina River, as a delightful change, they found palatable wild cherries and berries of all kinds in great profusion. On the banks of that tributary of the Athabaska they noticed coal outcropping. "It is seen in beds about six feet deep. Saw a volcano," proceeds the diary, "on one of the high hills; supposed to be coal burning below; smoke rushes out of the top. We are told by our guide that it has burned for a number of years."

On August 5th they crossed the Pembina, which at this point was about a hundred yards wide. The crossing was one of the most exciting of the journey. The water reached to the horses' backs. It was impossible to make a raft and it was too deep for fording. A new plan was evolved; the tents were spread out; the goods placed inside; and then the tents were drawn together like bags. Lines were fastened to the bags and two men on horseback towed them across while two others waded the ice-cold, shoulder-deep water endeavouring to support them and keep them from upsetting. Other goods were carried across by men on horseback who upheld or tried to uphold them on their heads or shoulders. It was indeed a busy scene in that wild and lonely spot; on the one bank the goods being unpacked and made up for crossing; on the other many men busy reassembling them into packs and loading the horses; in the centre the river, full of animals and men going and returning loaded and unloaded; here a couple tugging away against the current with their tent boat, while the luckless wights up to their necks in the water held on behind; there a bewildered equestrian making a vain attempt to guide his steed across the stream, while his nervous friend to whom he had given a *deck* passage held him firmly in his arms and put forth many spasmodic efforts which usually only resulted in wetting them both; and yonder another bold navigator astride an ox, sometimes in the water and sometimes out of it, boxing the compass in his frantic attempts to induce his bovine steed to shape his course towards the setting sun.

Then day after day the diarist exhausts his adjectives in a vain endeavour to do justice to the district through which they are travelling. It appeared to be a succession of beaver swamps, in which the whole train would frequently be mired at once. These swamps were separated by patches of higher ground, indescribably rough and rugged and rocky. In the end he abandons the attempt in disgust, saying on August 8th: "Language is absolutely inadequate to describe it." The next day in the midst of a dense forest of spruce and poplar they came suddenly upon a reminder of our mortality: "A solitary grave sheltered by birch bark, with the inscription on a large tamarac tree facing it, of a wearied traveller, James Mockerty, who died on a voyage to British Columbia in October, 1860."

Soon afterwards they came upon the McLeod River, also a tributary of the Athabaska. This stream they forded with the packs upon the animals. It was not so deep as the Pembina, but the current ran so swift that two of the party were swept off their feet into deep water and were only rescued with great difficulty. For two days they followed the McLeod River, when, emerging from a thick spruce swamp, they obtained their first distinct view of the Rocky Mountains one hundred miles away. "Their dark outline was plainly visible above the level of the horizon, and their lofty snow-clad peaks, standing out in bold relief against the blue sky beyond and glistening in the sunlight, gave them the appearance of fleecy clouds floating in the distance." The company were enraptured with the scene which gave promise of an end of the succession of hills and streams and swamps, and swamps and streams and hills, that had been their portion for so many days. Milton and Cheadle bear eloquent testimony on this subject. They say: "A day's journey on the road to Jasper House generally consists of floundering through logs, varied by jumps and plunges over the timber which lies strewn, piled, and interlaced across the path and on every side. The horses stick fast in the mire, tumble crashing amongst the logs, or driven to desperation, plunge amongst the thickly growing trees at the side, where they are generally quickly brought up by the wedging of their packs in some narrow passage between contiguous trunks."

On August 15th they reached the banks of the Athabaska. There they met a number of half-breed hunters on their way from Jasper House to Edmonton. Having recently killed some mountain sheep they were able to supply the emigrants with fresh mutton, a most unexpected treat. Five days' travel along the south bank of the Athabaska brought them to a narrow gateway at the foot of the Rockies, a scene magnificent and awe-inspiring. Overlooking their camp rose the Roche a Miette perpendicularly for a thousand feet; across the Athabaska rose, still higher, the symmetrical cone of Mount

Lacombe; while, overtopping all, Mount Miette, its craggy peak softened by eternal snows, towered grandly into the clouds.

The trail now led over a high hill and at its greatest elevation passed along a narrow shelf with perpendicular walls of rock above and below, where one false step of man or beast would mean utter destruction. From the top the emigrants could see Jasper House, a post of the Hudson's Bay Company, a perfect picture of loneliness and solitude, so far below them on the opposite side of the river that it seemed a collection of hen-coops. The scarcity of food had begun to tell upon their animals; and hardly a day elapsed without one or more being abandoned.

The crossing place on the Athabaska was reached early on the morning of August 20th. The river was about a hundred yards wide and fifteen or twenty feet deep, and flowing very rapidly. The emigrants at once commenced to build rafts and in three hours all were safely across, the animals swimming as usual. Along the northern bank they continued their march, occasionally pausing to wash its sands for "colours" or to seek their strayed cattle that now wandered further afield for food. The next day they passed the ruins of one of the numerous Rocky Mountain Houses, called Henry's House, situated near the confluence of the Miette. Their route now led up the narrow rocky gorge where flowed the Miette, a swift mountain torrent some thirty yards wide, having a rough and stony bed, with which they soon became well acquainted. In five hours they forded this ice-cold stream seven times. Wet, tired, and altogether miserable, but not downcast, they encamped beside the brawling stream. They crossed the Miette twice more, and, then, bidding a glad farewell to the unkindly river, they came into a region so encumbered with fallen timber that the expedition was compelled to rest, whilst axemen hewed out a roadway through the wooden entanglement. Slowly they made their way westward, and in the middle of the afternoon crossed the divide into British Columbia, though they did not realize the fact until they found streams flowing in the same direction. That night—August 22nd—they encamped on the shores of Cowdung Lake, the source of the Fraser, the golden river of their dreams.

Almost a month had now passed since they had left Edmonton, and food was becoming scarce. The diary, under date August 23rd, states: "Killed an ox this morning before starting; provisions becoming slack; pemmican about done and flour scarce." They had expected to make the trip in two months from Fort Garry, and had considered one hundred and sixty-eight pounds of flour and fifty pounds of pemmican per head to be sufficient. Almost three months had now been occupied and they were still in the mountains and ignorant of the distance yet to be travelled or the dangers yet to be overcome.

The next day being Sunday they were compelled because of the scarcity of food both for themselves and their animals to break their established rule and continue their journey. They dined that day upon what the diary describes as a perfect Epicurean dish—roasted skunk—prepared by their guide in true Indian style. All voted it most appetizing, and concluded that his skunkship was a much-maligned animal. Along the shores of Moose Lake, which they followed on the 25th, they killed porcupines; and that night their food was roasted porcupine and stewed huckleberries. Pasture there was none; the animals browsed from the trees and were in no condition to face the hardships of the daily drive. Each day some were abandoned; for facing starvation themselves the emigrants put forth every exertion to reach civilization. After wading streams and climbing hills for two days more the starving party found themselves on August 27th at the place of which they had spoken so often, Tête Jaune Cache at the Grand Forks of the Fraser. And none too soon! Their food was exhausted and they were relying upon their rifles. Anything edible they greedily seized upon. It is told that one man was found roasting a lariat which though but a strip of buffalo hide he regarded as suitable for food. There they fortunately met Shushwap Indians from whom they received dried and fresh salmon, and cakes made of huckleberries and saskatoons.

Deep in its rocky bed the Fraser rushed impetuously along; on each side rose rounded mountains, tree-covered to their summits; beyond them to the horizon snow-clad peaks upon whose sides as the day waned the colours changed as in a vast kaleidoscope; and towering above all, the giant peak, Mount Robson, now Mount Cavell, a magnificent white cone, silhouetted against the blue.

The remainder of the route was unknown. Their guide could give no information. The Indians whom they met were ignorant. Below them lay the Fraser sweeping onward to the west. Should they venture upon it? Or should they continue overland to Kamloops? Earnestly these questions were debated. Ultimately the party divided. Some twenty persons, including Mrs. Schubert and her family, chose to try the unknown route by way of the North Thompson to Kamloops; but the majority, of whom the diarist was one, determined to essay the Fraser. Hence we do not deal further with the Kamloops party; a summary of their adventures will be found in Milton and Cheadle's volume.

Five days were occupied in making rafts to navigate the river. These were unwieldy contraptions, about forty feet long and eighteen feet wide, lashed together with such unsuitable materials as were at hand. Great sweeps were fitted to them, not for the purpose of propulsion, but to exercise some little control over their otherwise erratic actions. Loading upon these queer vessels the remaining goods and the provisions obtained from the natives, the diminished party on September 1st set out from Tête Jaune Cache. The Indians, amazed at the boldness of the undertaking, looked on in stolid wonder and shook their heads mournfully as raft after raft departed on its perilous journey. At first the rafts drifted rapidly with the swift current of the river; but after a few hours the speed diminished greatly. Other rafts were ahead and behind that on which our diarist travelled—as quaint a procession of Argonauts as the western world has ever seen. Day by day they drifted placidly, uneventfully, into the unknown. The day's voyage lasted from 4 a.m. till 6 p.m. when the rafts were made fast for the night.

So five days went by in monotonous procession, but on September 6th, soon after daybreak, a sullen roar of rushing waters reached them, the forewarning of the Grand Canyon. Immediately they made for the shore which they, fortunately, succeeded in reaching before the indraught of the canyon became perceptible. The rapids, they found on examination, were in three distinct stretches, separated by little bays or eddies of quiet water. The precipitous banks contracted the river into a narrow channel obstructed by rocks whose jagged points ripped it into great, frothy, curling waves as the pent-up waters rushed through with resistless impetuosity and with a deafening noise as of continuous thunder. It seemed like courting death to risk the descent; but the alternative was death by starvation. The raft was lightened and the goods portaged to a place below the rapids. Ten men remained aboard to make the venture. Once the raft was in the current it swept onward into what appeared to be the very jaws of death. In the centre the rocky reef foaming and boiling; on the side the eddying whirlpool ready to engulf all—Scylla and Charybdis. In breathless suspense their companions watched the unwieldy thing rushing with frightful velocity toward the rock. Above nature's tumult and din rang out suddenly the commands of the pilot. Instantly all bent manfully to the sweeps. The rock was passed, but so close that the raft was half submerged and the stern rowlock torn off. Then it shot into the eddy. The tension was over. The suppressed feelings gave voice in cheers and sobs.

The other voyagers and the goods were soon once more on board and the raft resumed her journey.

Emboldened by this success and pressed by the dire need of provisions they determined to float night and day down the stream. All except two or three look-out men lay down to sleep as the unwieldy craft floated on through the night towards the land of their hopes. The next day at dawn they noticed that the speed had perceptibly increased. Almost instantly they found themselves in a long stretch of rapids, extending about fifteen miles. The channel was full of ragged rocks, contact with any of which would unquestionably have knocked the float into its component parts. Now they realized clearly the dangers of night navigation. All hands were at the sweeps again; and they made their way safely through the perilous spot. Then they floated along until about noon, when despite their utmost care the raft struck upon a sunken rock from which their best endeavours could not release it. Fortunately at this point the current was not swift. Three of the party swam ashore with a line and while those on the raft cut away several of the timbers others pulled upon the line and succeeded in getting the raft into deep water once more. They then encamped for the night;. and on the next day, September 8th, reached Fort George, at the junction of the Fraser and the Nechako, without further difficulty.

On their arrival Mr. William Charles, the gentleman in command of the post, was absent; but as his return was expected hourly they awaited his home-coming. Meanwhile other rafts arrived bringing the sad story of the drowning of Mr. Robertson, one of the party. He and two others had set out in a canoe from Tête Jaune Cache, preferring to risk the descent by that mode of travel, rather than to venture on the unwieldy and apparently unmanageable rafts. In the Grand Canyon the canoe was swamped. "Two of them," says the diary, "escaped by holding on to the canoe, and were drifted on an island and picked up by a raft, neither of them being able to swim; while Mr. Robertson, being a splendid swimmer, struck out for the shore and was lost (as the others thought) but a short distance from it. They lost everything they had but a little flour."

After remaining at Fort George for two days in the vain expectation of meeting Mr. Charles, whose return was long overdue, they hired an Indian guide and resumed their voyage. Fifteen miles below Fort George they encountered its canyon, which Fraser has so well described. Here, for a distance of half a mile, the river is cut by huge rocks into several channels. The rugged banks and overhanging cliffs bore a striking resemblance to the Grand Canyon, but the actual dangers were incomparably less. Whatever the dangers might be for canoes the illshaped rafts, though somewhat difficult to control, were found quite safe; for though the waters rolled over them, they rolled off again, doing comparatively little damage. In the afternoon they met the first gold miners—Chinese washing with rockers on the river bank. As they descended they found miners on almost every bar. According to their own stories these Chinese miners were only making five dollars a day each, but the travellers gave no credence to such statements.

On September 11th, they set out early in the morning on their last day's navigation. The weather being foggy, they accidentally ran upon a rock, which could not be seen in time to be avoided. The collision strained the raft greatly, but as the fastenings seemed secure they continued the descent, and about noon reached Cottonwood Canyon. In that narrow channel with its strong current and heavy swells the raft, according to the diary, behaved well, and when it came to the overfall, though the water rolled over it and flooded it as it took the downward plunge, the diarist declares that nothing was injured "where a canoe would undoubtedly swamp."

That day they reached Quesnel, then known as the Mouth of Quesnel to distinguish it from a village higher up the Quesnel river called the Forks of Quesnel. The diarist gives some rather startling prices as prevailing: meals $1.50, flour $1, salt $1, rice 55 cents, bacon 75 cents to $1, beans, 75 cents, tea $2, per pound. The day was fine and pleasant, and, he adds: "I got my supper off a table for the first time in four months at Whitehall store for $1.50."

On the arrival of the other rafts the future movements of the party were discussed at length. As a result the organization was disbanded. Some continued down the river on the rafts; some remained at Quesnel; while others, including our diarist, resolved, even at this advanced season, to go on to the mines at Williams Creek. The latter left Quesnel on September 13th for the Cariboo gold fields. The travelling was very difficult and the trail of the roughest. At the end of a hard and trying day they had only covered thirteen miles. Resuming their journey twelve miles of even worse trail brought them to Cottonwood at the crossing of the river of the same name. As they progressed they met returning miners, each telling a more discouraging tale than his predecessor. It was a real exodus of disappointed men, all striving to reach the coast without delay. They painted conditions at the mines as black and disheartening, prices high, wages low, and work scarce.

Depressed by these stories and concluding that it was unwise to proceed any further towards the mines this season they retraced their steps to Quesnel. Thence they took canoe to Alexandria and on September 18th began a walk of three hundred miles to Douglas on Harrison Lake. As they journeyed they found members of their party who were at work as farm hands, cooks, etc., at wages of $40 to $60 per month. By September 25th they reached Bridge Creek. The Cariboo road was then under construction, and when the road makers were met our diarist engaged as a cook at $40 per month and board. This was the realization of his dreams of affluence and easily-gotten wealth. Yet even here he felt himself fortunate as day by day the ebbing tide of disappointed gold seekers passed on. The reasons for this condition are not dealt with in the diary; they were in all probability unknown to its writer; but they are well-known to all who have studied the story of Cariboo in 1862.

The diarist continued with the road makers until the snow fell. On November 3rd the road camp having been closed for the season he resumed his journey to the coast. As this part of the Cariboo road has been described times out of number it is sufficient to say that on November 16th he reached New Westminster, then the capital of the colony, and the end of his wanderings, for the time.

A Contemporary Account of the Navy Island Episode, 1837

THE HONOURABLE WILLIAM RENWICK RIDDELL, LL.D., F.R.S.C.

(Read May Meeting, 1919)

The following account of the destruction of the "Caroline," etc., was written by George Coventry at the time, in order to be sent to England, where his people resided. It is dated at Chippewa, Upper Canada, 1838, and is in the form of a letter to his sister in England.

George Coventry, whom, when I was a boy, I knew in Cobourg, was born at Copenhagen Fields House at Wandsworth Common in the house "at the corner near the city road" and "within the sound of Bow Bell." His father was a ward of Baron Dimsdale of Thetford, and was placed by his guardian with Jones, Havard & Jones, merchants, in London. His mother was Elizabeth Thornborrow, from Lupton Hall, Westmorland, who was visiting at Sir Joshua Reynolds', when she was won by Coventry. Coventry, Senior, was afterwards a member of the firm of Jayson & Coventry, and seems to have been a man of literary tastes and considerable ability. The son was born on 28th July, 1793. He had the misfortune to lose his mother who died of cancer when Coventry was three years old. The lad was then placed in a Ladies' School, at Peckham, Surrey, kept by Mrs. Freith and her three daughters, one of whom, the elder Coventry afterwards married.

George Coventry was then sent to a Boys' Boarding School at Hitchin, Hertfordshire, kept by Mr. Blaxland, where he stayed for about three years. On the death of Mr. Blaxland, his undermaster, Mr. Payne, started a school near Epping Forest, which young Coventry attended until his fourteenth year when he was sent to Dover where he completed his education. He afterwards engaged as an employee in his father's firm, and in that capacity travelled over the greater part of Great Britain. He also visited France, where he thinks he saw at Fontainebleau some flowers, the offspring of certain plants which he had seen leaving Dover, a present from the Queen of England to the Empress Josephine. He came to Canada in the fourth decade of the 19th century, was an eye-witness of some of the occurrences of the Rebellion of 1837, and returned to England in 1838. Returning to this Province he lived for a time in St. Catharines; afterwards he was in Cobourg, then in Picton as editor of a paper there, then he returned to Cobourg and made that his home for the remainder of his life. He died at Toronto, February 11, 1870, and is buried in the St. James Cemetery at Cobourg.

He left at his death a considerable mass of manuscripts, one being "The Concise History of the Late Rebellion in Upper Canada" from which the accompanying is taken. The greater part of this history, which runs to about 20,000 words, is familiar ground; it does not differ from the current accounts of the rebellion and no small part of it is invective against Mackenzie and his followers. I have therefore not thought it worth while to copy all of it.

Coventry also left a considerable mass of poetry, more or less good; amongst the manuscripts is one seemingly based on Chaucer, which purports to be a poetical account of a fishing and hunting party at Rice Lake—it brings in a great many persons who were well known in Cobourg, Port Hope and the township of Hamilton, and each one of these is made to tell a story. At the present day, the stories are rather vapid and of little interest to anyone except those who were acquainted with the persons to whom they are attributed—I knew most of them by sight and all by name.

He also left a manuscript, "Reminiscences," which contains an account of his life up to the end of the second decade of the last century. He gives an interesting story of John Wesley, which I attach to this paper, and he also has the following:

"I was at Vauxhall the night that George IV died. Everyone was in full black dress, which gave the Gardens a most remarkable appearance. Such a sight will never be seen again, for they are now abolished."

Coventry was employed by the Government of Canada to collect material for the history of Canada, and it was through his efforts that the "Simcoe Papers" were obtained.

According to my recollection, Coventry was a man of fine presence and dignified bearing, and with the courtesy of an English gentleman. I have no reason whatever to suppose that he has misrepresented anything, although his account of the destruction of the "Caroline" does not agree in all respects with that given by Dent and others, nor with that given by an officer "G. T. D." (the late George Taylor Denison, Sr.) in the Canadian Monthly for April, 1873, Vol. 3, p. 289.

Anecdote of John Wesley

"In after years my father often narrated events that happened at that period; not the least remarkable was the following:

"There was another quiet house not far distant from Wandsworth Common at which the celebrated John Wesley visited, and my father being a neighbour was sent for when John arrived on his visit, which was pretty frequent. The little coterie assembled was more like a quiet Methodist meeting than a feast, there being some 20 or 30 generally present. Among these seekers of truth was an old man who knew the Bible by heart. His name was Samuel Best, who went under the cognomen of 'Poor Help,' as an innocent-minded man. The tea and evening passed pleasantly enough, all edified with Mr. Wesley's account of his voyage across the Atlantic. When the hour of ten announced the time of his departure, he being an early man and an early riser, his coat was brought and as was his custom he went round the room and shook hands with all present. On accosting 'Poor Help,' he remarked: 'Why Samuel, thee have been unusually silent this evening. I have not heard thee speak a word. There must be something remarkable on thy mind.' To which Sam replied: 'Yes, John, there is, and I cannot refrain from telling thee what it is, "Set thine house in order, for thou shalt die and not live." ' My father said the affair was taken in good part; but whether it operated on a mind at all times inclined to be superstitious, it is a singular fact that Wesley died in less than a fortnight, March, 1791. At this period my father was a bachelor, not being then of age.

"When I paid a visit to England in 1838 to see my father for the last time, I was one morning strolling around the Bricklayers' Arms, Kent Road, waiting for the Brighton stage, when I was arrested by a railing around an old church yard, and on peeping through, the first tombstone that caught my eye was the following!

'Here lies
Samuel Best,
Commonly called
Poor Help.
Aged 93.

"This was the identical man who gave John Wesley his warning to prepare for death. There are many remarkable circumstances connected with Sam Best which can be found in the magazines of the day; but Southey, in his life of Wesley, has not mentioned this, and perhaps never heard of it, although perfectly true.

"My father still continued to visit at this conference where he formed an intimacy with Sam Best, who gave him several texts of scripture applicable to his future movements in life. Strange to say he would never show them to any one, but he told me in after years that every one came true. He had great faith in Best's discrimination of character and looked upon him as a prophet.

"The King went one day in disguise with Lord Sandwich and two or three other eminent men. Best looked hard at the monarch, whom he had never seen, and told him to write down in his Tablet, Proverbs, Chap. 25, verse 5. After a little conversation the party retired. On reaching Saint James, the King turned to his Bible and read aloud to his courtiers, 'Take away the wicked from before the King and his throne shall be established in righteousness.' Sandwich was very angry with old Best, as well he might; but the King ever after was a friend to him and said he should never want, which was verified."

So far I have copied accurately the manuscript of Mr. Coventry. There is, however, a good deal about Mr. Best which he does not seem to have known. The D. N. B. gives us most of the following:

This pretended prophet, Samuel Best, was born in 1738, and before he was 50 years of age he had become an inmate of the Work House at Shore Ditch. His life before that time is rather obscure. By some he is said to have been a Spitalfields weaver and by others a servant in different establishments in the city of London. Before he was 50 years of age he disowned his children, he discarded his original name and took that of "Poor-help" (not Poor Help as Coventry thinks), describing as he thought his special mission.

He was a visionary and enthusiast, not wholly unlike his contemporary, the celebrated Richard Brothers who came from Newfoundland. He probably was a little touched with insanity and probably believed in his own prophetic and supernatural powers. He was in the habit of receiving his visitors, we are told, in a room adorned with fantastic emblems and devices; he would inspect the palms of their hands and from them give an outline of their past lives. He would also furnish guidance for the future in phrases of scripture, just as he did with Coventry's father; he also believed, or at least claimed, that by licking the hands of his patients he could determine the disease with which they were afflicted.

After acquiring considerable notoriety he removed to a house in the Kingsland Road and was consulted by many of the upper classes whom he also visited at their own homes. He professed to eat no food but bread and cheese and to drink only gin tinctured with rhubarb. He spent his nights, as he claimed, in communion with the celestial powers. For the last 30 years of his life he was convinced that he was to be the leader of the children of Israel to rebuild the city of Jerusalem. In that regard he imitated Richard Brothers, who about the same time, that is, the latter part of the 18th Century, gave himself out as a descendant of David, declaring that he was to be revealed as Prince of the Hebrews and Ruler of the World.

Brothers was more fortunate in some respects than Best in that he convinced many educated Englishmen, members of Parliament amongst them, of the verity of his claims, while Best never had any great following. Best, however, had the security of mediocrity, for he ended his life in peace and without prosecution, dying in 1825, while poor Brothers was first charged with treasonable practice and confined as a criminal lunatic, and was subsequently removed to a private asylum.

We have at the present day some instances of the same kind of prophet. Joseph Smith was a strong example, and since his time we have had the Holy Rollers, the Holy Ghost and Company, and like bodies of visionary enthusiasts.

Some of them are still with us.

Coventry's Account.

Grand Island belongs to our Neighbours, therefore to secure themselves from Molestation, they [that is Mackenzie's Forces] agreed to make the Conquest of Navy Island belonging to the British Government, and inhabited only by one old Woman and her daughter, whom they sent over to Grand Island in snug quarters there at a Log Hut within sight of their previous location.

. . . .

That no opposition should be made to their landing, they kept the place of their destination a profound secret, and marched through a Wild forest for four or five Miles, frequented by Nothing whatever but Deer and Wild Cats.—It so happened however, that early intelligence reached us, and had it been acted upon promptly, the whole trouble, confusion, expence and Inconvenience, might have been Easily avoided. It was early in the Morning of the 11th of December, I was at Captain Ussher's, when a respectable farmer called to give his deposition relative to their Movements. He stated he wished to do so from a fear that his Cattle and property would be plundered by these Brigands on their March. He owned a large farm on Grand Island as well as 300 acres of Land in Upper Canada—and therefore claimed our protection, by dispersing the pirates as quickly as possible. He happened to be at Tonawonta at the very time when they embarked—suspecting their place of destination, which on Enquiry was Confirmed, he hastened thro the Island to the shore—took his Canoe—came over and gave us the Information. This was the first Intelligence that reached us—we took down his deposition in writing—witnessed it, and after breakfast, Captain Ussher mounted one of his Horses and rode off to the Commanding Officer[1] then at Fort Erie to give him Intelligence.—It was considered an event so highly improbable, that no further notice was taken of it, further than passing the Communication on to another quarter; we were displeased, being firmly convinced that the farmer's testimony was implicitly to be relied on, but having No authority to act, nothing could be done, altho' Mr. Ussher volunteered for one to go over and keep guard—there were also numbers in readiness to join him.—The remainder of the day, we kept a sharp look out, allowing no Boats to pass without permission of a Magistrate, yet notwithstanding our vigilance some spies had been Known to Cross, higher up the River.—One of these, however, Corroborated the farmer's Testimony by mentioning the Circumstance at a small Tavern about ½ Mile distant, where I called every hour to ascertain if there were any suspicious Characters.—At four o'clock in the Morning, we went down to Chippewa and stated this fact also—but the Colonel was as little inclined to belief as the other; he promised however that a conference should be held in the Course of the day—which was accordingly done, but the golden opportunity was lost, by reason of the Time that elapsed in passing, repassing and conferring together. A handful of Men at that Crisis would have prevented the direful disasters that afterwards occurred. I wished for the spirit of Lord Peterborough's Movements, at that Juncture to act promptly, in order to prevent the annoyance which must inevitably arise from those Marauders taking quiet possession of an Island, from which, if they intrenched themselves well, they could with difficulty be removed.—The Militia are all very well as Secondaries, but from the Circumstance of being so little engaged in Warlike operations, they make but poor primaries in a case of Emergency of this kind.—This does not arise from any defect in personal Courage, because the late Events have proved this fact to the Contrary. It arises from a want of organised plans and extension of service, to teach them the importance of every position and advantage to be taken of the Movements of an Enemy, which can only be acquired by tact and Experience.

I nevertheless agree with my friend, that common foresight and prudence, should have induced the Colonel of the District, in the absence of any Regulars, to send over a guard to the Island, knowing, as he must have done, that Mackenzie was in Buffalo, inflaming the Minds of the People to revolt against us.

From ocular demonstration, it was proved, on the following day,[2] that our Information was Correct, for we could plainly see the pirates, walking around the Island, and preparing their fortifications.—All Night long, the axe was heard, felling Trees for breast work, and the Constructions of Shantys, as temporary huts to shelter them from the

Cold, until they could convey lumber over for building, which was soon effected, necessity being with them the rallying point to raise quarters as speedily as possible, not only for themselves, but from the Anticipated Kentucky boys, we could see them cutting down and carrying away fern and brushwood for Beds to repose on: they kept up large fires, most of them being apparently accustomed to Night Campaigning in the open air.

Dreary as our Midnight patrolling was before the arrival of the *Gineral* and his advanced Guard, you may readily suppose, we were no better off after the arrival of our piratical Neighbours whose plans we were totally ignorant of: they might come over in Boats, burn the Houses and pillage the Country, then return with the greatest alacrity without being Caught, for we had as I before stated, no other Guard along the frontier. Fortunately, however, they were too closely engaged in their Military Tactics and Shanty building to trouble us, although the circumstance of their being armed and not knowing precisely their Numbers, was a source of great alarm all around the Country.—

The very possession of our Soil, small as the Island is, aroused the Indignation of the Loyalists, and prompted them to greater exertion than they had hitherto manifested. The News, which had gone forward to Toronto as doubtful, was no sooner confirmed than Volunteers marched from all quarters, and dispatches forwarded to the Lower Province, to recall all the regulars they could spare. Order being partially restored in that quarter, since the destruction of Saint Charles and the flight of the prominent leaders, the Troops promptly obeyed the call and prepared for departure.

In Common Seasons, their transportation by Water would have been Impracticable, such an Occurrence being rarely remembered of Steam Boats plying towards the End of December. This Season however, as if aided by a superintending power in favour of our cause, was mild, enabling the Boats to run without interruption from the Ice. Detachments of the 24th and 32nd regiments quickly arrived at Toronto, from whence they rapidly pushed on, without the harass and fatigue of travelling by Land.—Whilst these brave fellows were on their route, Volunteers from various districts had arrived from as far North as Port Hope, Cobourg, Prescott and other Settlements along the Lake Shore.—Colonel MacNabb[3] also had returned from the West and pushed on with 300 Men, joined by Captain Kerr and his 200 Indians, who had painted their faces Red, a custom among them on warlike Expeditions.—We were not a little pleased at their arrival, having some chance of being relieved on our Midnight Guard.

The quiet Village of Chippewa suddenly assumed quite an animated appearance from the Influx of so many strangers. So rapid had been the Movements of the Troops that in a very short time upwards of 4000 had arrived to our protection.—Bands of Music — Bugles — Marching — Countermarching — drilling—firing—Cannon exercising—the bustle and stir of the Commissariat department—waggon loads of Bread—Beef, pork & potatoes moving along the road from the surrounding farms—presented a spectacle quite Novel to me, who for the first time was located in the very heart of the Contending parties—Private Houses were all turned into Barracks and the Methodist Chapel into a Hospital—our worthy Clergyman turned the sword of the Spirit into an Instrument of war, nothing in fine being thought of but preparations for defence in the Event of an Invasion—This all-engrossing Topic superceded every other consideration.

I should tell you, that in conformity with the Colonel's assurance, preparations were made for going over to the Island to make remonstrance against American Citizens taking possession of our Territory.[4] Accordingly, some of the Magistrates, accompanied by Volunteer rowers, proceeded on their way thither. This was an ill-judged Experiment,[5] as they must have been aware that the Brigands were too numerous and too well armed to allow them to land, although it was their policy to have done so, which would have secured the party prisoners, and secured the Boats.—Willing, however, to shew us that they, in reality had commenced their fortifications, and possessed Cannon;—so soon as the Boat neered the Northern Extremity of the Island, they opened their Battery and fired a Six pounder upon the adventurers. This was too warm a reception, so they deemed it most prudent to return, which they quickly did, without accomplishing the End in view. Two or three more shots were fired, but without effect, their artillerymen not being in sufficient practise to level a good aim, or make that allowance in the art of Gunnery with a Moving object, so as to do any injury.

So incredulous were the authorities in power, as to their numerical force, considering that merely a few lawless fellows had gone there on a freak, that they determined on another Experiment, which took place shortly after, and would doubtless have succeeded had they manned a sufficient Number of Boats. Unluckily however, as I hinted at the outset, we had no Boats of any consequence, but they were very quickly supplied from Queenston and Elsewhere. The Sleighing being good, a grand Movement took place, and it was really curious to see the rapid arrival of so many Boats. In a few days, near 100 were collected together. I saw one Immense Boat that would hold 50 men, drawn all the way from Hamilton, a distance of 44 miles, by 36 oxen,—a sight, I shall in all probability, never witness again. Schooners also were ordered from the shores of Lake Erie, and every other kind of craft that the Country possesed.—The two first Boats were soon brought into service, without waiting for a general attack, which, at one time, was determined on. These were manned by a reconnoitering party,[6] consisting of Intrepid young fellows, who had freely volunteered their services. The current being strong, they were towed up the river a little beyond Mr. Ussher's.—The party, consisting of Six in one boat, and Eight in the other, proceeded towards the Island, intending to row down the stream between Navy and Grand Islands. The object in view, was to ascertain what force was stationed at the back part, where the old lady's cottage stood, then taken possession of by VanRanselaer and Mackenzie, with their aid de Camps.

No sooner however, had they reached the line opposite the extremity of the Island, than a brisk Cannonading, with 6 pounders, opened upon them. It was an interesting and Novel sight, tho' an alarming one, lest our brave Countrymen should be swamped by a Cannon Ball. At the first fire, we distinctly saw where the ball struck the water, well directed as to the line, but too much elevated, so that the Ball passed over their heads, and struck some distance off.—The second shot was better directed and fell very near the bow of the Boat.—Finding it would be impracticable to get round, they rowed back and returned to Chippewa, about Midway in the Current on this side, but sufficiently near to the Island for any experienced Rifleman to have done great execution. By this time, a vast number had assembled with their rifles, who kept up one incessant firing, but all to no effect. I should think at the least, there were 200 balls fired, still no harm done, which satisfied us there was less to fear from the Brigands than had, by many, been anticipated, although it had been given out that their aim was as unerring as the Indians.—Whilst the Boats kept gliding along, our fine fellows only laughed at them, twirling, at the same time, a Hat at the End of a boarding Sword, with which they were all well armed, as well as pistols. Before they cleared the Island, another Cannonading commenced, with similar ill-success. The ruffians discharged 7 Six pounders, but none near Enough to either Boat even to splash them. One Ball, I noticed, dropped in the water, midway between the 2 Boats. This was the second best shot that was made.—On reaching Chippewa, they gave 3 cheers, and landed amid the applause of the byestanders.

After Mr. Ussher had played "God Save the Queen" on his Bugle, we walked down to see the results. I examined the Boats carefully, but no symptoms of a single bullet mark, out of the 200 fired on the Occasion, convincing us, that the recruits must be better practised in the art of Gunnery, before they attempted to cross over and pay us a visit.

These reconnoitering parties ceased soon afterwards, and a Council of War was held as to the best course to pursue to dislodge the Marauders. It was desirable, if possible, to spare the effusion of human blood, and on this account, it was considered advisable to act on the defensive, particularly as our reinforcements were numerous, and detachments arriving daily from distant districts. The Jewish Monarch declared formerly, that in the multitude of Councillors there is safety:—Unfortunately however from there being too many, the Country was harassed much longer with apprehensions of alarm than was consistent with the general character of the British Nation. This Indecision was afterwards a source of reproach by the American Authorities, who considered that it was our duty to remove a lawless band, who had taken possession of our soil, contrary to the existing Treaty between the two Countries.—Colonel McNabb was of opinion that the first shedding of blood by forcibly removing them, would weigh but trifling in the scale of Contention and prevent numbers afterwards falling a Sacrifice by the Sword, an Idea which was looked upon by the most Intelligent Men as a moral Certainty: indeed it was on the Eve of being accomplished, but afterwards Countermanded.—A plan of the Island was drawn by my friend Captain Ussher and Myself, where every spit was marked, so intimately acquainted were we with its location, from having gone over so frequently on shooting expeditions. This was forwarded to the Governor, preparatory to his taking a circuit along the frontier.—

Whilst the subject of attack was under Consideration, various Magistrates assembled at Fort Erie in Council, who drew up a remonstrance, signed by Mr. Merritt, chairman, requesting the Mayor and Authorities at Buffalo to inform them whether the aggression complained of were noticed by them, or in any way sanctioned, or whether in reality, any preparations were making for hostilities—an Event wherein there appeared some probability, from the circumstance of Drummers parading the streets of Buffalo on recruiting Service.—

Dr. Trowbridge, the Mayor, an Intelligent and highly reputable Man, finding the enthusiasm of the people had gone beyond the power of the Law to restrain their proceedings, resigned his situation in favour of Mr. Barker:—previous to this, however, he wrote a reply to the Magistrates assembled at Fort Erie assuring them that every thing practicable would be done to restore order, and that, so far from the Government wishing to sanction the proceeding of the Rabble, every precaution would be taken to allay the excitement.

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"Had these resolutions been promptly followed up by the Marshall and others in Authority, quiet would soon have been restored, and the rebellious faction disbanded—but a strong party of speculators arose in their favour and winked at their procedings, allowing Boats to convey arms, Ammunitions and provisions to them, which might easily have been prevented. Certain Authorities even saw Cannon with the United States mark upon them, and yet took no measures to secure them or to detain the parties who were known to be the pilferers.—

A steam Boat[7] was also hired for the conveyance of recruits, arms, Ammunition, etc., to the Island, which had arrived from Rochester and other districts on Sleighs, where the Jurisdiction of the Marshall extended.—A guard also, in time of peace, being allowed to watch the Boat at Night, without any warning that it was an infringement of Neutrality was truly unaccountable.—Strange as this conduct may appear to you, I have it from the best information—gentlemen who were over there when the Marshall conversed with Van Ransellaer and who saw a Cannon in his Boat belonging to the American Government.

Conduct so reprehensible, could not escape the Censure of our Authorities, who, finding that so much listlessness and apathy prevailed, considered it high time to look out for themselves, having previously ascertained that the American Militia refused to act.—

All these circumstances being taken into consideration, a Council of War, which was held at Chippewa, determined upon some vigorous measures to prevent further aggressions upon our Territory, and to open the eyes of the deluded Buffalonians, as to the impolitic course they were pursuing.—They would have rejoiced had the Authorities on the other side done their Duty, by putting a stop to Innovations so hourly Notorious. After allowing the American authorities a fortnight, and finding all their remonstrances unavailing, they determined to act decisively and to perform that Service which it was the bounden duty of the American Government to have done themselves. No alternative remaining, six[8] Boats were manned, under the Command of an intrepid officer, Captain Drew, with instructions from Colonel McNabb to proceed at Night and take possession of the piratical

Steam Boat, the "Caroline," which was known to be illegally conveying Cannon, Arms, Ammunitions, recruits and provisions over to the Marauders and rebels on Navy Island.—She was seen plying on the afternoon of the 28th[9] and not returning, was supposed she would moor there for the Night.—In whichever case, however, they were to take possession of her at all hazards.—Accordingly about 10 o'clock at Night, the preparations were completed and the Boats manned and well-armed for the Expedition—a more hardy, or intrepid set of fellows could no where be found, all in good spirits, and ready to achieve any event however hazardous.—On nearing the Island, they found that the said Steamer had left in the Evening for Schlosser on the American shore thinking to be protected and beyond our Control, but the result proved the Contrary. The first two Boats Kept ahead of the rest, having more experienced rowers and on arriving alongside, were hailed by the Sentry for the Countersign.—No satisfactory answer being given, the party on guard fired, but without effect; the Boat was soon boarded and taken possession of, but not without the loss of several lives in the Confusion that ensued.—This is a brief outline of the proceeding, columns of which have been written on the subject containing more untruths than I need trouble you with.—As the Current was too strong towards the rapids and falls, to tow her over, which was the original intention, she was set fire to, in three or four different places—unmoored and allowed to drift her course over the falls, a species of Navigation that was certain to consign her to oblivion for Ever. The Night was very dark, consequently, as you may suppose, it was a very grand sight, to see her gliding with the Current towards the whirlpool of her destination, whither she in due time approached and no vestige of her remains ever seen afterwards.[10]

The Boats quietly rowed back into the Chippewa, having two prisoners[11] and three of the party wounded[12], one of whom, Mr. McCormack, suffered severely, and afterwards received a Pension for his bravery—the other two soon recovered.—After eliciting all the Information they could obtain from the Prisoners, they were allowed to return home the following day, it appearing that they were strangers, who had taken shelter there for the Night, the small Tavern at Schlosser being quite full.—Many others being similarly situated took to their heels as fast as they could on escaping from the Vessel. The American papers as you may suppose published the most exaggerated statements, alleging that 40 or 50 individuals were on board when the Steamer was unmoored, who had no time to escape; but this, from the Nature of things was totally impracticable, as some time elapsed in setting fire to the Vessel; she was also moored so tight with a chain that the party had considerable difficulty in unloosing her—during these preparations therefore, ample time was afforded for any one to escape.—I saw several of the Gents who went on the expedition, the following Morning, but in the Confusion that ensued and the darkness of the Night, it was difficult to elicit the loss of the Enemy.—Mr. Chandler thought only one[13] and three or four wounded.—Lieut. Elmsley told me he believed five or six, which I believe to be the sum total of their loss.—One only, was actually found who had acted in the capacity of Sentry—he was interred in Buffalo amidst a large Concourse of sympathizing spectators—but however many might deplore his fate, others considered he had voluntarily placed himself in danger, when ought to have been Industriously employed elsewhere.

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The rebels on the Island were also very Indignant at losing so great an augmentation to their resources; they vented their spleen by opening a brisk Cannonading the following Morning on our houses opposite, as well as the Military Waggons and passengers who were passing and repassing along the frontier.—This they had occasionally done for a week, without doing much damage. I am sorry however to inform you that three Lives[14] were unhappily lost—one Individual who had taken shelter in Mr. Ussher's barn was so seriously wounded in the abdomen, that he died soon afterwards; another had his legs shot off; the third on undergoing amputation sunk with exhaustion.

The houses which contained Companys of Guards were battered severely; a ball went through the upper part of a room where 20 or 30 Men were stationed.—In the adjoining house, a Tavern, two Balls went through which induced the parties to decamp. A red hot ball fell near Captain Ussher which was afterwards preserved. In the house beyond, where I had been located for a Month—a ball entered the front door through the parlour and just took the corner of the Dining Table, forming a line on the surface as if ruled—went through Mrs. Ussher's bedroom and did considerable Damage.—Six others passed the House in different places, which ultimately rendered it untenable.—It was high time therefore to shift apartments below stairs into a Kitchen which was built behind an Embankment; here we were safe, but it was beyond a Joke the whizzing of the Balls, which at times came very near us.—You would have imagined that the people were here disciples of Charles the 12th of Sweden, had you seen the number of people congregated on the frontier, not only in waggons looking over to the Island, but on foot.—They were even imprudent Enough to stand in groups as a Mark for the rebels to fire at. I was one Morning walking with Mr. Meredith and Doctor

Hamilton in front of Mr. Ussher's house, when a warm firing Commenced—a ball passed behind us within 60 yards and tore up the ground; the whizzing Noise induced us to put our hands to our ears and I for one involuntarily lowered my head, upon which Dr. Hamilton coolly replied, it was better to walk on quietly upright; he however was used to such Matters in the last war.—Strange as it may appear, I believe now that it is possible even to be fond of the excitement, for Mr. Merritt's son who was up there one day, went away quite disappointed that he could not see them fire, and on those days when the Cannonading did take place, I have heard the byestanders exclaim "Go it ye Devils and take better aim."—There were many hair-breadth escapes and considering the immense number of times they fired, it is extraordinary so few fell a sacrifice.—A short time before the breaking out of the affray, we had built a foot bridge across the Creek at the back of Mr. Ussher's house. Captain Adams told me he was marching his Men across when a Ball struck in the Bank close beside them. I also saw one strike the water under the Bank when three officers were passing on Horseback.

Doubtless you will ask where the Balls were procured in so short a time for the use of the Ruffians, for I can call them No better.—Some they stole from the Arsenals, but the greater part were cast at a foundry in Buffalo.

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The Insurrection being quelled at Toronto and in the West, the Governor crossed the Lake to take a survey of the frontier. Landing at Niagara, he proceeded to Queenston and from thence to Chippewa, along the shore to Fort Erie, opposite Buffalo, the termination at that time of the guarded Coasts.—On his return, he was accompanied by Mr. Merritt and two other Gentlemen, who pointed out, as they rode along, every thing worthy of Notice on our own frontier, as well as the opposite shore and the Island where the rebels were encamped.—I was standing opposite Mr. Ussher's unconscious of their approach, when the Governor politely withdrew from his Company—shook hands and expressed his satisfaction at finding all along the line so vigilant and at their posts. I asked him when the Marauders would be dislodged, as they were a source of great annoyance to us by their frequent firing;—he replied that in a few days, on the arrival of the artillery, then on its way— it would be effected.—At this Intelligence from the fountain head, we were satisfied.—I have no doubt at the Time, this was fully contemplated, but on a Council of War being held, it was considered advisable if possible to spare the effusion of human blood. On leaving Chippewa, however, he left orders with the Colonels in command to use their own discretion.

The Artillery at length arrived and a Number of Men were despatched up the river to raise embankments and breast work, preparatory to a general Bombardment. This was done at Night, the first set of Men being obliged to retire from their work in consequence of Cannon having fired to dislodge them, which was soon effected. None of the workmen received any Injury, but the works having first commenced in front of my friend's House, sad dilapidation ensued: the front wall fell in soon afterwards, which rendered the building quite unsafe and uninhabitable. At length the works were completed and our Mortars and Cannon being in readiness, a regular attack was contemplated, but so many schemes and plans were devised, that Nothing effectual took place after all. Three Schooners were manned and stationed up the river under the Command of Captain Graham, Lieutenant Drew and Lieutenant Elmsley—three Gentlemen of confirmed bravery—they were to cut off all Communication by water with Buffalo; then there were near 100 Boats of various sizes in readiness which, when manned, were to effect a landing at one End of the Island, whilst the Artillery were playing upon the Centre and Northern End; these however were quiescent, to try the effect first of all, of the Bombardment; when this commenced, the Bravados were alarmed not a little. The 24 pounders and Mortars raked the Trees and the Shanties—tore up the ground and Killed some of the Rebels: but main body still clung to the Island. Had the Boats been ready Manned, a landing might with ease have been effected during their panic: this scheme was however overruled—so much for a multiplicity of Councillors, in which we are told safety Consists. The prolongation of storming the Island had a bad effect, inasmuch as the alarm was unabated; it also drove many peaceable families from their homes and domestic firesides at an inclement Season of the year. I never could comprehend the policy of their operations, further than what I stated before—the desire to prevent the dreadful Massacre that must have ensued for very few I apprehend would have escaped, so Indignant were the people on this memorable occasion.

That you may judge the situation of the contending parties, I hand you a small Map of our positions, sufficient to guide your Ideas to the spot, remarkable in history. There lay entrenched a handful of desperate fellows who Kept a whole Country in agitation for upwards of a Month, and we residing within Cannon shot, liable at a Moment's impulse to have a ball sent through the House or perhaps a leg shot off whilst perambulating the Banks of the River.

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From the time of their arrival there on the 13 December to the period of their Evacuation on the 15 January, you may be sure such restless adventurers were not idle in concocting mischief—fortunately however thro' the fickleness of their plans and their constant differences and quarrels, no measures were effected for our annoyance further than what I mentioned relative to their occasional Cannon Exercise and rifle shooting:—It was imagined however, that one Night, they were ripe for some expedition, and in order to give signals and divert us from their Movements—they lighted up a Machine which was moved to and fro on the Island.—From it issued a most dazzling and brilliant light, which could be seen for many miles around. It was supposed to consist of Tar Barrels and other Inflammable Materials, which burnt for several hours.—No movement however took place.—They had schemes to divert our attention in various ways, which were afterwards acknowledged.

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. . . . . . Their general Correspondence, which was freely carried on by Spies, notwithstanding our vigilance. They knew all our movements, although we could gather nothing of their's from their peculiar locality on an Island. . . . .

Nearly a day elapsed before we knew of their departure and great conjecture arose as to their point of destination. In the course of the day one solitary Individual was seen waving a flag but this was looked upon with suspicion—In the afternoon authentic Intelligence arrived of the Event, yet, very many even then were incredulous, altho from the circumstance of seeing none on guard as usual it was apparent some Movement had taken place.—To settle the question, a party volunteered to go over; it was considered a hazardous undertaking, more especially as many surmised that they had excavated subterraneous caverns to Enter, and knowing the schemes they planned to deceive us it was no wonder a source of anxiety to learn the result. At the time, the Information of very few could be relied on, as so many strange rumours were afloat and so many spies over here awaiting our Movements and spreading reports to mislead us.—A great number assembled on the shore as you may imagine to know the result, and many anxious hearts were relieved when a general huzza proclaimed that the Island was once more in our possession and the British flag flying.

Their movements had been so rapid to clear out, as they termed it, that one poor wretch was left behind,[15] who was glad enough to hail his rescuers, from the thraldom he had so long entrammelled in—

he stated that he was asleep, and knew nothing of their movements; on his examination but little could be elicited from him, further, than that he had been a hewer of wood and drawer of water and was heartily glad that the expedition was abandoned—he was soon released from Captivity, having been taught a lesson for his folly that he will not easily forget.

Had it been Brobdignag Island, greater Curiosity could not have been evinced to see it:—An old Shoe or a slip of Cloth were as great curiosities as some of the relics they shew you in France: grape Shot—pieces of punched Iron from Steam Boilers, furnished from Black rock foundry were as precious as current Coin; and as to Pikes, they were trophies of too intrinsic value to fall to the lot of many; they decorated Halls and curious Cupboards, whilst half a Bombshell or a Cannon Ball embellished a lady's work Table.—The few of the rebels who wore shirts carried them away, filthy as they were on their backs as scarce a vestige of linen was found with the exception of part of the tail of a shirt that had bound up a wounded Leg. Nothing can exceed the Miserable Condition of a Buccaneer's Life, far worse than that of savages, for they know no better.

The number who were killed or wounded, by our bombardment was never ascertained,[16] as their burying place was on Grand Island, where they occupied a Log-hut as Hospital—one newly made grave was found, which on digging the Earth away, was found to contain the body of a poor wretch who was supposed to have been shot by their own party, as he was lying with his arms pinioned; who this Individual was has never been ascertained.[17]

The miserable state of existence they must have endured, baffles all description. It is almost impossible to convey to you the disgusting scene which was exhibited. The Shanties wherein the Miserable wretches bivouacked were scarce fit receptacles for pigs, being strewed with beans, peas, pork rhine, vermin and dirt. Their beds were composed of brushwood, and nothing to shelter them from the Inclemency of the Weather but pine branches. Here they congregated at night, eating, drinking, smoking, swearing and sleeping. For an occasional bivouac on a deer hunting expedition, such a logement would pass Current but for fifty or sixty human beings to assemble nightly for one Month together, betokens a race of desperados worse than Savages.

Mrs. Mackenzie was over there part of the Time[18] living in a dirty house at the back of the Island which I before described to you. The only accommodation for her at Night was on a shelf covered with straw.

NOTES

In the following notes, contractions will be employed as follows:

"Dent." The story of the Upper Canadian Rebellion by John Charles Dent, Toronto, 1885. This work is more than usually accurate in the account of the "Caroline" episode. I have not referred to "The Cutting out of the 'Caroline' and other Reminiscences of 1837–38" by Robert Stuart Woods, Q.C., (afterwards Judge Woods), Chatham, Ont., 1885—everything of value in that work has been utilized by Dent.

"Head." A Narrative by Sir Francis B. Head, Bart. 2nd Edn., London, 1839. I have not quoted Head's "Emigrant"—it does not afford any useful material.

"Leg. Ass." Journal of the House of Assembly, Upper Canada, Session 1837–8, Toronto, 1838 (Official).

"G. T. D." The Burning of the "Caroline," by G. T. D. (George Taylor Denison, Sr., father of the Police Magistrate of Toronto, of the same name). The Canadian Monthly and National Review, Vol. 3, 289 (April 1873). The head note reads "The following narrative is by a Canadian officer who served against the rebels and their American sympathisers." It does not appear that Denison took part in the cutting out.

"Trial." Gould's Stenographic Reporter, Vol. II, Washington, D.C., 1841. This contains a full stenographic account of the trial at Utica, N.Y., October, 1841, of Alexander McLeod, charged with the murder of Amos Durfee at Schlosser, at the cutting out of the "Caroline." It was satisfactorily proved that McLeod was not in the expedition at all, although both he and his friends had claimed that he was.

"Kingsford." The History of Canada, by William Kingsford, LL.D., F.R.S. Can., Toronto, and London, 1898, Vol. X.

"Lindsey." The Life and Times of Wm. Lyon Mackenzie, by Charles Lindsey, two volumes, Toronto, 1862.

[1] Probably Col. Kenneth Cameron, formerly of the 79th Highlanders and at that time Assistant Adjutant General.

[2] Possession was taken by the "Patriots" of Navy Island, December 13th, 1837.

[3] Colonel (afterwards Sir) Allan Napier MacNab arrived at Chippewa, December 20th. His name is found spelled in many ways: McNab, McNabb, M'Nab, M'Nabb, Macnab, Macnabb. He was placed in command on this frontier and was afterwards knighted for his services.

[4] Lieutenant Governor Francis Bond Head as early as December 13th, 1837, had sent a remonstrance to Governor Marcy, of the State of New York, concerning the agitation at Buffalo to procure countenance and support for the disaffected in Upper Canada. Head. 332; Leg. Ass., 97—the Governor, December 19, issued a Proclamation against attempts to set on foot military expeditions or enterprises in violation of the laws of the land, and the relations of amity between the United States and the United Kingdom, Leg. Ass., 98—this was almost a dead letter and practically nothing was done for weeks to check the movement. On Navy Island being occupied, Head, December 23, sent Archibald McLean, Speaker of the House, to Washington with a full account for the British Ambassador, Henry S. Fox. Head, 335; Leg. Ass., 98.

[5] I have not seen this "experiment" of the Magistrates noted by any other writer.

[6] Richard Arnold's account is as follows (Dent, Vol. 2, p. 215):

"The next day (*i.e.* December 26, 1837) I and several other volunteers accompanied Captain Drew on a reconnoitering expedition. We set out from Chippewa Creek in a small boat and proceeded to circumnavigate Navy Island, where we could see the rebels in full force. As we approached the island they fired round after round at us, and the bullets whistled thick and fast over our heads. Our position was one of extreme peril. 'What a fool I am,' exclaimed Captain Drew, 'to be here without a pick-up boat. Should we be disabled we shall find ourselves in a tight place.' One of the rowers in our boat was completely overcome by fear, and funked. 'I can't help it boys,' said he—and threw himself at full length along the bottom of the boat. We made the trip, however, without any accident. The next day we made another expedition in a large twelve-oared gig, with a picked crew, chiefly composed of lake sailors. Again the shots whistled over our heads, and struck the water on both sides of us, but in the course of a few hours we found ourselves back again in Chippewa Creek without having sustained any injury. We had by this time become used to being under fire, and didn't seem to mind the sound of the whistling bullets."

[7] This was the "Caroline," a steamboat about 75 feet long and of 46 tons burthen, the property of William Wells of Buffalo, which was cut out of her berth in the ice at Buffalo and brought down to Schlosser, December 28th, plying across to Navy Island.

[8] Captain Drew, R.N., who was in command of the expedition, in his report, December 30th, says: "I directed five boats to be armed and manned with forty-five volunteers." Leg. Ass., 90. G. T. D. says: "Five boats were prepared, well manned, well armed and with muffled oars." Can. Monthly, Vol. 3, 290. Richard Arnold says: "The expedition consisted as far as I can remember of seven boats, each containing seven men, *i.e.* four rowers and three sitters." Dent, Vol. 2, 216. The number of boats is given as seven by most authors and is probably correct. Sir Allan MacNab, under oath in the McLeod trial, says: "they were seven in number . . . . seven or eight men in each boat . . . . about forty persons." Trial, 124. "The boats did not all return at the same time. Five arrived at about the same time, two at a different time." Trial, 125. John Harris gave the same evidence. Trial, 129. "Seven boats left Chippewa, five only reached the Caroline, five returned in company." With this Edward Zealand agrees word for word, Trial, 135. Robert Armour says: "Seven started, five crossed the river," Trial, 147; so do Christopher Bier, Trial 157, 159, Hamilton Robert O'Reilly, Trial, 162, 165, Sheppard McCormick Trial, 169, Frederick Claverly, Trial, 170, 175, and several others. The fact seems to be that seven boats started but two lost the way and did not cross the river.

[9] This should be "29th."

[10] It seems quite certain that the "Caroline" did not go over the Canadian Falls, nor as a whole (at least) over the Falls at all. Her engines seem to have sunk and portions of her charred wood work went down the river and over the Falls on the American side.

[11] Both British subjects—one was Sylvanus Fearns Wrigley, of the Township of Dumfries, who had enlisted with Dr. Duncombe; after Duncombe's men were dispersed, he crossed the Niagara River to join the "Patriots." He was on his way to Navy Island where he was captured. He was detained in gaol for three months and then discharged on giving bail for good behaviour. The other was Alfred Luce, a native of Lower Canada, who had also joined Dr. Duncombe; he shared in Wrigley's adventures until his capture. He was released the following day and sent across the ferry to the United States, as there seemed to be doubt whether he was not a citizen of that country. Dent, Vol. 2, 213; Leg. Ass., 91.

[12] Lieutenant Shepherd McCormack (so named by Drew in his official report, December 30, 1837, Leg. Ass., 90—but both his names are spelt in different ways, *e.g.* the pensioning Statute, 1838, I Vic. c. 46, calls him Sheppard McCormick)

was shot in several parts of his body and also received two cuts from a cutlass. He was permanently injured; he received a pension from Upper Canada of £100 ($400) per annum, counting from December 29, 1837. The Preamble of the Act is worth copying:

"Whereas Sheppard McCormick, Esquire, a retired Lieutenant in the Royal Navy, received several severe wounds in action at the capture and destruction of the piratical steamer 'Caroline,' in an attempt to invade this Province by a lawless banditti, by which he is disabled and it is just and right that he should receive a Pension during such period as he may be so disabled by said wounds."

He received the pension until his death when it was continued to his widow.

It was the conventional thing for all loyal Canadians from the Lieutenant Governor down to call the Canadian Rebels and their American "Sympathisers," "*Pirates*"—they were "Pirates" to precisely the same extent and in the same way as William of Orange and his English and Dutch followers—"Pirates," however, offset "Patriots" with "apt alteration's artful aid." "Banditti" ("we call them plain thieves in England") is another term of opprobrium equally well deserved: "a Banditti" is not quite without precedent in our literature—but then I recall a student of mine, *Consule Planco,* speaking of the distance between "one foci of an ellipse and the other." And Parliament is like Rex, *super grammaticam.*

The second reported wounded was Captain John Warren, formerly an officer in the 60th Regiment—his wounds were trifling and he resumed duty the following day, Dent, Vol. 2, 212; Leg. Ass., 89, 90. The third was Richard Arnold (wrongly called John Arnold in the official report, Leg. Ass., 90). His story is given in Dent, Vol. 2, 214—he was "struck by a cutlass on the arm and got a pretty deep gash just above the elbow;" he was "invalided and sent home to Toronto in a sleigh next day;" "there his wound healed rapidly, leaving him none the worse." He died in Toronto, June 18, 1884. He always was properly proud of being the last man to leave the "Caroline."

[13] Captain Drew in his official report said, "I regret to add that five or six of the enemy were killed," Leg. Ass., 90; but it is reasonably certain that there was only one killed—this was Amos Durfee of Buffalo, for the murder of whom Alexander McLeod was tried at Utica, N.Y., in 1841. There were several wounded, more or less severely.

[14] MacNab, writing to Lt.-Col. Strachan, from Chippewa, January 19, 1838, says, "Three of our brave and loyal Militia have unfortunately lost their lives in the service of their country against the Rebels and their piratical allies upon Navy Island. They were all killed by gunshot wounds." Leg. Ass., 264.

[15] He was arrested as a spy but released.

[16] The existing accounts mention that the casualties on the Island were one killed by a round shot, and one slightly wounded by a splinter. Dent, Vol. 2, 224, note.

[17] I have not seen any reference to this circumstance in any of the other accounts.

[18] Mrs. Mackenzie, née Isabel Baxter, a native of Dundee, was married to William Lyon Mackenzie at Montreal, 1822, when Mackenzie was living in Dundas. She was a woman of sterling character, a devoted wife and mother. She was the only woman who spent any time on Navy Island. "She arrived there only a few hours before the destruction of the 'Caroline,' and remained nearly a fortnight with her husband, making flannel cartridge bags and inspiring with courage by her entire freedom from fear, all with whom she conversed. At the end of about a fortnight, illhealth obliged her to leave." Lindsey, Vol. 1., 38, Vol. 2., 163.

Navy Island was abandoned by the "Patriots," January 14th, 1838, Dent, Vol. 2, 223.

Some Notes on the Minutes of the Town Meetings of the Township of Sidney

By W. S. HERRINGTON, K.C., F.R.S.C.

(Read May meeting, 1919)

The Township of Sidney was numbered eight among the first townships laid out upon the Bay of Quinte, although as a matter of fact it was not the eighth upon the list either from the date of survey or settlement. Richmond number ten had acquired some settlers as early as 1785 and was probably surveyed in the latter part of that year. Thurlow number nine was surveyed in 1786 and a few settlers had taken up land the same year, but Sidney was neither surveyed nor settled until 1787.[1] At that time it was so remote from the more thickly settled townships at the eastern end of the bay that it was regarded as beyond the bounds of civilization; and the surveyor evidently thought it scarcely worth his while to give his personal attention to the matter, but left it to his less competent assistant with the result that after a few years it was found necessary to direct a new survey to be made. A few straggling settlers followed upon the heels of the surveyors, and quite naturally selected what they deemed to be the choicest locations. The practice adopted in the first settled townships, of entering the names of the locatees upon a map provided for the purpose was not followed in Sidney so we have no reliable record of the locations of the original settlers. The records of the Land Board are not a safe guide as many changes might and no doubt did take place before the certificates of location were issued by that body.

Unlike the townships on the other side of the bay, Sidney, so named after the Colonial Secretary under George II, did not long retain its numerical appellation. It is not at all unusual, even at the present day, to hear Marysburgh, Sophiasburgh and Ameliasburgh spoken of respectively as the Fifth, Sixth and Seventh Town, but I cannot recall ever having heard the township of Sidney called Eighth Town.

Although Sidney lags a few years behind its sister townships upon the bay in the matter of survey and settlement it is the banner township in organizing its town meetings and thus providing a means, meagre though it was, for local self government. Adolphustown

[1] Canniff's Settlement of Upper Canada, p. 487.

(Fourth Town) points proudly to the fact that on March 6, 1792, was held the first Town Meeting at which were appointed a town clerk, a constable, two overseers of the poor, three pound-masters and two fence viewers. A similar meeting was held on the fifth of March, 1793. These meetings were the spontaneous acts of the inhabitants and were not authorized by statute. It was not until July, 1793, that a statute was enacted by the Legislative Assembly providing for the appointment of just such officers as had been appointed at the two annual meetings in Adolphustown.[1] Hallowell held its first meeting in 1798 and Sophiasburgh in 1800. There is no record of the first meetings held in any of the other townships upon the bay except the township of Sidney, whose officials have kindly placed in the hands of the writer, a well preserved minute book containing the records of all town meetings from 1790 to 1849 inclusive. Adolphustown easily took the lead among the townships at the eastern end of the bay in producing men qualified to lay the foundations of a municipal government and it is quite improbable that any of the neighboring townships took the initiative in this respect and held an annual meeting prior to 1792. In any event it is quite clear that until the minutes are produced and the fact clearly established Sidney must be accorded first place and credited with having held the first meeting in the district of Mecklenburgh. This distinction seems all the more creditable when we remember that the townships at the eastern end of the bay, besides being settled several years earlier than Sidney, possessed many other advantages, among them being a denser population and a closer relationship with Kingston, the recognized official centre of the district. We might, at first glance, quite reasonably expect to find these older townships taking some steps towards municipal organization at a much earlier date than Sidney.

On the other hand we must bear in mind that the first settlers of 1784 came in a body as a military organization. They were not equipped as fighting men, but for convenience they were in the charge of real army officers who had been in command for several months before they reached their final destination. Most of the companies were under the same officers who had commanded them during the war. The discipline was not so rigidly enforced as when on active service yet there were the two distinct classes, the officers and the rank and file. While these townships might be said to be under military rule it was of a very mild form. To the best of their ability the officers endeavored to enforce the civil law as they understood it;

[1] An Act to provide for the nomination and appointment of parish and town officers within this province. 33 Geo. III, Cap. II.

but for the most part they relied upon their own sense of justice and their decisions were, as a rule, accepted without cavil. Having ready at hand these arbiters, whom they were accustomed to obey and in whom they had confidence, several years passed before they felt the need of appointing other officers to assist in carrying on the affairs of the municipality.

In the township of Sidney the conditions were quite different. The population did not come in as a body and they were not on intimate terms with each other. Many of them met for the first time in the woods. They had no organization of any kind, no leaders upon whom they were accustomed to depend, hence there was in fact a greater need for providing some means of carrying on the affairs of the township through the medium of the town meetings than there was in the front townships of Frontenac, Lennox and Addington. After weighing all the facts I was not therefore so much surprised to find that the township of Sidney had held four town meetings before the passing of the Act authorizing the holding of such meetings, as I was to find that the minutes had been so carefully preserved. Too frequently such valuable documents, if ever obtained, are rescued from the dust covered rubbish heaps of some forgotten lumber room. Not so in the township of Sidney. There must have been a long unbroken line of painstaking officials down to the present day; for the precious records were not entrusted to my keeping until after two months of diplomatic negotiations and the most solemn assurances that I had no intention of appropriating them for our local Historical Society.

First as to the book itself. It is a well preserved quarto volume bound in mottled cardboard with sheepskin back, and a memorandum on the first page informs us that it cost 18s. 9d., and that this sum was made up of contributions of 7½d. each from twenty-six contributors and 1s. 3d. each from Caleb Gilbert and Cornelius Lawrence. The first name upon the list is Caleb Gilbert and he appears to have occupied the same prominent place in the general affairs of the township as he did upon the list of contributors towards the purchase of the book.

Although the first meeting was, according to the entry, held on the 15th day of May, 1790, this memorandum shews that the book itself was not obtained until March 8, 1806. It is quite evident therefore that although the book contains a faithful record of all the town meetings from 1790 the entries for the first sixteen years have been transcribed from some other original documents which have not been preserved. An examination of the book provides convincing proof that the records are genuine, but the transcriber, in his zealous endeavour to be precise, rather over-reached himself in his heading to the minutes of the first meeting which reads as follows:—

"1790 Upper Canada,

May 15. Pursuant to an Act of the Legislature of the Province of Upper Canada in such case Made and provided the first annual meeting of the Inhabitants of the Township of Sidney was held at the dwelling house of Aron Rose thence adjourned to the dwelling house of Stephen Gilbert, Esquire, in Sidney and to be held on the first Tuesday of May ensuing."

As the first session of the first Provincial Parliament was not held until the 17th September, 1792, and as the Act providing for the nomination and appointment of parish and town officers was not passed until July, 1793, the transcriber, without further evidence, stands convicted of gross anachronism in the first degree. The culprit appears to have been one Henry Smith, who was Town Clerk from 1803 to 1808; but we are disposed to pardon him for this offence, especially as the rest of his work, saving a few errors in spelling, was admirably done. It may be argued that the Sidney meetings may have begun earlier than those of Adolphustown; but when comparing the books themselves Sidney must give way as the Adolphustown book is the real original record. It has been so regarded for at least fifty years, and I do not like to shatter a belief that has so long been entertained; but the fact is that a close examination of the very page upon which the minutes of 1792 are written in the Adolphustown book discloses the water-mark "1796." It is quite evident from a closer scrutiny that the minutes for the first few years of Adolphustown have also been transcribed from some other documents.

The officers appointed at the first meeting in Sidney and at the annual meetings for the three following years were a Moderator, a Town Clerk, a Constable, two Pathmasters and two Fence Viewers. The Moderator during this entire period was Captain John W. Meyers, the pioneer mill builder upon the Moira River.

The statute of 1793 provided for the election of a Parish or Town Clerk, Assessors, a Collector, Overseers of Highways, a Pound Keeper and Town Wardens. As the duties of the Overseers of Highways, under the Act, included those performed by the pathmasters and fence viewers appointed at the Town Meetings it will readily be seen how closely the statute followed what had already been in practice for four years in the township of Sidney. It recognized the need of appointing a constable also but delegated this authority to the Justices of the Peace assembled in Quarter Sessions. The complete minutes for the first meeting held after the passing of the Act read as follows:—

Sidney, *March 3, 1794.*

At an annual Meeting of the Incorporated Townships of Sidney and Thurlow held this . . . for the Nomination and Appointing of Town and Parish officers and doing such other Business as the law directs Have Enacted (by a Majority of Votes) the following Laws and regulations and appointed the following Persons as Town and Parish Officers for the ensuing year, viz.:—

Regulations for Fences

1st. That Fences shall be four feet Six Inches high and not exceed five Inches open for three feet high for the Township of Sidney—And for the township of Thurlow not to exceed six Inches.

Regulations for Hogs

2nd. Hogs to run at Liberty until they Trespass through or over a lawful Fence. And Hogs to be confined from the first of May to the first of december.

Resolve

3rd. Resolved that the following Persons serve as Parish and town officers, viz.:

Town Clerk	Caleb Gilbert
Assessors	George Meyers and Archibald Chisholm
Collector	Samuel Reid
Pathmasters	Aron Rose
	David Palmer
	John Frederick
	William Johnston
Pound Keepers	William Kelly
	John Taylor
Town Wardens	Leonard Soper
	John Chisholm

In the foregoing we observe that the meeting professes to be for the "Incorporated Townships of Sidney and Thurlow," and the heading is the same for the next three years. By what authority were these joint meetings held? The only explanation I can offer is the provision of section XII of the Statute of 1793 which provides that when any township or reputed township shall not contain thirty inhabitant householders it shall be joined to the adjacent township containing the smallest number of inhabitants. Are we justified in concluding that Thurlow did not at this time contain thirty inhabitant householders? I hardly think so. The settlers of Thurlow were principally grouped on the western side of the township and were in closer touch with their neighbors in Sidney than with the other scattered inhabitants of their own township. There was no settlement to the north; they could not very well fraternize with the Mohawks upon the Indian Reserve to the east and they were cut off from the south by the bay. Sidney lay to the west and if they desired to join with any one they had no alternative; but I am inclined to the view that they found it to their advantage to unite for the purposes of a town meeting with their friends on the other side of the river and did so without taking the trouble to enquire whether or not it was in accord with the provisions of the statute. Instances of a tendency to disregard the requirements of legislative directions are not uncommon. To the minutes for the year 1798 we find this note appended, "This year the Township of Thurlow holds its first annual meeting by itself."

The regulations passed at the meeting of 1794 are interesting inasmuch as they are the first attempt at Municipal enactment in the County of Hastings. The putting of hogs upon their good behaviour under a penalty of imprisonment is rather unique. Here again we find the town meeting leading the way and taking upon itself authority to enact regulations before authority to do so had been conferred by Parliament. The Act authorizing the town meetings to determine in what manner and at what periods, animals might run at large was not passed until the 9th July, 1794.

We find no change in the proceedings at the annual meetings for the next few years, the same regulations remaining in force by resolution, year after year, until the meeting of 1798, when the following restraint was put upon rams running at large, "that Rams be confined from the first day of September to the tenth day of December under the penalty of twenty shillings." There is no suggestion either by statute or regulation as to the manner of imposing these penalties. This defect in the means of enforcing the regulations was remedied in part in the next year 1799 by the following: "Resolved that the Laws and regulations be the same as in the year 1798 with the addition that if any person or persons whomsoever shall find either said hog or Ram during the ensuing year running at large on the Highways or Commons they are hereby authorized and empowered to impound the same, the pound keeper (not?) to deliver them until the owner shall pay the sum of twenty shillings, the one half to the person or persons taking said Hog or Ram to the pound, the other half to the Collector to the public stock of the district."[1] If we desired to be hypercritical we might suggest that this amendment still left it open to both the owner and the animal to escape punishment if the wrong-doer effected his trespass upon his neighbor by any other means than over the highway and even by that means he would go scot-free if once he gained the sanctuary of his home pasture.

Sidney having given Thurlow a fair start and then launched it forth on its independent career, next, in 1801, took Rawdon under its wing. The latter township appears to have been a sort of junior partner in the town meeting business until 1820. The name does not always appear in the headings of the minutes during this period; but the last time it does appear is in the minutes of 1820.

The hog and ram appear to have been the cause of much anxiety to the early settlers and various expedients were adopted to restrain them from doing damage. In 1801 we find a regulation authorizing "any persons finding Hog or Ram within the said limited times running at large on the highways or commons to castrate them. The Owners to run the risk." In 1804 the yoke was first introduced by the following regulation "Hogs to run at large till they do damage the owners thereof to pay the same and yoke them with a Crotch yoke six inches above the neck and four below." So on year after year we find the resolutions of the town meetings directed chiefly towards devising means to check the trespasses committed by domestic animals.

How often when travelling through the country have we observed bends in the road with no apparent reason for deviating from a straight line. To-day in choosing a location for his buildings the farmer takes into consideration the course of the highway which he must use in going to and from his buildings. With the early settler it was quite different. When he built his first cabin there was perhaps no road, only a trail through the forest. Later on, when his improvements had been enlarged and assumed a more permanent character he sometimes invoked the machinery provided by statute[2] and had the road brought to his building.

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[1] The expression "public stock" is not peculiar to the minutes of this town meeting. In section IX of the town meetings' Act of 1793 will be found a direction that the fines imposed for neglecting to be sworn into office shall be paid to the treasurer "towards the public stock of the district."

[2] 33 Geo. III, Cap. IV.

Two fair illustrations of how this was done are recorded in the old minute book, one in the year 1804 and the other in 1808. The entry in respect to the former will better serve our purpose:—

"IId Concession Road Registered

We whose names are hereunder subscribed being summoned according to law as Jurors to take into consideration whether it be necessary to alter the plan for the road which was left by direction of the Government between the first and second concession of the townships of Sidney and part of Thurlow in the County of Hastings in the Midland District and Province of Upper Canada to some other place Have unanimously agreed that for the benefit of the Inhabitants and the Public in General that the said road should be removed and to begin at a dug-way on Lot Number one or nearly in the Second concession of Sidney aforesaid thence at right angles to the west line of the Township aforesaid (nearly) and as straight direction as the lands will admit to the dwelling house of Andrew Lott, thence to the cleared lands of John Row, thence to the dwelling house of Francis Van de Voort thence to William Sharrards Junr dwelling house thence as straight as the lands will admit to the rear of the dwelling house of Henry Smith thence with an Easterly Course and straight direction to the forty foot Road between Lots No 30 and 31 thence south 16° East along said Road to the front of said second concession, thence north 74° east along the same to the Township line Between Sidney and Thurlow, thence nearly at right angles across the lots and with as straight a line as the lands will admit of to Singleton's River at or near Capt. John W. Myers Mill or Bridge."

It frequently occurred that the regulations of the previous year would be deemed sufficient. In such cases we find the fact stated very briefly as in the year 1806, "Laws and Regulations the same as in the year 1805."

In the year 1808 we find the phraseology slightly altered and a new set of regulations provided. These evidently were regarded as very satisfactory as they remained in force for the ensuing fifteen years without a single amendment being made. It must be remembered they constitute the only code of municipal by-laws, as they were sometimes called, in force in the township during this entire period. As they played such an important part in the history of the township I give them in full:

"Hogs to run at large till they do damage, the owners thereof to pay the same and yoke them with a crotch yoke six inches above and four inches below the neck.

"Pigs to be confined till three months old. Rams to be confined from the first day of September to the tenth day of November, any person finding either ram or said hog running at large on the Highway or Commons they are authorized to castrate them, the owner to run the risk.

"The Lawful standard for fence is such as the fence viewer or viewers shall deem sufficient."

It speaks volumes for the law-abiding character of the citizens of the township that a population of over 1500 were content with such a brief and simple set of regulations for so long a period.

The by-laws of 1808 which remained in force for so long a period contained a provision respecting rams. This was done in direct opposition to a statute passed in 1804 taking out of the hands of the inhabitants the power to determine at what periods sheep shall be allowed to run at large.

At the annual meeting in 1823 there appears to have been a complete revolution. Not a single officer of the previous year was reappointed except two out of twenty-four pathmasters and one out of four poundkeepers. The old regulations met the same fate as the old officers. They dealt with them in a summary manner and wasted no words in their law-making which read as follows:—

"1st. The Town Law concerning Rams is repealed.

"2d. Seed hogs not to run at large at any time.

"3d. The remainder of the by-laws as in the year 1808."

This brief code served the purposes of the township for another five years. Year after year the sum total of the work done at the town meetings outside of the appointment of the officers would be covered by the simple entry "By-laws stand as they were." The only change in 1828 was a return to the practice of confining seed hogs for a limited period, and this slight change sufficed for another six years. In 1834 they threw aside their conservatism and ventured into an entirely new field by placing restraints upon geese and turkeys although there was no statutory authority for so doing. The entry is as follows:—"by-laws as they were last year with the additional clause gees and tirkeys to run at large till they do damage then the owner shall pay the damage and taken care of them. The Town Clerk shall make out the Road List of each Road Master after he shall receive the Assessors bill." In the following year there was but one brief entry whereby the height of a lawful fence was no longer left to the discretion of the fence viewers:—"Lawfull fence to be five feet in height."

It was about this period in our history that the inhabitants began to chafe under the administration of their affairs by the Justices of the Peace assembled in Quarter Sessions. All the business of the local municipalities, except such as was covered by the regulations passed at the town meetings, was in their hands and they were in no way answerable to the people for their conduct of public affairs. Sidney had grown to be a populous township and the inhabitants felt that they should have more to say in the management of their own local affairs. In the year 1836 there were no less than thirty-six overseers of highways appointed yet not a single cent of their taxes could be expended upon their highways except upon the order of the Justices based upon the report of a surveyor appointed at the Sessions and under the control of the Justices.[1]

From this time forward the minutes bear evidence of a deeper interest being taken in public matters. The by-laws for 1836 were as follows:—

"All horned cattle to run at large with the exception of those that are known to be breachy. Horses under the same restriction as horned cattle. Any horned cattle or horses running at large contrary to law the owner shall pay 5/- fine. Lawfull fence to be foure feet and a half in heighth. Seed hogs found running on the highways or commons the one (owner ?) shall pay 5/- fine Town Meeting to be held at the school house in the 5th con. 4 corners January 1837."

In 1837 we observe a further development in the municipal machinery. Joseph N. Lockwood was elected moderator, this title having been revived the previous year; and, in addition to the usual officers, three commissioners were appointed, the moderator being one. Forty-two overseers of highways were appointed and for the first time since 1793 the overseers of highways were relieved of their duties of passing upon the sufficiency of fences when required to do so and thirty-three fence viewers were chosen. The following by-laws were enacted at this meeting:—

"Lawful fence shall be four feet and a half in heighth. Hogs under the restrictions as in 1836. Bulls to run at large, Horned cattle to run at large until they do damage. Horses not to run at large under the penalty of one shilling and three pence fine upon the owner of each Horse Running Contrary to Law. Twenty shillings

[1] Even the fees and perquisites of every town clerk and pound keeper were fixed by the Justices in Quarter Sessions, see 33 George III, Cap. II, Sec. XIII and 34 George III, Cap. VIII, Sec. III.

fine on the owner of any Hound dog found Hounning Deer in the Township of Sidney"

The meeting in 1838 appears to have been an uneventful one, nothing being done except the appointment of the regular officers.

In 1839 some one appears to have muddled matters. A meeting was held at Joseph Courly's store house in the fourth concession on the 7th January. Joseph N. Lockwood who held office as moderator in 1836 and 1837 was elected chairman. A clerk, assessors and three wardens were also chosen; but Lockwood was not one of the wardens. The usual number of overseers of highways and pound keepers were appointed but no fence viewers nor commissioners as in the two previous years. Some slight alterations, afterwards obliterated, were made in the by-laws. An attempt to correct the irregularities and omissions of the proceedings of this meeting appears to have been made at a special meeting held at Thomas Ketcheson's school house in the fifth concession on the 18th of March following the regular meeting. Four stalwarts, Wm. Ketcheson, Wm. Bowen, Elijah Ketcheson and Rulif Perdy, according to the minutes, took matters into their own hands and filled up the vacancies and passed the following by-laws:—

"Resolved that all horned cattle be allowed to run at large on the commons or streets during the year of 1839 with the exception of 2 months, viz.: from the first of March to the first of May, if any chattles found running on the commons or streets, contrary to Law Made and provided in such cases the owner shall forfeit and pay seven pence half penny per head.

"Swine to run at large on the Commons or Streets till they do damage, then the owner to pay the damage and yoke his hogs with a croched yoake six inches above the neck and 4 inches below the neck.

"Rams to be restrained from running at large on the Commons or Streets from the 9th of September to the first of December the owner of any ram running at large contrary to law shall pay five shillings per head damages.

"N.B. all Horned chattles that are known to be breechy is not allowed to run at large on the Commons or streets during the year of 1839 if found on the Commons or Highways running at large may be impounded in the pound nearest to where such animals are running at large."

The four men who, according to the minutes, were responsible for what took place at this meeting were all Justices of the Peace and were designated "Esquires" in the minutes. If from any neglect a town meeting had not been held the justices assembled at Quarter

Sessions had power prior to 1835 to appoint officers for the township to fill the vacancies until the next town meeting but at no period had they authority to do what these four men appear to have done at a "special session." In 1835 all legislation relative to the appointment and duties of township officers was consolidated; but no provision was made for the justices to fill vacancies. The consolidated Act provided that when the inhabitants neglected or refused to assemble and appoint officers, or for any reason failed to appoint the required number, then the officers for the preceding year, or such of them as were not relieved by the appointment of other officers as their successors, should continue in office. Again in 1838 another consolidation was made but the provision in respect to the neglect or refusal to assemble and appoint a full quota of officers remained the same as in the consolidated Act of 1835 so that for four years at least before this remarkable "special session" the justices had been deprived of all power to interfere[1]

It seems incredible that such a high-handed proceeding could take place, but there is no mistaking the entry in the minute book which reads as follows: "At the special session held at Thomas Ketcheson's school House 5th con. of Sidney on Monday the 18th day of March 1839 Wm. Ketcheson:, Wm. Bowen, Elijah Ketcheson, Rulif Perdy Esqrs., have appointed the undernamed persons to serve the ensuing year as township officers." Then follow the lists of officers and the by-laws. This is the only instance where a meeting is styled a "Session," a term applied especially to a meeting of Justices of the Peace. The place of meeting was also unusual, as this was the only meeting held at Thos. Ketcheson's School House. If the incident was as bad as it looks upon the face of the minutes the District Councils Act[2] passed in 1841 was not introduced a bit too soon. By it the Quarter Sessions were shorn of much of their power which was thereafter vested in the District Council.

The minutes for 1840 are quite regular, the usual officers appointed and the former by-laws retained with some slight variations.

At the meeting of 1842 there were appointed 43 overseers of highways, 15 pound keepers, 12 fence viewers and water course men, and for the first time two representatives to the District Council and seven School Commissioners. The School Act of 1841 though crude in many details aimed at uniformity in the schools and was welcomed by the people. Like the District Councils Act it was one step in advance towards local self government.

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[1] 46 Geo. III, Cap. 5, Sec. II; 5 William IV, Cap. 8, Sec. 6; 1 Vic., Cap. 21, Sec. 5.
[2] 4–5 Vic., Cap. 10.

In 1843 and 1844 the town meeting appointed the usual officers, and each year enacted a complete set of by-laws instead of continuing in force those of some other year as so frequently occurred. There were no less than nine distinct resolutions in the latter year, and these appear to cover nearly every contingency that was likely to arise within the limited sphere of their jurisdiction. The draftsman exercised more care than in the earlier years in defining the restrictions and the penalties to be imposed for the violation of them. One can almost read between the lines an increasing desire for more power and a restless and irritating inclination to break away from their environment.

In 1845 and 1846 very slight alterations were made in the by-laws. In the latter year an innovation was introduced by inserting in the minute book declarations of office whereby all the newly appointed officers undertook to faithfully and diligently perform the duties of their respective offices.

The meeting of 1847 was marked by no special occurrence and the by-laws of 1844 were accepted with one or two minor variations. The meeting of 1848, however, reached the highest point yet attained in the matter of the making of by-laws.

The last town meeting was held on the first day of January, 1849. At this meeting 55 overseers of highways, 21 pound keepers and 15 fence viewers and water course men were appointed. The by-laws of the previous year were renewed. The several officers elected signed their respective declarations of office after which follow a schedule of pound keepers fees and a memorandum respecting the duties of their office, and thus conclude the minutes of the last town meeting of the township.

When the District Councils Act of 1841 was first introduced there was a great outcry from certain quarters that it was too democratic in principle and few attacked it more mercilessly than Mr. Robert Baldwin the member for Hastings who declared that it was an abominable bill and that he viewed it with detestation. So successfully did the Act work out the objects of its sponsors, that, within the space of two years, the same gentleman had become such a thorough convert to its principles, that in 1843, as the Honorable Robert Baldwin and Attorney General for Upper Canada, he introduced an Act going several steps farther and providing for the incorporation of Townships, Towns, Counties and Cities in Upper Canada. It passed the Legislative Assembly but was strangled in the Legislative Council. It, however, was a question that could not be kept down. Responsible government for the local municipalities was demanded from every part of the Province. Early in the session of 1849, when the Baldwin-Lafontaine Government was once more in office, Mr. Baldwin again introduced his bill, slightly improved since its last appearance, which is substantially our Municipal Act of to-day, and it speedily became law. During the same session the Township Officers Act of 1793 and the District Councils Act of 1841 with their respective amendments were repealed and the old town meeting became an institution of the past.

A Radical and a Loyalist

A Biographical Sketch of ELIAS HARDY,

Barrister-at-Law at Saint John, N.B., 1784–1799

By W. O. RAYMOND, LL.D., F.R.S.C.

(Read May Meeting, 1919)

In a nameless grave in the old burial ground in St. John, almost under the shadow of the Court House, repose the ashes of Elias Hardy, a man whose name was almost a household word in that community during the fifteen years that followed the founding of the City in 1783. His death at a comparatively early age, and the fact that none of his descendants remain to-day in New Brunswick will suffice to account for the lack of appreciation on the part of modern citizens of the services rendered in the early days of St. John by one of her most distinguished sons.

Elias Hardy was the son of a non-conformist minister. He was born at Farnham, in the County of Surrey, in the suburbs of London, in 1744. He was educated for the bar and in 1770 was admitted Attorney and Solicitor in the Courts of Chancery and King's Bench at Westminster Hall. Led by the spirit of adventure, while yet in early manhood, he came to Virginia with the intention of following his profession.

At this time the disputes between the Mother Country and the old colonies began to wax warm. Before the passengers had landed from their vessel in April, 1775, they received intelligence of the fight at Lexington. The disturbances spread so rapidly that soon afterwards the Courts of Justice were shut. Hardy at first sympathized with the Whigs, saying that he disapproved of taxation without representation. But on the appearance of Tom Paine's notorious pamphlet, "Common Sense," he expressed strong disapproval of the sentiments which it contained and declared his opposition to armed rebellion, and to any attempt at the dismemberment of the empire. He was so outspoken that he was seized by the mob with an intention to tar and feather him, but managed to escape their hands. He was obliged to flee for his life. He went to New York and tendered his services to Sir William Howe, either in a military or civil capacity.

While in New York he entered into a law-partnership with John Le Chevalier Roome.

Hardy and Roome proposed to make it their particular business to attend to the claims of the American Loyalists for compensation for their losses in the war. Memorials were prepared in the following form:

To the Commissioners appointed by Act of Parliament for inquiring into the Losses and Services of the American Loyalists.

The memorial of A. B. Sheweth.

First, Claimant should state acts of Loyalty and Services.

Secondly, Losses sustained in consequence thereof or of the Claimant's attachment to the British Government; a schedule whereof is desired to be subjoined to the Memorial, ascertaining very particularly and accurately the description and value of the property lost.

Your Memorialist, therefore, prays that his (or her) case may be taken into your consideration in order that your Memorialist may be enabled under your report to receive such aid or relief as his (or her) Losses and Services may be found to deserve.

N.B.—The names of the witnesses, their description and places of abode, with the particulars to which they are respectively to speak are to be inserted at the end of the schedule, and the documents whereby the claim is to be made out are to be given at the time of leaving the Memorial. The Commissioners will require the best evidence the nature and circumstances of the case will admit.

Hardy set out from New York for St. John in October, 1783, calling on the way at Campobello. He posted up advertisements in St. John stating his intention of proceeding to England with such claims as should be entrusted to him. Governor Parr and Chief Justice Finucane, however, engaged him in legal business, and in consequence he sent over to Mr. Roome his own claim and those of many others, fully confident that he would present them in time to the English Commissioners. This, Mr. Roome failed to do, and Hardy was censured. Commissioners Dundas and Pemberton afterwards came out to Nova Scotia and New Brunswick, and the claims were there considered and compensation made.

Meanwhile, Hardy had been brought into the limelight by an incident which occurred at New York late in the summer of 1783, and which was the cause of not a little excitement at New York and Parr-town.

The story, briefly told, is as follows: An association of fifty-five Loyalists, many of them of considerable prominence, others less conspicuous, submitted a memorial to Sir Guy Carleton, the Commander-in-Chief, praying for grants of lands in Nova Scotia. It was proposed that the grants should equal those for field officers of the Army, namely 5,000 acres. This would be equivalent to a tract of about 430 square miles, and it was supposed would include the best locations and most fertile lands on the River St. John. At once there were mutterings of a coming storm. On the 8th of August a meeting was held in New York and a committee was appointed to prepare and present a memorial to the Commander-in-Chief concerning the matter. The memorial was prepared by Hardy, in excellent form. We may quote the following paragraphs:

"Your memorialists are much alarmed at an application which they are informed fifty-five persons have joined in to your Excellency, soliciting tracts of land amounting in the aggregate to 275,000 acres, and that they have dispatched agents to survey the unlocated lands and select the most fertile spots and desirable situations.

"Your memorialists cannot but regard the grants in question, if carried into effect, as amounting nearly to a total exclusion of themselves and families, who, if they become settlers, must either content themselves with barren or remote lands or submit to be tenants to those whom they consider as their superiors in nothing but deeper art and keener policy."

There were at this time several thousands of loyalists at the mouth of the River St. John anxiously awaiting definite information as to their location. The lands had been promised them in the King's name before they left New York. The hope of re-establishing themselves in new homes on British soil was the beacon-star that had led them northward and eastward. But now landed in the Acadian wilderness, they found no adequate preparations for their reception. Congregated in huts and tents on the rocky hillsides at St. John, weeks and months passed in uncertainty and in helpless inactivity on account of the delay in alloting the lands.

The warm-hearted and impulsive Edward Winslow, who was doing what he could to stir up the authorities in Halifax, speaks of the poignant distress of the men of the disbanded loyal regiments. "We like the Country," they said, "only give us some place we can call our own and laws for our protection."

Governor Parr's presence in St. John was certainly very desirable in the fall of 1783. He tried to quell the hostile demonstrations, which broke forth in Parr Town, by removing some of the ring-leaders across the Bay.

Meanwhile the firmness and decision of Sir Guy Carleton helped to solve the difficulty. Hardy and his committee waited upon him with their memorial and met with a favorable reception. Sir Guy said that no person should be allowed to take up lands but those who meant to settle on them until the loyalists were first served. He assured the Committee that he would do everything in his power for them and believed that they would have no cause to complain. As an outcome of this episode Hardy became the recognized champion of the cause of the common people.

The arrangements for settling the loyalists at St. John were entrusted to Major Gilfred Studholme of the Royal Fencible Regiment, who commanded the garrison at Fort Howe at the mouth of the river. He was an honest and capable official, but it was quite impossible to please everybody. Old soldiers and old time profiteers were just as keen to seek their individual interests as their modern representatives are. The ultra-tories and aristocrats among the loyalists were not especially considerate for the disbanded soldiery and humbler classes. The latter were not as reasonable and patient, perhaps, as they might have been. It was but fair that the democracy of the day should have its champion and such an one was found in Elias Hardy.

In laying out the towns of Parr and Carleton the surveyor employed was Paul Bedell, and right well he did his work. The name of Parr, or Parr-town, as applied to St. John, came into use in August, 1783. Edward Winslow tells us in one of his racy letters that the town was christened by Major Studholme and others in consequence of a letter from Col. Parr, the Governor of Nova Scotia, to Studholme, wherein he makes the request pointedly, but says, "that the idea originated in female vanity." The name was never popular nor was it apparently adopted with unanimity. It lasted less than two years.

In the work of apportioning the lots, Studholme was assisted by a board of directors, including George Leonard, William Tyng, Rev. John Sayre, John Coffin and James Peters, with Oliver Arnold as Secretary. As the season passed the arrivals of those who had been sent to St. John by Sir Guy Carleton proved far greater than had been expected, and in consequence the lots were divided and subdivided, on the arrival of almost every Fleet of transports, until the lots assigned to the first comers had been reduced to one sixteenth of their original dimensions.

When the fall Fleet arrived on the 26th September, with more than 3,000 disbanded soldiers and their helpless dependents, no proper arrangements had been made for their reception, and winter was nigh at hand. There was an outcry that reached even to Halifax. It did not bring the Governor to investigate. But it brought Elias Hardy to the fore as the advocate of the people.

Complaints were by no means limited to the illiterate class. Colonel Edward Winslow, a Harvard graduate, in whose veins there flowed the best blood of the Pilgrims of 1620, is equally outspoken. He writes to his friend Major Joshua Upham in these words:

"Inattention, or want of exertion, in the agent of the Refugees has been the cause of extreme distress to those who have landed here. They are at present crowded into one spot without covering, and totally ignorant where they are eventually to settle. Why, Upham, was not some man, or men, of consideration and spirit appointed to take direction of these people?"

Those who arrived in the "Fall Fleet" included many who had engaged in the bitter controversy with the "fifty-five petitioners" for lands in Nova Scotia, to which reference has already been made. Owing to their late arrival many of the disbanded soldiers were obliged to hut in the "Lower Cove district," and some of them had to pass the winter in tents thatched with spruce bushes. Naturally, their complaints were emphatic. Governor Parr sent Chief Justice Finucane from Halifax to make investigation. Numerous complaints were submitted by Hardy. The charges were in effect that certain persons, whose names are specified, were believed to possess lots much in excess of their deserts.

Leonard, the chairman of the Board of Directors, admits that he had a principal share in settling and forming the town, and also that he and the directors were unfriendly to Hardy and the "Lower Cove Party," but he hotly denies that he had been guilty of partiality or improper conduct. He writes to Edward Winslow on April 30th, 1784:

"The Chief Justice has arrived here for the purpose of inquiring into and redressing grievances. He has unfortunately thrown the Town into confusion by attending to the illiberal insinuations of that man Hardy. The feelings of the gentlemen are hurt and many undeserving people, who are Hardy's connections, are benefited by his partial decisions.

"Those who have hitherto had the direction of matters here are in an indelicate way sent for and in the presence of that Man charged in the language and tone of a Bashaw with wrong and partial conduct without any regular inquiry into it."

Major John Coffin, another member of the Board, is equally inimical to Hardy. He writes:

"The time I hope is not far distant when I expect to see every thing undone, and Mr. Hardy thrown neck and heels with his party into the river. It is infamous and disgraceful to a degree.

"After all the trouble Studholme has been at for the settlement, to have this Chief with Brother Toady lay violent hands on everything, condemn everybody he thinks proper, and derange all our affairs is too much. Our memorials are going forward with all expedition. I have heard that Mr. Hardy is forming a party against it, and have no doubt he will throw everything in the way. He is, I assure you, a very troublesome fellow, but I hope we shall soon unhorse the Dog."

We learn from Winslow's correspondence the nature of Coffin's attempt to "unhorse the dog."

Gregory Townsend, the Commissary at Halifax, writes to Winslow on the 29th July, 1784: "Major Coffin and his coadjutors have declared war against the Governor and Chief Justice and are to have a pitched battle to-morrow in the Council Chamber."

Coffin's coadjutors were Gilfred Studholme, William Tyng, George Leonard and James Peters, who voluntarily repaired to Halifax and submitted themselves to trial before Governor Parr, Lieut.-Governor Fanning and the Council of Nova Scotia, Chief Justice Finucane also being present. After a public hearing of two days the following was the decision:

"The Council are of the opinion that Gilfred Studholme, William Tyng, George Leonard, John Coffin and James Peters, magistrates and agents on the River St. John, have acquitted themselves in their conduct with fairness, impartiality and propriety."

(Signed) RICHARD BULKELEY,
Secretary.

Halifax, *3rd August, 1784.*

We need not pursue the inquiry further. It left the line of cleavage between the opposing parties in Parr-town more distinct than before, and established Hardy as the leader of the democracy.

Hardy's legal ability led to his being employed by the government of Nova Scotia (previous to the division of the province) in promoting the escheat of lands on the River St. John, which were unimproved, for the accommodation of the loyalists.

The visit of Chief Justice Finucane to St. John—supposedly in the interests of loyalists seeking lands for settlement—had one curious result, namely, that on his return to Halifax, Finucane obtained for himself from Parr a grant of Sugar Island in the St. John River (containing 500 acres of fine alluvial land), situated about eight miles above Fredericton. The island had been reserved for the disbanded Prince of Wales American Regiment and Captain Edward Stelle and other officers and men of the regiment took possession. The result was the first ejectment trial in New Brunswick, the case of "Finucane vs. Stelle." It came to trial in 1787; Bliss and Hardy for the plaintiff, Wylly and Chipman for the defendant. Finucane was non-suited. The case was argued on appeal, pro and con, by Hardy and Chipman, and judgment reversed. Chipman subsequently carried the case to the King in Council, who upheld the original judgment. The trial excited much interest, not only in Fredericton and St. John but also in Halifax.

At this time communication with Halifax was difficult. There were no Courts north of the Bay of Fundy, and what is now New Brunswick had only four members in the Nova Scotia House of

Assembly. In consequence of the dissatisfaction, a new Province was formed and Col. Thomas Carleton came out in the fall of 1784 as its first Governor. Courts of Justice were speedily established and were hailed with great satisfaction. Benjamin Marston, first sheriff of the County of Northumberland, writes in his diary under date February 1, 1785:

"The Supreme Court of Judicature opened this day at St. John for the first time. The Chief Justice gave a very judicious, sensible charge to the Grand Jury. The advantage of a dernier resort for justice in all civil and criminal cases will be very great to the people of this new Province. They will find a mighty odds between having Justice travelling regularly about among them and being obliged to cross the Bay of Fundy and travel 130 miles to Halifax."

The clamour for lands still continued and Elias Hardy was kept busy promoting escheats and drafting memorials to the Governor in Council. Governor Carleton was assiduous and sat in Council three days in each week at the old Council Chamber in St. John. The extent of the labours of the Governor and Council can only be appreciated by those who have examined the immense number of land memorials on file in the Provincial archives.

Hardy was admitted Attorney at the Bar of New Brunswick on the occasion of the opening of the Supreme Court by Chief Justice Ludlow. He was not long in being recognized as a leader in his profession.

About this time steps were taken for the incorporation of the City of St. John and the consequent disuse of the name of "Parr-Town." Edward Winslow writes on Jan. 13, 1785, to his friend Chipman:

"I have never been an enthusiast for towns and cities, but I emphatically endorse the selection of Col. G. G. Ludlow as Mayor, and if Mr. Hardy is induced to accept the appointment of Common Clerk and the Council completed as planned I shall expect to see Halifax evacuated by the most respectable of its inhabitants and Shelburne totally eclipsed and that immediately."

Hardy did not get the position of Common Clerk, which passed to the nestor of the New Brunswick bar, Bartholemew Crannell.

On the death of Bartholemew Crannell in 1790, there were two applicants for the vacancy, namely, Elias Hardy and Gabriel V. Ludlow, the latter a son of the first Mayor and a nephew of the Chief Justice. Stephen Sewell, who was at that time a law student with Ward Chipman, wrote to his brother Jonathan (afterwards Chief Justice at Quebec) as follows:

"Gabe Ludlow has lost the Clerk's office in a strange manner. It is considered a curious circumstance by all the Whigs here. He had made application to the Chief Justice a long time ago to use his influence in his behalf, but as the demon of ill luck would have it the Chief never mentioned it to the Governor till the latter showed him an application from Hardy, which the Governor considered entitled to priority. The Chief Justice was excessively urgent for his nephew, the Governor was as strenuous for Hardy and appointed him. It is supposed by some that the whole is political business, but I am convinced that what chiefly actuated the Governor was his strict adherence to his word, for I am told he has declared that the first applicant for any vacant office, if the person is capable and not immoral, shall be appointed."

Hardy retained the position until his death. His services were especially valuable in connection with much of our early civic legislation. For years nearly all the acts and by-laws connected with the Government of the City were drafted by his hand. He also filled the offices of surrogate for the City and County of St. John and of Clerk of the Court of Chancery. Meanwhile, he continued to build up a large legal practice.

The date of the incorporation of Saint John was the 18th of May, 1785, the second anniversary of the landing of the Loyalists.

Carleton was rapped over the knuckles by Lord Sidney (not severely) for venturing to grant a charter of incorporation to St. John, without consulting the Home Government. He was asked to forward a copy of the charter for the consideration of the King in Council. The City Charter was confirmed by the Provincial Legislature at the ensuing session. There was some correspondence with Lord Sidney over the matter, but the act of Assembly was not disallowed by the Crown. However, it was more than fifty years before any other city in British America ventured to take the risk of seeking incorporation.

The first provincial election in New Brunswick was held in November, 1785, under an exceedingly liberal franchise, as we learn from an announcement in the *Royal Gazette*, that "All males of full age, inhabitants of the Province, that have resided three months therein are entitled to their votes on this occasion." Hardy was regarded as the leader of the democratic party in St. John, but to the surprise of many of his friends he issued the following card:

"Mr. Hardy returns his thanks to such of his friends as have been pleased to declare their intention of voting for him at the election as a representative for this City and County; but begs they will not reserve their votes, as he does not propose offering himself as a candidate."

The sequel, however, will appear in the following extract from Sheriff Marston's diary, under date Thursday, November 17, 1785. He writes at Miramichi:

"To-day held an election for two members in the General Assembly. William Davidson, an inhabitant of Miramichi, who has great influence over the people here, many of them holding lands under him and many others being in his employ, was chosen for one, and by the same influence Elias Hardy, an Attorney, an inhabitant of the City of St. John, was chosen as the other. This will disappoint some of my friends who hoped that George Leonard, Esq., and Capt. Stanton Hazard would have obtained the election. But 'twas impossible. They were unknown here and we who recommended them were but strangers. 'Tis therefore no wonder we did not succeed against an artful man who had an influence and knew how to use it."

In St. John the government candidates were strong in the district of the "Upper Cove," and the opposition were just as strong in the "Lower Cove," and as the election progressed the hostility between the two parties became intense. On the evening of the third day a tremendous riot took place at the Mallard House, on the corner of King and Germain Street, in which windows were smashed by the "Lower Cove" party, who were the attacking faction. A number were injured on both sides, brickbats being freely used, and eventually it was found necessary to call out the troops in garrison at Fort Howe to support the civil authority. Several arrests were made, one of the "Lower Cove" candidates being among the number. At the subsequent trial some of the rioters were punished by fine and imprisonment.

At the conclusion of the voting the opposition candidates had seemingly a considerable majority, but a scrutiny was demanded and Sheriff Oliver returned Messrs. Bliss, Billopp, Chipman, Pagan, Hazard and McGeorge as elected, while the "Lower Cove" candidates, Dickinson, Lightfoot, Grim, Bonsall, Boggs and Reid were declared defeated. An appeal was afterwards made to the House of Assembly, which sustained the Sheriff's return. It is not necessary to enter into the merits of the controversy. Hardy, although a reformer, was not a bitter partizan, and seems to have shown his sagacity in keeping out of the turmoil of the first St. John election. As a member of the legislature his services were important. He was painstaking and industrious in Committee work and his eloquence and ability in debate soon obtained for him a leading place. The first House of Assembly lasted seven years.

At the second general election, in 1793, Hardy and his party were triumphantly returned. In St. John he won a signal victory over his old antagonist Ward Chipman. The story is told in Chipman's letter to his former law student, Jonathan Sewell of Quebec, to whom he writes on the 23rd of February, 1793, in the following terms:

"My dear Jonathan, Here I am once more, to my great mortification, a legislator. The Governor wished very much I should be in the House again. I offered myself in the City, but the 'Lower Covers,' headed by Hardy, were uppermost, and I was distanced by him. I put up in York Co, but too late, the bulk of the voters were engaged. A party was sent off without my knowledge to Miramichi, where I came in all hollow, without the faintest opposition. My object from the beginning was to get the Speaker's chair, or I would never have become a candidate. A majority of the members are quite under the influence of the St. John politicians, so that I find I can be of no service to the public and most cordially wish I was clear of them, and, like Bliss, enjoying my own fireside."

When the third House of Assembly was elected Hardy was again pressed to be a candidate, but was obliged to decline on account of his health.

Throughout his life he was an extremely busy man. In addition to his civic and parliamentary duties and the calls of his profession he had the social and benevolent claims of the Masonic Order, of which he was one of the founders in Saint John.

As an all round lawyer tradition says Elias Hardy had no peer. Among the important cases in which he was concerned was that of Benedict Arnold versus Munson Hoyt. Arnold was for a time a resident of St. John. The suit was brought by the General against his former business partner for slander. Hoyt accused Arnold of setting fire to their store in Lower Cove, on which he had recently effected insurance to the amount of £5,000. The store with its contents was entirely consumed. The case came to trial before Judge Isaac Allen at the September Court in 1790. Arnold claimed damages to the amount of £5,000, but the jury only awarded him twenty shillings, which was regarded practically as a verdict for the defendant. Attorney-General Bliss and Ward Chipman appeared for Arnold, and Elias Hardy for Hoyt. The St. John public apparently had not a high opinion of Arnold's integrity and their sympathy was with the defendant.

Another celebrated case in which Hardy was retained, and which proved a lucrative one for the lawyers, was that of William Hazen versus James Simonds. The case was the outcome of business transactions between the parties extending over a period of twenty years. The case was of so intricate a character that it was before the Courts, in one form or another, for twenty-five years. Chipman was retained to look after the interests of his father-in-law Hazen, and Simonds was represented by Elias Hardy.

The proceedings of this suit in Chancery are preserved in the record office in Fredericton. The student will find much information in the venerable parchments concerning the mode of procedure in vogue in early days and will gain some idea of the industry and ability of Hardy and Chipman, who were giants in their profession in their generation.

A few words must be added with regard to the character of Elias Hardy in private life. Here we may quote from the obituary notice printed by Christopher Sower in the *Royal Gazette* of January 1, 1799:

"Elias Hardy formed but few friendships, but in these he was always sincere, and the brilliancy of his wit and good humour made him the life of every circle of which he formed a part. He has left a wife and four children to lament the loss of an affectionate husband and indulgent parent."

The death of Elias Hardy took place at his residence on Christmas day, 1798, in the 54th year of his age, "after a long illness which he bore with the greatest fortitude." Three days later, his mortal form was borne to its last resting place in the old burial ground attended by a large concourse of leading citizens.

Hardy's wife, Emma, was the daughter of Peter Huggeford, M.D., surgeon of the Loyal American Regiment. Dr. Huggeford was living in New York in 1800, and his daughter, Mrs. Hardy, went there to live with her children after the death of her husband.

But while friends and kindred returned to the United States, all that was mortal of Elias Hardy remains with us, and though the exact spot where he was laid at rest is not known, this we know, that the City of the Loyalists retains within her bounds all that could die of one of her distinguished founders, that his ashes lie beneath the shadow of the meteor flag that waves aloft above the neighboring hall of justice, and that his memory is preserved by the memorial tablet lately placed in the Court, of which he was in his day and generation a conspicuous ornament. The Hardy memorial tablet, a very beautiful one, was unveiled in the auditorium of the Court House with befitting ceremony by His Honour Chief Justice H. A. McKeown on the afternoon of Tuesday, September 24th, 1918, in the presence of the members of the New Brunswick Historical Society and many of the leading citizens of Saint John.

The writer of this paper deems it an honour to have gathered the fragments which tell, however imperfectly, the life story of the son of the non-conformist minister of Farnham, and to lay this humble chaplet on his nameless grave.

Toronto, *May 18th, 1919.*

The Significance for Canadian History of the Work of The Board of Historical Publications

By ADAM SHORTT, LL.D., C.M.G., F.R.S.C.

(Read May Meeting, 1919)

It has been remarked from time to time, not without a sub-acid implication as to the mere relativity of Historical Science, that every age demands the rewriting of history to suit its changing tastes and shifting interests. There is a sense in which this is not only quite true but is proof, also, of the progress of civilization and of the broadening interests of humanity. In Shakespeare's time, and earlier, it was bad form to treat seriously the lower orders of society otherwise than as necessary servants and dependents of the nobler orders of humanity. Broad-minded and versatile as he was, Shakespeare himself shows no interest in the lot of labourers, peasantry, and petty tradesmen. Their usefulness and fidelity to their masters are treated as of much the same nature as those of the dog or the horse. The more important virtues and the more interesting villainies are all reserved for the higher orders of society. With their deeds and misdeeds alone serious history is concerned. So far have we travelled since then, however, that we seem already to have passed well into the opposite quarter. We may even be inclined to take seriously the erstwhile facetious appeal "Spurn not the nobly born, nor the well-connected treat with scorn." Now-a-days, to be sufficiently poor to be afflicted by the high cost of living, is *prima facie* evidence of virtue. And yet there may be those who can remember when it was no particular disgrace to be rich.

In the transition from one of these extremes to the other, history has been continually broadening its scope. It is to history in its most disinterested form—a broad and impartial presentation of conditions as they have actually developed—that we may yet have to appeal to save us from many wild phases of economic and social doctrine. A study of history in its broadest sense is simply the intelligent appraisement of the development of a people or a nation, not merely in its outward political and international relations, but even more particularly in its social, economic, and intellectual progress. It involves a clear-visioned presentation of the varied experiences through which peoples or nations have passed in the constant attempts to improve their condition individually and collectively. It presents the outcome in failure or success of the numerous and varied experiments which communities have made in settling new countries and in reducing the relatively unproductive wilderness to a fruitful basis for life, relative comfort, and even what the framers of the Declaration of Independence, with wise restraint, called "the *pursuit* of happiness."

In this connection it traces the growth of the varied institutions which constitute the articulated skeleton of society which supports the flexible social and economic life which clothes it with flesh and blood, making of it a living body; subject, however, unfortunately, to all the diseases which afflict these marvellous living mechanisms. Among the transitional forms through which the developing community passes, we have the change from a condition of predominantly rural to one of predominantly urban life. Here we trace the rise of the artisan and trading classes, the development of industry on a large scale, and the consequent emergence of those dread factors, the capitalist, the financier, the railway king, and all those high and mighty potentates of wealth, who can buy their way into almost anything, and even occasionally out of it again. Indeed, so complex has become this modern industrial and financial texture of society, and so far-reaching its relations, that even the controlling factors in it have lost trace of the real relations and connections of the parts with each other. Taking advantage of this general ignorance of relations, several new factors, with the avowed purpose of promoting their sectional interests, have undertaken to deny stoutly what have been long accepted as at least fundamental relations. They come forward with sweepingly radical propositions for readjusting values and connections, the effect of which shall be to eliminate all the more successful economic magnates, and, even without the formality of selling all they have, to give it to the poor.

Now the only satisfactory appeal in all such cases between those who would retain and those who would abolish the present economic and social orders, is the appeal to history. How did these complex structures grow up? What changes have they undergone in the process? And, so far as may be gathered from the past, what would be the reaction in the case of sudden and radical changes at the various stages in the process?

Not only therefore does a properly conceived presentation of historical facts afford an indispensable basis for the satisfactory answer to any intellectual questions which arise, as to the growth and present structure of modern society, but it affords the only satisfactory data for testing the relative truth of the rival analyses of industrial and political societies of the present day, and the consequent value of practical economic and political programmes which depend upon the soundness of these analyses. It is desirable, of course, that there may be as little dispute as possible as to what it is that history teaches with reference to this or that problem. It is necessary, therefore, not only to set forth a conscientious view of historical facts, but, as far as possible, the actual documents, or at least the most important of them, arranged in such a manner that they may be the most readily accessible, not only at large, but in their natural historical relations with each other, in point of time, place, and similar interests. It is the object of the Board of Historical Publications to furnish in the case of Canada such first-hand historical material in the most readily available form.

The publications of the Board have no special appeal to make, and no special message to deliver. Actual national life presents many conflicting ideals, many rival interests, and many different programmes of action, and therefore a great variety of actual experiences. Some of these gain the ear of the majority at one time, some at another. Many ideas are broached but lie dormant, sometimes forgotten, sometimes kept alive by a few ardent disciples. Then may arise special crises and reactions from more popular courses which have disappointed the expectations of the majority. Suddenly propositions long held as mere theories, or more recently formulated, step into the street and become the main-springs of action. Obviously, an adequate documentary history will present all these conflicting measures without favour or bias, leaving to the teacher, the student, or the intelligent reader to reach his own conclusions as to their validity or significance. They do at least furnish the record of experience—the basis of all wisdom.

Owing to the peculiar relations which Canada bore to the mother country, both as a French and as an English colony, and the necessity for a constant interchange of information and instructions, special facts, views, and interests, there was produced and accumulated a remarkable body of documentary records embodying the chief facts of Canadian history. There is a greater variety than might be expected, in the presentation of the facts and views, since there were several effective channels, public and private, through which these might be presented and appeals made to the imperial authorities. Thus in the long run most currents of colonial life were represented in one form or another, whether for approval or condemnation, in criticism or defence. Much local material, considerable private correspondence, and many descriptive accounts of the country and the condition of the people have been preserved and recovered. Early newspapers and pamphlets, though many of them rare or unique, and quite scattered in their location, are also extant and furnish a very necessary atmosphere of fact and comment for the more central and official documents. Owing to the very volume of this material, even so far as collected at the Archives in Ottawa, and more so as scattered in various Canadian centres, it is possible for only a very limited number of students to consult it. To do so requires at once a strong personal interest, a special historical training, the necessary leisure, and last, but far from least, the requisite means, to enable one at all adequately to consult the documentary and other evidence necessary to satisfactory results. The successful student must spend not merely weeks but months, or even years, according to the nature and extent of his researches, first in locating and afterwards in examining, comparing and transcribing the materials necessary for accurate first-hand work. Needless to say, it is still more difficult for those beyond the limits of Canada, whether in other parts of the British Empire, in the United States, or other foreign countries, to avail themselves of the varied treasures of our Archives. If, therefore, our Canadian history is to be known in authentic form, not only to our own people, but to the outside world, whose interest in Canada is steadily rising, it requires the facilities for direct knowledge to be greatly increased. It is necessary to put in available form the chief documents relating to the various phases of the country's history.

In order that these documents may be of the greatest service it is desirable that, in addition to being arranged chronologically, they shall be classified according to the chief interests which were developed in the country. They should, for instance, enable us to trace the original settlement of the country with the sources of its population, the condition of their arrival, and the terms of their settlement, the origin and growth of the various political institutions, local and general, the foundation and extension of trade relations both domestic and foreign, the opening of the means of transport and communication, the first establishment and future growth of the instruments of exchange, and the public finances, etc. This arrangement according to the chief national interests, is also the most suitable and effective for cross-reference, as in tracing the influences of these factors on each other. In fact as many combinations as are desired may be readily effected without confusion.

While, of course, only the documents of primary importance, or containing the fullest and most typical treatment of any special events, can be presented in full, reference to many secondary documents and a few of the more important extracts from them will be furnished in the foot-notes; thus enabling the documents to serve as guides to further or more detailed studies of the various sections of Canadian History.

The volumes issued by the Board will not, of course, take the place of detailed researches by students of special historical problems. They should, however, furnish the training ground for specialists by preparing a broad highway into the land of original documents and other first-hand materials, encouraging an increasing number of students to undertake more detailed researches into scores of unexplored sections of Canadian History. For all such special researches our volumes should furnish a general background and a reliable atmosphere uniting and relating the special researches to each other and to the general history of the country. The general programme as mapped out is as follows:

Political and Social

1. Constitutional Development to Confederation
   (*a*) Ontario and Quebec.
   (*b*) Maritime Provinces.
   (*c*) Western Provinces.
2. External Relations, including Boundaries.
3. Militia and Defence.
4. Immigration and Settlement, including Land Granting.
5. Municipal Development.
6. Indian Relations and Exploration, including operations of Hudson's Bay and Northwest Companies.
7. Relations of Church and State, including Clergy Reserves, etc.
8. Education, Literature, Art, etc.

Economic

1. Public Finance and Taxation.
2. Currency, Banking and Exchange.
3. Trade:
   (*a*) Domestic.
   (*b*) Foreign.
4. Transportation:
   (*a*) Shipping, including Canals, Shipbuilding, etc.
   (*b*) Highways and Railroads.
   (*c*) Postal Developments.
5. Agriculture.
6. Fisheries, marine and inland.
7. Industry: labour, manufacturing, lumbering, mining, etc.

The purposes aimed at in setting forth so large a programme in advance are chiefly these: First, it will serve to avoid doubt and possible confusion in the classification of documents to know what are the various sections under which they may be grouped. Thus, when one is tempted to incorporate an important but only partially related document in any volume in preparation at a given time, one can safely set it aside, knowing that it will find more appropriate place in another volume reserved for the future. Secondly, in going through the masses of miscellaneous manuscript documents, it will accomplish a very great saving of time for the future, if one can note and classify for subsequent reference those documents which are not of special interest to the subject in hand, but which are certain to be of special importance for other volumes to follow.

The documents will be given from the most authentic sources available and in the language in which they were prepared or officially presented. In the English edition the French documents will be given in the original but will be followed by an English translation, while in the French edition the original French documents will remain unaltered while the English documents will appear in French translations.

Apart from the revision and reissue of the first volume of Constitutional Documents, 1759–1791, for some time out of print, and now nearing completion, the new subjects at present in preparation are three in number. First, the largest and in some respects the most important, is that of the original settlement of the various sections of Canada. This will deal with the sources of our population, the occasion of the coming to this country, the inducements and assistance afforded by the government, as also the restrictions imposed on certain aliens, the terms on which lands were granted, and the variation from time to time of these terms and conditions. This is a large and complex subject and the documents relating to it will fill several volumes, but it is fundamental to the study of all other phases of Canadian History . The second is the constitutional development of the earliest English administration in Canada, that namely in Nova Scotia, which originally covered the three maritime provinces. This furnishes the necessary link between the earlier constitutional organization, in the various types of British Colonial Establishments in America, and the later administration in Canada after the Conquest, and still later in British Columbia and the Northwest Territories, originally occupied by the Hudson's Bay Company. The completion of this treatment will require the presentation of the French Constitutional Development to the periods of the taking over of the

French dominions, in the east under the Treaty of Utrecht, and in the west under the Treaty of Paris. The third subject is one of economic and financial interest, the establishment and development of the instruments and processes of exchange, or the Monetary and Foreign Exchange History of Canada from the earliest French period down to Confederation, at least, after which the documents are fairly generally available.

Such is the programme immediately before the Board and it is hoped to place the volumes to be issued in all public and educational libraries throughout Canada, as, also, in the leading general and historical libraries in the British Empire and the United States, and in allied and other countries so far as they manifest an interest in our history, and this is already very general. They will also be available at moderate cost for private possession by historians, journalists, teachers and others who manifest an interest in the authentic history of the country.

David Ramsay and Long Point in Legend and History

By JAMES H. COYNE, LL.D., F.R.S.C.

(Read May Meeting, 1919)

INTRODUCTION.

In August, 1893, the writer with a party of friends visited the Long Point Settlement. Carriages were taken at Simcoe, and the tour included such historic sites as Vittoria, Normandale, Turkey Point, Fisher's Glen and Ryerse Creek. The interest and enjoyment of the trip were greatly enhanced by the companionship for a time of the late Mr. Simpson McCall, then eighty-five years of age, who proved a very mine of information regarding the Settlement. Mr. McCall had for many years been prominent in the County of Norfolk, filling various positions of honour and responsibility, including that of representative in the Provincial Legislature for two full terms. Mr. McCall died in 1898 at the great age of ninety-one. Tasker in his history of the Settlement refers to him in these terms: "In the respect and veneration of the whole community, Mr. McCall in his old age received his reward for the sterling honesty which was the predominant feature of his whole life, and the unflinching justice and impartiality which were his most notable traits of character."

Possessed of a retentive memory, Mr. McCall delighted in recounting to eager listeners many incidents of national, local and family history. From Mr. McCall's own lips the writer of this paper wrote down at the time pages of narrative, condensing as he proceeded, but using the narrator's words as far as possible. The narrative included among various matters of interest the following story of buried treasure:—

RAMSAY'S BURIED TREASURE.

"One Ramsay, before and after the Revolution, traded with the Indians of this region up to Detroit, &c. Dr. Troyer believed in magic, and had a mineral rod, by which he divined where gold was buried. About 1790, when Ramsay was coming from Detroit with two men and his boat loaded with furs and gold, he had a dispute with Indians living at Port Stanley where they had large corn fields, over his refusal to furnish them with liquor. They followed him from the land down to Port Burwell and the carrying place, and Long Point to the end of the peninsula, and prevented him doing any further trade. At the portage he buried his money in an iron chest, and killed a black dog and buried it over the chest as a protection. This was Ramsay's last trip. About 1817 Dr. Troyer and his son, Michael, having found out by his divining rod where the treasure was, went out towards evening to dig it up. I saw them going out in the boat. My father was the only one I know about that they had consulted, but he was an unbeliever, and would not go. The Doctor afterwards told me that they dug down to the box. The Doctor was a Tunkard. He held a Bible open and a lighted candle to keep away the Evil One. Michael dug and tried to pry the chest out of the ground, when a big black dog rose up beside the chest—grew right up bigger and bigger, until the light went out, and then they took to their boat and went home.

"Doctor Troyer had a stone, which he covered with a hat, and when one of the Fick girls put her head under the hat, she could see everything that was hidden—stolen money, and goods, &c. Many things were recovered in this way, amongst others some things stolen from my Uncle, Ephraim C. Mitchell."

In a later conversation, which I did not record at the time but give from memory, Mr. McCall added some details, furnished by Michael Troyer to himself. The Doctor and Michael arrived at the portage a little before dusk. This was to give them time to fix the exact location of the treasure. Having found the spot, they withdrew to the boat and waited until midnight, when they proceeded to the place, the Doctor leading the way with a lighted candle in one hand and an open Bible in the other, Michael following with pick and spade. Precisely at midnight they heard the clink of the spade on the iron chest, and Michael endeavoured to pry up the lid, when the frightful apparition rose up, expanding to an enormous size, and the daring intruders, brave as they had thought themselves, dropping book, candle and digging implements, fled to the boat, leaped in, and rowed with all their might for home.

Historical Basis.

So much for the story of the buried treasure. The legendary factors are old enough, to be sure. The witch doctor, the divining rod, the buried gold, the black dog, the exorcism with book and candle, the ghostly guardian of the treasure, the magic stone, the "thinking cap"—these are among the commonplaces of folklore. That Mr. McCall was firmly convinced of the truth of his story was manifest.

The supernatural elements in the narrative are for the psychologist. The writer's interest in it was chiefly concerned with its historical aspect. Who was Doctor Troyer? What was the relation of Ramsay to the first settlers? How did the two names come to be associated with the Evil One? How did it happen that the blended folk-lore of European countries, transplanted to the shores of Lake Erie, found congenial soil, took root, and thrived as if in its native environment?

Making all necessary and proper allowance for Mr. McCall's advanced age, and the time elapsed since the occurrences recalled by him, the writer endeavoured to ascertain the historical basis for the legend and discovered interesting particulars relating to both Ramsay and Troyer, much light being thrown upon the former especially by official correspondence between Sir William Johnson, Superintendent of Indian Affairs in North America, and his superior officer, the Colonial Secretary in England, as well as by autobiographical material furnished by Ramsay himself.

A brief summary of available information may not be unacceptable.

In the early days of settlement on Lake Erie no names were more widely known than those of David Ramsay and "Doctor" Troyer. Troyer's name is prominent in other tales of witchcraft and magic art, current among pioneer settlers, not only at Long Point, but westward as far as the River Detroit and Lake St. Clair. Owen, in his "Pioneer Sketches of the Long Point Settlement," has something to say about him. A pamphlet entitled, "The Belledoon Mysteries, an O'er True Story, by Neil T. McDonald," first published more than a generation ago, shows him as the active agent in solving and ending certain mysterious manifestations on the Chenail Ecarté, near Wallaceburg, which had caused wide-spread interest throughout the lake-shore region, and even far beyond. Tasker's volume on "The United Empire Loyalist Settlement at Long Point, Lake Erie," published as Volume II of the Ontario Historical Society's Papers and Records, refers to Ramsay. Official records printed in Volume VIII of "Documents Relating to the Colonial History of the State of New York," show some of the grounds upon which his evil notoriety was acquired. That very rare volume, "Captain Patrick Campbell's Travels in the Interior Inhabited Parts of North America," published in 1793, contains the case for the defence as presented to Campbell by Ramsay himself.

Ramsay, the Indian Killer.

David Ramsay, a Fifeshire lad, came to Quebec as ship's boy on board a transport, and after the war, in 1763, settled on the Mohawk River. After serving the Northwest Fur Company of Montreal for some time on the Upper Lakes, he returned to the Mohawk, where he was soon joined by his brother George from Scotland. "Having the assistance of this lad," Ramsay states, "I thought of trading with the Indians on my own account, and for that purpose purchased a large battoe at Skennectity, and procured credit to the amount of 150 pounds York currency's worth of goods." With these he proceeded *via* Wood Creek, Oswego and Lake Ontario to Niagara. He adds: "Carried my battoe and goods across the portage to Lake Erie; from thence to the river Sold Year" (which is Ramsay or Campbell's phonetic transformation of Chaudière) "or Kettle Creek, and proceeded up that river for sixty miles, where we met tribes of different nations of Indians encamped for the purpose of hunting, and informed them of my intention of residing among them during the winter, and erected a sufficient house of logs." Here he bartered goods for furs until towards January, 1772, when trouble began with some Ojibwas, Mississagas and Ottawas. He was compelled to furnish them rum, his life was threatened, his goods plundered, and at last his hut was attacked by night. He killed and scalped three Ottawas, according to his own story, the other Indians having departed previous to the attack. One of those scalped was a woman. When the ice broke up, he and his brother, a boy of seventeen, put his furs and other goods, chiefly deerskins, into the bateau, and set out for Niagara by way of Lake Erie. At Long Point he was forced by the ice to go ashore and camp. Some days afterwards Indians came to the same place and at once began to quarrel with him, chiefly over rum, which he was compelled to furnish them. They threatened his life, and actually seized and pinioned him, tying his arms behind his back and his hands up to his neck, and making him sit by the fire. To make a long story short, Ramsay, in the end, got the better of his assailants. His brother had been able to help him in the struggle, owing to the fact that he had been less carefully watched. It is easy to imagine the effect of the rum as a factor in the battle. Ramsay killed his guard and four other Indians, including a boy, scalped them, and got away with his brother. At Fort Erie he told the commanding officer about the Indians he had killed. The officer put him under arrest and sent him to Niagara where he was imprisoned. The Indians gathered at Niagara in great numbers, demanded his surrender, and threatened to burn the fort. "They became at last so clamorous," says Campbell, "that the Governor sent a party, unknown to the Indians, to Montreal with David, where he was fifteen months in prison; and as no proof could be brought against him in a regular trial, and everybody knew he acted in self defence only, he was liberated. And what is strange, and what the like never was known before is, that he now lives in intimacy and friendship with that very tribe, and the sons and daughters of the very people he had killed. They gave him a grant, regularly extended upon stamped paper, of four miles square of as good land as any in Upper Canada."

Campbell says the Indians used violent language about Ramsay only when intoxicated. They charged that he had been "drunk and mad all winter." If this was true it would account for their failing to make good their charges, as it was customary to consider drunkenness on the part of an offender as a mitigation, if not a complete defence, to any accusation, even murder. It will be seen in the sequel that they availed themselves of this defence, when charged with the murder of a trading party.

In his story to Campbell, Ramsay speaks of the Indians in a violent and contemptuous fashion. One of his assertions is worth quoting: "After killing the first Indian, I cut lead and chewed above thirty balls, and above three pounds of Goose Shot, for I thought it a pity to shoot an Indian with a smooth ball."

The Case for the Crown.

So much for Ramsay's own story. The Indian version is given by Sir William Johnson, Superintendent General of Indians, in a report to the Colonial Secretary, the Earl of Hillsborough.

In a letter dated Johnson Hall, June 29th, 1772, addressed to the Earl of Hillsborough, Sir William Johnson refers with some anxiety to "a late unlucky transaction, the particulars of which," he says, "(as it may be productive of very ill consequences) it is my duty to lay before your Lordship." The details that follow are in Johnson's words:

"A certain man of the name of Ramsay who formerly lived among the Indians, and was by Capt. Brown, late commanding officer at Niagara sent away to Quebec to prevent his doing further mischief amongst them, has since found means to get a small cargo of goods upon credit, with which he went to Lake Erie, where he traded some time with the Chippawaes and Mississages at a considerable distance from any Fort or place of inspection, or control, but being of a disagreeable temper, and probably endeavouring to over-reach them, they warned him to remove otherwise they would maltreat him, of which however he took no notice, but seemed to set them at defiance, which shortly after occasioned a quarrel between him and some of them which were in liquor, of whom he killed three, upon this he withdrew to another place on Lake Erie, apprehensive of their Resentment, and last April a Party of the Mississagaes called at his trading hut where they drank very plentifully, and as is usual with them on all such occasions, quarrelled and threatened him, as he sayd, with death, to which he adds that they laid hands upon him and bound him. However he freed himself and killed three men, one woman and one infant, and as an aggravation of the same took off their scalps, which he brought into Niagara where he was immediately confined by order of the Commanding Officer. This Acct. is part taken from his own Confession to the Officer, and from the account given of it by his brother before the story was new modelled as it has been since to favour him. To excuse his having scalped them (which with Indians is considered a National Act and Declaration of War) he sayd he was told that War had been actually commenced between the English and Indians and that in his hurry and confusion the woman and child were killed, but it appears clearly to me, and it is likewise the opinion of General Gage that he has been guilty of these murders thro' wantonness and cruelty. For in the first place, the Indians whenever they meditate mischief carefully avoid liquor, whereas it appears that they were verry much disguised, and tho' apt to use threats and quarrel at such times, yet incapable of putting them in execution, as is evident from the number he killed of them, and in the next place he could have had but little temptation to kill the woman, and not the least inducement to murder the child but what has arose from sentiments of barbarity superior to the most cruel savage who seldom puts an infant to death. The General has directed him to be sent to Canada to be tryed, but (as is usual on such occasions) the Interest which his creditors will make with those who are his jurors, and the prejudices of the Commonalty against Indians, will probably prove the means of his being acquitted, altho he makes use of threats that he will do much more mischief when enlarged.

Indians Demand Justice.

"The Nation immediately sent down fifteen Deputys to lay the matter before me, and to assure me that they had given strict orders to prevent any sudden act of Resentment, and that they relied on our Justice in affording them such satisfaction as the case required, as well as in preventing the like for the future, to which end they (after complaining much of the want of any regulation for Trade) requested that Traders might not be suffered to go where they pleased, but confined to the Posts, and there duely inspected. I enlarged much on the circumstances alleged by Ramsay that the Indians threatened his life, in which case I observed that not only the English Laws, but the laws of nature justified his defending himself, and after adding everything I thought prudent and necessary, I covered (according to custom) the Graves of the Eight persons whom he killed and dismissed them with a very handsome and large present, and with proper Belts and Messages to their Nation. The Indians at parting expressed themselves very favourably, and I am willing to hope that the affair may be accomodated, nevertheless I am so sensible of their Resentment that I have judged it necessary to be thus particular, because the Chippewas and Mississagaes are by far the most numerous and powerfull Nation with whom we have any connection in North America, being second only to Sioux in numbers, and from their situation capable of affording great encouragement to Trade, or putting an entire end to it, nor could it be expected that others would enter warmly into Our Alliance when they considered the cause of their Defection. The Traders are all come into Niagara and to avoid the Resentment they apprehend from the Indians. I have already described what may reasonably be apprehended whilst I use every endeavour in my power to prevent its being realised, but I leave Your Lordship to judge how difficult a task it is to calm the passions of incensed Savages and to keep them faithfull to engagements whilst they find themselves exposed to the licentious outrages of our own people against which no remedy is as yet provided."

The Earl of Dartmouth, who had succeeded Lord Hillsborough as Colonial Secretary, replied to Sir Wm. Johnson's statement by commenting on the "atrocious and inhuman nature" of the "murders committed by Mr. Ramsay" and a strong recommendation "to bring that person to condign punishment." He added that he would "not fail to write Lieutenant Governor Cramahie on the subject and to exhort him to use his utmost endeavours that he do not escape with impunity; and if a Bill of Indictment be found against him, that the Judges be directed in their charge to the Jury, to guard them as much as possible against the influence of those prejudices which you think would probably be the means of his acquittal."

Danger of Indian War.

Johnson's description of the temper and disposition of the Indians impressed the Colonial Secretary with the fear of an Indian war, as the result of "the numberless frauds and abuses which are at present committed by those who carry on trade and have intercourse with them."

On the 4th November, 1772, Johnson reminds the Earl of Dartmouth of his former letter of 29th June, "and of the murder of the eight Mississagues and Chippewas by one Ramsay, a small Trader on Lake Erie, in which he appears to have been actuated by wanton cruelty more than by any other consideration." The chiefs and principal warriors of the Six Nations had been at Johnson Hall and made representations with reference to the "great irregularities in the present state of the Indian Trade, the promises made to them that the same should be on a good footing, the want of Regulations therein, the Abuses committed by Traders rambling where they pleased with strong liquors, and the General discontentment amongst all the Nations on that account, to which I made them the best answer I could, considering the little prospect there is of any such Regulations being made in the Colonies."

Referring to the general lawless behaviour of "the back inhabitants, particularly those who daily go over the mountains of Virginia," their hatred of the Indians, their frequent murders and robberies, he dwells upon the complaint of the natives "that whatever these people do their Jurys will acquit them, the Landed men protect them or a Rabble rescue them from the hands of Justice. The truth of all which I am equally sensible of."

He adds: "The Common Traders or Factors who are generally rapacious, ignorant and without principle pretending to their merchants that they cannot make good returns unless they are at liberty to go where and do as they please, and present extravagant gain being too much the Object and the only object of all, they are tempted in pursuit of it to venture amongst the most distant Stations where they are daily guilty of the most glaring impositions—of the fatal effects of Rum (so often requested by the Indians not to be brought amongst them) I have just received a fresh instance in the murder of a Trader and his two servants on Lake Huron by some of the Nation whose people were killed by Ramsay. The Trader sold them Rum and neglecting to leave them, tho' advised by themselves to do so, on being refused more liquor they seized it, got intoxicated, a squabble ensued, which ended in the death of the Trader and his Servants. The Nation have promised to deliver the murderer but I doubt it much, as the murders committed by Ramsay cannot be easily forgotten by them, especially when disguised by Liquor which they always consider as a mitigation of the offence."

Ramsay Escapes Punishment.

On the 26th December, 1772, Johnson again refering to Ramsay, reports: "I have lately heard that thro the want of a material evidence which by some means was permitted to escape from one of the out-posts nothing was done in this affair, but I understand he is still in confinement, tho I have little expectation of its final issue in any manner satisfactory to the Indians, who whenever ill disposed, are well pleased with our delaying or denying justice as it serves for a pretext to commit hostilities, a pretext we should never afford them."

THE RAMSAY TRADITION.

The story of Ramsay s adventure with the Indians is told with some variations in Tasker's book "The United Empire Loyalist Settlement at Long Point, Lake Erie," from the traditions of the Maby family.

In his narrative, Ramsay appears as an English trapper one "accustomed to make yearly visits up the lakes for the purpose of trading with the Indians." His brother of 17 is transformed into a little nephew about ten years of age. In the adventure which brought him so much notoriety, his canoe was laden with goods, "and also with a considerable quantity of liquor." There were nine Indians in the party which seized his canoe and stock in trade. Having consumed the liquor, they resolved to burn him at the stake and hold a war dance round his flaming body. He was tied with his back to a tree, his arms being tied around the tree by buckskin thongs. The Indian left on guard for the night followed the example of his comrades by drinking copious draughts of liquor. All his captors being thus disabled, the burning of the prisoner was necessarily postponed until next day. The boy. left untied, handed Ramsay a knife, with which he soon released himself and stabbed to the heart the one Indian who was on guard, but who by this time was tottering with the drink. The Indian's comrades in their drunken sleep were easily brained with a musket. Ramsay then reloaded his canoe, and proceeded with his nephew on their journey.

Nothing is said about scalping in this story, nor about his arrest and trial. This is perhaps not to be wondered at, when we learn that Ramsay himself was the original narrator in occasional visits to New Brunswick, where the Mabys and Peter Secord, a cousin who had settled there in 1785, first heard through him of the Long Point district. Tasker takes little stock in the story, which. however, appears to have been handed down in the Maby family with reasonable accuracy.

Secord accompanied Ramsay on one of his trips up the great lakes. As a result he and the Mabys settled in Charlotteville in 1793.

It will be seen that the Maby tradition does not differ materially from the official documents or Captain Campbell's account of the killing.

A Certificate of Character.

Captain Campbell took a great fancy to Ramsay. He found Ramsay to be "a man of strict veracity, honesty and integrity" and gave full credit to his narrative.

He adds:—"David was a staunch friend to the British during the last war; and was well known to those who were in high command, and had ample recommendations and certificates of his services from them. Scarce a corner of the British colonies or United States but he is acquainted in."

When Campbell wrote, Ramsay had never married, and Campbell thought he never would. Engaged in smuggling skins into the States he had suffered a loss of £150 by a seizure of goods, and was reduced in circumstances. His sole employment at this time was "carrying dispatches and money for gentlemen of the fort and district of Niagara to and from any place they may have occasion." He had a conspicuous reputation for honesty and fidelity. No receipt was required from him for moneys entrusted to him. Congress made use of his influence with the Indians in negotiations with chiefs assembled at Philadelphia.

The Captain also informs us that Ramsay's strange adventures were well known. A New York printer had offered him £100 for an account of them. The offer had ben refused, as Ramsay was unwilling to incur the trouble. He was more complaisant to Captain Campbell, for he sat up a whole night to give the latter his story.

Let us now turn to the historical basis for the other character in the drama.

Troyer, the Witch Doctor.

The late E. A. Owen's book was published in 1898. He had been assiduous in gathering traditions of the pioneers and a whole chapter is devoted to "Doctor Troyer and his big 'witch-trap.'" From this it appears that Troyer was the first white settler to erect a habitation in Norfolk. The date was not long after 1790. His log house was erected on a bar or flat of about fifteen acres running into Long Point Bay, about a mile and a half east of Port Rowan. The earliest apple trees in the settlement were planted by Troyer. Some of these are still productive. He was "Norfolk's first medical practitioner," uncertificated, it is true. Owen describes him as "insanely superstitious, being a hopeless and confirmed believer in witchcraft. This peculiar mental malady caused him a world of trouble and made him ridiculously notorious. To prompt the recital of some witch story, all that is necessary is to mention the name of Dr. Troyer in the presence of any old settler in the county. The name 'Dr. Troyer' and the term 'witches' are so interwoven in the minds of the old people that they cannot think of one without being reminded of the other.

"The old doctor was terribly persecuted by these witches. All his troubles of mind and body were attributed to the witches who existed in human form and possessed miraculous powers for producing evil. He looked upon certain of his neighbors as witches, one of the most dreaded being the widow of Captain Edward McMichael. Mrs. McMichael was a very clever woman, and to be considered a witch by the superstitious old doctor was highly amusing to her. She was a woman of strong mind and great courage, and it is said she frequently visited the lovely ravine and made grimaces at the poor old doctor from some recess or clump of bushes, just for the pleasure it gave her to tease and torment him. He was a great stutterer, and her appearance in the ravine would throw him into a fit of wild excitement, during which he would stutter and gesticulate in a threatening manner. He was a great deer hunter, but if he chanced to meet Mrs. McMichael when starting out on a hunting expedition he would consider it an omen of ill-luck, and would turn about and go home. He kept a number of horse-shoes over the door of his house, and at the foot of his bed a huge trap was bolted to the floor where it was set every night to catch witches. The jaws were about three feet long, and when shut were about two and a half feet high. There are people in Port Rowan to-day who have a distinct remembrance of having seen this witch trap in Dr. Troyer's bed-room. But in spite of this defensive means the witches would occasionally take him out in the night and transform him into various kinds of animals and compel him to perform all sorts of antics. Whenever he met with an experience of this kind he would suffer from its effects for some time afterwards. One night the witches took him out of a peaceful slumber, transformed him into a horse and rode him across the lake to Dunkirk where they attended a witch dance. They tied him to a post where he could witness the dance through the windows, and fed him rye-straw. The change of diet and the hard treatment to which he was subjected laid him up for some time. It required several doses of powerful medicine to counteract the injurious effects of the rye-straw and restore his digestive organs to a normal condition. Strange as it may appear, Dr. Troyer believed all this, yet, aside from witchcraft, he was considered a sane man. He is described as wearing a long white flowing beard; and it is said he lived to be ninety-nine years old and that just before his death he shot a hawk, off-hand, from the peak of the barn roof."

Dr. Troyer's only son, Michael, commonly called Deacon Troyer, was highly respected, a pillar of his church, and at his death mourned by the whole community.

It is perhaps not irrelevant to Dr. Troyer's case to mention the fact that his son the Deacon is said to have fallen into a trance in the earlier part of his life, and to have been "dead to all appearances for three days and nights." Preparations were made for burial, from which he was saved by resuscitation. During the trance he was conscious and believed he was in the realm of eternal happiness. He would fain have remained, but was informed that he must first return to earth to do the task assigned him. His restoration to life and health was followed by his conversion.

According to Owen, although Dr. Troyer had no less than four sons and five daughters, the family name has disappeared from Norfolk. Descendants in the male line are however still to be found in Illinois, and a considerable number of persons both in the Long Point region and in the United States claim the famous witch-doctor as ancestor through female links in the chain of descent.

Dr. Egerton Ryerson's book on "The Loyalists of America and their Times" contains a valuable memorandum by his cousin, Mrs. Amelia Harris, on the early days of the Long Point Settlement. Her father, Captain Samuel Ryerse, settled at Long Point in 1794. She describes the arrival of the family at Ryerse Creek, where after a day's rest they re-embarked, "and went fourteen miles further up the bay, to the house of a German settler who had been there two years, and had a garden well stocked with vegetables. The appearance of the boat was hailed with delight by those solitary beings and my mother and child were soon made welcome and the best that a miserable log house, or rather hut, could afford was at her service. This kind, good family, consisted of father, mother, one son and one daughter. Mr. Troyer, the father, was a fine-looking old man with a flowing beard, and was known for many years throughout the Long Point settlement as "Dr. Troyer."

"He possessed a thorough knowledge of witches, their ways and doings, and the art of expelling them, and also the use of the divining rod, with which he could not only find water, but could also tell how far below the surface of the earth precious metals were concealed, but was never fortunate enough to discover any in the neighbourhood of Long Point." The Troyer family were of use to the new settlers in many ways. From Dr. Troyer, Ryerse procured apple, peach and cherry trees for his orchard. A daughter was employed as "help" in the Ryerse house, and Troyer's son was of assistance at important moments.

Development of the Ramsay-Troyer Legend.

Troyer's settlement at Long Point seems to have been as early at least as 1792. At that time Ramsay had been familiar with the north shore of Lake Erie for nearly thirty years. His fame or notoriety as trapper, trader, Indian-killer, smuggler and guide, was firmly established and wide-spread. He still acted as guide to travellers in Upper Canada along Lake Erie and was no doubt personally known to the McCalls and others among the first settlers. Immigrants reporting at Fort Niagara before proceeding westward would carry away with them stories of his adventures, recited by himself or repeated by soldiers at Fort Niagara, settlers on the River banks, or Indians of the various tribes.

The combination of two such romantic characters as Ramsay and Troyer was sure to have an important psychological effect upon the Long Point pioneers. Among the latter were people of Dutch descent as the Ryersons and Ryerses, of German as the Troyers and Dedricks, of Highland Scotch origin, as the McCalls, Munroes and MacQueens. Their ancestral folk-lore would be gradually interwoven into their own personal experiences and reminiscences. It was at Kettle Creek, and Long Point in the near neighbourhood, that Ramsay had crowned his career by the killing and scalping of the Indians. The development of the legend is then not difficult to understand.

Strange Happenings in Baldoon.

Troyer's fame also extended to the remotest parts of Lake Erie and northward to Lake St. Clair. It reached Lord Selkirk's ill-fated Baldoon Settlement, where strange things were happening in 1829 and following years. Witchcraft was at work among the Highland Settlers, to their great discomfort and peril. John McDonald's house stood on the banks of the Chenail Ecarté. In or about November, 1829, his troubles began. Stones and bullets crashed through the windows and on to the floor. Mysterious fires started up in different places in the house; when one was extinguished, another would appear in a different room. No one was hurt, but many were badly frightened. At last his buildings were burned in January, 1830. He then removed the family to his father's house. The breaking of windows began afresh, until all were destroyed. From a corner cupboard with glass doors bullets pierced their way through to the floor. The bullets were gathered up, marked, and put in a leather shot bag. A string was tied around the mouth of the bag, and the bag itself hung up on the chimney. Immediately the same bullets came back through the window.

The balls were then thrown into the deep water of the Chenail Écarté. In a short time the same balls came back through the windows as before. The "Black Dog" figures prominently in some of the narratives. Certain ludicious features, in others, are vaguely reminiscent of "Mother Goose" stories. Many other incidents, as mysterious and startling as those mentioned, are recorded in the pamphlet on "Belledoon Mysteries."

The fame of Baldoon's witchcraft spread throughout the Province. People came from far and near, some even from New York, to see for themselves, and went away convinced by the evidence of their own eyes.

Dr. Troyer Called In.

Every effort was made to conjure away the evil spirit. Ministers of every known denomination were called to assist. The regular formulas for exorcism were used by the authorized ministers of religion. Even the priest, with bell, book and candle, failed to check the manifestations. Happily, the Methodist minister, Rev. Mr. McDorman, thought of Dr. Troyer of Long Point, more than a hundred miles away, and John and the minister went together to consult him.

Witchcraft accompanied them through the Longwoods, a stretch of about thirty miles of forest, north of the Thames, without a single dwelling on the road, and in which they had to pass the night. McDonald was terrified by the melancholy wind stirring the tree-tops, owls hooting, wolves yelping, then the heavy tramp, tramp of a vast multitude, inarticulate voices of men, crashing of boughs and snapping of twigs, and then the rush of some great unseen host. Soon there was the sound of combat in the air with an opposing multitude, followed by groans of the wounded and shrieks of the dying.

In three days they arrived at Dr. Troyer's. The various narratives differ greatly in important details. According to one version, it was Troyer's daughter, a sallow fragile girl of fifteen, with wild eyes gleaming when excited, who possessed the gift of divination. She used a stone, which, she said, was "by some called the moonstone," but as its employment was "always attended by great physical prostration and much mental agony," she used it only "under very extraordinary circumstances." Before doing so on this occasion, she had already divined that John had had trouble with neighbours over his refusal to sell them a portion of his land. "I see," she continued, "a long, low, log House." McDonald listened in wrapt wonder to the alliterative description of his evil-minded neighbour's dwelling, and minute details of the personal appearance and peculiarities of its inmates.

Promising to look into the stone, she "retired to her chamber, and after three hours returned with a worn look as if suffering from some acute nervous irritability." Then she informed McDonald that his outbuildings had been "burnt to the ground just two hours ago." This turned out exactly true.

"Have you ever seen a gray goose in your flock?" she asked. He had, he had shot at it with a leaden ball, and the fowl had escaped. She assured him, "no bullet of lead would ever harm a feather of that bird." The bird was merely a shape assumed by his enemy. He must use a silver bullet, and if he hit the mark, his enemy would be wounded in a corresponding part of the body. He and McDorman returned to Belledoon. Next morning, the goose reappeared with the flock in the river. He fired, and the bird, "giving a wierd cry like a human being in distress," fluttered into the reeds, with a broken wing. Rushing to the long low log house, he found "the woman who had injured him, with her broken arm resting on a chair, and her withered lips uttering half-ejaculated curses." From that moment the witchcraft ceased. The witch lived for some time, but suffered always from racking pains throughout her whole body.

Conflicting Narratives.

More than a score of people residing in or near Wallaceburg signed statements respecting the startling manifestations. Apparently 50 years had elapsed, the witnesses were of course well advanced in years, and there had been time for amplification of whatever were the actual facts. Most of them assert positively that they were actual witnesses, others spoke from information received from near relatives who had been witnesses. There are, of course, many and very serious discrepancies in parts of the story.

Dr. Troyer is in some statements called Rev. Father Troyer, a Roman Catholic priest. Some of the witnesses state that McDonald and McDorman went to Troyer's place at Long Point, and received the explanation and recommendation there. In one narrative, McDonald would seem to have gone alone. It is left in doubt whether Troyer or his daughter was the clairvoyant.

According to one circumstantial statement, Troyer came to Baldoon, remained some days, and his presence alone conjured away the evil one. Some witnesses make no reference to the shooting of the gray goose. One asserts that McDonald shot and killed the witch. There are almost innumerable other inconsistencies in the stories, which show evident signs of very extensive development during the half century. The significant fact remains, that there were some extraordinary happenings at Baldoon between the years 1829 and 1831, causing wide-spread commotion in the neighbourhood, the flame of which was carried to other parts of Canada and to the United States, and brought many curious visitors to Baldoon.

Legends Unite in Troyer.

The interest of the story, as far as this paper is concerned, is in its connection with Doctor Troyer, the famous witch-doctor of Long Point. The various incidents of the Baldoon narratives, coupled with the story of Ramsay's buried treasure, bring to our notice an extraordinary combination of the folk-lore of various parts of western Europe, a combination quite natural, when we consider the heterogeneous origin of the various settlements along Lake Erie—German, Dutch, French and British. Teuton and Celt have contributed each his share to the stories. The celestial hosts and battles in the air are known to many countries. Pliny refers to them. Milton celebrates them. The legends of the Chasse Galerie, the Hunting of Arthur, the "Wilde Jäger," all deal with them. The black dog, the divining rod, the mysterious fires, the divining hat, the witch-stone, the mysterious movements of stones and bullets, the gray goose with broken wing, the conjuring with book and candle at midnight, there is perhaps not an original feature in the narratives. The important fact is that they are all brought practically into one story through the connection with Dr. Troyer.

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SECTION III

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The Development of Modern Acoustics

By LOUIS V. KING, D.Sc., F.R.S.C.

(Read May Meeting, 1919.)

A few years ago one would have pronounced the science of acoustics *dead.* A few papers on minor researches were published from time to time, but, on the whole, text-books of physics reiterated the same old experiments, few of which had any real application to music and fewer still to the affairs of everyday life. The advanced musical student might, it is true, read Helmholtz's great work on "Sensations of Tone," and Rayleigh's two mathematical volumes on the "Theory of Sound." He would still find, however, that although nearly all acoustic phenomena could be accounted for by the higher developments of Newtonian mathematics, few of the questions dealt with had much concern with human interests.

Many of the most recent developments of our modern civilization are associated with the sense of hearing. Music, which may be said to be the art of thinking in terms of musical sounds, has to-day attained to a degree of refinement little dreamt of by the great composers of the past. Associated with musical composition are the instruments by means of which we are enabled to communicate musical thoughts to others. These two factors have continually reacted on each other with the result that music has evolved with a rapidity much greater than is to be observed in other forms of art. It is generally stated that before the days of Bach there was practically no appreciation of the beauty or meaning of a number of musical notes played simultaneously, that is, of a chord, and that from that time dates the manifestation of a new vehicle of thought. Such a physical invention as that of the equally tempered scale has, through the simplification of musical instruments, made modern music possible.

These few remarks will indicate the close relationship existing between the development of music and the invention and perfection of musical instruments. Hitherto there seems to have been little scientific plan or purpose in the design and construction of what are, after all, physical instruments. The reason is not far to seek; it is because until recently we have not had adequate means of measuring and analyzing sound-waves. In the "phonodeik," of which we had so interesting an account a year ago by Professor Dayton C. Miller himself, we have an instrument of sound measurement and analysis comparable only to the human ear in delicacy and sensitiveness, and having above all the advantage of leaving a *permanent record*.

It would take me too far from my main theme to mention, even briefly, the magnificent harvest of information of the greatest scientific and artistic interest garnered by Professor Miller during the past few years. You will find some of it in his "Science of Musical Sounds," and I hope that we may hear further from Professor Miller himself on a not far distant occasion.

The wave form of practically every form of orchestral instrument, including the human voice, has been recorded and analyzed in the laboratory of the Case School of Applied Science. The importance of this collection of data cannot now be fully estimated. We are literally standing on the threshold of developments in the art of musical expression the ultimate significance of which can hardly be grasped at the moment.

Musical expression has in the past been limited by the inadequacy of musical instruments, which in turn have been limited by imperfect materials of construction; and the best use of these, again, by the absence of scientific principles of design. Then again, diffusion of musical thought has, until quite recently, been retarded by the physical limitations of time and space. The interpretations of great artists can directly reach only a select few. The number of great musical interpreters is unfortunately too few, and these cannot undertake more than a limited number of recitals annually. As regards the public, the size of auditoriums built to give most effective results is limited, and really great music directly interpreted is not available to all on the score of expense.

One of the most interesting applications of exact measurement to acoustic problems was commenced about the year 1900 by the late Professor W. C. Sabine, of Harvard University, in the study of the hearing qualities of auditoriums and halls. The subject is one of the greatest practical importance as many of the audience present may confirm by their experience in trying to understand a lecturer speaking in a badly designed hall. According to the testimony of musicians, singers and public speakers, it would appear that very few halls indeed are satisfactory in their acoustic qualities. The most common defect is due to reverberation brought about by the successive reflection of sound from the walls, floor and ceiling. A sound once produced may, as a result, remain inaudible for several seconds to the detriment of clearness of utterance. Absorbing materials, such as carpets, thick hangings, cushioned benches, and the presence of the audience itself tend to attenuate these reverberations. If the absorption is too great, it is difficult for a speaker to make himself heard at a distance, while a musician would pronounce the room to be "dead." Professor Sabine has shown how to remedy the defects of halls already constructed as well as to predict from the architect's plans their acoustic qualities. It is not putting the case too strongly to state that no auditorium, large or small, no music room public or private, should be constructed without regard to the principles of architectural acoustics laid down by Professor Sabine.[1]

Scientific invention and organized research may at the present time be fairly stated to have indefinitely extended the limits I have mentioned. Great artists, through the phonograph, now number their audiences by the million. The every-day contact with the masterpieces of the great composers is, in my opinion, developing and moulding the musical mentality of the human race at large, and preparing the way for what may be a world-wide "renaissance" in the art of music.

Turning now to the more practical and prosaic developments of acoustics during recent years, we again find that marked progress has resulted from the introduction of sound-measuring instruments. On the present occasion, I may perhaps be pardoned for referring briefly to the study of fog-signalling, a branch of *acoustic engineering* to which I have devoted considerable attention during the past few years. For the protection of ships at sea in foggy weather powerful sirens have been developed and installed on the coasts of most maritime countries. The extent to which it is possible to protect a trade route in this way from accidents due to fog depends ultimately on the power, penetration and reliability of fog-alarms which can be installed and operated at a given cost.

[1] A new acoustical laboratory has just been completed at Riverbank, Geneva, Illinois. This laboratory was built for the late Professor Wallace C. Sabine, of Harvard University, by his friend, Colonel George Fabyan. In this laboratory Professor Sabine proposed to carry on the study of a number of problems in architectural acoustics requiring special building construction and entire freedom from extraneous noises. The building was constructed with the most careful attention to details, according to Professor Sabine's plans, and has many interesting structural features. It was just ready for occupancy at the time of his death. Colonel Fabyan, the founder of the laboratory, purposes to carry out, as far as possible, the original purpose for which the building and its equipment were intended. (Note from "Science," May 30th, 1919, p. 514.)

Since 1913 I have been engaged on the problem of applying the science of measurement to the production of sound by various types of fog signal apparatus. Recent work has been carried out under the auspices of the Honorary Advisory Council for Scientific Research. In Bulletin No. 2, published by this body in 1918, I have summarized recent achievements in this direction as follows:—

"To sum up the results achieved by the tests referred to above, it may be stated that methods of measuring sound quantitatively and qualitatively have been developed and tested in practice. The acoustic characteristics of a siren may now be determined with fair accuracy in absolute measure, whereas, previous to these experiments, an almost complete ignorance existed on these points. Measurements of the intensity of the master tone may now be carried out at distances of several miles and the influence of meteorological condition on the propagation of sound may be studied in the light of accurate data. These achievements conclude an important chapter in practical acoustic engineering. The next step is to bring these results to bear on the improvement of fog-signal machinery. In spite of war conditions, several inquiries from engineering firms and makers of fog-signal apparatus have been received by the writer for information on points connected with the measurement of sound. It is evident, however, that rapid progress in the design of such apparatus can be made only by the organization of a well-equipped experimental station or laboratory under Government auspices. Not only could the actual construction of new sound-generating apparatus be undertaken along lines suggested by the results of tests on existing sirens, but the machines and designs of various makers could be subjected to comparative tests and recommendations made with a view to their amelioration. It has been stated that development of the diaphone in recent years in the matter of power has already led to a noticeable diminution in the annual loss of lives due to fog at points where the more modern types have been installed. There is no reason why further progress should not be made in this direction.

"It has been proposed to issue fog-signal warnings by submarine acoustic signals, and the results achieved in this direction in the United States lend support to the view that audible signals may be generated more efficiently and will travel with more certainty and to greater distances in water than in air. The attention paid to the development of anti-submarine devices as a result of the war, has led to the invention of extremely sensitive receiving microphones. As soon as these achievements in submarine acoustics shall have been made public, their application to navigational problems of all kinds should be undertaken by various government organizations according to some definite programme of research. In particular the application of submarine acoustic devices to fog-signal and ice-berg problems might well be undertaken in this country as being of special importance to navigation in Canadian waters. In the writer's opinion, scientific concentration on these problems with adequate facilities for experimental work at sea would in a few decades more than repay the expenditure incurred, through reduction of the yearly toll in lives and property resulting from accidents at sea."

We have been fortunate in hearing directly from Professors McLennan and Eve of some of the achievements resulting from scientific war researches with which both these members of our section have been intimately connected—Professor McLennan as Scientific Adviser to the Admiralty and Colonel Eve as Director of the Admiralty Experimental Station at Harwich. In the field of acoustics the harvest has been a rich one. In military operations the science of sound-ranging has developed to such a point that it is possible to locate the position of an enemy's gun to within less than a hundred feet from a distance of several miles. This is achieved by automatically recording on cinematograph film the arrival of the explosive sound wave from the gun at each of several suitably-placed stations. By a process of triangulation, the location of the source of sound may be determined with the precision just mentioned. Of special interest to the members of this Section is the fact that the technique of making the important correction for wind-velocity was worked out by Captain J. A. Gray, R.E., of McGill University.

In the field of submarine acoustics, researches instituted for the purpose of submarine detection have resulted in many interesting and important developments which are destined to find practical application to problems of every-day navigation. In this connection it is a pleasure to hear of the splendid work now being done under the Admiralty by Dr. Boyle of the University of Alberta. Although details of this work have not yet been made public, we may hope before long to hear from Dr. Boyle himself of his achievements along these lines. The practical possibilities arising out of the war researches I have briefly mentioned are such that, in the words of Colonel Eve, it will in a few years be considered a scientific crime to run a ship ashore.

It will be manifest from the various topics I have briefly reviewed in the one scientific domain of acoustics that the key to the development of our future civilization may be summed up in the three words—*research, research, research.*

On the Absorption Spectra of Thallium, Aluminium, Lead and Tin, and Arsenic

By PROFESSOR J. C. MCLENNAN, F.R.S., MR. J. F. T. YOUNG, M.A. and MR. H. J. C. IRETON, M.A.

(Read May Meeting, 1919.)

I. INTRODUCTION

Recent work by Foote, Rognley and Mohler[1] on the resonance and ionization potentials of thallium vapour by electrical methods gave the values 1·3 and 7·3 volts respectively for these magnitudes. In previous work by McLennan and others[2] it has been found that the resonance potential for certain elements is related by the quantum relation $ve=h\nu$ to the lowest frequency of the series $v=(1\cdot5\ S)-(m,\ p_2)$ and that the ionization potential is similarly given by applying the same relation to the limiting frequency of the series $\nu=(1\cdot5\ S)-(m,\ P)$. By analogy it was thought that the values of the potentials obtained for thallium could be used to determine these two series. The resonance voltage given above corresponds to radiation of wavelength 11, 513 A.U. which is a well known line in the infra-red while the ionization voltage gives the wavelength 1700 A.U. Reference to a recent paper by McLennan, Ainslie and Fuller[3] shows that no line had as yet been found with the frequency of the latter in the spectrum of thallium.

In a previous paper by two of the authors[4] the method of arc reversals was successfully applied in determining the series $\nu=(1\cdot5,\ S)-(m.P)$ for calcium strontium and barium. It was thought, therefore, that possibly further knowledge of the series of thallium and other metals might be obtained by an application of this method.

II. EXPERIMENTAL ARRANGEMENTS

A small Hilger quartz spectrograph Type A and Schumann plates prepared by the Adam Hilger Co., were used in taking the photographs of the spectra. The best results were obtained by focussing the light from the source on the slit with a cylindrical quartz lens. The arc arrangements were the same as that described in a previous paper.[5]

[1] Foote, Rognley & Mohler, Phys. Rev. Vol. XIII, No. 1, Jan., 1919, p. 59.

[2] Guthrie Lecture by Prof. McLennan, Proc. Phys. Soc. London, Vol. I, pt. I, Dec. 15, 1918. Tate, Phys. Rev. Vol. X, No. 1, p. 81, 1917.

[3] Proc. Roy. Soc. Sec. A. Vol. 95, Mar. 15, 1919, p. 316.

[4] McLennan & Young, Proc. Roy. Soc. A. Vol. 95, 1919.

[5] McLennan & Young, loc. cit.

The arc was struck between blunt carbons, held at right angles, the vertical one being filled either with metallic salt or with the metal itself. Owing to the high melting point of the metals investigated it was found necessary to use currents of from 10–20 amperes at 200 volts. The vertical carbon was made positive and it was found that a few seconds after the arc struck metallic vapour was passing up in dense clouds in front of the arc which was maintained at the back edges of the carbon. The length of exposure varied fiom 30–60 seconds. Small supplies of vapour in the arc gave the emission spectrum only.

A calibration curve based on standard wavelengths in the spectra of mercury, zinc, cadmium and magnesium was employed to obtain the absorption wavelengths, measurements being taken for some known line as zero. A Hilger comparator was used in measuring the plates.

III. Absorption Spectrum of Thallium

Previous work by Guthrie[1] on the absorption spectrum of thallium has shown that pure thallium gives four absorption bands at 3230 A.U., 3092 A.U., 2330 A.U. and 2380 A.U. and on adding mercury additional bands appeared at 3776 A.U., 2768 A.U. and 2580 A.U. It was considered advisable to carry this work further into the ultra violet in the hope of obtaining absorption over a series of wavelengths.

With thallium the vertical carbon was filled with the chloride. In the heat of the arc the salt became dissociated and free metal was obtained in the form of vapour with a current of from 8–12 amperes at 200 volts.

The spectrograms showed absorptions at several places which agreed with those given by Dunz[2] for the series $\nu=(2,p_2)—(m,d_1)$ and $\nu=(2,p_2)-(m,s)$.

These are: For series $\nu=(2,p_2)-(md')$

m=	6	7	8	9	10
λ=	2168·68	2129·39	2105·1	2088·2	2077·
m=	11	12	13	14	
λ=	2069	2062	2057	2053	

and for series $\nu=(2,p_2)-(m,s)$

m=	5·5	6·5	7·5	8·5
λ=	2152·18	2119·2	2098·5	2083
m=	9·5	10·5	11·5	
λ=	2073	2065	2059	

[1] Guthrie Dissertation—Baltimore—1908.

[2] Dunz—Inaugural Dissertation—Tübingen—1911.

In addition to the above, absorptions were recorded at 3230 A.U. and 2530 A.U., the latter line not yet assigned to any series. No absorption was found at 3776 A.U. which would indicate that the presence of mercury is necessary for this absorption. Two of the sixteen series lines have not previously been recorded. They are 2065 A.U. and 2059 A.U. belonging to the series $\nu=(2,p_2)-(m,s)$.

The reproduction in Plate I illustrates the nature of the absorption obtained with thallium vapour. Attempts were made to obtain absorption at 1700 A.U. with thallium salts in the carbon arc in vacuo with the fluorite spectrograph, but these have been up to the present unsuccessful. This may be due to the difficulty in producing dense enough vapours in vacuum arcs which were open to the pumps.

IV. Absorption Spectrum of Aluminium

In case of aluminium it was found impossible to use any of the salts owing to the formation of the oxide which was irreducible in the arc, so that the metal itself was used. No absorption was observed visually with a small glass spectroscope but the spectrograms revealed series of absorption bands in the ultra violet. When carefully measured it was found that the values agreed exactly with those given by Dunz[1] for the series $\nu=(2,p_2)-(m,d')$ and $\nu=(2,p_2)-(m,s)$.

In the former series nine absorption bands were found and in the latter, five. They were as follows:

Series $\nu=(2,p_2)-(m,d')$

m=	6	7	8	9	10
λ=	2263·83	2204·73	2169	2146	2130
m=	11	12	13	14	
λ=	2119	2111	2105	2100	

Series $\nu=(2,p_2)-(m,s)$

m=	4·5	5·5	6·5	7·5	8·5
λ=	2258·27	2199·71	2165	2141	2124

Since no other absorptions were observed, no new series relations can be predicted from the work, but it is of interest to note that the frequencies

$\nu=(2,p_2)-(12,d')$, $\nu=(2,p_2)-(13,d')$
$\nu=(2,p_2)-(14,d')$, $\nu=(2,p_2)-(6\cdot5,s)$ and
$\nu=(2,p_2)-(7\cdot5,s)$ have been recorded for the first time.

The reproduction shewn in Plate II is that of the absorption spectrum of aluminium.

[1] Dunz, loc. cit.

V. Absorption Spectrum of Lead

Up to the present nothing has been known of the spectral series of lead. Hence it was thought the method of arc reversals spectra might throw light on the subject.

As in the case of aluminium the metal in granulated form, chemically pure, was used. Absorption bands were obtained fairly readily and extended down well into the ultra violet. It is interesting to note that absorption could be observed visually at $\lambda = 4058$ A.U.

In all, 19 reversals were obtained varying in type. It was found possible to classify them as follows:

Narrow Absorptions.	Diffuse Absorptions	Other Absorptions
4058 A.U.	2833 A.U.	2155 A.U.
2614 "	2400 "	2088 "
2247 "	2170 "	2054 "
2060 "	2015 "	2051 "
1973 "	1938 "	2049 "
1925 "	1911 "	2023 "
1900 "		

Since the absorption spectra of thallium and aluminium showed the same characteristics of narrow and diffuse absorptions it is possible that the series of narrow absorptions found in lead may correspond to that in thallium and aluminium, *viz.* $\nu = (2,p_2) - (m,s)$ and similarly the diffuse absorptions to the series $\nu = (2,p_2) - (m,d')$. Further work will be necessary to confirm this. The reproductions of Plate III show (*a*) the carbon arc spectrum, (*b*) the lead arc emission spectrum, (*c*) the lead arc absorption spectrum, and (*d*) that of the lead spark.

VI. Absorption Spectrum of Tin

The results obtained from the absorption spectrum of lead suggested similar work with tin for which nothing is known of spectral series. Unfortunately, the results were too meagre to make any prediction regarding series, since the only absorptions obtained were narrow reversals at 2141 A.U., 2096 A.U. and 2058 A.U. It is possible that these may belong to the same series but the other members have yet to be found.

The reproductions of Plate IV show (*a*) the spectrum of the carbon arc, (*b*) that of the tin emission arc, (*c*) that of the tin absorption arc, and (*d*) that of the tin spark in air.

VII. The Absorption and Flame Spectra of Arsenic

As a result of the extension of the work on electrical determination of resonance and ionizing potentials to the case of metallic arsenic[1] it became of great interest to apply various methods of spectrum analysis to identify the predicted series. The resonance potential was found to be 4·7 volts and the ionisation potential 11·5 volts. These correspond to the emission of radiation of wave length $\lambda=2620$ A.U. and $\lambda=1070$ A.U. As has been pointed out already in the case of mercury, zinc, cadmium and magnesium, the absorption spectrum of the vapour and the Bunsen flame spectrum have been confined to the series $\nu=(1\cdot5,S)-(m,p_2)$ and $\nu=(1\cdot5,S)-(m,P)$ of which the first member of the former and last line of the latter are determined by applying the quantum relation to the resonance and ionising potentials respectively.

(*a*) *Absorption of Arsenic Vapour*

The same experimental arrangements were used as in the case of aluminium, thallium, tin and lead. Chemically pure metallic arsenic was vaporised from the vertical carbon of an ordinary rectangular arc with a current of 8–10 amperes. No visual absorption was observed but the spectrograms revealed strong unilateral band absorptions the sharp edges of the bands having the following wave lengths:

Head of band extending to approximately,

$\lambda=2634\cdot5$ A.U.	$\lambda=2624$ A.U.
2570·0 "	2550 "
2503·5 "	2483 "
2437·3 "	2418 "

The above are recorded as emission bands by Kayser.[2]

No line reversals were obtained in any part of the spectrum down to $\lambda=1850$ A.U.

(*b*) *Flame Spectrum of Arsenic*

As will be observed the work on absorption spectra was in no way conclusive in determining the series which one would have expected from the work on resonance potential of arsenic vapour[3] to have its slowest frequency at about $\lambda=2620$ A.U. In a further attempt to locate the series a study of the flame spectrum was undertaken.

The type of burner employed consisted of a steel annulus around the top of the tube of a Bunsen burner. The annulus was covered with a conical steel cover to direct the arsenic vapour into the Bunsen flame. This type of burner was previously successfully employed by

[1] Foote, Rognley & Mohler, Phys. Rev. Vol. XIII, Jan., 1919, p. 59.
[2] Kayser—Handbuch der Spectroscopie.
[3] Foote, Rognley and Mohler, *loc. cit.*

McLennan and Thomson.[1] The arsenic metal was placed in the steel annulus which was heated by a Bunsen burner; the vapour being driven into a gently burning flame.

Spectrograms were taken with a Hilger type A quartz spectrograph on Schumann plates prepared by the Adam Hilger Co. The exposures were of about seven hours' duration and the following arsenic radiation was recorded in addition to the ordinary Bunsen flame spectrum.

Lines at λ 3266 A.U., λ 2860 A.U., λ 2780 A.U., λ 2350 A.U. and λ 2288 A.U. and bands with heads at λ 2634 A.U., $\lambda = 2570$ A.U., $\lambda = 2503 \cdot 5$ A.U. and λ 2437·3 A.U., the weaker parts of the bands being towards the ultra violet.

A number of these correspond to flame lines found by Eder and Valenta.[2]

VIII. Summary

(*a*) *Thallium*

1. In addition to absorptions of thallium already discovered by Guthrie[3], further absorptions were obtained as arc reversals.

2. These additional absorptions in the ultra violet region were confined to the two series $\nu = (2,p_2) - (m,d')$ for values of $m = 6 - 14$ inclusive and $\nu = (2,p_2) - (m,s)$ for $m = 5 \cdot 5 - 11 \cdot 5$ inclusive.

3. The series $v = (2,p_2) - (m,s)$ has been observed for values of $m = 10 \cdot 5$ and $m = 11 \cdot 5$ for the first time.

4. No absorption was obtained in the region 1700 A.U. with the thallium arc in vacuo.

(*b*) *Aluminium*

1. The absorption spectrum of aluminium has been found to consist of fourteen bands in the extreme ultra violet.

2. As with thallium these absorptions are given by the series $\nu = (2,p_2) - (m,d')$ for values of $m = 6 - 14$ inclusive and $\nu = (2,p_2) - (m,s)$ for values of $m = 4 \cdot 5 - 8 \cdot 5$ inclusive.

3. The series $\nu = (2,p_2) - (m,d')$ has been verified for $m = 12$, 13 and 14 and the series $\nu = (2,p_2) - (m,s)$ for $m = 6 \cdot 5$ and $7 \cdot 5$ for the first time.

(*c*) *Lead*

1. In all, 19 absorption bands of lead were measured.

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[1] McLennan and Thomson. Proc. Roy. Soc. A. Vol. 92, 1916, p. 584.

[2] Eder and Valenta, Atlas, Typischer Spektren.

[3] Guthrie—*loc. cit.*

2. It is possible that the systems of narrow and diffuse absorptions may correspond to the analogous series absorptions of thallium and aluminium.

(*d*) *Tin*

1. Three absorption bands of tin were obtained but no identification of series is yet possible.

(*e*) *Arsenic*

1. The flame spectrum of metallic arsenic has been found to consist of five lines: $\lambda=3266$ A.U., $\lambda=2860$ A.U., $\lambda=2780$ A.U., $\lambda=2350$ A.U. and $\lambda=2288$ A.U. together with four bands with heads at $\lambda=2634 \cdot 5$ A.U., $\lambda=2570$ A.U., $\lambda=2503 \cdot 5$ A.U. and $\lambda=2437 \cdot 3$ A.U.

2. The arc absorption spectrum has been found to consist of four strong unilateral bands, the sharp edges of which were towards the red and occurred at wavelengths $\lambda=2634 \cdot 5$ A.U., $\lambda=2570 \cdot 0$ A.U., $\lambda=2503 \cdot 5$ A.U., $\lambda=2437 \cdot 31$ A.U.

3. Contrary to expectation no single line absorption or emission was found which could possibly be supposed to correspond to the line $\lambda=2620$ A.U. predicted by Foote and others.[1]

Admiralty Physical Laboratory,
South Kensington.

14th April, 1919.

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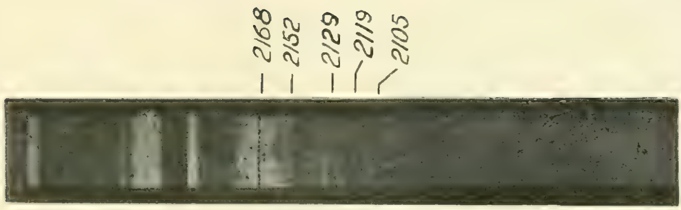
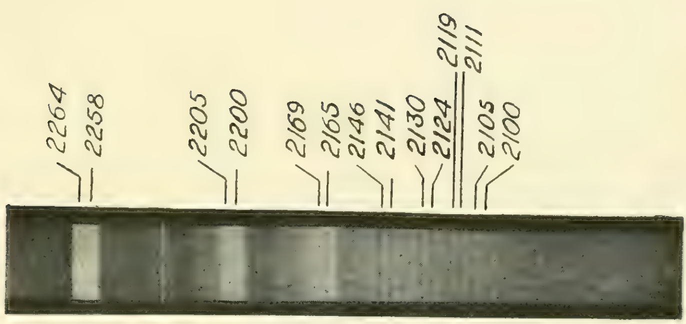
[1] Foote, Rognley and Mohler—*loc. cit.*

Plate I.



Thallium Absorption Spectrum.

Plate II.



Aluminium Absorption Spectrum.

PLATE III.

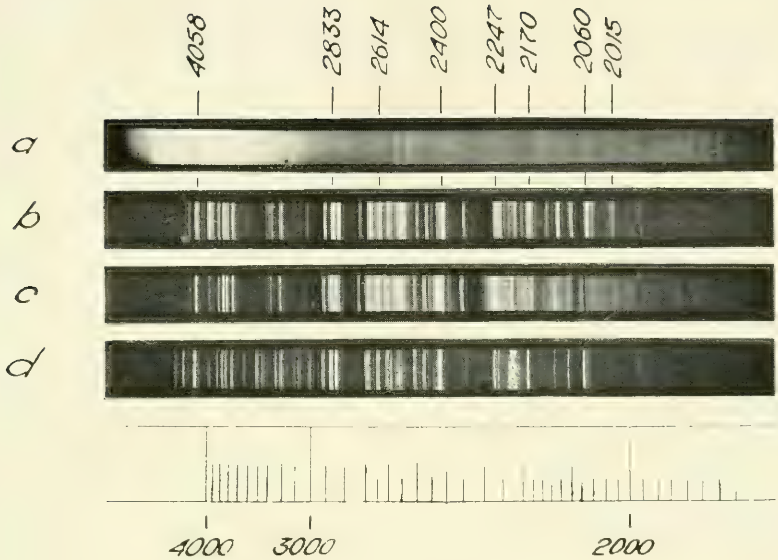
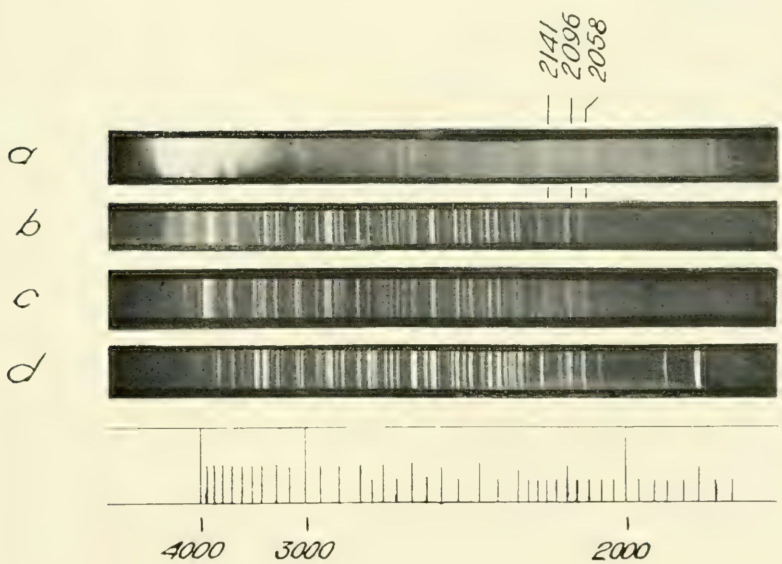


PLATE IV.



On the Optical Transparency of Certain Specimens of Fluorite

By MR. J. F. T. YOUNG, M.A. and MR. H. J. C. IRETON, M.A.

Presented by PROFESSOR J. C. MCLENNAN, F.R.S.[1]

(Read May Meeting, 1919.)

Recent researches in spectroscopy have shown the increasing importance of a complete study of the ultra-violet spectra of the elements, and attempts have been made to carry out such work at various times. Schumann, Handke and Wolff have employed the prism spectrograph, the optical train of which consisted of white colourless fluorite supplied by Zeiss. The range of this type of instrument depends of course on the transparency of the fluorite which, for thin plates, reaches a lower limit at about 1200 A.U. A second method employed for studying the Schumann region by Lyman, involves the use of a vacuum grating spectrograph. The grating must be specially ruled to throw the maximum of energy into the ultra-violet of one order of the spectrum and since its focal length is limited by the size of the vacuum chamber and the necessity of keeping the distance comparatively short to maintain intensity at the camera, it has been found in practice that the dispersion of the grating spectrograph is not greatly superior to that of the 60° fluorite prism spectrograph. This smaller dispersion of the fluorite spectrograph is, however, more than compensated by the increase in intensity which is always secured by such an optical train. In vacuum work this has its decided advantage, for the range of spectrum covered, in the study of weak sources and in the photography of the weaker lines in spectra, as well as in a shortening of the time of exposure to ordinary light sources.

It will be seen therefore that it is most desirable for the requirements of spectroscopy to locate a source of supply of pure quality colourless fluorite, the monopoly of which in pre-war days was held by Zeiss. Lyman has recorded in his work on absorption of crystalline solids that certain samples of a green variety of fluorite, from New Hampshire, U.S.A., were almost as transparent as that supplied by Zeiss, whereas all the other coloured varieties began to absorb strongly at about 1700 A.U. However, this New Hampshire source does not seem to have been developed, for at the present time there is a great

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[1] Communicated by permission of the Admiralty by Professor J. C. McLennan, F.R.S.

shortage of fluorite suitable not only for spectroscopic trains, but also for achromatic combinations as well.

Source of Samples of Fluorite Tested for Transparency

Quite recently the Adam Hilger Co., Limited, obtained some samples of fluorspar from South Africa. These deposits which occur to the south of Ottoshoop, in the Zeerust district of the Transvaal, have apparently been worked for some time in connection with the supply of fluorspar for gold refineries and for steel making plants. The Geological formation appears to be of the nature of a large pipe in the dolomite of the Transvaal system. The spar is colourless and has been shewn by chemical analysis to be of great purity.

Experimental Arrangements for Testing

The fluorite spectrograph specially constructed for vacuum work by McLennan, Ainslie and Fuller[1] was used to test samples of this fluorite over the spectrum range available which was to below 1400 A.U. The source of light used was the vacuum carbon arc in the type of lamp developed by McLennan, Ainslie and Fuller. The only difference in the experimental details adopted was that a small absorption chamber to contain the fluorite samples was inserted between the arc and the slit of the spectrograph. The whole apparatus could then be evacuated and spectrograms taken of the light transmitted by each sample. The time of exposure was from 30–45 minutes, a steady carbon arc being maintained by a current of 10 amperes at 100 volts. At frequent intervals spectrograms were taken with no fluorite in the absorption chamber in order to test the light from the source. In every case these spectrograms showed the carbon bands at $\lambda = 1464$ A.U and at $\lambda = 1430$ A.U. Schumann plates prepared by the Adam Hilger Co. were used throughout the experiments.

The following table is a summary of the tests.

[1] McLennan, Ainslie and Fuller, Proc. Roy. Soc. Jan., 1919.

TABLE I

No.	Source	Thickness	Colour and Characteristics	Lowest Wave-length Transmitted
1	Zeiss	0·57 cm.	Clear, white and fleckless.	1400 A.U.
2	"	0·55 c.m.	" " "	1550 A.U.
3	"	0·58 cm.	" " "	1500 A.U.
4	S. Africa	0·60 cm.	White, fleck across centre, a few starts, not cloudy	1563 A.U.
5	"	0·82 cm.	White, slight flecks, no starts, clear	1563 A.U. (faintly)
6	"	1·07 cm.	White, flecked	1563 A.U. (very ")
7	"	0·65 cm.	White, a few flecks, not cloudy	1550 A.U.
	Recut of 7			
	(a)	0·2 cm.	" " "	1430 A.U.
	(b)	0·4 cm.	" " "	1464 A.U. (faintly)
8	S. Africa	0·89 cm.	White, flecks and starts, fairly clear	1550 A.U.
9	"	0·54 cm.	White, very cloudy, and flecked, no starts	1900 A.U.
10	"	0·70 cm.	White, slightly cloudy, a few starts	1550 A.U.
11	"	0·96 cm.	White, slightly cloudy and flecked	1550 A.U.
12	"	1·21 cm.	Very clear, a few starts and flecks	1550 A.U.
13	"	1·30 cm.	White, slightly cloudy a few flecks and starts	1550 A.U.
14	"	2·09 cm.	White, cloudy, large starts	1900 A.U.
15	"	2·05 cm.	Very white, clear, no starts	1550 A.U.
16	"	2·17 cm.	White, very cloudy, large starts	1550 A.U.
17	"	2·01 cm.	Purplish tint, clear, small starts	1650 A.U.
18	"	2·68 cm.	Slight purplish tint, slightly cloudy, a few large starts	1650 A.U.

The samples of fluorite described in this paper were supplied by the Adam Hilger Co., and the investigation was carried out in the Admiralty Physical Laboratory, South Kensington.

The illustration Plate I shows spectra of the carbon arc radiation transmitted by various types of fluorite (*a*) transmission to 1900 A.U., (*b*) to 1656 A.U., (*c*) to 1550 A.U., (*d*) to 1464 A.U., (*e*) the carbon arc through the optical train of the spectrograph only.

SUMMARY

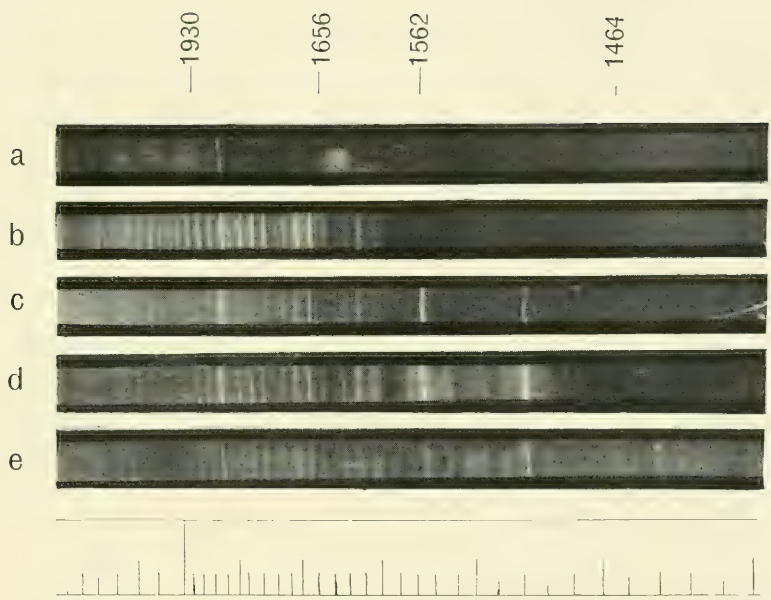
It will be seen from the above table that many of the samples compare favourably with the fluorite supplied by Zeiss for spectro-

scopic purposes and most of it would be suitable for use in constructing achromatic combinations.

There does not seem to be any direct connection between the transmissive properties for ultra-violet light and its physical characteristics, such as flecks, clouds or starts.

It would seem that we need no longer be dependent on foreign sources of supply with such a source as the South African one available.

April 15, 1919.


1930
1656
1562
1464
a
b
c
d
e

The Use of the Jamin Interferometer for the Estimation of Small Amounts of Helium or Hydrogen in Air[1]

By PROFESSOR J. C. MCLENNAN, F.R.S., and R. T. ELWORTHY, B.Sc.

(Read May Meeting, 1919.)

INTRODUCTORY

In the determination of the permeability of balloon fabrics to helium and to hydrogen a method was required for the estimation of small amounts of these gas in air.

Various types of interferometer have been employed in similar work on other gases. Frenzel,[2] for example, used a Rayleigh Zeiss instrument for hydrogen-air mixtures, and the same instrument has been adopted at the United States Bureau of Standards[3] in the course of work on the permeability of balloon fabrics to hydrogen. Several other observers[4] have used the Jamin interferometer for the determination of refractive indices and dispersions in various gases.

W. Burton[5] in a determination of the refractive indices and the dispersion in argon and helium, made use of the relation

$$N_o - 1 = \frac{(1+\alpha t)\ 76 \cdot f\ \lambda}{P.L}$$

where N_o = refractive index
f — number of bands passing a standard line
λ = wave length of standard line
P—change of pressure
L = length of tubes of interferometer.

In Burton's work, two brass tubes of equal length, fitted with worked plane-glass ends of equal thickness contained respectively

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[1] Communicated by permission of the Admiralty.

[2] Frenzel. Zeit fur Flugtechnik und Motor Luftschiffahrt, 5–264–1914.

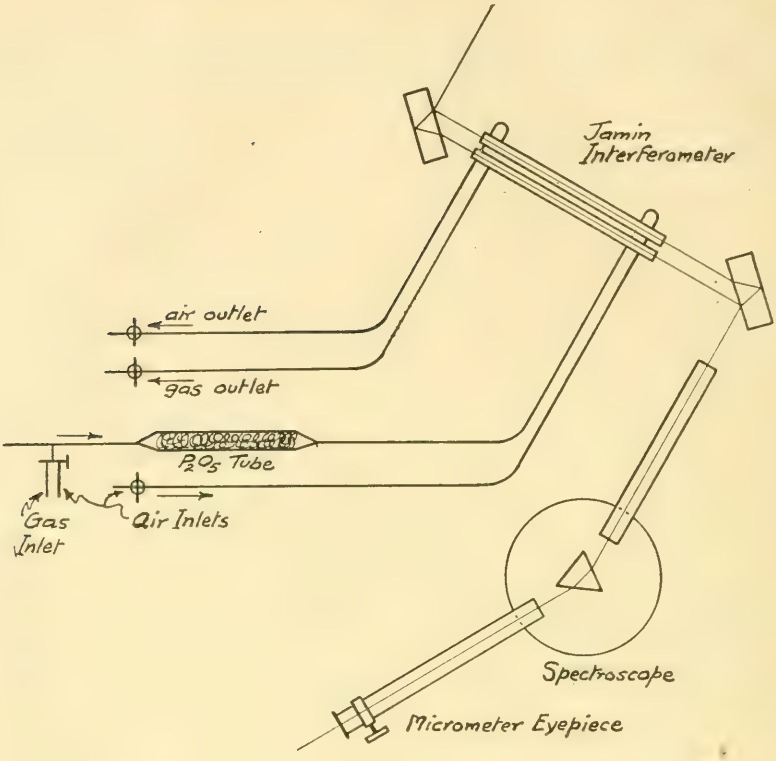
[3] United States Bureau of Standards. Tech. Paper. No. 113, 1918.

[4] "The Refractive Indices of gaseous nitric oxide, sulphur dioxide and sulphur trioxide." Cuthbertson & Metcalf, Proc. Roy. Soc. A 80–406–1907–1908.

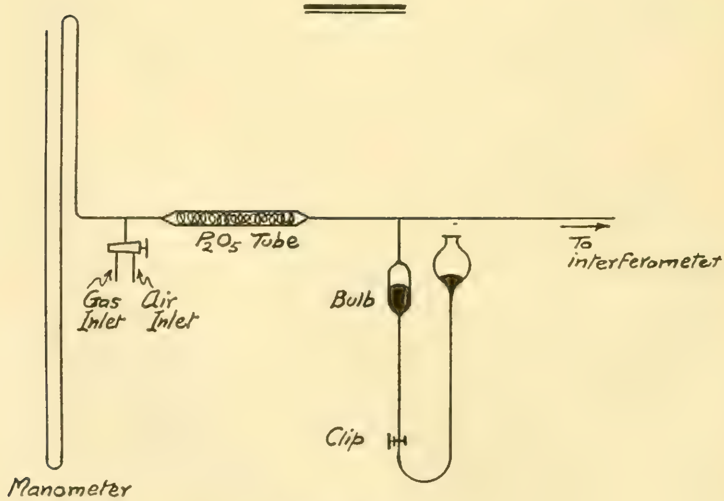
"On the dispersion of gaseous mercury, sulphur, phosphorus and helium." Cuthbertson and Metcalf. Proc. Roy. Soc. A 80–411–1907–1908.

"On the refraction and dispersion of Krypton and Xenon and their relation to that of Helium and Argon." Cuthbertson. Proc. Roy. Soc. A 81–440–1908.

[5] "The refractive index and dispersion of light in Argon and Helium." W. Burton. Proc. Roy. Soc. A 80–390–1908.


Jamin
Interferometer
air outlet
gas outlet
P2O5 Tube
Gas
Inlet
Air Inlets
Spectroscope
Micrometer Eyepiece

—FIG. 1—


P2O5 Tube
To
interferometer
Gas
Inlet
Air
Inlet
Bulb
Clip
Manometer

—FIG. 2—

the standard gas and the gas whose refractive index was required. The pressure on the gas was changed by varying amounts up to ten atmospheres, the corresponding shift of bands being measured and the refractivity calculated from the relation just given. Burton found for argon, that 300 bands passed the cross line in the spectroscope for a change of pressure of two-thirds of an atmosphere, while for helium a shift of the same number of bands required five atmospheres change in pressure.

Method Adopted

In the method described in this paper estimations had to be made every few minutes. Burton's procedure proved unsuitable and was modified, as it was found it could be, by using a much smaller pressure change. The greater refractivity of air, and of low percentage helium-air mixtures, gave a correspondingly greater shift of bands than pure helium would, for the smaller pressure change and therefore measurements of the same accuracy could be made. By the use of a micrometer eyepiece in the observing telescope, the shift of bands could be measured to one hundredth of the distance between two bands.

From a knowledge of the shift of bands caused by a definite pressure change, the refractivity of a mixture of helium and air or hydrogen and air was found by means of the formula just given. The percentage of hydrogen or helium was then calculated from the refractivity as described later.

During preliminary experiments with this method it was observed that the displacement of air by the gas mixture in one tube of the interferometer gave a sufficiently large shift of bands for accurate measurement, without making a pressure change.

From the relation $(N_a - N_x) L = f \lambda$ where

N_a = refractive index of dry air at Pcms. and t°C
N_x = refractive index of a 1% gas mixture at the pressure and temperature
L = length of interferometer tubes
f = shift of bands past the cross line
λ = wave length of the standard line.

Curves were plotted for various pressures and temperatures showing the relation between the difference in refractive index of air and of a 1% gas mixture and the shift of bands.

N_a and N_x were calculated from the relation

$$N_tP - 1 = \frac{(N_o - 1)\,P}{(1+\alpha t)\,76} \quad \text{where}$$

N_o = refractive index at O°C and 76 cms.

$\alpha = 0\cdot00365$

The refractive indices of the 1% hydrogen-air and 1% helium-air mixtures at O° and 76 cms. were found by using the ordinary additive law for the refractive index of a mixture, the validity of which has been established for similar gas mixtures by several observers.[1]

The factors N_a and N_x in the formula $(N_a - N_x)L = f\,\lambda$ were thus obtained; *f* was therefore calculated for various temperatures and pressures at which readings were to be made.

As $(N_a - N_x)$ is proportional to the percentage of hydrogen or of helium in the mixture, such percentages were plotted directly against the values obtained for *f* as shown in Fig. 3.

The following refractive indices were employed in the various calculations:

	Refractive index at 0° & 760 mm. for λ = 5461x 10^{-8} cm.	Observer	Reference
Air	1·0002936.	Cuthbertson	Proc. Roy. Soc. A. 83–151–1909.
Helium	1·000034525	"	Proc. Roy. Soc. A. 80–411–1908.
		W. Burton	Proc. Roy. Soc. A. 80–390–1908.
Hydrogen	1·000139	Cuthbertson	Proc. Roy. Soc. A. 81–444–1908.

Arrangement of Apparatus

The arrangement of apparatus is shown diagrammatically in Fig. 1. It consisted essentially of the interferometer, spectroscope to observe the bands and the necessary connecting tubes.

The Jamin interferometer—made by Adam Hilger Ltd., London —consisted of the usual two parallel glass blocks of equal thickness, silvered at the back and mounted on a heavy metal base. The two 25 cm. glass tubes, fitted with plane parallel ends, supported in rests between the mirrors were each joined by side tubes to the respective inlet and outlet taps, drying tubes and manometer, as shown in the figure.

A parallel beam of light from an Ediswan Pointolite lamp after reflection from the mirrors and passage through the tubes fell on the

[1] Ramsay and Travers. Proc. Roy. Soc. 62–225, 1897.
Jones and Partington. Phil. Mag. 28–29–1915.

slit of a Hilger glass prism spectroscope and the bands were observed in the field of the micrometer eyepiece.

The telescope of the spectroscope was set in such a position that the moveable cross hair in the micrometer eyepiece when set at 500 on the scale, was focussed on the green mercury line, $\lambda = 5461 \times 10^{-8}$ cm., which served as the standard line.

Procedure in Taking Readings

For measurements, both interferometer tubes were initially filled at atmospheric pressure and temperature with dry air. The spectroscope was then adjusted so that the centre of a band coincided with the cross hair, set at 500.

The gas mixture to be examined, was then passed through the gas tube of the interferometer until the air was completely swept out. When this was accomplished the bands remained stationary. Usually the gas flow was continued for three to five minutes. The inlet taps of both gas and air tubes were then closed, and the outlet taps left open so that atmospheric pressure was established in both tubes. The movement of the bands, the centre of which coincided with the standard line when both tubes contained air, was then measured as well as the distance between the centres of two bands adjacent to the zero position. The shift was calculated as a percentage of the distance between the two bands.

From the appropriate curve, shown in Fig. 3, the percentage of gas was obtained.

Calibration

The theoretical method of calibration employed has already been discussed under "Method Adopted." As a check on this method a further one, proposed by J. D. Edwards[1], was employed.

After dry air had been passed through both tubes and atmospheric pressure established, the gas tube was closed and the pressure in the tubes lowered by successive amounts by letting mercury slowly run out of the bulb in Fig. 2, through the screw slip. The shift of bands for each pressure change was measured. The refractive index of the air at each pressure was calculated and also the composition of the helium-air or hydrogen-air mixture that would have a similar refractive index at the initial atmospheric pressure and temperature. The percentage of helium or hydrogen thus found was plotted against the shift of bands. The curves so plotted agreed with those obtained by the first method.

[1] J. D. Edwards. Jour. Amer. Chem. Soc., 2382–1917.

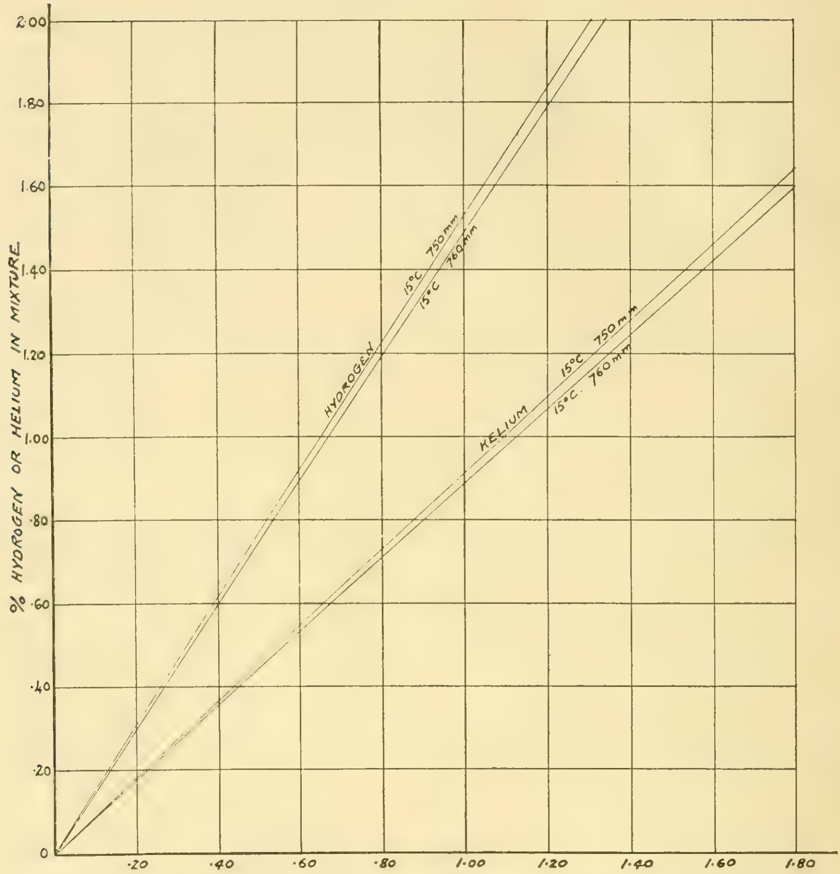


FIG. 3.—SHIFT OF BANDS A.P.L. 303

CHECK OF CALIBRATION BY MEANS OF KNOWN MIXTURES

Several mixtures of hydrogen and air and of helium and air were made up from dry air, pure hydrogen and pure helium, in a water-jacketted burette fitted with a compensation tube. The mixtures were then passed into the gas tube of the interferometer in the usual way and readings were made.

The following table shows some of the results obtained:

Hydrogen—Air		Helium—Air	
By Volume	By Interferometer	By Volume	By Interferometer
%	%	%	%
1·61	1·55	0·39	0·42
1·38	1·35	0·16	0·15
0·09	0·07	0·13	0·13

Accuracy of the Determination

The mean error of setting the cross hairs of the micrometer eyepiece on the centre of a band was about 11-100 of the distance between two bands. For mixtures up to 0·2% helium and 0·4% hydrogen this would give an error of about 4% on the result. For percentages up to 1% of either gas, the error due to this cause would be about 2% on the result. Slight changes of position of the metal parts of the interferometer, owing to temperature changes caused greater errors on some occasions, manifested by a considerable zero shift during readings, which could not always be allowed for. Such errors could be made negligible by using longer interferometer tubes and by keeping the instrument at a constant temperature.

Altogether it was considered that determinations of percentages in mixtures containing less than 1% hydrogen or helium were made with a mean error of $\pm 5\%$.

Summary

1. A method for the determination of small percentages of helium or of hydrogen in air has been described, making use of a Jamin interferometer.

2. Two methods of calibrating the instrument have been outlined; one based on the relation between the difference in path, caused by the displacement of air in one of the tubes by the mixture and the resulting shift of bands; the second, a method based on the change of refractive index of the air in one tube caused by lowering the pressure on the air.

3. With the instrument that was used the accuracy with which determinations were made, was about $\pm$ 5% on the result. With longer tubes a greater accuracy could be obtained.

The work was carried out at the Admiralty Physical Laboratory, South Kensington.

April 15th, 1919.

The Estimation of the Helium Content of Mixtures of Gases by the Use of a Katharometer[1]

By V. F. MURRAY, M.A., B.Sc.

Presented by PROFESSOR J. C. MCLENNAN, F.R.S.C.

(Read May Meeting, 1919.)

INTRODUCTION

The katharometer instruments dealt with in this paper were designed for use with mixtures of hydrogen and air. In view of the use of helium in airships it seemed desirable to investigate whether such instruments could be utilised for mixtures of helium with air, helium with oxygen, and helium with nitrogen.

Since the katharometer is based upon the thermal conductivity of a gas mixture, it would be anticipated that the instrument, at least in the case of high percentage mixtures of helium with the gases mentioned, could be employed. Values for the thermal conductivity of hydrogen at 0°C have been given as $K \times 10^{-6} = 327$ (Winkelmann); 397 (Eucken)[2]; 416·5 (Weber)[3]; while that for helium at 0°C has been found to be $K \times 10^{-6} = 336$ (Eucken); 338·6 (Schwarze); 343·8 (Weber)[3]. Thus the thermal conductivities of helium and hydrogen are of the same order.

On experiment it was found that the various instruments responded when helium mixtures were used, and they were therefore calibrated for mixtures made with this gas and air, oxygen or nitrogen.

PRINCIPLE OF THE KATHAROMETER

Dr. G. A. Shakespear has supplied us with information on the design and details of the instruments dealt with in this paper and we are indebted to him for the greater portion of the material of the description which follows.

In a katharometer the measurement depends upon the cooling of a platinum spiral on exposure to the gas mixture which is being tested. This spiral, carried on a copper frame, is mounted in a copper cylinder pierced at the end and with three small orifices to admit

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[1] Communicated by Professor J. C. McLennan, F.R.S., by permission of the Admiralty.

[2] Landolt–Börnstein Tab.

[3] Weber. Annal. d. Physik. Bd. 54, 1917.

the gas mixture in question. This sensitive element, which is used in conjunction with a pointer indicator (See Plate II) or a galvanometer, is called a Katharometer[1] or an explorer, and is illustrated in Plate I.

We are indebted to the Cambridge Scientific Instrument Co., Ltd., the makers of the instruments, for permission to reproduce Plates I and II, and also Fig. I.

The electrical bridge arrangment used with the katharometer is shown in Fig. 1. In this diagram, S and E are switches, D a 2-volt accumulator, C two sliding resistances for rough and fine adjustment

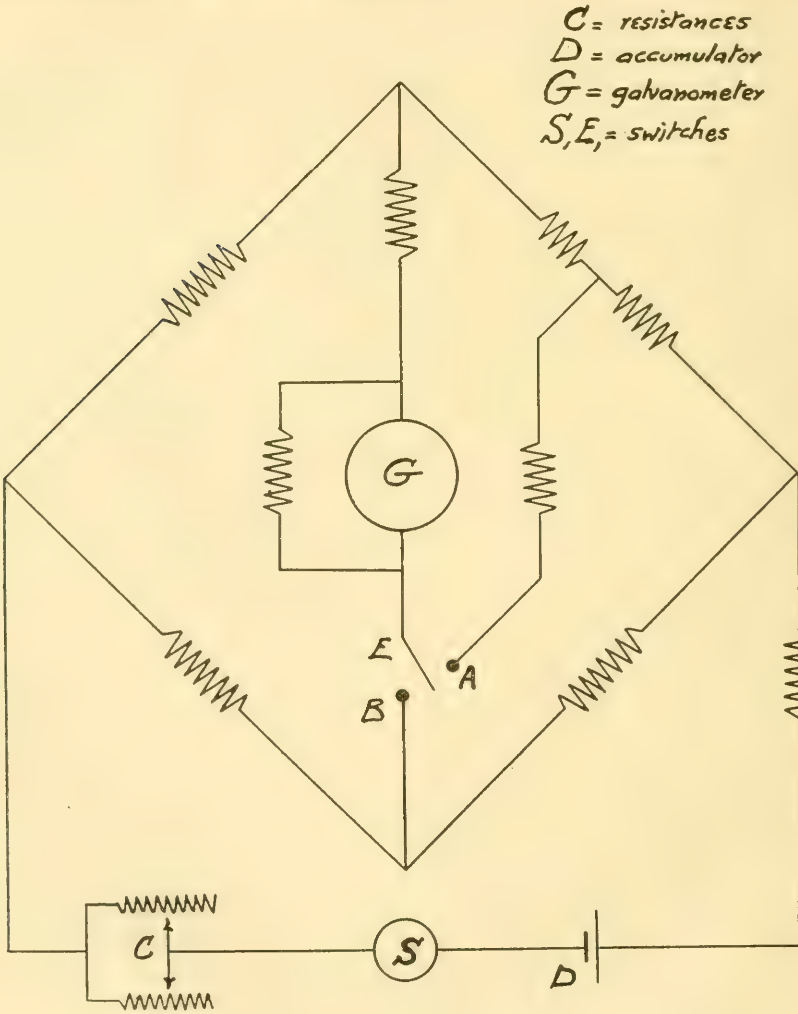

Figure 1

and G a galvanometer. In one arm of bridge there is a comparison protected spiral corresponding to the exposed spiral previously mentioned. In the case of detection of hydrogen in air the exposed and protected spirals are symmetrical and of equal resistance; in the case of detection of air in hydrogen the two spirals are unsymmetrical, and the exposed spiral about one-quarter the resistance of the protected spiral.

When a reading is to be made, switch S is closed and switch E turned to A—the "calibration" position. By means of the resistance at C, the deflection of the indicator is adjusted to a calibration deflection. In this way the current is standardized. Switch E is then turned to B, the "on" position, and the indicator read.

Instruments Calibrated

The instruments calibrated were:

1. Shakespear Hydrogen Purity Meter No. 35944.

2. Detail Explorer No. 39273 with Indicator No 37868. (100–70% scale).

3. Detail Explorer No. 39272 with Indicator No. 37868. (0–20% scale).

4. Permeameter Explorer No. 39275 with Tinsley Galvanometer No. 5753.

With the exception of the mirror galvonometer, made by H. Tinsley & Co., the instruments were manufactured by the Cambridge Scientific Instrument Co., Ltd.

Experimental Apparatus

The general arrangement used in the calibration work is shown diagrammatically in Fig. 2.

Gold-leaf filter-tubes were placed on each side of the sensitive gas cell to act as a protection against mercury vapour. The gas mixture on leaving the mercury aspirator set passed through a phosphorus pentoxide drying-tube and gold-leaf filter to the gas chamber. On leaving the chamber the gas passed through a gold-leaf filter, over a mercury-trap and mercury manometer to the mercury-pump which was used to create a flow of gas when required. If desired, a sample of the gas mixture could be pumped off and collected over mercury as indicated in the figure.

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[1] Shakespear. Advisory Committee for Aeronautics. A new Permeability Tester for Balloon Fabrics. Feb., 1917.

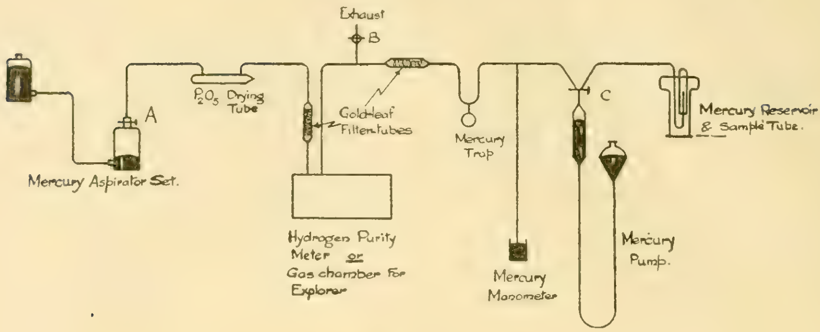

FIG. 2.
DIAGRAMMATIC SKETCH OF APPARATUS USED IN CALIBRATION

PROCEDURE

The apparatus between taps A and C (the volume of which was about 250 ccs.) was exhausted through tap B by a Fleuss pump. This procedure was adopted in order to economise in pure helium, as the amount available at the date of the calibration work was small. Tap B being closed, the gas mixture was slowly admitted at A till the pressure was atmospheric as shown by the manometer. Readings were then taken by the katharometer and also when a slow flow was created by slightly opening tap C.

PER CENT. COMPOSITION OF MIXTURES USED

Two methods were employed to determine the percentage of helium in the mixtures:

1. For high percentages (85–100% helium) the mixture was made approximately by volume, and a sample taken for analysis after passing through the apparatus.

2. For low percentages (0–30% helium) the mixture was made exactly by volume.

The pure helium was prepared from high grade impure gas by passing through cocoanut charcoal at the temperature of liquid oxygen, and was stored in glass gas-tubes over mercury till required.

The analysis referred to in 1 was made by measuring the contraction in volume of a sample after absorption by cocoanut charcoal at the temperature of liquid oxygen. A correction of 0.2 cc. per 18 cc. residual volume was made to allow for the absorption of helium itself by charcoal—a figure obtained for the analysis apparatus employed.

CALIBRATION OF SHAKESPEAR HYDROGEN PURITY METER

This meter is a field instrument designed for measuring the purity of hydrogen in balloons. The indicator readings were from 75–100 with subdivisions of 0·25 per cent.

Mixtures were made of (*a*) helium and oxygen, (*b*) helium and nitrogen, (*c*) helium and air, (*d*) helium, oxygen and nitrogen.

The oxygen for (*a*) was prepared from potassium permanganate in the usual manner; the nitrogen for (*b*) from sodium nitrite and ammonium chloride with a purifying train of red-hot copper, potassium hydroxide, sulphuric acid and phosphorus pentoxide.

The results obtained are plotted in Fig. 3 as percentage helium against instrument reading, the various mixtures being distinguished according to the legend.

This calibration was carried out at room temperature about 16°C.

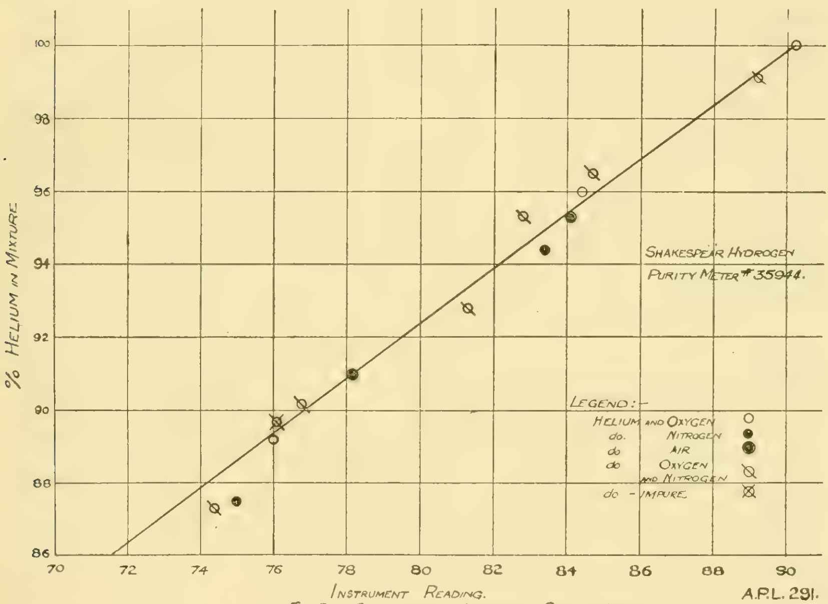

Fig 3. Shakespear Hydrogen Purity Meter.

A straight line has been drawn from which the variations are slight, and according to this line

% Helium = $\cdot 7537 \times$ instrument reading $+ 32 \cdot 1$

Thus if the instrument indicates 82, the corresponding percentage helium = $\cdot 753 \times 82 + 32 \cdot 1 = 93 \cdot 8$, which can be read direct from Fig. 3.

Calibration of Indicator with Explorer No. 39273

For purposes of calibration the explorer was screwed into a brass chamber. The inside dimensions of this cylindrical chamber were $1\frac{7}{8}$ inches diameter and $1\frac{3}{8}$ inches high. Inlet and outlet tubes for the mixture under examination were provided, diametrically opposed,

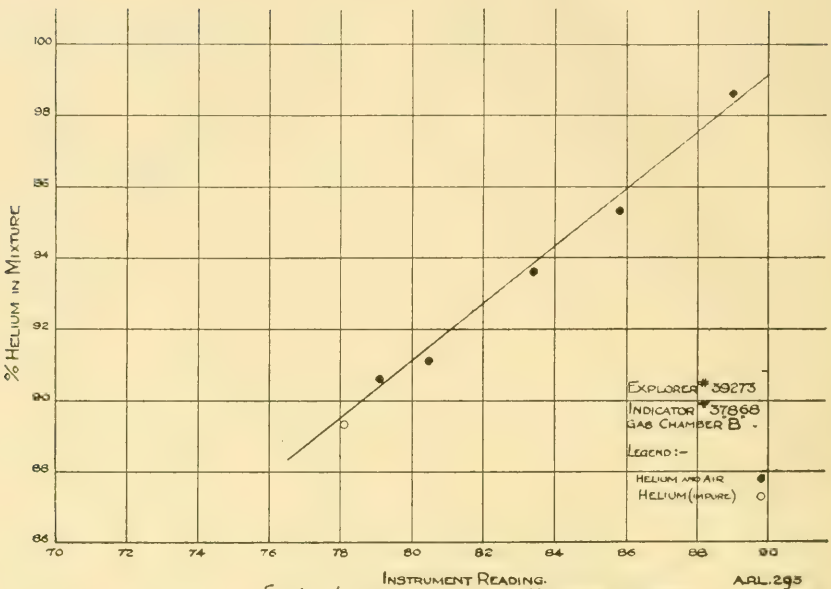

Fig. 4. Indicator with 100–70% hydrogen explorer

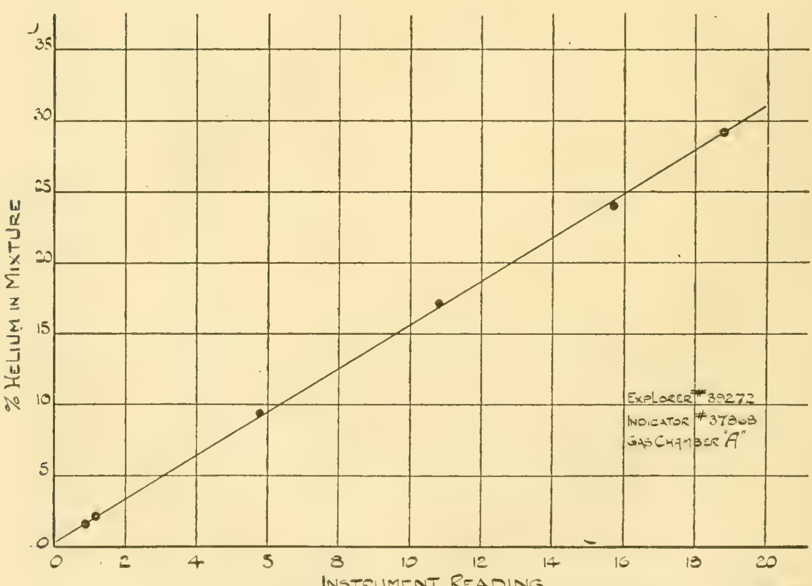

Fig 5. Indicator with 0–20% hydrogen explorer.

1 inch from the bottom of the chamber and ⅛ inch inside diameter. The explorer was screwed in up to the shoulder and the junction made tight with Chatterton's Compound.

Mixtures of helium and air only were used in this case and the procedure was as previously outlined for the Purity Meter.

The results at room temperature of about 16°C are given in Fig. 4.

According to the straight line drawn in the figure

$$\% \text{ Helium} = \cdot 799 \text{ Instrument Reading} + 27 \cdot 2$$

Thus, if the instrument indicates 82, the corresponding percentage Helium $= \cdot 799 \times 82 + 27 \cdot 2 = 92 \cdot 7$, which can be read direct from Fig. 4.

Calibration of Indicator with Explorer No. 39272

This explorer was calibrated with mixtures of helium and air only at a temperature of about 15·5°C.

Mixtures were made up by volume from dry helium and dry air; and the percentage calculated.

The results are plotted in Fig. 5, from which it is evident that

$$\% \text{ Helium} = 1 \cdot 56 \times \text{Instrument Reading}.$$

Calibration of Permeameter Explorer No. 39275

This explorer was used in conjunction with a reflecting galvanometer, Tinsley, No. 5753, N. P. L. 39016.

The total scale deflection at 1 metre distance was 500 mms., the scale being divided in mms.

The deflection for 1% Hydrogen in air was given by the Cambridge Scientific Instrument Co., Ltd. as 259 mms.

The explorer was calibrated for

1. Hydrogen-air mixtures;
2. Helium-air mixtures

at 15·5°C, the mixtures being made by volume.

Percentages of hydrogen are plotted against scale deflection in mms. in Fig. 6; and percentages helium against scale deflection in Fig. 7.

The deflection for 1% helium in air was taken from the straight line drawn in Fig. 7 as 165 mms. at 15·5°C.

From Figs. 6 and 7 it is evident that % Helium $= 1 \cdot 57 \times$ Hydrogen percentage for the same scale deflection; or in other words, more helium than hydrogen has to be present to produce the same movement of the spot of light.

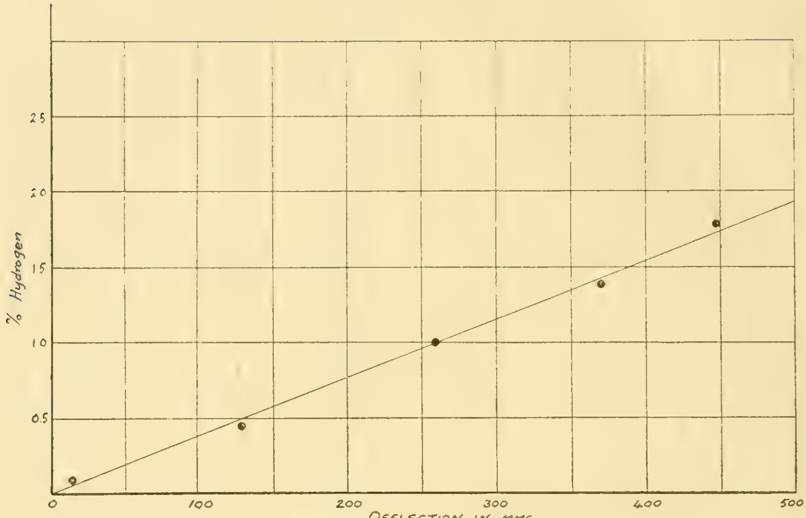

Fig. 6. Mirror Galvanometer and Permeameter Explorer APL. 294

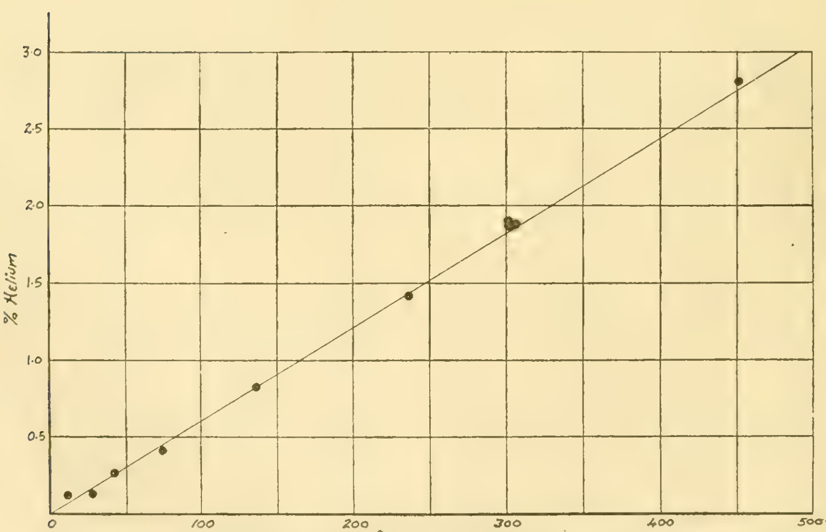

Fig. 7. Mirror Galvanometer and Permeameter Explorer. APL. 295

SUMMARY

The Shakespear Hydrogen Purity Meter, high and low percentage hydrogen explorers and a Shakespear Permeameter Explorer have been calibrated for use with helium.

Graphs are given by means of which indicator readings can be converted into percentages of helium.

It was found:

(*a*) that with the Shakespear Hydrogen Purity Meter with helium-air, oxygen or nitrogen mixtures about 89–100% helium could be read.

(*b*) That with 70–100% hydrogen explorer about 84–100% helium could be read.

(*c*) That with a 0–20% hydrogen explorer about 0–30% helium could be read.

(*d*) That the permeameter explorer gave 165 mm. deflection at 1 mm. distance for 1% helium at about 15·5°C.

In concluding, we have to acknowledge indebtedness to Dr. G. A. Shakespear for information on the design of the katharometer, and to the Cambridge Scientific Instrument Co., Ltd., for permission to reproduce Plates I and II, and Fig. 1.

This calibration work was carried out at the Admiralty Physical Laboratory under the direction of Professor J. C. McLennan, F.R.S., Scientific Advisor to the British Admiralty.

South Kensington,

15th April, 1919.

Plate I.—Shakespear Detail Ball on Fabric Explorer.

Plate II.—Indicator, resistances and accumulator (permeameter and dipper.)

The Permeability of Balloon Fabrics to Hydrogen and to Helium [1]

By R. T. ELWORTHY, B.Sc., and V. F. MURRAY, M.A., B.Sc.

Presented by PROFESSOR J. C. McLENNAN, F.R.S.

(Read May Meeting, 1919.)

INTRODUCTION

In view of the proposed use of helium in place of hydrogen for filling airship envelopes, it became necessary to investigate the permeability of fabrics to this gas; and more especially to obtain the ratio of the permeabilities to helium and to hydrogen of typical airship fabrics.

If it be assumed that the phenomenon of leakage through a fabric can be classified as effusion, a leakage of helium 0·71 times by volume that of hydrogen would be expected. If this ratio be calculated by the Hugoniot-Reynolds formula for the adiabatic efflux of a monatomic and a diatomic gas a value 0·75 is obtained.

The passage of a gas through a rubbered or a skin-lined fabric is not, however, a case of simple effusion, but is a more complex phenomenon. The solubility of the gas in the material may be a factor of importance[2].

Recently, Dewar[3] repeated the classical work of Graham on the diffusion of gases through rubber membranes. Gases at varying pressures and temperatures were allowed to diffuse through Para rubber membranes 0·01 mm. thick into a vacuum. Relative rates of diffusion were determined and are given in this paper as well as absolute rates expressed in cubic centimetre per day per square centimetre. Dewar found that the relative rates differed for different temperatures and he states that "the order of diffusibility is difficult to associate with any chemical or physical property." From his data the ratio of the diffusibility of helium to that of hydrogen is 0·43 at 15·5°C.

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[1] Communicated by Professor J. C. McLennan, F.R.S., by permission of the Admiralty.

[2] Barr. Advisory Committee for Aeronautics. Permeability of Balloon Fabrics by Helium. 1915.

Edwards. U.S. Bureau of Standards. Tech. Paper 113. The Determination of Permeability of Balloon Fabrics. 1918.

[3] Dewar. Proc. Roy. Inst., pp. 813–26. 1918.

Work on the relative permeability of fabrics to helium and hydrogen has been carried out by Barr[1] who made careful measurements in 1915. The amount of helium at his disposal was limited, the total being about 310 ccs. The area of the test pieces used was 25 square centimetres; and measurements were made employing the volume-loss method.

Experiments on the permeability of fabrics to helium and to hydrogen have recently been carried out at the United States Bureau of Standards. While no account of this work has yet appeared in print, it is understood that the results obtained are in close agreement with those given in this paper.

For the present work the area of the test piece used was 500 square centimetres, and a supply of helium of practically 100 per cent purity was available.

Definition of Permeability

The British practice is to express permeability as the volume in litres of dry gas at 15·5°C. and 760 mm. which leaks through one square metre of fabric in 24 hours. Permeabilities are expressed in this paper according to this definition. Some experiments, however, express the volume in litres at 0°C. and 760 mm. In British practice the temperature of the fabric is usually 15·5°C.

The United States Bureau of Standards on the other hand, expresses permeabilities in litres of dry gas at 0° and 760 mm. passing through one square metre in 24 hours. The fabric is maintained at 25°C. during the period of test.[2]

The essential requirements for the determination of the leakage of a gas through a fabric are (*i*) an apparatus—usually called a permeameter—to hold a sheet of fabric so that air may be passed over one surface at a definite rate while the gas passes over the other surface, (*ii*) a means of determining the amount of this gas which diffuses through the fabric into the air.

In these tests a Shakespear permeameter was used and two methods were employed to determine the amount of gas in the air, (*i*) by using a Jamin Interferometer, (*ii*) by using a Katharometer. The permeameter is described below under "Description of Apparatus," while the use of the Interferometer and Katharometer is detailed under "Measurement of Permeability."

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[1] Barr. *Loc. cit.*

[2] Tech. Paper. No. 113.

Description of Apparatus

The general arrangement of apparatus is shown diagrammatically in Fig. 1.

(*a*) *The Air Circuit*

The air stream maintained by means of a water pump and kept at a constant pressure by a blow-off, passed (*i*) through a flow meter which served to check the uniformity of the rate of flow, (*ii*) through a gas meter which measured the volume of air, (*iii*) through a drying train of calcium chloride and of sulphuric acid (*iv*) through a copper coil in a thermostat which ensured that the air was at the temperature of the fabric and then (*v*) through the air chamber of the permeameter. The outgoing air containing hydrogen or helium which had leaked through the fabric then passed (*i*) through a coil at air temperature, (*ii*) through a drying tube and then (*iii*) through a Jamin Interferometer or out into the air as desired.

(*b*) *The Gas Circuit*

The gas, helium or hydrogen, passed (*i*) through calcium chloride tubes and a sulphuric acid wash bottle, (*ii*) through a Shakespear Hydrogen Purity meter which indicated the purity, (*iii*) through a coil in the thermostat, (*iv*) through the upper chamber of the permeameter, (*v*) through calcium chloride and phosphorus pentoxide drying-tubes, (*vi*) through a chamber communicating with a Katharometer which indicated the purity of the gas and (*vii*) through a wash-bottle which served as a pressure regulator (*viii*) to the gas-outlet.

(*c*) *The Permeameter*

The permeameter, made to the design of Dr. G. A. Shakespear, was supplied by the Cambridge Scientific Instrument Co. Plate I shows the exterior with the Katharometer in position. It consists of two shallow circular drums, each about 26 cms. diameter and 1 cm. depth, with machined flanges 1·6 cms. wide. The volume of the air chamber is 500 cc. As will be seen from Plate II, the fabric is supported by concentric rings of metal which are notched so as to obtain uniform diffusion of gas or air throughout the chamber.

Conditions of Testing

As permeability is dependent upon a number of factors, the conditions under which the tests in this paper were carried out are stated under the following headings:

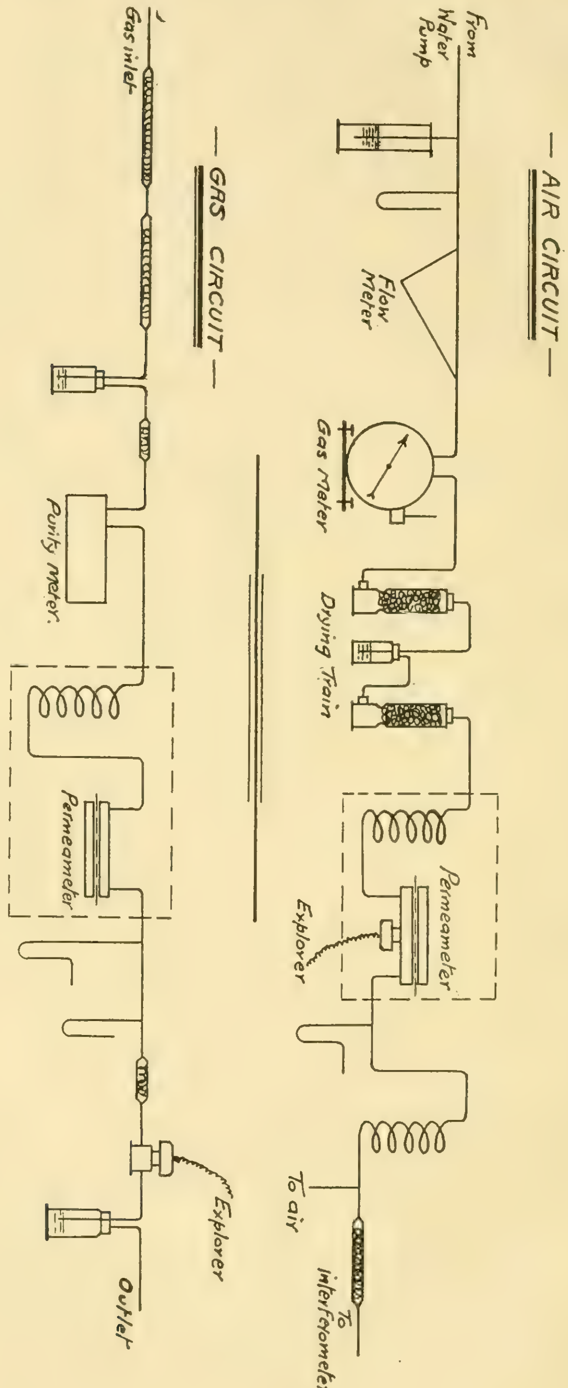

FIG. I
Diagrammatic Sketch of Apparatus

(*a*) *Purity of Gases*

In these experiments the hydrogen used was supplied by the British Oxygen Co., Ltd., and was guaranteed to contain less than 0·5% impurities (nitrogen and carbon monoxide). The helium, separated from natural gas by a liquefaction process, had been purified by a continuous-flow charcoal-absorption method[1] and was practically 100% pure.

(*b*) *Temperature Control*

As permeability has a considerable temperature coefficient, the permeameter and coils enclosed in dotted lines in Fig. 1 were placed in an electrically controlled thermostat maintained at a constant temperature (15·5°C. for the majority of the tests). The variation of the thermostat temperature was about 0·1°C. In some preliminary tests when the temperature was not at 15·5°C, the hydrogen permeability was corrected to the temperature of the helium permeability, using a temperature coefficient of 5%. This correction (for less than 1°C.) was applied to results IIA, IIIA, IVA, VA and VIA in Table III given below.

(*c*) *Rate of Air Flow*

The rate of air flow was varied from about 2 to 15 litres per hour according to the type of fabric under examination.

(*d*) *Pressure Control*

The gas and air drums of the permeameter were connected by a differential gauge and the pressure on the gas side controlled so as to give an excess gas pressure over air of about 3 cms. water. *Extreme* accuracy of control was not aimed at, but the pressure difference was substantially the same for the same fabric for hydrogen and for helium.

(*e*) *Time for Equilibrium*

After adjustment of the gas and air rates, readings of the gas outlet Katharometer were taken until it was ascertained that the gas chamber was completely filled with gas—except for the small amount of air leaking through the fabric. The diffusion of gas into the air chamber was followed by Katharometer observations. It was found that a period of an hour sufficed for equilibrium conditions to be established.

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[1] Edwards and Elworthy. Proc. Roy. Soc. of Canada, 1919.

(*f*) *Fabrics*

The airship fabrics tested were supplied by the Department of Aircraft Production of the Admiralty, and are described in Table I (given below). Laboratory Reference Numbers are given in Column I of the Table.

The date of manufacture of the fabrics was not known.

The test-pieces were cut from the roll, choice being made of a portion of the fabric free from seams or apparent defects, and inserted in the permeameter without any preliminary drying or dessication.

TABLE I

Lab. No.	Description of Fabric	Approx. weight in grammes per square meter
I	2-ply, diagonal, rubber on inner face and between plies	140
VII	2-ply, diagonal, rubber between plies	230
II	2-ply, diagonal, rubber on inner face and between plies	330
III	2-ply, diagonal, rubber between plies, outer face aluminium	340
VI	2-ply, diagonal, rubber between plies, outer face aluminium	310
V	3-ply, inner diagonal to outers, rubber on inner face and between plies, outer face aluminium	450
IV	3-ply, parallel, rubber between plies, outer face aluminium	440
VIII	Single-ply, rubber on inner face, outer face one layer Goldbeaters' skin	85
IX	Single-ply, rubber on inner face, outer face 2 layers Goldbeaters' skin	85

MEASUREMENT OF PERMEABILITY

It has already been stated that two distinct methods were employed in these experiments to determine the amount of gas diffusing into the air through the sample of fabric.

(*a*) In the first method, the hydrogen or helium in the air was estimated by means of a Jamin interferometer, used in the manner described in another paper[1].

The general procedure adopted was (*i*) to establish the rates of flow of gas and of air, then, after an equilibrium condition in the permeameter had been attained, (*ii*) to take readings of the percentage of gas in the air at equal intervals of time over a period of about one hour. The rate of flow of air was given by a gas meter which was read at the beginning and end of the period. Intermediate readings were also taken to check the uniformity of the air flow.

[1] McLennan and Elworthy. Proc. Roy. Soc. of Canada, 1919.

These readings with the necessary temperature and pressure readings yield the following results:

V = the rate of flow of air expressed in litres per hour of dry gas at 15·5°C. and 760 mm.

r = the percentage of hydrogen or helium in the outflowing air.

If the area of the fabric exposed = A sq. cms. the permeability, P, is given by the equation

$$P = \frac{V \times r \times 10{,}000 \times 24}{100A}$$

In the permeameter employed A = 500 sq. cms. and, on substituting, the formula becomes $P = 4 \cdot 8 \times Vr$.

(*b*) In the second method, a Katharometer together with a mirror galvanometer was used. The Katharometer, manufactured by the Cambridge Scientific Instrument Co., Ltd., was designed by Dr. G. A. Shakespear and has been described by him elsewhere[1].

The explorer and galvanometer employed have been referred to in another paper[2].

In making Katharometer readings about 1 minute was allowed after adjustment. The permeameter air-chamber was then closed and readings taken at one minute intervals for about 20 minutes. When the readings were completed the exit-trap from the air-chamber of the permeameter was opened, and the air stream re-established. If subsequent readings were made, sufficient time was given for equilibrium conditions being reached.

With the Katharometer, the permeability (P) is given by the expression: P = galvanometer-scale divisions × a constant.

The constant for hydrogen-air was calculated from data supplied by the Cambridge Scientific Instrument Co., Ltd., while that for helium-air was deduced making use of the calibration results obtained by one of the writers.[3] The actual values of the constants found were for hydrogen 0·4377, and for helium, 0·6870.

RESULTS

The results obtained by the two methods are collected in tables II and III. Column 1 gives the fabric number as described in Table I; column 2, the sample mark; columns 3 and 4 the permeabilities to the nearest decimal place at 15·5°C. and 760 mm.; column 4, the

[1] Shakespear. Advisory Committee for Aeronautics. No. 317. A new Permeability Tester for Balloon Fabrics. 1917.

[2] Murray. Proc. Roy. Soc. of Canada, 1919.

[3] Murray *loc. cit.*

thermostat temperature and column 5, the ratio of the helium to hydrogen permeability from permeabilities calculated to two decimal places.

The mean value of the ratio from Table II is 0·66, from Table III (omitting skin-lined fabrics) is 0·72. As the ratio with fabric 2 was abnormal, additional tests are being carried out on this fabric to ascertain the reason. For the two skin-lined fabrics the ratio is about unity. Additional tests of higher accuracy are also being made on these fabrics. Barr[1] concludes that the ratio for gold beaters' skin is about 1·5, with a footnote that this ratio may probably be more nearly equal to unity.

TABLE II

Interferometer Results

Lab. No.	Sample Mark	Permeabilities		Temp.°C	Ratio
		Hydrogen	Helium		
VII	A	9·4	6·1	15·5	0·65
II	B	8·4	6·5	15·5	0·77
III	B	7·5	5·0	15·5	0·67
VI	B	7·6	4·6	15·5	0·61
V	B	6·7	4·1	15·5	0·61
IV	B	5·5	3·5	15·5	0·64
					Mean 0·66

[1] Barr. *Loc. cit.*

TABLE III

Katharometer Results

Lab. No.	Sample Mark	Permeabilities		Temp. °C.	Ratio
		Hydrogen	Helium		
VII	A	10·0	7·1	15·5	0·71
II	A	9·2	7·6	15·9	0·83
	B	9·5	7·6	15·5	0·81
III	A	8·6	5·6	15·5	0·65
	B	7·4	4·9	15·5	0·66
VI	A	8·1	6·1	15·9	0·75
	B	7·3	4·9	15·5	0·68
V	A	6·0	4·8	14·5	0·80
	B	6·4	4·8	15·5	0·74
IV	A	4·7	3·2	14·6	0·69
	B	5·2	3·4	15·5	0·65
				Mean	0·72
VIII	A	2·4	2·5	15·5	1·02
	B	2.5	2·4	15·5	0·97
IX	A	0·13	0·17	15·5	1·27

SUMMARY

1. Tests have been carried out on the permeability to hydrogen and to helium of typical samples of fabrics.

2. With rubbered fabrics the permeability to helium has been found to be less than to hydrogen, the ratio of the helium to hydrogen permeability being (*i*) 0·66 by Interferometer method, (*ii*) 0·72 by Katharometer method.

3. With skin-lined fabrics the ratio of helium to hydrogen permeability was found to be about unity.

This investigation was carried out at the Admiralty Physical Laboratory under the direction of Professor J. C. McLennan, F.R.S., Scientific Adviser to the British Admiralty.

South Kensington,

14th April, 1919.

Plate I.—Shakespear Permeameter (closed)

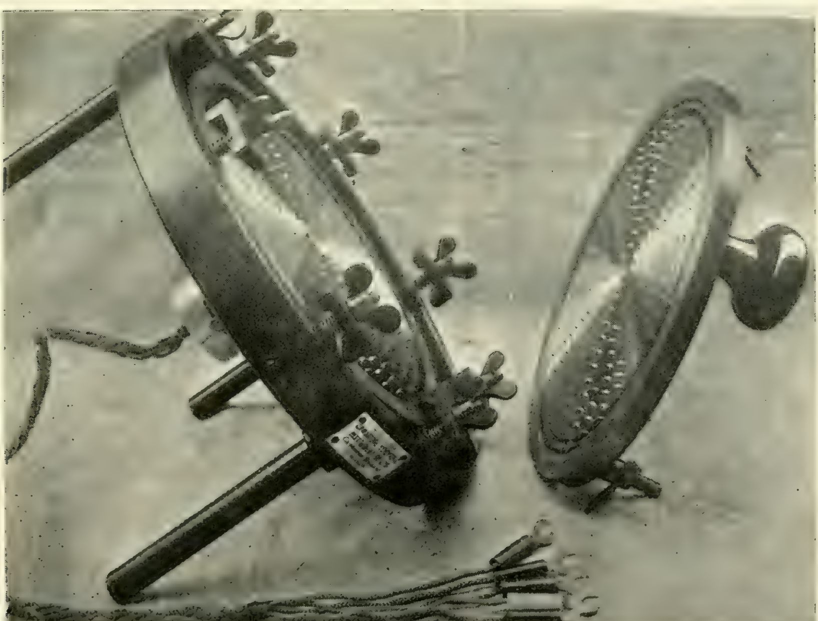

Plate II.—Shakespear Permeameter (open)

A Continuous Flow Apparatus for the Purification of Impure Helium Mixtures.[1]

By E. EDWARDS, M.A., B.Sc., and R. T. ELWORTHY, B.Sc.

Presented by PROFESSOR J. C. MCLENNAN, F. R. S.

(Read May Meeting, 1919.)

INTRODUCTION

The utilization of the absorbent property of cocoanut charcoal, cooled to a low temperature, introduced by Dewar[2] primarily for the production of high vacua and later for the separation of gases, has been practically the only laboratory method adopted for the isolation and purification of helium.

The usual practice is to admit impure gas gradually at low pressures to the charcoal contained in vessels immersed in liquid air and as soon as equilibrium is attained the unabsorbed helium is pumped off.

Ramsay[3] made use of this method for the final purification of helium obtained by fractional distillation of liquid air and in his examination of the rare gases evolved from the mineral springs at Bath. It was used by Moureau and Lepape[4] in their analyses of rare gases given off from French mineral springs, by Cady and McFarlane[5] in work on the helium content of natural gases in Kansas, U.S.A., and by Professor J. C. McLennan and others in an investigation of the helium resources of the British Empire.[6]

Two hundred litres of helium prepared from monazite with which Professor Kammerling Onnes[7] carried out determinations of isothermals—work which culminated in the liquefaction of helium—was purified by charcoal cooled in liquid hydrogen. Until recently the gas at Leiden constituted the greatest supply of pure helium existent,

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[1] Communicated by Professor J. C. McLennan, F.R.S., by permission of the Admiralty.

[2] Dewar. *Proc. Roy. Soc.*, 1904. A 74, 122.

[3] Ramsay. *Proc. Roy. Soc.*, 1905. A 76, 111.
Proc. Roy. Soc., 1908. A 80, 599.
Chem. News, 1912–105–134.

[4] Moureau and Lepape. *Comp. Rend.*, 155, p. 197–1912.

[5] Cady and McFarlane. *Jour. Amer. Chem. Soc.* 1907–29–1523.

[6] Vide this Journal.

[7] K. Onnes. *Proc. K. Akad. Wetensch Amsterdam*, 1908–11–168.

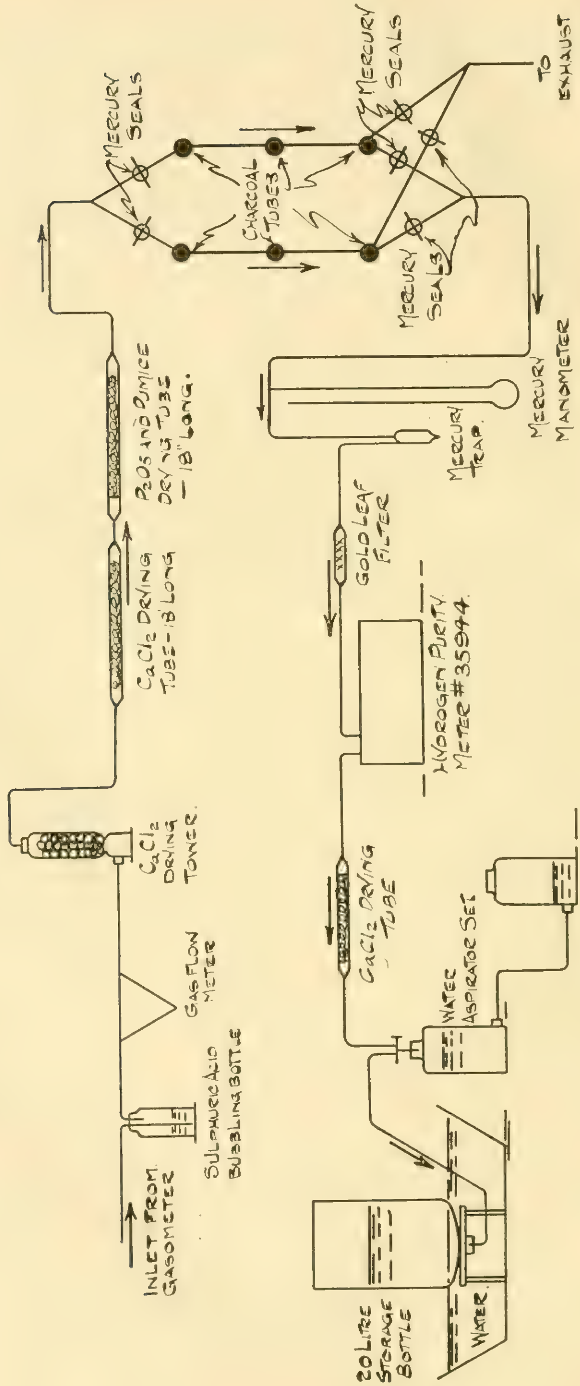

Figure 1.—Diagrammatic Sketch of Flow Apparatus.

a fact sadly referred to by the author[1] of a German aeronautical book published in 1914, after pointing out the great advantage of using helium as a balloon gas.

On account of the great advances which have now been made in the commercial separation of helium from natural gas, more rapid laboratory methods of purification are required.

Most of the work on the absorptive power of charcoal has been carried out at low pressures. Dewar,[2] however, investigated the volumes of various gases absorbed at atmospheric pressure, the heat evolved during the absorption and the rate of absorption.

Claude[3] published data on the charcoal absorption of nitrogen, hydrogen, neon and helium at pressures varying from a few hundredths of a millimeter to 247 mms. He found that the volumes absorbed increased with pressure although a considerable time was required for the complete establishment of equilibrium at the higher pressures.

In view of this work it was considered probable that cooled charcoal would be effective in removing nitrogen from impure helium, passing over its surface at atmospheric pressure at a slow rate.

As a result of successful preliminary experiments the apparatus described in the following paper was constructed.

It consisted essentially of two sets of charcoal tubes arranged in parallel so that when one set became saturated with impurity the gas flow could be diverted through the second set while the first set of tubes was revivified.

Description of Apparatus

The diagrammatic sketch, Fig. 1, indicates the general arrangement of the apparatus. The impure gas passed from the gasometer (*a*) through a Venturi meter to approximately measure the rate of flow (*b*) through a drying train into (*c*) either set of charcoal tubes as desired, (*d*) past the side tubes leading to the exhaust pump, to (*e*) a Shakespear Hydrogen Purity Meter, which, calibrated for helium[4], showed the purity of the treated gas and through it (*b*) into the receiving bottle and finally into the storage bottles. The purity was also checked by density measurements.

The appearance of the central portion of the apparatus is shown in Fig. 2, which represents the two sets of charcoal tubes arranged in parallel and the six mercury seals used instead of glass stop cocks

[1] G. Austerweil. *Die Angewandte Chemie in der Luftfahrt.*

[2] Dewar. *Loc. cit.* Also Proc. Roy. Inst. 21–240–1914.

[3] Claude. *Comptes Rendus.* 1914, 158, 861.

[4] V. F. Murray, *vide* this journal.

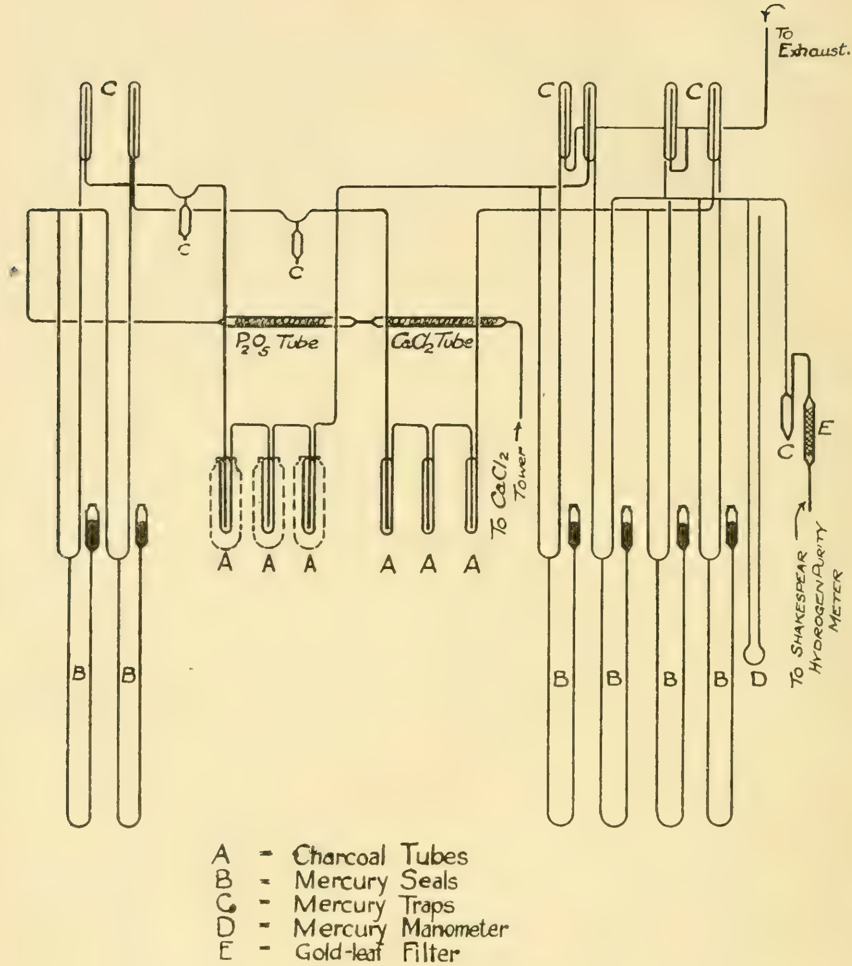

Figure 2.—Central Portion of Flow Apparatus.

to preclude the possibility of air leaks at taps. These seals were operated by lowering or raising the mercury reservoirs according as it was desired to open or close a path to the gas flow.

For use the whole apparatus was first exhausted; the charcoal tubes were surrounded by liquid air and gas was allowed to stream slowly in until atmospheric pressure was attained. When a steady condition was obtained, a flow of gas was started, and continued so long as the purity meter read above 99·8%. When this percentage began to fall the gas stream was diverted through the second set of tubes and the purification continued. Meanwhile the charcoal in the first set of tubes was revivified for use, when the second set became saturated.

The Preparation of the Charcoal

The charcoal used in the tubes was prepared by heating fragments of cocoanut shell out of contact with air in a muffle furnace at a temperature of about 800°C. for ten hours. When cool, the pieces were crushed and screened, that which passsed 10 but was retained by 30 meshes to the inch, being used.

After being put in the tubes the charcoal was again heated in vacuo. Each tube held about 30 grams.

The Revivification of the Charcoal

When saturated the tubes were allowed to warm up to atmospheric temperature while the gas given off was withdrawn. The tubes were raised to about 200°C. by means of cylindrical electric heaters and after half-an-hour a vacuum pump was connected and the tubes thoroughly exhausted and allowed to cool. The tests have shown that the absorptive power of the charcoal is not decreased by successive treatments, but is rather increased, a fact confirmed by Lemon[1], working on the critical temperatures at which absorbed gases are evolved from charcoal.

Results

Altogether, seven runs were made, with the object of testing the efficiency of the method, the quantity of gas that could be purified by the amount of charcoal used (90 grams), the maximum rate the gas could be passed through the apparatus, and the efficacy of the revivification process. The following particulars outline the salient features of the runs:

No. of Run	Set of Charcoal tubes used	Time occupied Hours	Amount of pure gas obtained. Litres	Rate of flow. Impure gas in litres per hour	Purity %
I	1	5·62	11·1	2·38	99·9
There was no indication that the charcoal was saturated when the run was stopped.					
II	1	5·27	17·6[1]	4·15	99·9
	2	0·83	3·9	5·60	99·9
At the end of Run I the charcoal tubes of Set 1 were only pumped out by means of aspirator bottles, accounting for low figure for saturation.					
III	1	3·27	23·6[1]	8·65	99.9
	2	1·5	7·0	5·60	99.9
IV	1	3·82	21·3[1]	6·95	99.9
	2	1·05	7·2	8·20	99.9
V	1	2·00	16·7	10·0	99·9
VI	1	3.16	25·0[1]	9·50	99·9
VII	1	2·15	21·2[1]	10·9	99.9

[1] Signifies that the charcoal was saturated.

[1] Lemon. *Physical Review* 9, p. 336, 1917.

The first set of charcoal tubes was given the most complete trial. The following volumes of pure gas were recovered before the charcoal was saturated.

Run	III	23·6 litres
"	IV	21·3 "
"	VI	25·0 "
"	VII	21·2 "
	Mean	22·8 "

The impure gas contained 88% "C" gas, therefore 26 litres of impure gas was treated on an average. Ninety grams of cocoanut charcoal was saturated by 3 litres of impurity (in this case nitrogen). The partial pressure of the nitrogen was about 90 mms. From Claude's data 11·2 litres of nitrogen was absorbed at 90 mms. by 100 gms. of charcoal, but the gas was left in contact with the charcoal for hours. In these experiments the impure helium was in contact with the charcoal for from one to two minutes only. It is probable that charcoal in a more efficient condition could be prepared, resulting in an even greater volume of gas being passed through before the charcoal becomes saturated.

Summary

The results of the tests show:

1. That helium containing at least 12% impurity can be readily purified by passing in a continuous stream over charcoal at the temperature of liquid air or oxygen.

2. The rate of flow can be increased up to at least ten litres an hour without decreasing the efficiency of the process. The maximum possible rate of flow was not determined.

3. By the use of two or more sets of charcoal tubes, arranged in parallel, the process may be made a continuous one as this form of apparatus permits of revivification of the charcoal without disturbing the flow.

This work was carried out at the Admiralty Physical Laboratory, South Kensington, under the direction of Professor J. C. McLennan, F.R.S.

The Production of Helium from the Natural Gases of Canada[1]

By PROFESSOR J. C. MCLENNAN, F.R.S.

(Read May Meeting, 1919.)

Shortly after the commencement of the war, it became evident that, if helium were available in sufficient quantities to replace hydrogen in naval or military airships, the losses in life and equipment arising from the use of hydrogen would be enormously lessened. Helium, as is known, is most suitable as a filling for airship envelopes, in that it is non-inflammable and non-explosive, and, if desired, the engines may be placed within the envelope. By its use, it is also possible to secure additional buoyancy by heating the gas (electrically or otherwise), and this fact might possibly lead to considerable modifications in the technique of airship manœuvres and navigation. The loss of gas from diffusion through the envelope is also less with helium than with hydrogen, but on the other hand, the lifting power of helium is about ten percent less than that of hydrogen.

Proposals had been frequently put forward by scientists in the British Empire and in enemy countries regarding the development of supplies of helium for airship purposes, but the first attempt to give practical effect to these proposals was initiated by Sir Richard Threlfall, who received strong support from the Admiralty through the Board of Invention and Research, under the presidency of Admiral of the Fleet, Lord Fisher O.M., G. C. B., etc.

It was known that supplies of natural gas containing helium in varying amounts existed in America, and it became evident from the preliminary investigations made by Sir Richard Threlfall and from calculations submitted by him as to cost of production, transportation, etc., that there was substantial ground for believing that helium could be obtained in large quantities at a cost which would not be prohibitive.

The writer was invited by the Board of Invention and Research in 1915 to determine the helium content of the supplies of natural gas within the Empire, to carry out a series of experiments on a semi-commercial scale with the helium supplies available, and also to work out all technical details in connection with the large-scale production of helium and the large-scale purification of such supplies as might be delivered and become contaminated with air in service. In this work he received valuable assistance from his colleagues, Professors John

[1] Communicated by permission of the Admiralty.

Satterly, E. F. Burton, H. F. Dawes, Captain H. A. McTaggart, and from Mr. John Patterson of the Meteorological Office, Toronto, and Mr. R. T. Elworthy of the Mines Branch, Ottawa.

In the course of these investigations, which were carried out with the co-operation of L'Air Liquide Co., it was found that large supplies of helium were available in Canada which could be produced at a cost of about one shilling per cubic foot.

In the preliminary work of development, an experimental station was established at Hamilton, Ontario, to treat the natural gases of Western Ontario. This phase of the work was placed in charge of Professor Satterly, and with him were associated Mr. John Patterson, Professors E. F. Burton and H. F. Dawes and Mr. Lang. In treating the gas considerable difficulty was experienced at first in getting rid of the heavier hydro-carbons but by making suitable modifications in, and additions to, the ordinary type of L'Air Liquide oxygen rectifying column, the problem of separating out the helium which was present in the gas to the extent of only 0·33% was solved. In February, 1918, it was found possible to raise the percentage of helium in the gas by passing it through the rectifying column once only. As the gas obtained in this way consisted of nitrogen and helium with a small percentage of methane, the problem of obtaining helium with a high degree of purity was a comparatively simple one.

In one particular set of experiments on this final rectification, helium of 87% purity was obtained. For the actual running of the station and for the technical modifications in, and additions to the rectifying column, Mr. John Patterson was largely responsible. The experimental station was removed in the autumn of 1918 to western Canada, and placed in charge of Mr. Patterson. At this station a new type of rectification equipment was installed. No serious experimental difficulties were experienced and the investigation is now well advanced on the road to production on a moderate scale. The helium content of the richest gases in western Canada was found to be about 0·36%.

In the summer of 1917, when the U.S.A. had decided to enter the war on the side of the Allies, and after the investigations referred to above were well under way, proposals were made to the Navy and Army and to the National Research Council of the U.S.A. to co-operate by developing the supplies of helium available in the United States. These were made on behalf of the Admiralty, through the Board of Invention and Research by Sir Ernest Rutherford and a special Commission, consisting of Commander Bridge, R.N., Lieut.-Commander Lowcock and Professor John Satterly.

The authorities cited agreed to co-operate with vigor in supporting these proposals, and large orders were at once placed by them with the Air Reduction Co., and the Linde Co., for plant, equipment, cylinders, etc. The Bureau of Mines also co-operated by developing a new type of rectifying and purifying machine. By July, 1918, the production of helium in moderate quantities was accomplished, and, from that time onward, the possibility of securing large supplies of helium was assured.

During the progress of the development and production stages in Canada and in the United States of America, steps were taken by the Admiralty to institute near London, England, an experimental station under the direction of the writer. This station was designed for purifying supplies of low percentage content helium which might come forward from the base of supplies, or which might have become contaminated with air in service at the front.

Investigations were also set in train to develop industrial and scientific uses for helium, and to work out experimental details of the technical use of helium in aircraft. Among others, investigations were begun on the inflammability and explosibility of mixtures of hydrogen and helium, on the use of helium for thermionic amplifying valves, on the suitability of helium for gas filled incandescent lamps and gas arc lamps, on the permeability of balloon fabrics for hydrogen and helium, on large scale charcoal absorption methods of purifying the gas, on the use of helium for high electrical resistances, and progress was made in the installation of equipment for the production of liquid helium for low temperature research. Steps were also taken to examine spectroscopically all samples which came forward with the object of ascertaining whether any indication could be obtained of the existence of any new and hitherto unobserved gaseous elements.

Those who participated in these investigations were Professors Satterly and Burton, and Captain H. A. McTaggart, Mr. R. T. Elworthy, Mr. V. F. Murray, Mr. E. Edwards, Mr. J. T. F. Young, Mr. H. J. C. Ireton and Mr. K. H. Kingdon, all with one exception members of the University of Toronto.

In the early stages of the investigation, valuable help was secured from Lord Shaughnessy and the members of his staff on the Canadian Pacific Railway, from the President and Board of Governors of the University of Toronto, from the Director of the Meteorological Office, Toronto, and from the Directors of the various natural gas producing companies in Canada, in particular from those of the National Natural Gas Co., of Hamilton, and those of the Canadian Western Natural Gas, Heat, Light & Power Co., of Calgary.

The solution of the problem of producing helium in large quantities was, before the beginning of the war, one which would have been considered by many visionary and chimerical, but through the enthusiastic support and financial aid received from the British Admiralty and from the Bureau of Mines and the Naval and Air Boards of the United States, the possibility of the production on a large scale has been realised.

May 1st, 1919.

Composition of the Vapour and Liquid phases of the System Methane-Nitrogen[1]

By CAPTAIN H. A. MCTAGGART and MR. E. EDWARDS, M.A., B.Sc.

Presented by PROFESSOR J. C. MCLENNAN, F.R.S.

(Read May Meeting, 1919.)

SYNOPSIS

1. Introduction. 2. Measurement of Temperature. 3. Gases Used. 4. Method of Analysis. 5. General Description of Apparatus. 6. The Cryostat. 7. Manipulation. 8. Results. 9. Summary.

INTRODUCTION

The problem—now a commercial one—of the separation of helium from natural gases bears a resemblance to the recovery of argon from the atmosphere. Helium occurs in the richest natural gas wells in about the same proportion—0·9%—as argon does in the atmosphere, and its separation at present is being effected in a similar way, *viz.:* by the method of liquefaction and rectification.

There is this difference, however, that while argon is recovered as a by-product in a very important industry, *viz.:* the manufacture of oxygen and nitrogen from the air, the separation of helium from natural gases is being carried out for its own sake. This adds considerably to the cost of production, a cost which might be reduced and probably will be when the liquefaction method as applied to natural gases is made more efficient.

A detailed examination of the conditions under which these gases liquefy ought to give useful information in this direction.

Wells yielding helium to any extent are found to contain as the chief constituents, methane and nitrogen. For example, a well in Texas, U.S.A., yields a gas of the following composition:

N, 34·0%; CH_4, 52·0%; Hydrocarbons, 12·3%; CO_2, 0·8%; O_2, 0·8%; He., 0·9%.

Another well in Alberta, Canada, has:

N, 8·7%; CH_4, 91·1%; CO_2, 0·1%; O_2, 0·1%; He., 0·36%.

For this reason the system CH_4-N was chosen for preliminary study, and the boiling points at atmospheric pressure of various

[1] Communicated by Professor J. C. McLennan, F.R.S., by permission of the Admiralty.

mixtures with the composition of the vapour and liquid phases are now given in this paper.

Measurement of Temperature

Temperatures were measured by means of a Cu-Const. thermocouple, the E.M.F. being read on a slide wire potentiometer. An accumulator was used as a source of electric supply and a Weston cell as a standard.

The fixed points chosen for calibration were[1]:

Boiling point of	Nitrogen	77·3 abs.
" " "	Oxygen	90·0 "
" " "	Methane	109·0 "

at atmospheric pressure. The reference junction of the thermocouple was kept in melting ice.

Variations in the E.M.F. of the accumulator were corrected by frequent comparison with the Weston standard.

Gases Used

The Methane, oxygen and nitrogen used were all obtained commercially.

Methane

This was obtained from Messrs. Insoles, Cymmer Collieries, Porth, Wales, and had a purity of 95% to 97%. The impurities, carbon dioxide, oxygen, nitrogen and hydrogen were removed by absorption and liquefaction followed by fractional distillation.

Nitrogen

This was supplied by the British Oxygen Company from their Birmingham Works, and was fairly pure. Any carbon dioxide present was absorbed in potassium hydroxide solution and the remainder liquefied. It was found to boil away at a fairly constant temperature.

These gases were stored separately in aspirator bottles over boiled water containing caustic soda in solution. These bottles were graduated roughly in half-litres. When a mixture was to be made, the two gases were admitted to the cryostat in the proportions desired, approximately, and liquefied.

This mixture, after a reading of it was taken, was stored in a third bottle and reserved for making other mixtures.

No attempt was made to prepare mixtures of a known composition but merely to obtain mixtures in sufficient variety for the purpose.

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[1] Kaye and Laby's, Phys. and Chem. Constants.

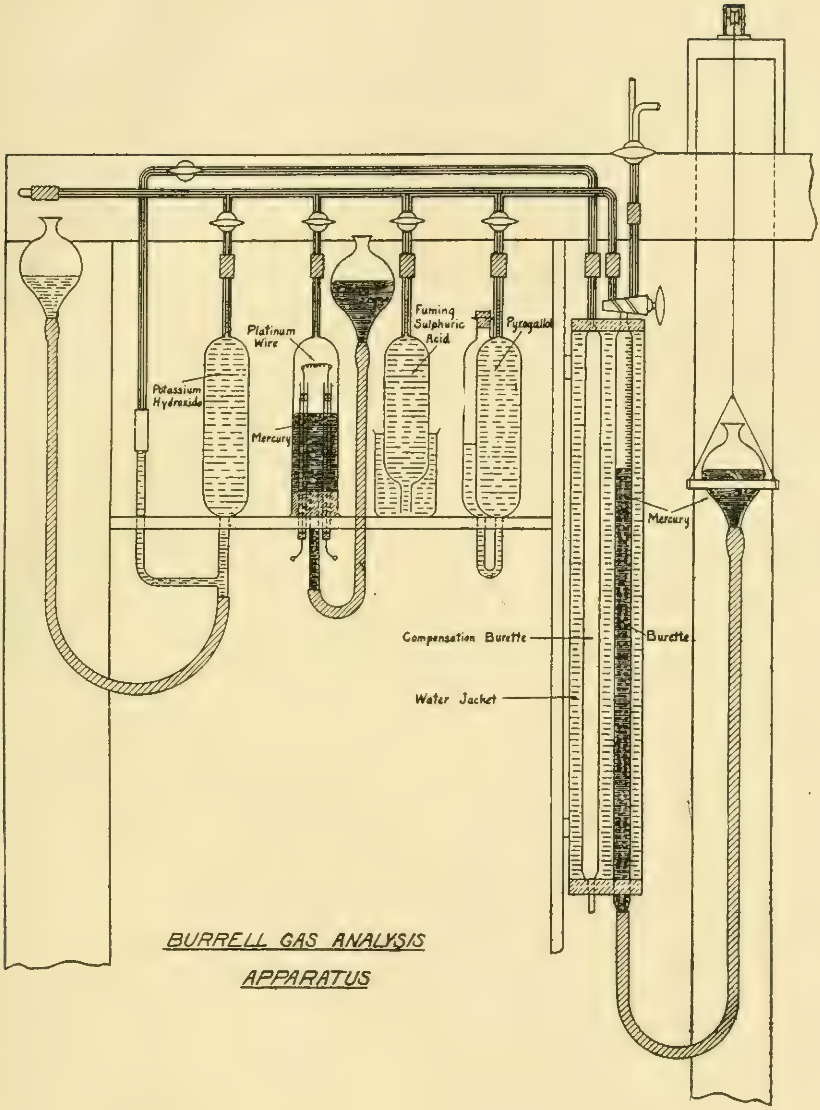
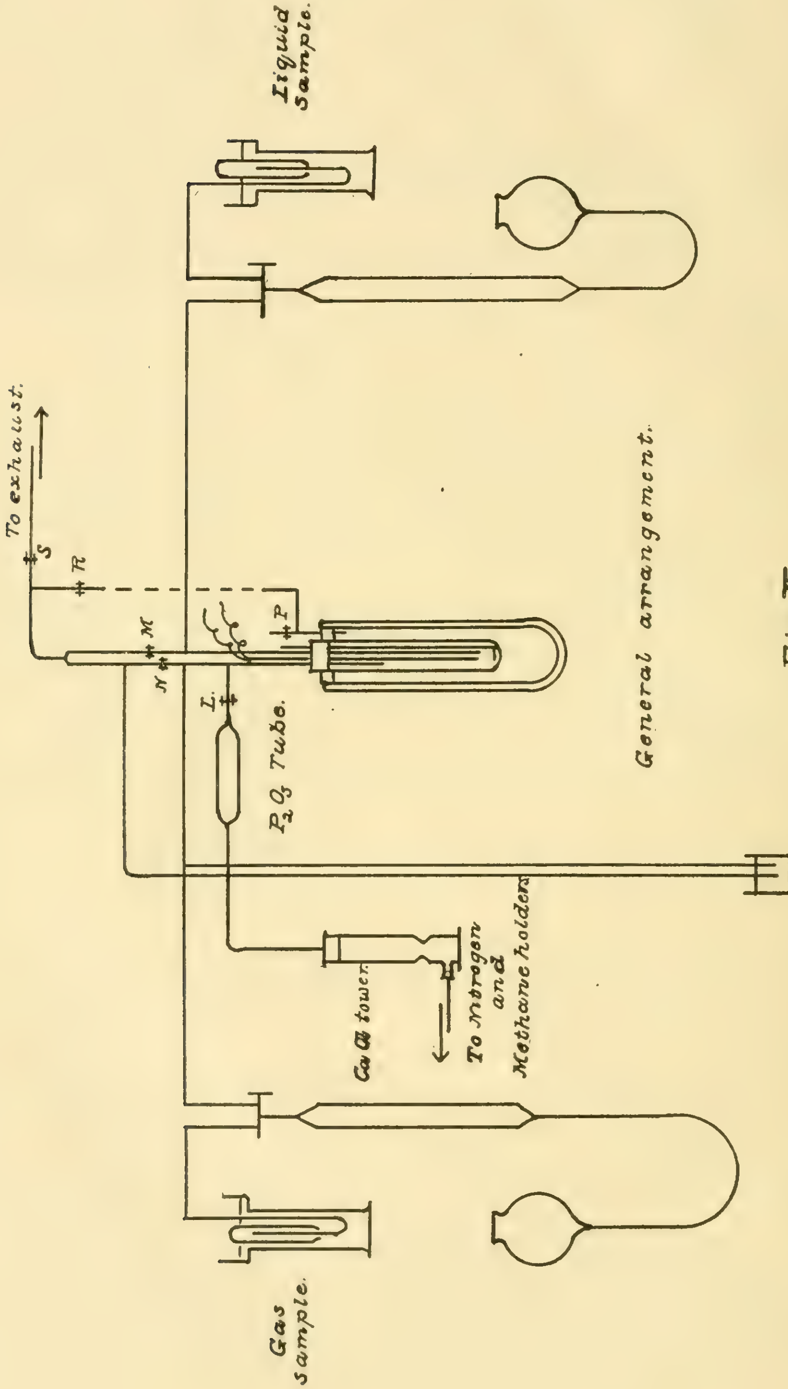


Fig. 1.

Oxygen

This was used in calibrating the thermocouple and was obtained in the liquid form from the British Oxygen Company. A sample was allowed to boil away till the temperature became constant, any small percentage of nitrogen present in it boiling off in the process.



General arrangement.

Fig II

Analyses

The composition of any sample of methane-nitrogen was determined by estimating the methane by combustion and the nitrogen by difference. The apparatus used was of the Burrell Gas analysis type. A sketch is here attached, Fig. 1, showing the combustion chamber, KOH absorption pipette and the measuring burette. This latter could be read to hundredths of a cc.

General Description of Apparatus

Fig. 2 shows in diagram the essential features. The mixtures of methane and nitrogen were liquefied in a tube surrounded by a bath of liquid oxygen. This part of the apparatus is shown in the centre of the diagram and may be referred to as the cryostat. The mixtures were admitted to it after passing through drying tubes of calcium chloride and phosphorus pentoxide. Samples of the liquid and vapour phases were drawn off over mercury in burettes shown on each side of the diagram and collected in small sample tubes for analysis. In place of glass taps it was found convenient at some points in the apparatus to insert short lengths of rubber compression tubing which could be closed by screw clips. These are shown at L, M, N, P, R, S.

The Cryostat

This is shown in detail in Fig. 3. The liquefying tube (*a*) was closed by a rubber stopper through which four small tubes passed, (*b*) used as exhaust tube as well as for the admission or withdrawal of gas samples, (*c*) a capillary tube used to withdraw samples of the liquid phase (this device was used by Baly, Phil. Mag. 49, 517, 1900), (*d*) a tube for the thermocouple wires—one wire running down inside it, the other outside—(*e*) a tube closed outside by a short length of rubber tubing and containing a glass stirring rod, which could be moved by hand through the rubber.

The vacuum flask holding the bath of liquid oxygen had part of the silvering removed so that the progress of liquefaction could be seen.

The flask was closed by a rubber stopper and connected by the tube (*g*) to an exhaust pump. By reducing the pressure to 5 cms. of mercury a temperature of $-200°$C. or lower could easily be reached. The pressures in the liquefying tube and in the vacuum flask were observed on simple mercury manometer columns.

Manipulation

In carrying out an experiment with any mixture the following order of proceeding was adopted. The liquefying tube was first exhausted through (*b*), the vacuum flask being removed. The storage

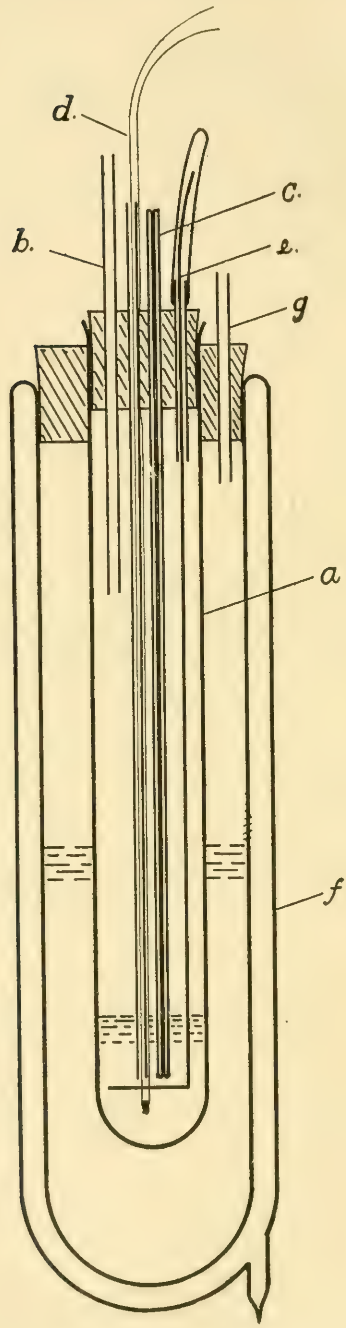


Fig. III

bottle containing the mixture was then connected to (*b*) and the vacuum flask with the bath of liquid oxygen placed in position. The temperature of the bath was then lowered if necessary by exhausting through (*g*). The liquefaction of any mixture took place quite readily when the temperature of the bath was kept about 5°C. below the boiling point of the mixture. When 7 or 8 litres had liquefied the flow was stopped and the vapour pressure allowed to rise to 1 atmosphere. This was done by raising the temperature of the bath or, in some cases, by lowering the bath. While the vapour pressure was kept at 1 atmosphere samples of both phases were taken, the first portion drawn off being rejected in each case. The liquid was kept thoroughly stirred to avoid any superheating and to ensure as complete an equilibrium as possible between the two phases.

Results

The experimental results are given in Table I.

Table I

Temp. (abs.)	% CH_4 in liquid phase	% CH_4 in vapour phase
84·5	33·2	14·8
88·0	49·0	24·6
95·5	72·2	43·4
98·0	82·2	49·3
100·5	80·9	59·4
104·5	92·9	67·3
106·5	94·9	87·1

These numbers are shown graphically in Fig. 4 which constitutes a temperature-composition diagram.

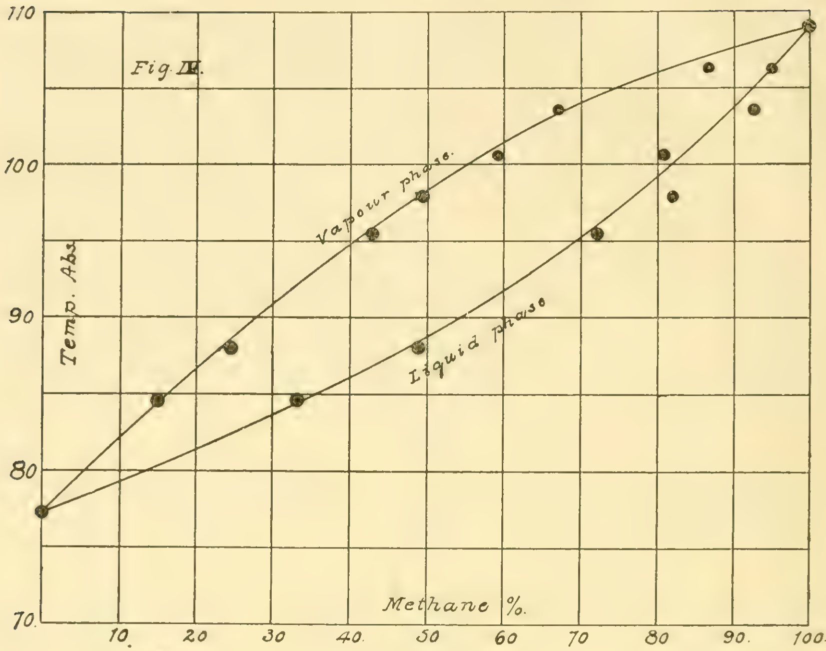
In Fig. 5 the composition of the liquid phase is plotted against that of the vapour phase, a few additional observations being added for which temperatures were not determined.

From this curve the relation:

$$\log r' = a + b \log r$$

where

$$r = \text{the ratio, } \frac{\%\ \text{Methane}}{\%\ \text{Nitrogen}} \text{ in liquid}$$



$$r' = \text{the ratio, } \frac{\%\ \text{Methane}}{\%\ \text{Nitrogen}} \text{ in vapour}$$

was found to hold very approximately, the constants in this case being:

$$a = -0{\cdot}47$$
$$b = +0{\cdot}85$$

as obtained from the graph.

This relation was used to obtain a more complete and smoother series of results. The corresponding temperatures were taken from the temperature composition diagram. Such a series (proceeding by two-degree intervals) is given in Table II.

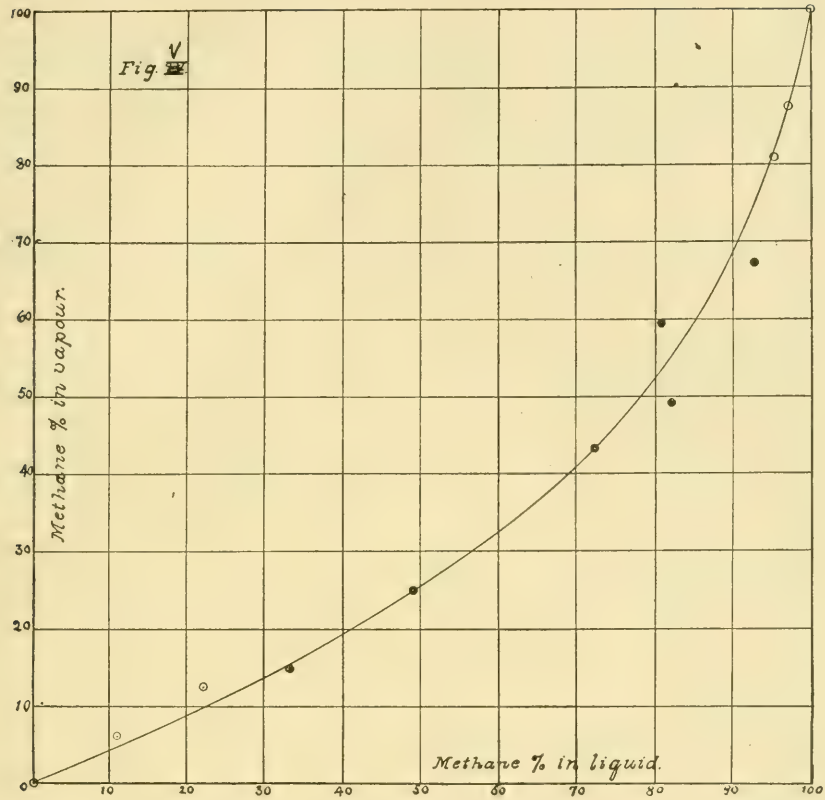


TABLE II

Temp. (abs.)	% Methane in liquid	% Methane in vapour
109°	100	100
108	98·4	92·0
106	94·8	80·0
104	90·5	69·6
102	86·0	61·6
100	81·6	54·5
98	77·0	48·7
96	72·4	43·5
94	66·6	37·6
92	61·0	33·0
90	54·2	28·0
88	47·0	23·3
86	39·4	19·0
84	30·6	14·4
82	22·2	10·0
80	13·0	6·0
78	3·4	1·6
77·3	0·	0·

Summary

The temperature-composition diagram for the system methane-nitrogen at atmospheric pressure has been worked out and the constants in the formula—

$$\log r' = a + b \log r$$

determined.

It may be added in conclusion that though exceptional accuracy is not claimed for these results yet it is believed that they are fairly correct.

Admiralty Physical Laboratory,
South Kensington,

12th April, 1919.

On the Extreme Ultra-violet Spectra of Magnesium and Selenium

By PROFESSOR J. C. McLENNAN, F.R.S., MR. J. F. T. YOUNG, M.A.
and MR. H. J. C. IRETON, M.A.

(Read May Meeting, 1919.)

INTRODUCTION

The present work is a continuation of that carried out by two of the authors with a Hilger quartz spectrograph, Type C, in the region down to 2000 A.U. The present paper deals with the spark and arc emission spectra of magnesium from 2100 A.U. to 1850 A.U. with a Hilger Type A quartz spectrograph, and the vacuum arc spectra of magnesium and selenium from 2300 A.U. to 1400 A.U. with a specially constructed fluorite spectrograph.

In the spark spectrum of magnesium, four new lines have been observed, in the arc spectrum of this metal, eleven, and in the arc spectrum of selenium, some thirty-one.

MAGNESIUM

Experiments

Three sources of radiation, the spark in air, the arc in air, and the arc in vacuo, were used in obtaining the spectra of magnesium. The spark in air was produced by the condensed discharge of a Clapp-Eastham half-kilowatt transformer, giving 10,000 volts at the secondary terminals. With this apparatus a strong thick spark was easily produced.

The arc in air was produced by using rods of magnesium metal in the carbon holders of an ordinary hand-fed arc lamp. The voltage applied was 200 volts, and the current varied from eight to twelve amperes. With such heavy currents the metal soon became hot and exposures had to be intermittent to allow for cooling of the rods.

The type of arc lamp developed for vacuum work by McLennan, Ainslie and Fuller[1] was employed with the fluorite spectrograph, magnesium metal rods being fastened to the electrodes. With good vacua it was found that a current of 4 to 5 amperes at 100 volts produced a brilliant and steady arc.

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[1] Proc. Roy. Soc. Ser. A. Vol. 95. Mar. 15, 1919, p. 316.

The spectra were recorded on Schumann plates made by the Adam Hilger Co. With the quartz spectrograph no difficulty prevented the securing of clear, sharply defined spectrograms, but with the fluorite spectrograph, the fluorescence of the prism and lenses produced a heavy general fogging of the plate. Since this did not occur with other arc sources of equal intensity in the visible region, it is possible that this may be due to the strong ultra-violet emission in the magnesium arc between 2700 A.U. and 3000 A.U.

Typical spectra are reproduced in Fig. 1. The upper spectrum is that of the magnesium spark in air, and below it is the spectrum of the magnesium arc in air, both taken with the quartz spectrograph. The lower illustration is the spectrum of the magnesium arc in vacuo taken with the fluorite spectrograph. Wave length scales are attached for reference.

It may be noted that as was observed by Saunders[1] and as mentioned in the previous work, reversal was readily obtained with the arc in air at 2852 A.U. and 2026 A.U., the frequencies of which are given by $\nu = (1 \cdot 5, S) - (2, P)$ and $\nu = (1 \cdot 5, S) - (3, P)$, while no reversals were obtained with the arc in vacuo.

The wave lengths with the quartz spectrograph were obtained from a calibration curve constructed by using the following prominent lines in the mercury arc and the zinc, cadium and aluminium sparks.

Mercury	Zinc	Cadmium	Aluminium
4046·78 A.U.	3076 A.U.	3260·1 A.U.	1990·57 A.U.
3650·31 "	2558·2 "	2748·68 "	1935·90 "
3341·70 "	2502·2 "	2573·15 "	1862·81 "
3131·66 "	2138·7 "	2313·88 "	1854·80 "
	2100·06 "	2288·12 "	
	2062·08 "	2265·04 "	
	2025·51 "	2194·71 "	
		2144·44 "	

The calibration curve for the fluorite spectrograph was obtained by measurement of the following prominent carbon, tin and lead vacuum arc lines.

[1] Saunders. Astro.-Phys. Jl. Vol. 43, No. 3. April, 1916.

Carbon	Tin	Lead
2307·5 A.U.	1756·6 A.U.	2204·4 A.U.
1930·5 "		1821·7 "
1656·9 "		1796·5 "
1562·0 "		26·5 "
61·2 "		1682·5 "
60·5 "		71·6 "
1464·5 "		1555·8 "
		1434·0 "

The wave lengths of the lines and their relative intensities are given in Table I, together with lines recorded by other observers in the region below $\lambda = 2026$ A.U. In reaching these values, a great many plates were taken and the best measured with a Hilger comparator.

Series Relations

In the present investigation the series of single lines given by the formula $\nu = (1 \cdot 5, S) - (m, P)$.

m=	2	3	4	5	6	7
λ=	2853·22	2025·08	1828·1	1748·09	1707·3	1683·64

has been verified for the values m=3, 4, 5, 6.

Lorenser[1] has calculated the wavelengths of the different members of the series $\nu = (1 \cdot 5, S) - (m, p_2)$ to be

[1] Lorenser, Mang. Diss. Tübingen, 1913.

TABLE I

HANDKE		LYMAN		SAUNDERS		THE AUTHOR'S					
Spark in Air	Int.	Spark in Hydrogen	Int.	Vacuum Arc	Int.	Spark in Air	Int.	Arc in Air	Int.	Vacuum Arc	Int.
..		..		2026 A.U.	10	2026 A.U.	10	2026 A.U.	10	2026 A.U.	10
..		..		..		..		2004	1	..	
..		..		..		2000	1	2000	1	..	
..		..		..		..		1996	1	..	
..		..		..		1990	1	..		..	
..		..		..		1978	1	..		..	
..		..		..		..		1973	1	..	
1930.9 A.U.	6	..		..		1931	10	..		..	
..		..		..		1909	2	..		..	
1886·8	5	..		..				..		..	
1864·1	4	..		..		1887	4	..		..	
55.9	5	..		..		1864	2	..		..	
39·6	3	..		..		1856	2	..		..	
..		1828·1 A.U.	1	1828·0 A.U.	6	..		..		1828	5
1753·0	3	1753·6	6	..		..		..		1753	3
1750·7	2	50·9	5	..		..		..		51	1
50.0	1	..		..		..		..		..	
..		..		..		..		..		1748	3
1746.7	1	..		..		..		..		..	
44·1	5	..		..		..		..		..	
..		..		..		..		..		1743	1
1741·4	5	..		..		..		..		..	
..		1737.8	7	..		..		..		1738	4
1736·3	2	..		..		..		..		..	
..		1735·0	6	..		..		..		1735	1
1734·0	1	..		..		..		..		..	
		..		..		..		..		1707	1

m=	2	3	4	5	6	7
λ=	4571·27	2090·08	1843·08	1757·1	1711·6	1621·00

Although the existence of a line at $\lambda=2091$ A.U. was verified in the present work in both arc and spark spectra in air, no indication was obtained of the existence of members of the series with higher frequencies.

Summary

1. The spectra of magnesium for spark in air and arc in air has been investigated in the region between $\lambda=2026$ A.U. and $\lambda=1850$ A.U. and some seven new lines recorded.

2. The spectrum of the magnesium arc in vacuo has been investigated in the region between $\lambda=2300$ A.U. and $\lambda=1400$ A.U. and seven new arc lines measured. Several of these agree with lines found by Saunders with the spark in hydrogen and with lines found by Handke with the spark in air.

3. The series $\nu=(1\cdot5,S)-(m,P)$ has now been verified for values of m from two to six, but the experiments have failed to detect any further lines of the series $\nu=(1\cdot5,S)-(m,p_2)$ beyond, possibly, the second member.

Selenium

These experiments were also a continuation of previous work.[1] To secure an arc in vacuo emitting selenium radiation, solid commercial carbons were bored to a depth of one and a half inches and filled with compressed selenium metal powder. These were placed in the vacuum arc lamp previously mentioned, and a steady bright arc was obtained with a current of 4 to 6 amperes at 100 volts.

In the illustration, Fig. II, the upper spectrum is that of the carbon arc in vacuo, and the lower that of selenium in the carbon arc. The following table contains the wavelengths of all the lines measured with relative intensities. As before, several of the best of a large number of plates were measured.

[1] McLennan and Young, Phil, Mag., Vol. XXXVI, p. 450, Dec. 1918.

TABLE II

Wave-length	Int.	Element	Wave-length	Int.	Element
2307·5 A.U.	8	Carbon	1619 A.U.	1	Selenium
2165	10	Selenium	1615	2	"
38	2	"	09	1	"
2073	10	"	04	3	"
51	10	"	1591	1	"
38	10	"	85	2	"
1993	2	"	78	2	"
60	8	"	61	10	Carbon
30	8	Carbon	48	1	Carbon
17	4	Selenium	33	1	Selenium
14	4	"	31	1	"
1898	6	"	30	1	"
59	8	"	03	1	"
55	8	"	1474	1	"
1761	2	"	68	1	"
52	1	"	65	3	Carbon
1691	2	"	58	1	Selenium
75	3	"	51	1	"
71	3	"	48	1	"
56	10	Carbon	46	3	"
25	1	Selenium	37	3	"
21	1	"	30	1	"

Owing to the difficulty of securing sufficient vapour density around arcs in vacuo it was found impossible to obtain any reversals in the arc spectrum so that no conclusions can be made from the point of view of absorption about the series of selenium in this region of the ultra-violet.

SUMMARY

1. Thirty new lines have been recorded in the selenium arc spectrum between $\lambda = 2300$ A.U. and $\lambda = 1400$ A.U.

Admiralty Physical Laboratory,
South Kensington.

14th April, 1919.

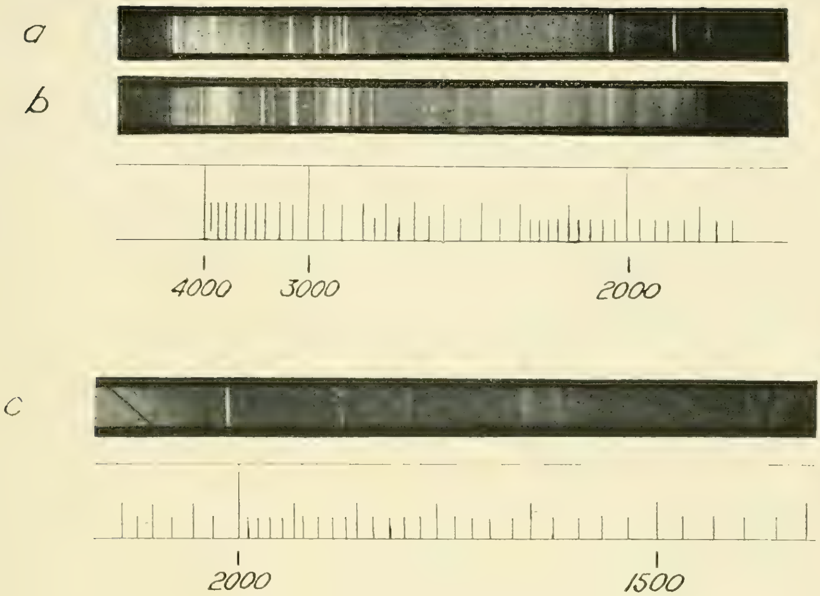

Figure 1

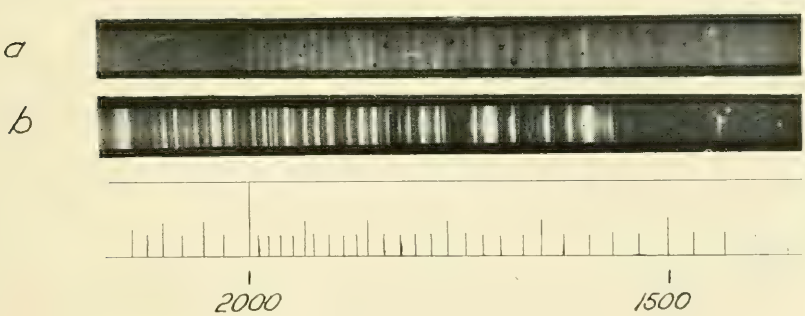

Figure 2

Measurements of Temperature Gradients in Air Between Parallel Planes Maintained at Different Temperatures and their Application to a Determination of the Temperature Variation of Thermal Conductivity

By G. H. HENDERSON, M.A.

Presented by DR. L. V. KING, F.R.S.C.

(Read May Meeting, 1919.)

This paper is a summary of an investigation of the temperature gradient in air at atmospheric pressure between parallel planes maintained at temperatures differing considerably from one another, with the object of determining the variation of thermal conductivity with temperature over a wide range of temperature. A more detailed account of the investigation will be given elsewhere.

If we have two infinite parallel planes at different fixed temperatures, the quantity of heat Q, crossing unit area of any intermediate plane, is constant when a state of steady flow of heat is reached and is given by $Q = K\partial\theta/\partial z$,[1] where K is the thermal conductivity of the gas between the plates and $\partial\theta/\partial z$ is the temperature gradient.

Hence, without determining Q which is difficult to measure, the variation of K with temperature may be determined from a knowledge of the temperature gradient alone.

APPARATUS

The apparatus consisted of a lower plate of copper under which water circulated, and an upper plate of asbestos blocks wound with nichrome wire and heated electrically. Between the two plates a volume of air was enclosed by a glass ring and plate. Temperatures in the air were measured by means of a thermo-element, which could be moved up and down by a screw and whose height above the lower plane was measured with a cathetometer.

Fig. 1 is a diagram of the apparatus. The glass ring was 1·4 cm. high and 7·8 cm. internal diameter. The cold resistance of the heating coil was about 5 ohms. The thermocouple was made of 1 mil constantan and 1·6 mil copper wires, calibrated in steam, napthalene and sulphur vapours.

A series of observations was carried out at four different power inputs. At a given power input the number of temperature determina-

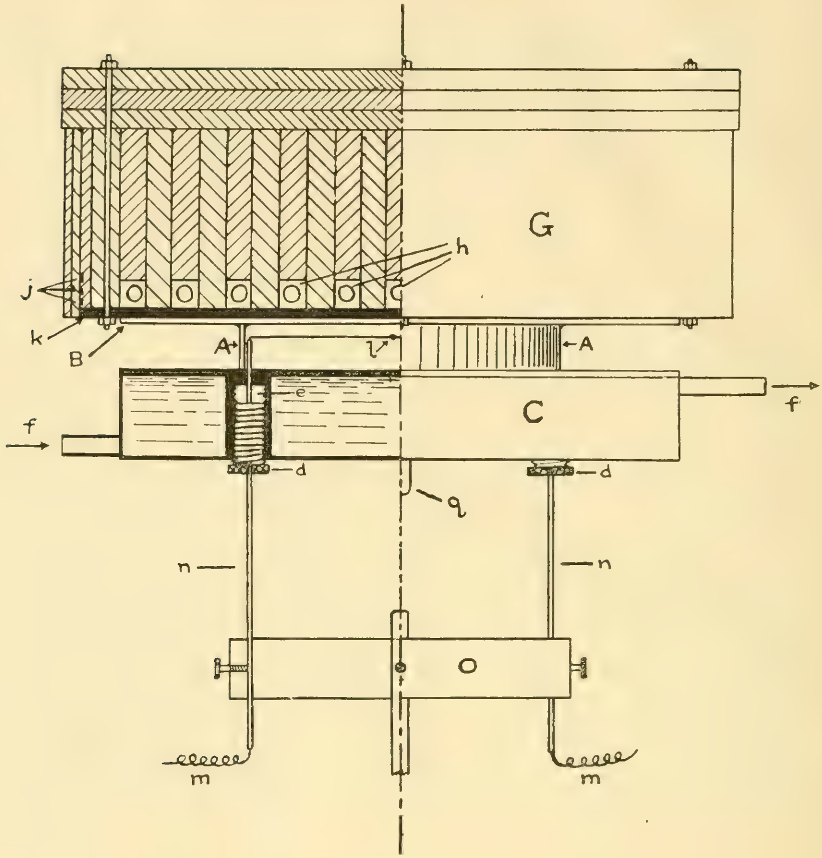

Fig. 1.

A—Glass ring. B—Glass plate. C—Copper water vessel. ff—Water inlet and outlet. e—Packing box. d—Packing nut. nn—Fine glass tubes. 1—Thermo-element. o—Cross arm. mm—Thermocouple leads. q—Side tubes carrying constantan wires. G—Heater. hh—Nichrome wire coils. j—Auxiliary nichrome strip. k—Copper equalizing plate.

Asbestos guard ring strip removed to show details of apparatus.

tions was between 20 and 40, the thermo-element being twice moved over the whole distance between the plates. To determine the influence of radiation, the glass plate was silvered and a series of observations was carried out at the same power inputs as before. The plate was then blackened with soot and a similar series of observations taken. As an example of the results obtained Fig. 2 is given, showing the plotted observations for silvered glass. The broken curves refer to the observations (uncorrected for radiation) at the four power inputs.

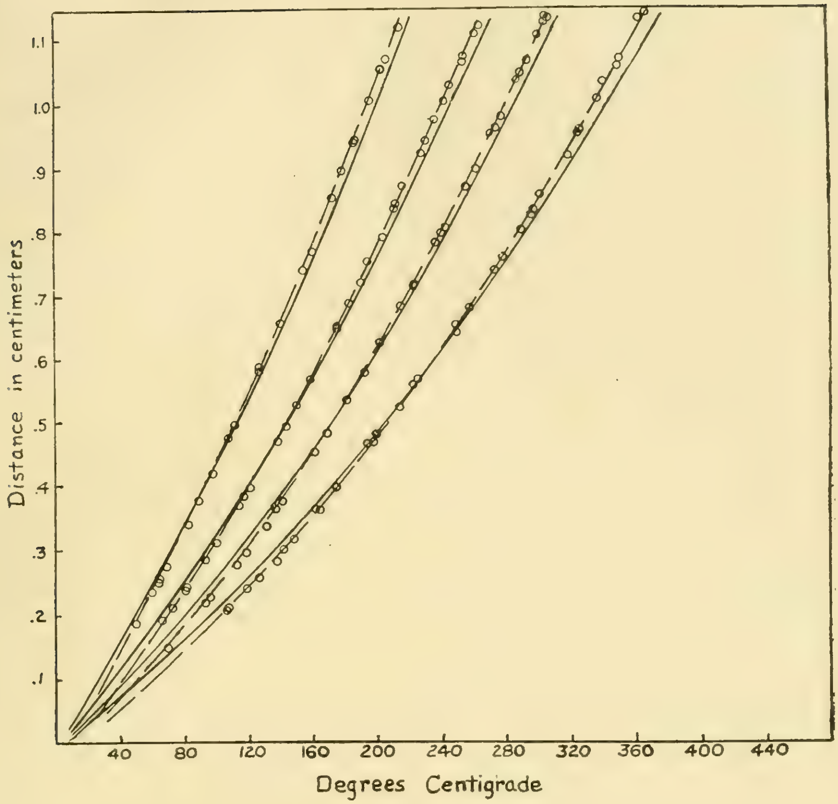

Figure 2

Convection and Radiation

The arrangement of the air in layers of density decreasing with height ensured stability, the guard ring also being of assistance in this regard. From the agreement and reproducibility of the observations it was concluded that convection was negligible. The region within the ring was explored horizontally by means of the thermo-element. Within the limit of error no variation could be detected on a horizontal plane over about two-thirds of the width of the ring. Furthermore, tobacco smoke blown into the vessel was observed to settle gradually down to the bottom of the vessel in well defined horizontal layers with no sign of movements due to convection.

It was necessary however, to make a correction for radiation. The thermo-element, at a temperature intermediate between those of the upper and lower plates, may be receiving more heat than it loses by radiation, consequently its temperature will rise above that of the surrounding gas until the losses by conduction and convection (*i.e.* by "free convection"), equalize the gain by radiation. At other temperatures the thermo-element may be losing more heat by radiation than it receives, with the result that its temperature will fall below that of the surrounding gas.

The following method was used to estimate the correction to be applied to the temperature indicated by the thermo-element. It has been shown by Langmuir[1] that the free convection of heat from small wires can be calculated correctly by assuming that the heat flows by conduction alone through a stagnant layer of gas around the wire. If T_2 be the temperature of the wire, T_1 that of the surrounding gas, and

$$\phi_2 = \int_0^{T_2} K d\theta$$

$$\phi_1 = \int_0^{T_1} K d\theta$$

then by Langmuir's theory the heat loss by free convection per centimeter length is

$$S(\phi_2 - \phi_1)$$

where S is the "shape factor" given by the equation

$$\frac{a}{B} = \frac{S}{\pi} e^{-2\pi/S}$$

a being the diameter of the wire and $B = \cdot 43$cm. at atmospheric pressure. We may thus write

$$S(\phi_2 - \phi_1) = W_r$$

where W_r is the heat due to radiation gained by one centimeter of the wire. W_r may be calculated from the dimensions and radiation constants of the plates. Thus knowing S and ϕ_2, ϕ_1 may be calculated, and finally T_1, the temperature of the surrounding gas.

The corrections thus involved were found to be quite large, varying from +12°C. near the upper plate to −14°C. near the bottom plate in the extreme case of blackened glass at 8·42 amperes current input. The unbroken lines in Fig. 2 are curves corrected for radiation by the method outlined above.

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[1] Langmuir, I., *Phys. Rev.*, 34, p. 401, June, 1912.
Trans. A.I.E.E., p. 1229, 1912.
Trans. Am. Elect. Chem. Soc., p. 299, 1913.

Temperature Co-efficient

Assuming $K = K_0(1+\alpha\theta)$, (3)

then from the equation $K\partial\theta/\partial z = Q$,

we obtain by integration $K_0(\theta + \frac{1}{2}\alpha\theta^2) = Qz$

Thus, if assumption (3) is correct, the temperature-distance curves would be parabolic.

On plotting temperatures as abscissæ and distances from the lower plate divided by the corresponding temperatures as ordinates, the points were found to lie approximately on straight lines. From these lines the values of α were obtained, as $\alpha = -2/c$ where c is the intercept on the axis of abscissæ.

The experimental curves were also tested on the assumption that

$$K = K_0 \, (\theta/\theta_0)^n$$

Since $K\partial\theta/\partial z = Q$, we have $z \propto \theta^{n+1}$

On plotting θ^{n+1} against z approximate straight lines were also obtained when a suitable value of n, chosen by trial and error, was used.

Results at High Temperatures

The results obtained from the experimental curves are given in the following tables:

Table I

Clear Glass

Current input	α	α^1	n	T° C
5·00	·00451	·00495	1·30	226
6·35	·00457	·00564	1·20	318
7·62	·00428	·00556	1·15	393
8·42	·00517	·00644	1·12	438

Table II

Silvered Glass

Current input	α	α^1	n	T° C
5·00	·00394	·00394	1·32	277
6·35	·00435	·00466	1·20	328
7·62	·00488	·00550	1·17	393
8·42	·00445	·00466	1·05	456

Table III

Blackened Glass

Current input	α	α^1	n	T° C
5·00	·00484	·00484	1·32	246
6·35	·00544	·00602	1·30	319
7·62	·00500	·00571	1·12	413
8·42	·00500	·00600	1·12	483

The first column shows the current in amperes passing through the heating coil. In the second column are given the values of a determined from the corrected observations. For purposes of comparison the column headed a^1 gives the values of the temperature co-efficient obtained from the uncorrected observations. Values of n from the corrected observations are given in the fourth column. In order to show the range of temperature involved, the temperature of the upper plate, obtained by extrapolation, is shown in the fifth column.

The only other determination of a for temperatures higher than 100°C. is that of Stafford.[1] His results may be expressed approximately by the empirical formula

$$K=K_0\ (1+\cdot 0015\theta+\cdot 0000057\theta^2)$$

This would give mean values of a over the range covered in the above experiments from ·0030 to ·0042.

It will be seen from the values of a given in Tables I, II and III, that they are considerably higher than those which Stafford's formula gives. In general they increase with increasing range of temperature.

The values of n are more concordant among themselves and decrease with increasing temperature range.

The values of a and n depend on the corrections for radiation applied to the original curves, the corrections in some cases materially altering the original values. The probable errors involved in the assumptions made in evaluating the corrections are large. The largest error is probably in the value of the "effective diameter" of the wires of the thermo-element. In the process of fusing the wires a comparatively large bead of metal was unavoidably formed at the junction. It was assumed that the effective diameter of the wires was that of the larger wire, *viz.* 1·6 mils. This value is very unlikely to be too large, but may be considerably too small. The shape factor S is only slightly affected by changes in the diameter of the wire, but the heat gained by radiation, W_r, is proportional to the diameter. An increase in the effective diameter of the wire would thus require larger corrections for radiation, which would further decrease the values of a. For instance, if the radiation corrections for the last series of observations for blackened glass (Table III) had been doubled, the value of a would have been reduced from ·00500 to ·00357.

In view, then, of the uncertainties involved in the determination of the radiation corrections, the values of a given above may be considered only as upper limits. From their variation with the temperature range it seems evident that a simple formula of the type

[1] Stafford, O. J., *Zeits. fur Phys. Chem.*, 77, p. 67, 1911.

$$K=K_0(1+\alpha\theta)$$

is not sufficient to express the variation of thermal conductivity with temperature over the range employed (0° to 500°).

A formula of the form

$$K=K_0(1+\alpha\theta+\beta\theta^2)$$

would probably be needed to express approximately the variation of K with θ over this range, but with the uncertainty of the given values of α it would be futile to evaluate the coefficient β.

Summing up the results of measurements of temperature gradients over a wide range, it may then be stated that a two power formula seems necessary in order to express approximately the variation of thermal conductivity of air with temperature. Owing to the errors involved in evaluating a correction for radiation, only upper limits to the first coefficient can be obtained from the present measurements. These values are given in the column headed α in Tables I, II and III above.

A formula of the form

$$K=K_0(\theta/\theta_0)^n$$

was also found to express approximately the variation of K with θ. The values of n obtained are given above. They are, however, not independent of the temperature range and can be regarded only as upper limits owing to the uncertainty in the radiation corrections.

Temperature Co-efficient Between 0° and 100°C.

If the temperature range be decreased, the radiation corrections become smaller and errors in them have less effect on the temperature co-efficient. Accordingly, experiments were carried out over the range 0° to 100°.

The electrically heated plate was replaced by one of copper, over which steam was made to circulate. Both silvered and blacked plates were used. The results obtained are given in Table IV.

Table IV

Silvered Glass		Blackened Glass	
α	α^1	α	α^1
·00256	·00292	·00243	·00256
·00281	·00289	·00265	·00297

The mean of the given values of α is ·00261.

As the value of α is small, slight variations in the shape of the curves have considerable effect on its value. Hence very close agreement in the individual values of α could not be expected, and the variations shown in Table IV may be considered as reasonable for this method.

Some recent determinations of α by other observers over the range 0° to 100°C. are given below:

Eckerlein, P. A., *Ann. der Phys.*, 3, p. 120, 1900	·00362
Schwarze, W., *Ann. der Phys.*, 11, p. 303, 1903	·00253
Pauli, E., *Ann. der Phys.*, 23, p. 928, 1907	·00197
Eucken, A., *Phys. Zeits.*, 12, p. 1101, 1911	·00271
Mean of these values	·00271

Of these results the most trustworthy is that of Eucken, which agrees with the mean of the four.

It will be seen that the result of the present determination is in good agreement with the mean of determinations by other observers. This indicates that the method described in this paper will give satisfactory results if the radiation corrections are relatively small, *i.e.* if the temperature range is not too large. The range, however, may be between any two temperatures which experimental arrangements would permit, so that the temperature variation of thermal conductivity over a wide range of temperature might be found in a series of steps.

In conclusion, the writer wishes to express his thanks to Dr. L. V. King for placing the facilities of the laboratory at his disposal and for directing this research. He also wishes to express his gratitude to the Honorary Advisory Council for Scientific and Industrial Research of Canada, under whose auspices the earlier part of this work was done.

McGill University, Montreal, Canada.

The Correction Factor of the Canadian Standard Anemometer and the Most Probable Maximum Velocity and the Possible Extreme Velocity in Gusts

By J. PATTERSON, M.A., F.R.S.C., PHYSICIST TO THE METEOROLOGICAL SERVICE OF CANADA

(Read May Meeting, 1919.)

THE CANADIAN STANDARD ANEMOMETER

The wind velocities at the Canadian Meteorological Stations are obtained from a Robinson anemometer, with cups 4″ in diameter on arms $6 \cdot 72''$ long, measured to the centre of the cups. The revolving system is mounted on ball bearings, is made of aluminium and weighs 1 lb. 10 oz. The anemometer registers each mile of wind on an anemograph and the gearing is cut so that the velocity of the wind is three times the linear velocities of the cup centres.

The Dines pressure tube anemometer (described later) is also used to measure wind velocities and as its corrections can be accurately determined it was used as a standard with which to compare the Canadian anemometer, and thus determine the correction, if any, of the latter.

HISTORICAL NOTE

The factor three which expresses the relationship between the velocities of the cup centres and the wind velocity was obtained by Dr. Robinson in 1846[1], when he designed the cup anemometer, and is still used by instrument makers, no matter what the diameter of the cups or the length of the arms may be. The accuracy of the factor was unquestioned until about 1875, when experiments pointed to this factor being too high. During the succeeding 20 years many experiments were carried out to determine the factor accurately, and to improve the instruments for measuring the velocity of the wind. The principal experimenters were Dines[2] in England, Marvin[3], in the United States and Wild[4], in Russia. Their experiments indicated that the factor depended on the relationship of the diameter of the cups

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[1] Robinson, Rev. T. R. Trans. of the Roy. Irish Academy, 1850. Vol. XXII, p. 163.

[2] Dines, W. H. Quar. Jour. Roy. Met. Soc. Vols. XIV and XVI.

[3] Marvin, U.S. M.W.R. Feb. 1889 and Jan., 1890.

[4] Wild, H. Zeitschrift der oester Gesell, fur Met. Band VIII, p. 282, 1873. Bulletin de l'Acad, St. Petersburg. Vol. XXIII, p. 176, 1876.

to the length of the arms, that it was less than three, and in some cases varied with the velocity. Dines found that the factor for the Standard Robinson Anemometer at Kew, which has cups 9″ in diameter, on arms 2′ long, was 2·2 instead of 3. 4″ cups on arms 5·8″ long gave a factor of 2·51, and 2½″ cups on arms 6·75″ long gave a factor of 2·96, or practically 3. Marvin (*loc. cit.*) deduced the following equations as more nearly expressing the true value of the wind from the run of the cups for an anemometer with 4″ cups on 6·72″ arms (the same as the Canadian instrument).

(1) $V = \cdot 225 + 3\cdot 143v - \cdot 0362v^2$ (whirling machine)

(2) $V = \cdot 263 + 2\cdot 953v - \cdot 0407v^2$ (reduced to open air)

(3) $\text{Log } V = \cdot 509 + \cdot 9012 \log v$

where V is the velocity of the wind and v the velocity of the cup centres. Equation (1) was obtained from observations on a whirling machine in an enclosed space, while (2) and (3) were obtained from whirling machine observations reduced to open air conditions.

The significance of these factors will be seen from table I, where the wind velocities as derived from the different factors are tabulated.

TABLE I

Factor	Miles per hour obtained by multiplying run of cup by the given factor					
3	5	10	20	40	60	80
2·96	4·9	9·9	19·7	39·5	59·2	78·9
2·51	4·2	8·4	16·7	33·5	50·2	66·9
2·2	3·7	7·3	14·7	29·3	44·0	58·7
(1)	5·4	10·3	19·6	35·8	52·8	58·5
(2)	5·1	9·4	18·1	32·4	43·8	50·1
(3)	5·1	9·6	17·8	33·3	48·0	62·2

(1), (2) and (3) are Marvin's equations.

According to the anemometer readings the wind velocity would be given by the factor "3," and the above table shows how much the actual velocity differs from that recorded if these different factors are correct for the instruments to which they refer. Special interest attaches to the velocities given by Marvin's equations as they are for an anemometer of the same proportions as the Canadian. The equations are empirical and were deduced from observations on wind velocities under 35 miles per hour; on this account equations (1) and (2) cannot be used for velocities much over 30 miles per hour, but Marvin states his belief that equation (3) more nearly represents the true velocity as given by the anemometer in use in the United States.

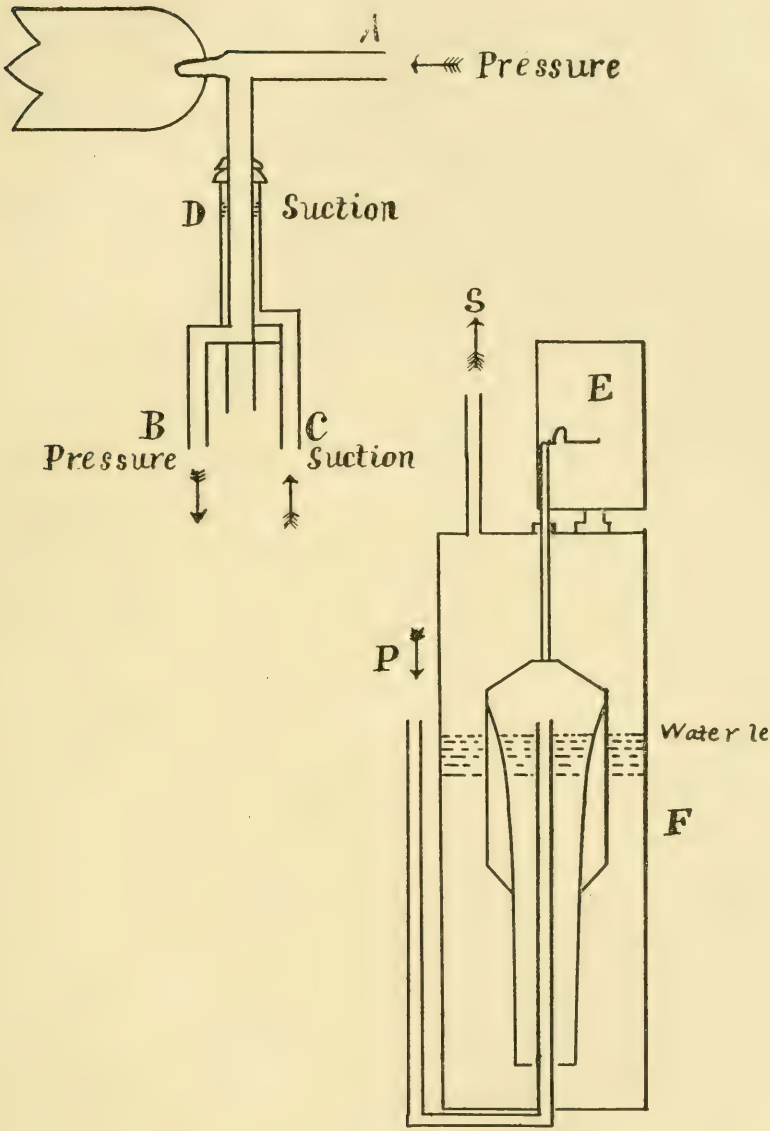


Fig. 1

Dines Pressure Tube Anemometer

Dines in the course of his experiments designed a pressure tube anemometer by which the velocity of the wind is measured by its pressure. The instrument is described by himself and by instrument makers, so that only a brief description of it is given. It is shown diagrammatically in Fig. 1. The mouth of the tube A is held into the wind by the wind vane and connects through tubing with the registering apparatus. On the vertical tube at D, several rows of small holes are bored and the wind blowing across these produces a suction which is communicated to the recording apparatus through another tube. The recording apparatus consists of a specially designed float F; the tube A connects through P to the inside of the float and the tube C through S to the reservoir at the top of the float, and as A produces a pressure and C a suction, they both act together to raise the float; the rise and fall of the float are recorded on the drum E. The pressure of the wind varies as the square of the velocity and the float is so designed that the amount of its rise or fall is proportional to the velocity of the wind; the scale of velocity is thus linear. The relation between the pressure and wind velocity as deduced by Dines in his experiments is

$$P = \cdot 003\ v^2$$

when P is the pressure in lbs. per square foot, and v the velocity of the wind in statute miles per hour.

The charts are graduated according to the results of Dines' experiments on an empirical basis, but the indications of the different instruments can be compared with a pressure gauge and so calibrated as follows:

One end of a U tube half filled with water is connected to the inside of the float so as to be air-tight and provided with a means to alter the pressure. The other end of the U tube and the reservoir above the float is left open to the air in the room. If now the pressure of the air inside the float and the arm of the U tube with which it is connected is increased, the increase of pressure can be measured by the difference in the level of the water in the two arms of the U tube and the velocity to which the pressure corresponds is given by the pen on the recording chart. If the instrument is properly constructed and thoroughly adjusted the relation h/V^2 where h is the difference in level of the water in the U tube and V is the velocity in miles per hour given by the chart, should be constant and equal to ·00073[1]. Table II gives the results of the calibration for the pressure tube used in the experiments.

TABLE II

V	h Up	h Down	h Mean	$\frac{h}{V^2 10^{-6}}$	$\frac{h/V^2}{\cdot 00073}$
10	·09″	·09″	·09″	900	1·23
12	·14	·11	·125	868	1·19
14	·17	·16	·165	842	1·15
16	·22	·20	·210	820	1·12
18	·27	·26	·265	818	1·12
20	·33	·31	·320	800	1·10
24	·44	·45	·445	772	1·06
30	·70	·69	·695	772	1·06
40	1·26	1·21	1·235	772	1·06
50	1·92	1·95	1·935	774	1·06
60	2·73	2·74	2·735	760	1·04
80	4·94	4·98	4·960	775	1·06
100	7·70	7·70	7·700	770	1·05

Up = the pressure was increased from the lower to the next higher.
Down = the pressure was decreased from the higher to the next lower.

The calibration shows that in this instrument the factor is not constant below 30 miles per hour and that for values above 30 miles per hour it is 6% higher than that for which the instrument is calibrated. The density of the fluid in the tank was tested and found to be one. The values in the last column are plotted against the velocities in Fig. 2, and the curve thus obtained gives the factor for correcting the recorded to the true velocity.

CORRECTION FACTOR FOR THE CANADIAN STANDARD ANEMOMETER

The Dines pressure tube anemometer was erected on the same tower as the Canadian anemometer. The tower is 40 feet high, and the anemometer and pressure tube are about 10 feet above the top of the tower. They have a free exposure in all directions, being on a narrow strip of land between the Bay at Toronto, and Lake Ontario.

[1] The value of $\frac{h}{V^2}$ depends on the density of the air and is thus not constant but for all practical purposes it can be assumed constant for most places on the earth's surface.

The tubing connecting the head of the pressure tube with the recorder was one half inch in diameter, and about 50 feet long.

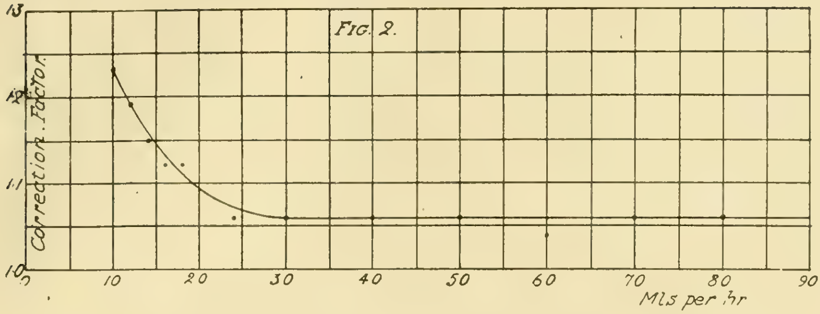
In working up the results, the pressure tube anemometer (uncorrected) was taken as the standard and the mean velocity for each hour was easily obtained from the chart by estimation. The velocities were divided into groups according to the limits of velocity of each number on the Beaufort scale of wind force, the cup anemometer reading for the same hour was obtained and placed in the same group.

The average for each group was obtained for each month and then a final mean from the monthly results; these final mean values of the pressure tube readings were then corrected according to the factor given by Fig. 2. The results are given in Table III.

TABLE III

Miles per hour	1–3		4–7		8–12		13–18		19–24		25–31	
Date	P	A	P	A	P	A	P	A	P	A	P	A
1914												
October			5·00	8·00			15·28	23·21	20·0	28·0		
November			6·11	8·78	10·37	13·69	15·69	19·17	21·55	26·14	26·72	32·25
December	2·04	5·28	5·73	9·35	10·18	14·05	15·13	19·91	20·90	26·85	27·70	34·47
1915												
January	2·46	5·64	7·50	10·66	10·02	14·00	15·23	19·94	21·18	26·60	26·80	34·20
February	2·50	5·50	5·60	8·93	9·98	13·40	14·76	18·94	20·56	24·90		
March	2·38	6·19	5·53	9·44	9·68	13·98	14·69	18·91	21·20	27·35	27·81	34·25
April	3·00	8·00	4·34	5·73	10·29	12·62	14·20	17·22	19·50	22·00		
May	2·60	3·80	5·60	6·82	10·32	13·01	15·57	19·37	20·33	24·04	27·33	32·00
June	2·00	4·14	6·09	8·12	10·68	13·21	14·34	17·27	20·94	24·51		
July	2·66	5·91	5·77	9·25	9·92	13·32	14·57	18·03	21·57	26·71		
August	2·60	5·60	5·86	9·00	9·25	13·71	14·69	18·83	20·71	28·42	26·72	35·72
September	2·60	5·46	5·84	8·54	9·87	13·11	15·31	19·37	19·50	25·10	27·33	36·83
October	2·46	4·19	5·42	7·52	9·97	12·21	14·58	17·92	21·73	26·70	25·66	30·00
November	2·37	4·66	5·56	8·00	10·16	13·22	15·19	19·14	21·46	26·69	26·57	33·63
December	2·44	5·44	5·60	9·10	9·67	13·60	15·24	19·56	21·00	26·54	25·00	35·75
1916												
January	2·91	4·57	5·27	7·84	9·92	12·44	15·52	18·71	21·19	24·76	27·29	31·85
February	2·45	5·59	5·63	8·40	9·80	12·89	15·38	18·81	21·22	24·92	26·23	31·00
Mean	2·50	5·33	5·67	8·44	10·57	13·28	15·02	19·08	20·86	25·90	26·75	33·50
P corrected	3·77		7·77		12·89		17·61		22·78		28·65	
$\frac{P}{A}$	·71		·91		·97		·93		·88		·85	

P = Pressure Tube Anemometer.
A = Canadian Standard Anemometer.



The pressure tube velocities below 8 miles per hour are not trustworthy, for it is in this range that most of the defects of the pressure tube are found; one of them is due to the head requiring a wind velocity of about seven or eight miles an hour to turn it, and if the wind is from some other direction than that to which the head is pointing the registered velocity will be too small. In this region also, the pressure of the wind is very small and the pen is liable to stick. Sometimes during a heavy snow storm in winter the tubes become blocked with snow, causing the instrument to register too low a velocity, but in all other respects the instrument worked very well. Omitting then the results for velocities below 10 miles an hour, it would appear that the factor "3" for the cup anemometer is approximately correct for velocities under 15 miles per hour, but for higher velocities the readings are too high. There are too few observations however above 30 miles an hour to enable one to determine with accuracy the value of the factor from the pressure tube instrument, but by employing the method of least squares a probable curve for the correction factor, as given in Table III, is

$$Y = 1 \cdot 24 - \cdot 25 \log Vr$$

where Y is the correction factor and Vr is the recorded velocity. This equation is plotted in Fig. 3 together with the values of the factor obtained in Table III, and it will be seen that the agreement is fairly good. The actual wind velocities corresponding to the recorded velocities as calculated from this equation are given in Table IV, and the values obtained by Marvin's equation

$$\log V = \cdot 509 + \cdot 9012 \log v \qquad (3)$$

are also tabulated. The two results agree very closely.

TABLE IV

Recorded Velocity	10	20	30	40	50	60	70
Actual Velocity	9·7	18·3	26·1	33·6	40·8	48·0	54·6
Actual Velocity from Marvin's equation	9·6	17·8	25·7	33·3	40·8	48·0	53·2

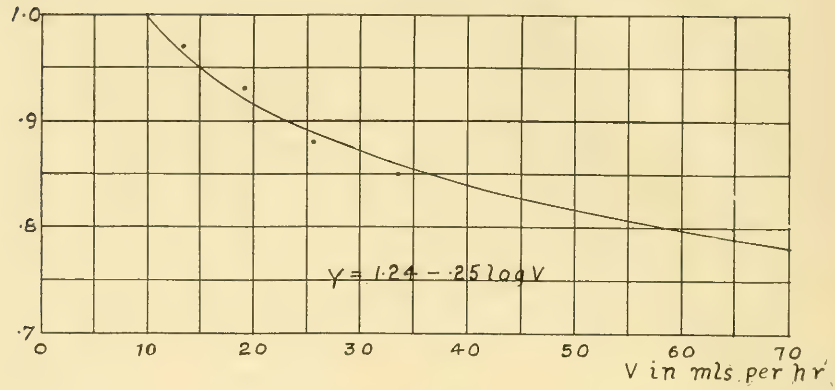


Fig. 3

This comparison thus shows that the records given by the Canadian anemometer are too high for velocities above 15 miles per hour and that for higher velocities they should be corrected by means of the equation

$$Y = 1\cdot24 - \cdot25 \log V^r$$

or the correct values can be obtained directly from

$$V^a = y\ V^r = V^r(1\cdot24 - \cdot25 \log V^r)$$

where V^a is the corrected velocity and V^r the recorded; Marvin's equation can also be used.

Relation Between the Most Probable Gust Velocity and the Mean Hourly Wind Velocity

The pressure tube anemometer by its construction gives a graphic representation of the actual character of the wind, showing the gusts and the lulls, and, at the same time, permits the determination of the mean velocity of the wind. It is thus possible to determine the mean velocity during a given interval and the highest and lowest velocities that occurred during that interval. The exception to this is when the gusts or lulls are of such short duration that the recording part has not time to follow the pressure changes in the wind. On the other hand, the cup anemometer gives the mean velocity during an interval but not the highest or lowest velocities occurring during that interval. If, however, a relationship between the maximum velocity and the mean velocity as given by the pressure tube anemometer can be determined, then this relationship can be used to determine the highest maximum velocity from the mean velocity of the cup anemometer.

To determine this relation, the highest velocity in the gust during the hour was tabulated with the mean hourly velocity used in the anemometer comparison described in the preceding section, and the weighted mean of the highest gust velocities was then obtained for each mean velocity; the results are given in Table V. (Mean wind velocities below 16 miles per hour were not used, nor were thunderstorm squalls in which the wind rose to a high value and then died down again in the course of an hour.)

TABLE V

Mean hourly velocity—miles per hour															
16		17		18		19		20		21		22		23	
P	A	P	A	P	A	P	A	P	A	P	A	P	A	P	A
30	1	32	1	33	1	31	5	38	1	36	3	38	5	39	1
28	4	30	3	32	3	30	15	36	2	34	7	36	8	38	3
26	20	28	6	30	11	28	15	34	5	23	15	34	28	36	16
24	30	26	16	28	24	26	14	32	24	30	14	32	52	34	19
22	24	24	28	26	37	24	16	30	39	28	21	30	46	32	24
20	10	22	17	24	19	22	5	28	51	26	17	28	20	30	31
18	3	20	6	22	14			26	33			26	5	28	18
				20	1			24	14						
								22	1						
23·5	93	24·3	77	26·1	110	26·9	69	28·6	170	29·6	77	31·5	164	31·9	112

TABLE V

24		25		26		27		28		29		30		31	
P	A	P	A	P	A	P	A	P	A	P	A	P	A	P	A
45	1	44	1	48	1	45	1	46	1	45	1	52	1	48	1
42	1	42	1	46	1	44	3	44	4	47	6	50	1	46	3
40	3	40	11	44	2	42	14	42	6	42	11	48	5	44	6
38	11	38	18	42	5	40	17	40	20	40	12	46	4	42	10
36	23	36	25	40	19	38	19	38	17	38	18	44	5	40	5
34	45	34	39	38	26	36	15	36	11	36	12	42	16	38	6
32	45	32	35	36	34	34	19	34	9	34	8	40	21	36	2
30	26	30	13	34	25	32	7					38	16		
28	4			32	18							36	16		
				30	2							34	4		
33·5	159	34·6	143	36·5	133	37·6	95	38·6	68	38·8	64	40·0	87	41·6	33

TABLE V—Continued

32		33		34		35		36		37		38		39		40	
P	A	P	A	P	A	P	A	P	A	P	A	P	A	P	A	P	A
50	2	50	1	52	2	53	1	56	1	60	1	53	3	51	1	55	1
48	3	48	1	50	1	52	2	54	1	58	1	50	1	50	1	54	1
46	2	44	5	48	1	50	4	52	1	52	1	48	3	48	1	50	1
44	7	42	3	46	4	48	2	50	1	48	1	44	2	46	2	47	1
42	6	40	6	44	4	46	2	48	3	46	1			44	1		
40	3	38	2	42	2	44	3	46	5	44	1						
38	2			40	2												
43·8	25	42·5	19	45·6	16	44·9	14	48·8	12	51·5	6	49·1	9	47·9	6	51·5	4

P = Highest gust velocity in the hour.
A = Number of times the velocity was recorded.
The mean gust velocity is the weighted mean velocity.

To correct for errors in estimating velocities the results were smoothed by taking the mean of three successive velocities as the velocity for the middle reading. The results were then corrected to actual wind velocities according to the factor given in Fig. 2. The results are given in Table VI, and the corrected results are plotted in Fig. 4. The most probable value for this curve as deduced by the method of *Least Squares* is

$$Vg = 2 \cdot 8 + 1 \cdot 26\ Vm \text{ or } Vg = 3 + 1 \cdot 26\ Vm$$

where Vg is the probable gust velocity and Vm is the mean velocity during the hour. Simpson[1] deduced the equation

$$Vg = 1 \cdot 5 + 1 \cdot 3\ Vm$$

for this value. For practical purposes these two equations are identical and the results here simply confirm those obtained by Simpson (*loc. cit.*) that the gustiness of the wind is linearly proportional to velocity.

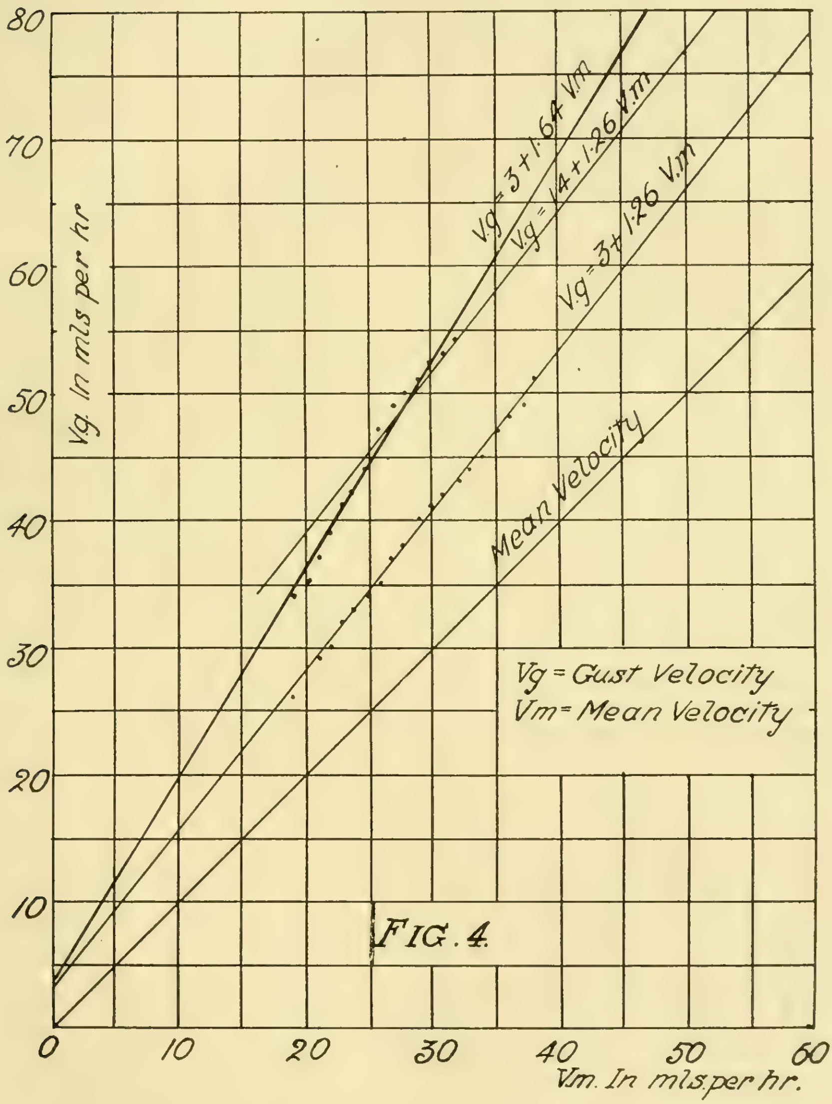

80
70
60
50
40
30
20
10
0
10
20
30
40
50
60
Vg. In mls per hr
Vm. In mls.per hr.
Vg=3+1·64 V.m
Vg=14+1·26 V.m
Vg=3+1·26 V.m
Mean Velocity
Vg = Gust Velocity
Vm = Mean Velocity

FIG. 4.

Table VI

A	B	C	D	E
16	23·5			
17	24·3	24·6	19·0	26·3
18	26·1	25·8	20·0	27·6
19	26·9	27·2	21·0	28·8
20	28·6	28·4	21·9	30·1
21	29·6	29·9	22·9	31·6
22	31·5	31·0	23·8	32·8
23	31·9	32·3	24·7	34·2
24	33·5	33·3	25·7	35·2
25	34·6	34·8	26·6	36·8
26	36·5	36·2	27·6	38·3
27	37·6	37·6	28·6	39·8
28	38·6	38·3	29·7	40·5
29	38·8	39·1	30·7	41·4
30	40·0	40·1	31·8	42·6
31	41·6	41·5	32·9	44·0
32	43·8	42·6	33·9	45·2
33	42·5	44·0	35·0	46·6
34	45·6	44·3	36·0	48·0
35	44·9	46·4	37·1	49·2
36	48·8	48·4	38·2	51·3
37	51·5			

A = Mean velocity in miles per hour uncorrected.
B = Most probable maximum gust velocity.
C = B smoothed.
D = Mean velocity in miles per hour corrected to true velocity.
E = C corrected to true velocity.

Possible Extreme Gust Velocity

The equation,

$$Vg = 3 + 1 \cdot 26\ Vm$$

only gives the most probable gust velocity occurring during the hour but does not give the highest gust velocity that may occur. To obtain some idea of this value, which is very important, the maximum velocities given under each mean velocity were plotted against the number of times that they occurred and a smooth freehand curve drawn through them. The point where the curve cuts the line giving one as the number of times that the velocity is likely to occur, gives the highest gust velocity that is possible.

By this method the following values (Table VII) were obtained for the possible extreme maximum velocity occurring in a gust for a

[1] M. O. 180 of the London Meteorological Office, p. 40.

given mean velocity of the wind, excluding thunderstorm squalls. The results were smoothed in the same way as before by taking the mean of three successive readings as the value for the middle reading. The pressure tube anemometer readings were not corrected at first to true readings, but the final results were all corrected. On subtracting the mean maximum velocity from the highest maximum velocity the results given in the column "A-B" were obtained, and from them it would appear as if this difference was fairly constant above 25 miles per hour and equal to about 11. Using the curve

$$Vg=3+1\cdot 26\ Vm$$

for the most probable gust velocity it would give

$$Vg=14+1\cdot 26\ Vm \qquad (3)$$

as the possible extreme gust velocity that might be recorded for mean velocities above 25 miles per hour, or if one assumes that the difference is not constant, the equation takes the form

$$Vg=3+1\cdot 64\ Vm \qquad (4)$$

This result gives higher values of Vg than equation (3). The Equations (3) and (4) are plotted in Fig. 4. There are unfortunately not enough observations on mean velocities above 30 miles an hour available to determine with accuracy the correct form of the equation.

TABLE VII

Uncorrected Readings			Corrected Readings			
Mean Velocity	Highest Maximum	Smoothed Highest Maximum	Mean Velocity	A Smoothed Highest Maximum	B Mean Maximum Velocity	A—B
16	30					
17	32	31·7	19·0	34	26	8
18	33	33·3	20·0	35	28	7
19	35	35·3	21·0	37	29	8
20	38	37·3	21·9	39	30	9
21	39	39·0	22·9	41	32	9
22	40	40·0	23·8	42	33	9
23	41	42·0	24·7	44	34	10
24	45	44·0	25·7	46	35	11
25	46	46·3	26·6	49	37	12
26	48	47·2	27·6	50	38	12
27	48	48·3	28·6	51	40	11
28	49	48·7	29·7	52	41	11
29	49	50·0	30·7	53	42	11
30	52	51·0	31·8	54	43	11

The Most Probable and Possible Extreme Gust Velocity Derived from the Canadian Standard Anemometer

If now the readings of the most probable and extreme maximum velocities are calculated from the observations of the Canadian anemometer after correcting it according to the equation

$$y = 1 \cdot 24 - \cdot 25 \log Vr$$

or from

$$Va = Vr\ (1 \cdot 24 - \cdot 25 \log Vr)$$

where Va is the actual and Vy the recorded velocity, a most interesting result is obtained as shown in Table VIII and Fig. 5.

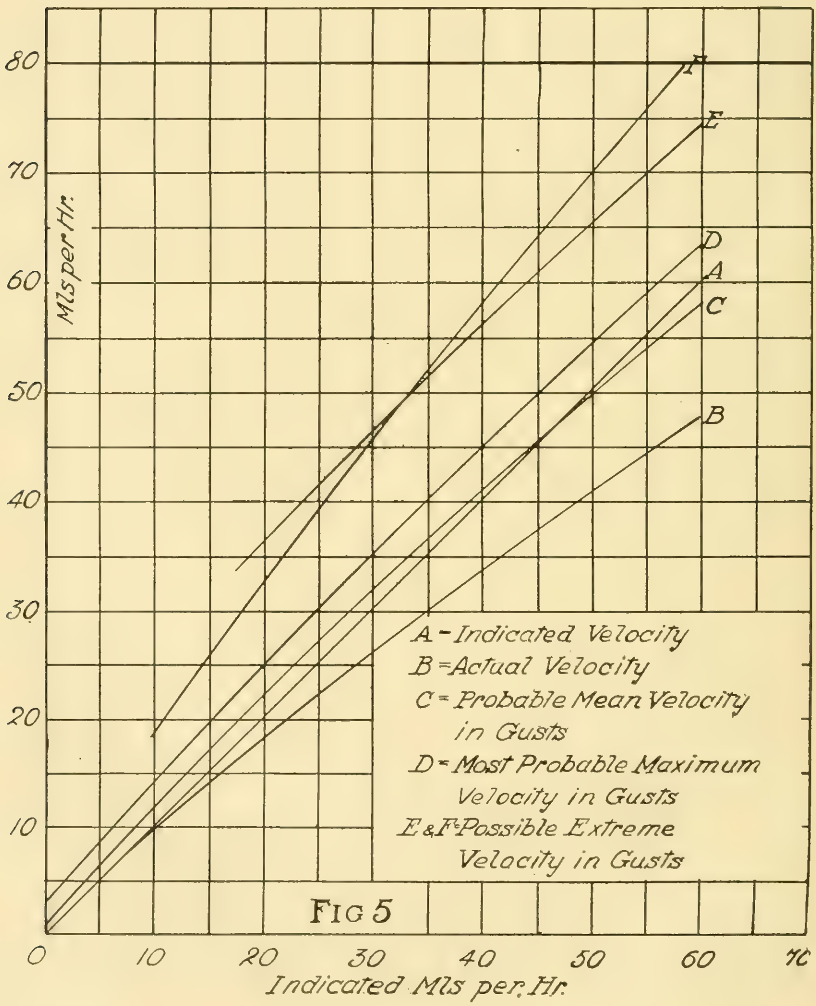


Fig 5

TABLE VIII

Indicated	Actual	Most probable Maximum	Possible extreme (3) Maximum	Possible extreme (4) Maximum	Probable mean velocity of the wind in the gust
10	9·7			19	12·1
15	14·2	20		27	17·5
20	18·3	26	37	33	22·5
25	22·2	30	42	40	27·2
30	26·1	35	47	46	32·0
35	30·0	41	51	52	36·5
40	33·6	45	56	58	41·0
50	40·8	54	65	70	49·5
60	48·0	63	75	82	58·5
70	54·6	71	83	92	66·1

The Canadian anemometer registers a velocity a little less than the most probable maximum velocity that occurs in gusts and the higher the velocity the more nearly does it approach this value. Again Simpson (*loc. cit.*) has given what he calls the probable mean velocity in the gust, as

$$V = \cdot 5 + 1 \cdot 2\, v$$

where V is the probable mean velocity and v is the mean wind velocity. Their values are also given in the table and they show that for all winds above 50 miles per hour the Canadian anemometer registers a greater velocity than the probable mean velocity in the gusts.

The Kew standard anemometer (9″ cups on 24″ arms) has a factor 2·2 instead of 3, and expressing the equation $Vg = 3 + 1 \cdot 26\ Vk$ where Vg is the most probable gust velocity and Vk the mean hourly velocity in terms of the indicated velocity on the Kew anemometer we have

$Vg = 3 + \cdot 92\ Vk$; Vk = velocity given by Kew anemometer.

For all practical purposes this may be written

$$Vg = Vk$$

and we have the important result that the Kew Standard Anemometer records the most probable maximum velocity in gusts.

SUMMARY

1. The comparison of the Canadian Standard Anemometer with the Dines Pressure Tube Anemometer has shown that the factor "3" is not correct and the factor is variable.

2. The actual velocity can be obtained from the recorded velocity by means of the equation

$$Va = Vr\ (1 \cdot 24 - \cdot 25 \log Vr)$$

where Va is the actual velocity and Vr the recorded velocity.

This equation is practically identical with Marvin's equation

$$\text{Log } V = \cdot 509 + \cdot 9012 \log v$$

where V is the actual velocity and v the velocity of the cup centres.

3. The most probable velocity in a gust can be obtained from the equation

$$Vg = 3 + 1 \cdot 26\ Vm \qquad (a)$$

or from Simpson's equation

$$Vg = 1 \cdot 5 + 1 \cdot 3\ Vm$$

where Vg is the gust velocity and Vm the mean hourly velocity.

4. The possible extreme velocity that may occur in a gust would appear to be

$$Vg = 14 + 1 \cdot 26\ Vm \qquad (b)$$

or

$$Vg = 3 + 1 \cdot 64\ Vm \qquad (c)$$

5. Equations (*a*), (*b*) and (*c*) when applied to the Canadian Standard Anemometer may be put in the form

$$Vg = 3 + Vr\ (1 \cdot 56 - \cdot 315 \log Vr) \qquad (a)$$

$$Vg = 14 + Vr\ (1 \cdot 56 - \cdot 315 \log Vr) \qquad (b)$$

$$Vg = 3 + Vr\ (2 \cdot 04 - \cdot 41 \log Vr) \qquad (c)$$

Marvin's equation

$$\text{Log } V = \cdot 509 + \cdot 9012 \log v$$

was obtained from the results of experiments on a whirling arm corrected to open air conditions and the results agree so closely with those obtained at Toronto by an entirely different method that there can be no doubt about the velocity given by the standard anemometer in use in the United States and Canada being much too high for the higher velocities. The results in both cases were obtained from observations of winds under 35 miles per hour, and to determine the correction accurately for high velocities it will be necessary to make the investigation where high winds are of frequent occurrence. These conditions can be obtained at some of the Atlantic coast stations, but it cannot be done until after the war.

The Meteorological Office,

Toronto.

September 1st, 1916.

Note on a Modified form of Freezing Point Apparatus

By O. MAASS

Presented by PROFESSOR R. F. RUTTAN

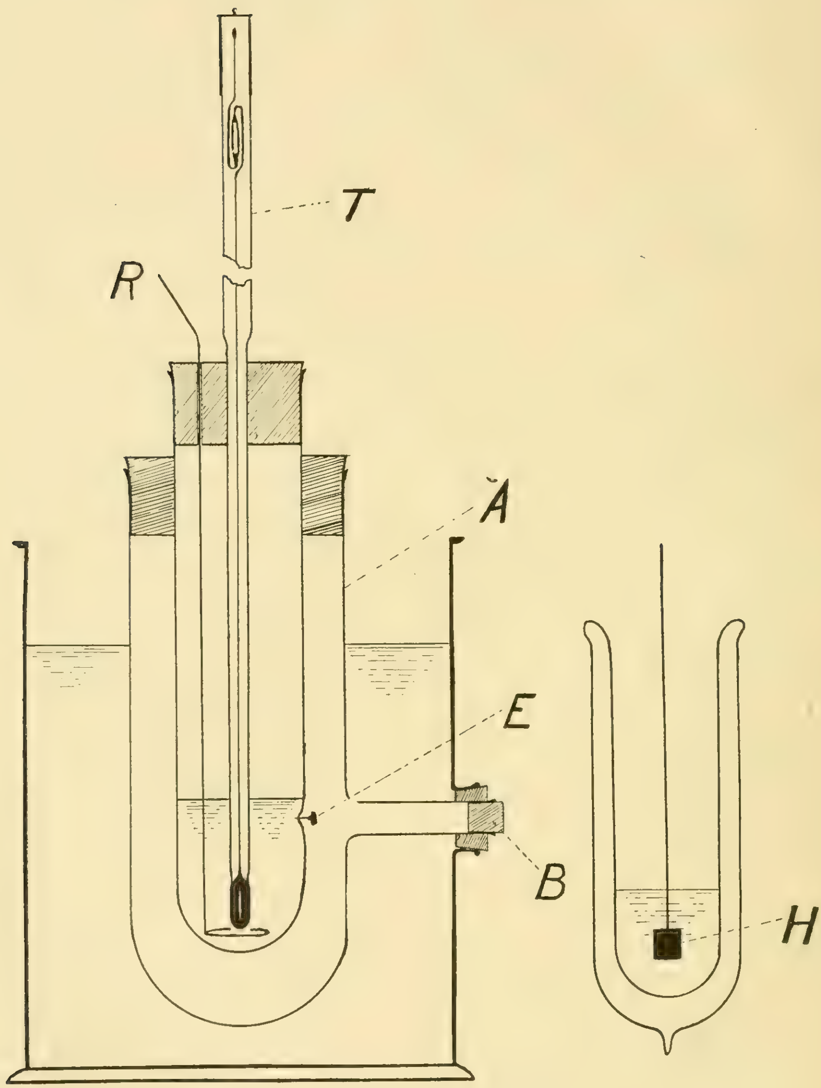
(Read May Meeting, 1919.)

The molecular weight of a dissolved substance is most commonly determined by the freezing-point method. Familiarity with this method may be assumed so that it is possible to proceed immediately with the subject of this note.

M the molecular weight of a dissolved substance is given by $M = k\ ^{w}/Wct.$, where k is the cryoscopic constant, t the lowering of the freezing point when w gms. of solute are dissolved in W gms. of solvent. In the ordinary experimental determination the temperature of the freezing-bath must be as close as possible to the freezing-point of the solution, otherwise the observed reading of the freezing point will be too low. A similar error is brought about by supercooling, for if t' represents the supercooling, s the specific heat of the solution and L the latent heat of fusion, the W in the equation given above is diminished by st'/L. The combined errors may easily result in a 3 per cent error in the molecular weight.

These errors persist to a certain extent. It is generally necessary to have the freezing bath at least 3° lower than the freezing point and supercooling of several degrees is unavoidable in the case of certain solutions even when much time is spent in trying to get the solution to "freeze out" by vigorous stirring, scraping the sides, etc. The only certain method to prevent excessive supercooling is that of introducing a crystal of the solvent. If this is done in the ordinary way the method is cumbersome and the results are uncertain, the crystal having a habit of sticking to the sides of the test tube, or of melting before it reaches the solution. Besides this, there are certain unavoidable errors connected with bodily introducing a crystal; for one thing—the concentration of the solution is altered and subsequent redeterminations rendered inaccurate.

By means of the apparatus shown in the accompanying diagram a crystal can be introduced without any of the objections mentioned in the last paragraph. The inner test tube, fitted out in the ordinary way with a Beckmann T and a stirrer R, has a small piece of platinum wire E sealed into the glass at a short distance below the surface of the solution. The platinum wire ends in the form of a tack. The outer


T
R
A
E
B
H

test tube A has a T tube opposite E, leading outside the freezing bath and closed by a cork stopper B. The experiment is carried out in the ordinary way until it is felt that supercooling has started. Then cork B is removed and a heat extracter H is applied to E. H is a small copper cylinder fastened to the end of a stiff wire and kept immersed up to this time in solid carbon dioxide (-78°). The heat capacity of H is small and it is kept in contact with E for only a short time. That suffices, however, to cause a crystal to form at the tip of the platinum wire, with the consequent "freezing" of the solution if supercooling actually has taken place.

When the freezing point is determined a second time, it is possible to prevent supercooling of more than one-tenth of one degree and the temperature of the freezing bath throughout need only be half a degree lower than the freezing point of the solution. A great advantage is the speed with which freezing points may be determined. The best position for the platinum wire E in the solution is being investigated.

The Velocity of Sound and the Ratio of the Specific Heats for Air

By DR. T. C. HEBB

Presented by DR. D. McINTOSH

(Abstract, Read May Meeting, 1919.)

The paper contains an account of a new determination of the velocity of sound by the method previously used by the author.[1] This was considered desirable as the author's first determination did not seem to give a ratio of the specific heats equal to that obtained by the Lummer-Pringsheim method. This was shown by Moody,[2] who obtained $1 \cdot 4003$ for γ using the author's value of V, whereas the Lummer-Pringsheim method gives a value in the neighbourhood of $1 \cdot 4030$. He, however, failed to correct for the fact that air is not an ideal gas. But even with that correction the value is still too low by the velocity of sound method. This new determination supports the old value—the new and the old values being $331 \cdot 26$ and $331 \cdot 29$ meters per second respectively. The explantion of the discrepancy between the two values of γ as obtained by the two methods lies in the method of obtaining the velocity of sound for dry air at 0°C. from observation taken in moist air at t°C. The formula for conversion used was

$$V_o = V_m \sqrt{\frac{\rho_m}{\rho_o}}$$

where V^o is the velocity at O°C., V_m is the velocity at the time of the experiment, ρ_m is the density of air at the time of the experiment and ρ_o is the density of dry air at O° C. and pressure equal to that at the time of the experiment. This equation assumes that γ for moist air is the same as γ for dry air. To correct the formula the right hand side of the equation should be multiplied by

$$\sqrt{\frac{\gamma_o}{\gamma_m}}$$

Where γ_o is the ratio of the specific heats for dry air at O°C. and γ_m is the ratio of the specific heats for air at the time of this experiment. This ratio is small and is calculated. When the correction is applied to the two values of the velocity of sound there results the values $331 \cdot 44$ and $331 \cdot 38$ meters per second. From these two values, γ is

[1] Phys. Rev., Vol. XX, No. 2, Feb., 1905.
[2] Phys. Rev., Vol. XXXIV, No. 4, p. 275, 1912.

calculated, making use of Van der Waals equation to obtain γ for the real gas. The values of γ obtained are $1 \cdot 4031$ and $1 \cdot 4026$. These two values agree very favourably with the best determination of γ made by the Lummer-Pringsheim method.[1] The average also agrees very closely with the value calculated on the basis that air is a mixture of $\cdot 95\%$ of a monatomic gas and $99 \cdot 05\%$ of a diatomic gas. This calculated value the author finds to be $1 \cdot 4029$. The complete results will be published later.

[1] Phys. Rev., Sev. 2, Vol. X, No. 5, p. 525, 1917.

A New Method of Weighing Collodial Particles

By PROFESSOR E. F. BURTON, F.R.S.C.

(Read May Meeting, 1919.)

Probably the first method suggested for the determination of the size of collodial particles depended on the application of Stokes' Law for the rate of fall of rigid spheres through fluids. Such spheres attain after a very short interval of time a limiting velocity, v, such that the force of friction of the fluid is given by the equation

$$F = 6\pi \text{ n a v} \tag{1}$$

where n = coefficient of viscosity of the fluid

a = radius of the particle.

For steady motion this force must be equal to the gravitational force acting on the particle immersed in the fluid. The latter force is given by

$$F = \frac{4}{3}\pi \text{ a}^3 (\rho - \rho_1) \text{ g} \tag{2}$$

where ρ and ρ_1 are the densities of the material of the particle and of the fluid respectively. Equating these forces we have

$$\frac{4}{3}\pi \text{ a}^3(\rho - \rho_1) \text{ g} = 6\pi \text{ n a v}$$

from which

$$\text{a}^2 = \frac{9}{2} \cdot \frac{\text{n v}}{(\rho - \rho_1) \text{ g}} \tag{3}$$

Unfortunately, this simple formula is of very narrow application to aqueous solutions because the fall of particles less in radius than about 10^{-5} cm. is masked by the Brownian movement, which, as a result of molecular agitation prevents any settling of the colloidal particle. One can see at any time in the Faraday collection at the Royal Institution, samples of gold colloidal solutions, prepared by Faraday before 1860; these solutions, which are suspensions of metallic gold particles of radius about 10^{-6} cm. show no sign whatever of settling.

The method outlined in the present communication may be described as an artificial production of the settling due to gravitation by super-imposing the motion produced in an electrical field maintained in the liquid medium upon that due to gravitation.

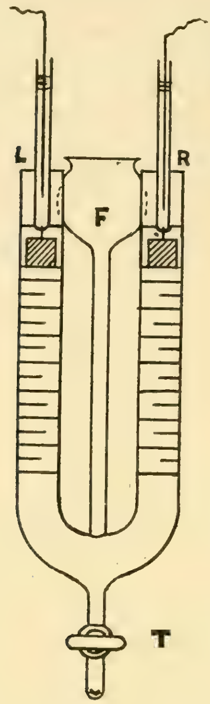


Figure 1

In Fig. 1 is represented the U tube used by the writer some years ago in determining the mobility of colloidal particles in an electrical field. The method is as follows:[1]

"The colloidal solution to be tried is poured into the funnel so as to fill the funnel and small tube to the tap, which is closed; water having a specific conductivity equal to that of the colloid is then poured into the U tube so as to fill it to a height of about 3 cms. The whole tube then is placed in a large glass water bath so as to be almost submerged; this water should be kept at a constant temperature during the course of any experiment. At the end of a few minutes the tap (T) is opened very slightly and the colloidal solution allowed to force the water gently up the limbs of the tube to any required height. If carefully manipulated the surface of separation between the clear water and the solution is very distinct and will remain so for hours. Two electrodes are attached to the terminals of a set of storage cells of constant voltage, and when the current is completed, the surface of separation in one limb will at once begin to rise gradually, while that

[1] Physical Properties of Colloidal Solutions. (Burton), p. 131–2. Phil. Mag., 6, 11, 1906, p. 436.

in the other will sink. In practice, the connections may be made through a reversing key and the voltage, usually fixed at about 110 volts, may be left on one way for ten minutes and then reversed for twenty minutes. The velocity is reckoned from the displacement of the surfaces during this final twenty minutes; one-half the sum of the displacements in the two tubes taken as the distance travelled by a particle in the given time. A typical set of observations is given in Table I.

TABLE I

Time	Voltage-Sign of Right Electrode	Temp.	Height of Colloidal Surface		Observed Velocity in cms. per sec.
			Left	Right	
11·37	118	11°C	54 mms.	55 mms.	
11·47	118		61 "	50 "	
Current off					
11·48	−118	11°C	61 "	50 "	
11·58	−118		55 "	56 "	96×10^{-5}
12·08	−118	11°C	50 "	62 "	

Electrodes at 15 mms. in each limb.

"It will be seen from the table that there has been an apparent settling of the colloid in the tube while the current was running. This is quite usual, but, as the reckoning is made, it could not affect the rate, since this slight lowering of the surface is uniform in both limbs, so that while it is added to the velocity in one limb it is subtracted from the velocity in the other."

The settling referred to above was at the time looked upon as merely a disturbing circumstance. The true importance of it has just recently appealed to the writer. It will be seen from the table that during the first 10 minutes, the colloid moved up in the right side and down in the left side of the tube; during the second ten minutes the motion was reversed. From the figures quoted, which were typical of a large number of experiments, there was a settling in each tube of one mm. It is quite apparent that this settling is due to the action of gravity. As in the case of Millikan's[1] work with single droplets of liquids in air, we are dealing here with a motion which is caused during one period of 10 minutes by the force $Xe+mg$ and during the second 10 minutes by $Xe-mg$, where X is the electric field maintained

[1] Millikan. The Electron. Phil. Mag., June, 1917.

in the liquid, "e" the effective charge on the particle and mg the gravitational pull on the particle in the water. The difference between the up and down motion will then be due to the settling caused by gravity and to this motion Stokes' Law can be applied.

The objection suggests itself that we are taking account of the action of the weight of the particle although when the solution is not acted upon by the electric field there is no settling noticeable. When there is any appreciable settling the particle must attain a limiting velocity, v, corresponding to the Stokes' formula,

$$\text{Weight} = mg = 6\pi \text{ n a v}$$

This requires a certain interval of time, for the particle begins to move from rest and is accelerated under the force of gravity; the smaller the particle the less the limiting velocity. At the same time the smaller the particle, the greater the influence of the Brownian movement caused by molecular shocks. Particles which do not show any settling are those for which the Brownian movement is so large, that is, those for which the molecular shocks in random directions are so potent, that the particles do not get a chance to attain the limiting velocity in a downward direction due to gravitation. However, when a vertical electrical field is applied, which gives a motion to the particle greatly in excess of either the gravitational or Brownian movement, the particles are dragged up or down through the liquid; under such conditions, the comparatively insignificant gravitational force will be added to the electrical for downward motion and subtracted for upward motion.

If V = limiting velocity due to electrical field,
and V = limiting velocity due to gravitation

$$Xe + mg = 6\pi \text{ n a } (V + v) \qquad (4a)$$

$$Xe - mg = 6\pi \text{ n a } (V - v) \qquad (4b)$$

Subtracting these we have

$$2 \text{ mg} = 12\pi \text{ n a v}$$

from which by equation (1)

$$a^2 = \frac{9}{2} \cdot \frac{\text{n v}}{(\rho - \rho^1) \text{ g}}$$

In the table above for colloidal silver particles we have a motion of 1 mm. in 20 minutes recorded. This gives for "v" in the above formula $8 \cdot 3 \times 10^{-5}$ cm. per sec. Putting n equal to the viscosity of water at 11°C. *viz.* $0 \cdot 012$ and ρ for silver equal to $10 \cdot 5$, we have

$$a = 2 \cdot 2 \times 10^{-5} \text{ cm.}$$

The radius of these particles as determined at the time by the counting method was $1 \cdot 7 \times 10^{-5}$ cm. The closeness of the agreement of these two determinations is an indication that careful observation of this settling would give an extremely serviceable method of determining the size of colloidal particles much below the microscopic size. It should be noted that there was no particular incentive to record exactly the portion of the colloidal surfaces in the U tube at the end of the first 10 minutes run, as this reading was used merely as a check as to whether or not the apparatus was working normally.

Experiments are now being carried out by Mr. W. W. E. Ross, under direction of the writer, to determine the settling very exactly. By the application of ultramicroscopic illumination of single particles in a slowly alternating electric field acting in a vertical direction, it is hoped that the settling will be observed over a very much more extended interval of time and that an exceedingly exact method of weighing these particles will be developed. In addition, this method should prove useful in determining the effect of the addition of various electrolytes on the size of colloidal particles, and thereby shed a great deal of light on the incipient processes of coagulation.

Department of Physics,
University of Toronto.
March 7th, 1919.

On the Partial Condensation of Natural Gas at Liquid Air Temperatures and a Curious Effect Observed with the Nitrogen which Dissolves in the Condensate

By JOHN SATTERLY, M.A., D.Sc., F.R.S.C.

(Read May Meeting, 1919.)

When so-called natural gas consisting largely of methane, other hydrocarbons, nitrogen and sometimes helium, is passed into a tube immersed in liquid air the hydrocarbons condense. This is the early stage in the process employed for the analysis of natural gas for helium, etc.[1]

APPARATUS

The method and apparatus used in the Physics Laboratory of the University of Toronto is shown in Fig. 1. The natural gas is stored in a 5 gallon demi-john B. This is provided with taps and by this means a supply of water entering along the pipe A, displaces the gas into a "collector" E, standing in a jar, D, of water. In our experiments the collector, when full, held a volume of gas equal to 1200 cc. at atmospheric pressure. This is taken as the unit of volume, and the gas passes on to the rest of the apparatus in these units. The gas is then dried by calcium chloride contained in a tube, F.

The condenser is a glass tube about 27 cms. long and 4½ cm. diameter. Its approximate volume is 400 cc. It is provided with inlet and outlet tubes. The former communicates to a T-piece, of which one limb joins up through a tap to the drying tube F, and the other through a tap, T, to the outside air at O. The latter tube from G also communicates with a T-piece of which one limb joins up to a manometer, H, and the other passes through a tap to a tube, P, en route for a pump, and the rest of the helium-extraction apparatus. The condenser may be surrounded by the liquid-air vessel L. A barometer, K, stands in the same cistern, M, as the manometer, H, and the pressure in G is obtained from the difference between the heights of the two columns in H and K read off on a scale S.

In the process of analysis for helium the apparatus is exhausted through O, then washed out with natural gas, the taps O, T, P are

[1] See Cady and McFarland. Journal Amer. Chem. Society. Vol. XXIX, etc., and McLennan, Burton, Satterly and Dawes. Trans. Roy. Soc. Can. Vol. XIII, 1919, and Report to the Admiralty on the Helium Content of the Natural Gases of Canada. 1916.

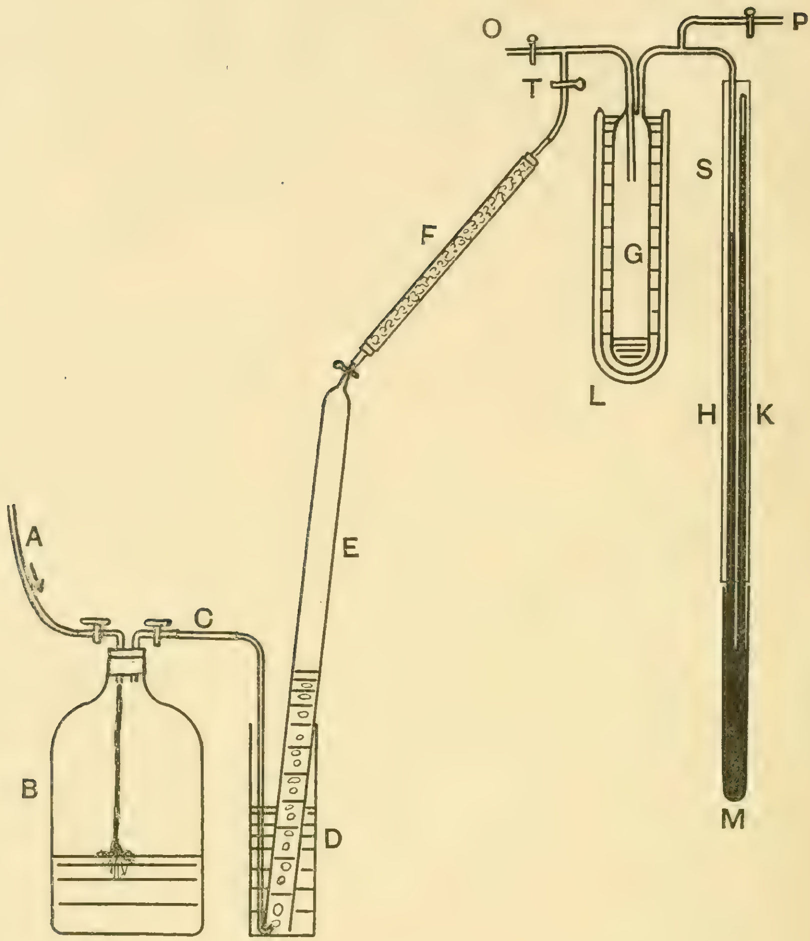


Figure 1

then turned off and liquid air applied to G. The mercury in H rises nearly to barometer height. E is then filled with gas and on opening T the unit volume passes into G, where a portion condenses. When the water reaches the top of E, T is turned off and E refilled from B. As each unit passes into G, the pressure on the manometer is observed. In the usual process of helium analysis this filling and refilling is repeated from five to ten times until the gauge H may be down nearly to atmospheric pressure. The tap at P is now turned and the non-condensable gases sent on through the rest of the apparatus. That part, however, does not concern us at present. If the non-condensable gases are pumped out through P and the apparatus allowed to stand for a while we should expect the gauge H to read the vapour pressure of methane at liquid air temperature. This reading is about 6 to 7 cm. of mercury. The reading directly after exhaustion through P is usually much less than this, somewhere about 3 to 4 cm. Apparently, the pumping causes evaporation from the condensate with consequent cooling.

Behaviour of Contents of Condenser.

In this series of experiments observations were made on the condensate in G, on its vapour pressure as registered by the gauge H, and the behaviour of this pressure under different temperature conditions. The condensate is usually solid with western Canadian gases and Texas gas, but liquid with most of the Ontario gases. The liquidity is due to the presence of dissolved ethane with consequent lowering of the freezing point.

The temperature of the liquid air was not taken. Sometimes the air was fresh, in which case the temperature would be about $-190°C$ other times it was old and its temperature would approximate to $-183°C$. As an example of how the temperature may be obtained, the following may be quoted. One day pure dry air at 20°C was sent into the apparatus, all the taps turned off and the pressure read. It was 752 mm. Liquid air about 18 hours old was then placed around G and the final air pressure read. It was 242 mm. Calculating from temperatures and assuming the gas laws, the final pressure should have been

$$752 \times \frac{79}{293} = 203 \text{ mm.}$$

Conversely calculating the temperature from the pressures we find the effective temperature to be

$$293 \times \frac{242}{752} = 94°\text{A or-}179°\text{C.}$$

A reading at another time gave a pressure reduction from 758 to 252 corresponding to $-176°C$.

It follows from these readings that if at any time when liquid air is around G, a gas pressure is recorded as p cm. the volume of this gas at 75 cm. pressure and room pressure =

$$400 \times \frac{293}{96} \times \frac{p}{73} = 16p$$

nearly. This is a useful equation.

If successive units of pure methane are passed into G, the methane, having a boiling point of $-164°C$. at atmospheric pressure, should condense and the only pressure recorded should be the vapour pressure of methane at liquid air temperature which, as mentioned above, is between 6 and 7 cm. of mercury.

If the 1200 cc. of gas passed in is largely methane but contains ome nitrogen, then if the nitrogen is insoluble in methane it should

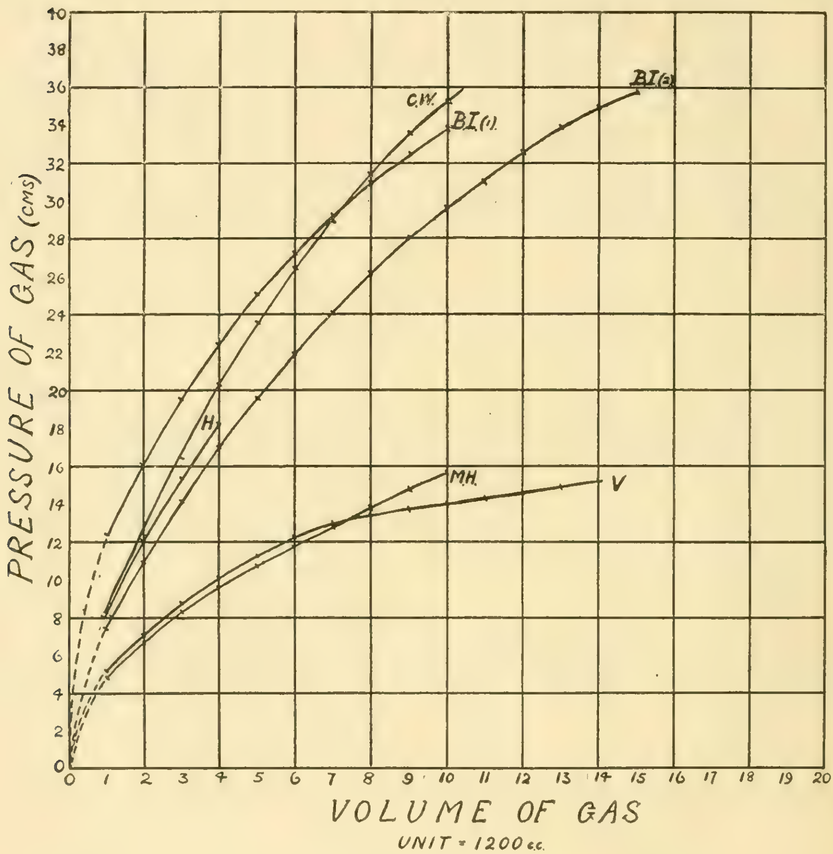


Figure 2

exert its pressure independently of the methane. If x% for example is nitrogen, then 12 x cc. is the volume under atmospheric conditions and the nitrogen pressure in G should be given by

$$16p = 12x$$
$$\text{or } p = \tfrac{3}{4}x$$

Therefore, the pressure after the first collector has been passed in should be $6\frac{1}{2}+\frac{3}{4}x$ and the pressures after 2, 3, 4, etc. collectors should be $6\frac{1}{2}+1\frac{1}{2}x$, $6\frac{1}{2}+2\frac{1}{4}x$, etc. This neglects the alteration in the capacity of G due to the accumulation of the small quantity of condensate. The graph between pressure and number of collectors should be a straight line. Now this straight line was never obtained. If it had been the percentage of noncondensable gas in nitrogen, helium, etc. in the natural gas could have been calculated at once from $x = 4/3p$.

Results

Fig. 2 shows the graphs obtained with some samples of natural gas. H refers to the gas from the pipe line at Hamilton, used by Satterly, Patterson, Burton and Dawes in their experiments on the Production and Purification of Helium from Natural Gas. It was the first gas experimented on in Canada or elsewhere for commercial manufacture of helium. MH refers to the gas from the Cousins & Sissons well at Medicine Hat, V refers to the gas from Viking, and BI (1) and (2) to the gas from the Pipe line at Bow Island and CW to the gas from the Walker well at Calgary. With the exception of the Hamilton gas these samples were collected by Professor McLennan in the spring of 1916.

Fig. 3 gives similar curves from the gas at Petrolia, Texas, collected by myself in October, 1917, using new and old liquid air and from the natural gas at Hanmer, New Zealand, sent by Mr. McLaurin, the Dominion Analyst.

The quoted analyses of these gases are:

	Hamilton	Medicine Hat	Viking	Bow Island	Petrolia (Texas)	Hanmer (N. Zealand)
Methane	80·0	90	94	91·3	50·9	96·1
Ethane	12·2	3	?	?	10·5	?
Nitrogen	7·7	5	5	8·5	37·6	3·5
Other constituents	1	2	1	2	1·1	?

It is evident from the curves that the pressure does not mount linearly. The inference is that some of the nitrogen dissolves in the methane. The condensate in some cases is a clear liquid. This was true for most of the Ontario gases examined. In the case of the gases from Western Canada, the condensate was usually a white solid. This was also true for the gas from Petrolia. Several of the gases from New Zealand gave also a white solid which melted to a milky liquid showing presence of considerable quantities of carbon dioxide.

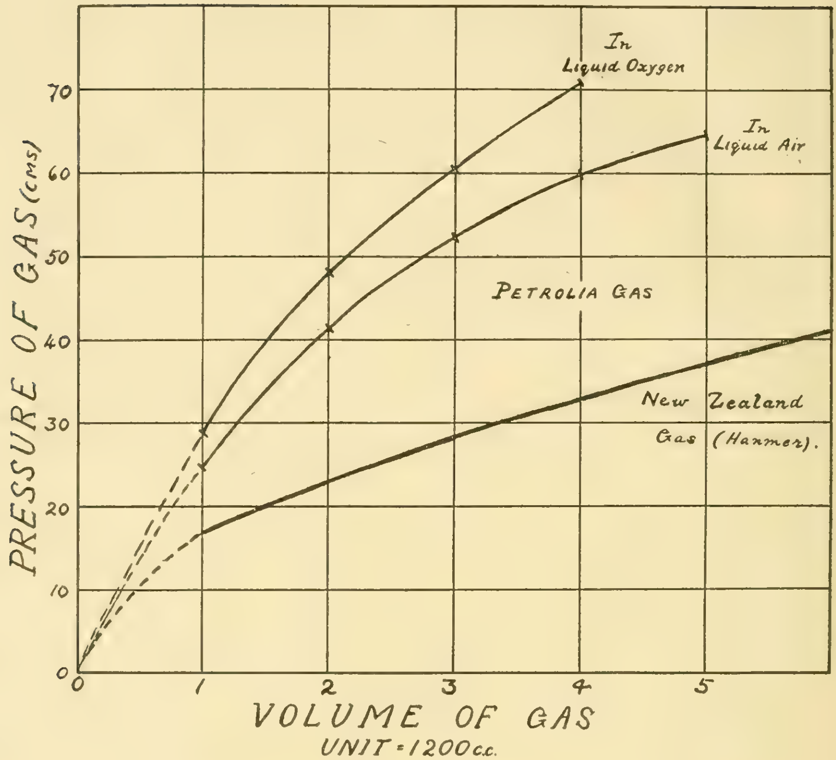


Figure 3

If the nitrogen dissolves in the methane the solubility will increase with the partial pressure. This will account for the curve turning over in the horizontal direction.

Equations of the Pressure Curve

Attempts were made to get the equation of the pressure curve in the hope of finding out something about the solubility of the nitrogen in the methane. In the case of the curve marked BI No. 2, the readings were carefully taken. The units of volume were passed in at regular intervals of one minute and the pressures read at corresponding intervals, usually at the half minute. The readings are as follows, and if the increase of pressure per unit volume is denoted by p it will be noted that over a large part of the curve Pp is approximately constant where P is the average pressure for the interval.

Volume (in units)	Total pressure	p	Pp
1	7·5		
2	10·9	3·4	31·4
3	14·1	3·2	40·0
4	17·0	2·9	45
5	19·6	2·6	47
6	22·1	2·5	51
7	24·0	1·9	44
8	26·2	2·2	55
9	28·1	1·9	51
10	29·5	1·4	40
11	30·9	1·4	45
12	32·5	1·6	50
13	33·9	1·4	47
14	34·9	1·0	34
15	35·7	·8	28

If Pp is constant, then P^2 should be proportional to the volume of gas sent in.

Tabulating this way, we get:

Volume	P	P^2	P^2/V
1	7·5	56	56
3	14·1	199	66
6	22·1	487	81
9	28·0	783	87
12	32·5	1050	81
15	35·7	1270	84

In some cases the agreement is better than in others.

Henry's law tells us that the volume of gas dissolved by a given volume of liquid is independent of the pressure. In this statement, the volume of gas is supposed to be measured at the existent pressure. The mass of gas dissolved is proportional to the pressure. In my experiments the volume of the liquid increased linearly with the volume of gas passed in. Working on this basis it should be possible to find the equation of the pressure curve.

Let n = number of units of volume passed into G. If there is no solution of nitrogen, etc., in the methane, the pressure is proportional to n. Let us say, pressure = k n.

If solution occurs according to *Henry's law*, then since the volume of the methane is proportional to n there will be on this account alone a lowering of the pressure proportional to n from that given in the above equation. Also, since the pressure of the gas is mounting nearly proportional to n, there is extra solubility on this account, and this causes another lowering of the pressure, also roughly proportional to n.

$\therefore$ Final pressure $= kn - ln^2$

which tells us that the curve between pressure and n is a parabola with its axis vertical. The apex is reached when the introduction of more gas does not raise the pressure. This is borne out generally by the shapes of the curves in Figs. 2 and 3.

If instead of writing

$$p = kn - ln^2$$

we put the lowering of the pressure (due to the increased solubility under the greater pressure) proportional to p, we get

$$p = kn - lnp$$

whence

$$p = \frac{kn}{1 + ln}$$

which gives a straight line between n/p and n.

The Solubility of the Nitrogen in the Condensate

If now the liquid air tube is withdrawn from the condenser G, and the latter allowed to warm up, one would expect the mercury in the gauge to drop gradually down to the level of the mercury in the dish M and then to blow out if the tap O is not turned. This, indeed, often happens, but also very often a curious phenomenon occurs. The mercury drops gradually to a certain point, then halts for a while and then suddenly jumps up several centimetres, keeping again steady for a short time after which it gradually descends. It may do this more than once before the mercury drops to the dish level. Sometimes the upward kick is accompanied by rapid oscillations. The kick may extend many centimetres. It should be remembered that an upward kick means decrease of pressure. This phenomenon has been observed over and over again with many gases.

A possible explanation is that as the temperature rises the methane vapour pressure and nitrogen gas pressure increase, and suddenly some of the nitrogen is forced into solution and leaves the space above. I may say the condensate is sometimes solid when the condenser is in liquid air and in many cases the upward kick in the gauge occurs at the instant the solid melts.

Suppose now that the tube has warmed up so that the mercury is down low. Now if the liquid air be applied again the contents of G cool and the mercury rises. It rises steadily for some time, then, in many instances, it halts and kicks down suddenly to the extent of many centimetres. It rests in its new position for some time and then gradually climbs up to somewhere near its old position. A possible explanation of the down kick is that as the contents of G cool, nitrogen re-dissolves in the liquid. The pressure in G then becomes smaller and smaller until less energy is required to keep the nitrogen in the gaseous state than in the liquid state. It accordingly suddenly leaves the liquid. Often, when such a down kick has occurred, I have heard a noise in the condenser like a splash or a mild explosion, and on removing the liquid air the condenser has been seen to have frozen hard and to have a very jagged crust on it as if at the instant of freezing a violent outburst occurred. Sometimes pieces of the frozen condensate have been scattered over the walls of the tube. After having once removed the liquid air and then replaced it as above described, the final pressure is usually greater than the initial pressure, showing that some of the gas which before was dissolved in the condensate at liquid air temperature has now gone into the space above.

In many cases I have put on a vacuum pump to P and exhausted all the uncondensed gases from G. The pressure has been brought down as low as 3 or 4 cm. so that not only have the uncondensed gases been removed, but much of the methane, some of the methane even boiling away at the lower temperature induced by the pressure. Even in these cases I have observed the upward kick in the gauge after removal of the liquid air, and the downward kick after the application of the liquid air, though the extents of these kicks diminish gradually if the vacuum pump is applied several times.

The following are examples:

November 17, 1917. *Making Helium in Quantity from Petrolia Gas.* Twenty-five "collectors-ful," *i.e.* 30 litres of natural gas had been passed into G and the pump attached to P had been in operation some time in order to transfer the uncondensed gas from G to the next part of the apparatus. The pressure in G had been reduced to 7 cm. of mercury (the vapour pressure of methane) when suddenly there was a violent ebullition of gas and the mercury fell in the gauge to a pressure of 34 cm., *i.e.* the gas pressure had risen 27 cm. All this occurred without any tampering with the liquid air. The dissolved nitrogen (and possibly helium, too) had evidently reached an unstable state and much of it was forced to leave the liquid for the space above. An increase of gauge pressure of 27 cm. means an outburst (measured under atmospheric pressure and temperature of well over 400 cc. of nitrogen—including helium). After this outburst, the pressure was allowed to rise to atmospheric pressure and the tap O was opened.

The issuing gas was not inflammable, indicating the presence of nitrogen.

On December 19, 1917, the observation was repeated with gas from the *Landrum Well at Petrolia, Texas.* Here, after passing five units of gas into G (see Fig. 3), I was in the act of pumping over the uncondensed gas to the next part of the apparatus, when the pressure having been lowered to 18 cm. suddenly rose to 28 cm. Later on in the same evening I observed a similar sudden elevation of pressure, from 8 cm. to 23 cm. In this case the condensate was a white solid.

The earliest instance noted, however, of these pressure kicks was on May 9, 1916, when working on the gas from *Medicine Hat.* The liquid air having been removed, the gauge was observed to halt for some time as the condensate melted and when the pressure had risen to 35 cm., the mercury column in the gauge oscillated rapidly up and down several times, indicating instability of the liquid and gaseous phases within the condenser.

The next notable instance occurred on June 9, 1916, with *Bow Island Gas.* Gas had been passed into G (see Fig. 2, BI (1)) until the final pressure was 34 cm. The following observations were then made:

Removed L,* momentarily. The deposit was found to be a white solid.

Replaced L. Pumped off all the gas. Got the pressure down to 4, to 2-8 and finally to 2·5 cm.

Removed L, momentarily. The deposit was drier and whiter than before.

Replaced L.

Removed L. The gauge fell. When the pressure was 17 cm. there was an upward kick. Then pressure gradually rose to 19 cm. and another kick occurred. The condensate was all liquid at a pressure of 21 cm.

Replaced L. The gauge rose and became steady at 10·7 cm. The increase of 10·7 above 6·5 (the vapour pressure of methane) is evidently due to gas which has escaped from the liquid.

Readings with Medicine Hat Gas, June 13, 1916. After 10 collectors had been passed in, the final pressure was 15·6 cm. (see curve in Fig. 1).

Removed L. White condensate. Icy streaks on walls of G.

Replaced L, quickly.

Exhausted by air pump until pressure fell to 3 cm.

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* L signifies the liquid-air container.

Removed L, to see if plenty of condensate left. There was. Allowed pressure to rise to 18 cm.

Replaced L. Pressure fell to 9·6 but no further. Evidently plenty of gas had come out of the liquid.

Removed L. Allowed pressure to rise to 28 cm.

Replaced L. Pressure fell to 10 cm. Pumped off the gas until pressure back to 3 cm.

Removed L. Pressure increased to 16·7 cm., then kicked back 1 cm. and remained steady for some time before making further increase.

Replaced L. Pressure back to 5 cm.

Removed L. Pressure rose to 24½ cm., then there was a kick back to 18½ cm. These operations were repeated over and over again, but at this time I had never observed the pressure suddenly rise after the application of the liquid air to the condenser.

Readings With Viking Gas. June 19, 1916. See curve in Fig. 1 for record of increase of pressure as the gas was passed in. The condensate was a white solid. Here, on removal of L, the kick occured, at a pressure of 10 cm., and I observed when the liquid air was applied that the down kick on the gauge occurred at the same place. This was the first record of the "down" kick (*i.e.* the kick caused by increase of pressure). In the case of this gas seven halts were observed as the pressure gradually rose to atmospheric pressure.

Readings With Bow Island Gas. June 19, 1916. See curve B.I.2., Fig. 2. I quote here the gist of the readings:

Pressure 35·6 cm. White solid condensate in streaks on side of tube.

Pumped off gas until pressure down to 4·3 cm.

Removed L. At 21 cm. melting steadily, at 23 and 24 cms. oscillations occurred. Clear liquid produced.

Applied L. Pressure back to 15·2 cm. only.

Pumped down to 3·1 cm.

Removed L. Gauge fell to 15 cm., then up to 12½; slowly passed 14, 15 to 16, then kicked up to 14 cm.

Applied L. (Pressure down to 7·7 cm.) Pumped down to 3·2 cm.

Removed L. Steady at 11. Kicks at 11·3 and 11·5 cms.

Applied L. Pressure down to 4·3. Pumped to 3·2 cms.

Removed L. At 9½ a halt, then at 22 a kick up to 14 cm., *i.e.* a sudden dimunition of pressure of 8 cm., etc., etc.

I observed here, the explosion of the solid in the act of freezing, the pressure suddenly increasing from 7 to 11 cm. Repeated this and got an increase of from 5 to 15 cm. In fact it is now sometimes easier to get the increase of pressure kick as the condenser cools than the decrease of pressure kick as the condenser warms up. It was also observed that at the time of the explosion the liquid air in L boiled.

Gas From Walker Well at Calgary. See CW, Fig. 2. Here, after 10 collectors were passed in, the pressure was 35·3 cm. The vacuum pump lowered this to 3·1 cm. The liquid air was removed when oscillations were observed at 25, 26½, 28½ cm., as the condensate melted. After allowing the pressure to rise to 50 cm. the liquid air was replaced. The final pressure was 16·2 cm., a large increase over the pressure before removing the liquid air. The gas was again pumped off and even after this, on removal of the liquid air, the pressure on rising to 30 cm. kicked back to 20 cm. After another pumping the liquid air was removed and re-applied, and when the pressure had fallen to 4 cm. it suddenly rose to 7 cm., the liquid air in L boiling vigorously at the same time. On the removal of L, I found that the condensate had been violently disturbed before being frozen for the solid was all over the inside of the tube.

Gas from Bow Island Pipe Line. September 26, 1918. Doing this experiment very carefully, I observed kicks of 14 cm. and in one case after removing the liquid air, the pressure rose to 19 cm., kicked back to 15 cm., rose to 17 cm. and halted and then oscillated three times from 17 cm. back to 15 cm. before rising further. On replacing the liquid air the pressure fell to 6 cm. and then suddenly rose to 20 cm. The observations were repeated over and over again.

In some ways the sudden solution and expulsion of nitrogen by the liquid methane is very similar to the occlusion and spitting of oxygen by silver.

Much work on the solution of helium in liquid methane has been done by Professors Cady and Seibel at the University of Kansas, but their results have not yet been published.

In the design of liquefaction plants attention must be paid to this question. A sudden evolution of gas may upset the balance in the rectifying column, also the solution of helium in the liquid hydrocarbons must greatly impair the efficiency of the extraction process unless the mixed liquids are rectified. This is especially important in the case where the original gas worked on has only a small percentage of helium.

These results were communicated (in part) to the Admiralty in May, 1916, in a report which I wrote of the work done in Toronto on the Analysis of Natural Gases of Canada for Helium. The work was extended in the following years and I understand the observations

I made have been checked and verified quite recently by workers at the Admiralty Research Laboratory in London.

I have much pleasure in thanking Professor McLennan for collecting some of the gas and for providing facilities for this work, and also Professors Burton and Dawes for occasional help gladly given.

University of Toronto.

On the Latent Heats of Vaporization of Methane and Ethane.

By JOHN SATTERLY, M.A., D.Sc., F.R.S.C., and JOHN PATTERSON, M.A., F.R.S.C.

(Read May Meeting, 1919.)

In connection with the designing of a column for the manufacture of helium from natural gas by the condensation process it is important to have some idea of the various heat changes involved, and as natural gas is largely methane with sometimes a considerable proportion of ethane, and as these are liquefied in the process it was desirable to know their latent heats of vaporization.

The column which we used in our factory at Hamilton was a modification of the ordinary Claude oxygen column, and from it we procured, during our experiments on the production of helium in the early part of 1918, large quantities of liquid methane and ethane.

In order to get quick results we decided on a simple process. An approximate knowledge of the latent heats is good enough for the purpose of design. We understand that the Bureau of Standards at Washington is engaged on an accurate determination which will, however, take some time.

Two methods were adopted. In each case the liquid was at the boiling point. In the first method an electrically heated wire served to evaporate some of the liquid, in the second a piece of copper was lowered into the liquid. In both cases the evaporated hydrocarbon was collected over water in a graduated jar and the mass estimated from the volume. The heats supplied were estimated from the wattage applied in the first case and from the mass and specific heat of the copper in the second case.

Method I. The figure gives the arrangement of the apparatus. The liquefied hydrocarbon is placed in a thermos bottle, B, provided with a rubber stopper. Through this stopper penetrate two stout copper leads, LL, which are joined at the lower ends by a nichrome spiral, S. The rest of the electrical connections are shown diagrammetrically. A is the ammeter and V the voltmeter. The gases liberated from the hydrocarbons in the bottle pass by way of bent tubes, TT, and a rubber connection and are collected over water in a graduated litre cylinder, G, standing in a dish, D.

The experiment was first done with liquid oxygen as a test of the method. The oxygen was placed in the bottle. Exposed to the atmosphere it gradually attains the temperature of its boiling point at atmospheric pressure. Heat always leaks into the liquid so that the liquid is always boiling away. Therefore we measured first of all the wastage of oxygen before the electrical circuit was completed. This gave us on an average about 120cc. per half minute. The current was applied for a half minute and while one observer manipulated the apparatus, the other read the ammeter and voltmeter, and at the end of the half minute read the gas liberated. If the gas liberated per half minute is 750 cc., then, allowing for the leakage, the heat supplied by the current has been responsible for the evaporation of 630 cc. of oxygen. If, for example, the current was $2 \cdot 56$ amperes and the voltage $2 \cdot 46$ volts, the heat supplied $= 2 \cdot 56 \times 2 \cdot 46 \times 30 \times \cdot 24$ calories. The density of oxygen gas at the time of the experiment being $\cdot 00130$ gm. per cc. the mass of oxygen evaporated $= \cdot 00130 \times 630$ gm. and therefore the latent heat of evaporation

$$= \frac{2 \cdot 56 \times 2 \cdot 46 \times 30 \times \cdot 24}{630 \times \cdot 00130}$$

$$= 55 \text{ calories per gm.}$$

The following table gives the readings obtained with oxygen:

Amperes	Volts	Watts	Gas liberated per half minute, allowing for "wastage"
2·56	2·45	6·27	660 cc.
2·56	2·45	6·27	600 "
2·56	2·46	6·30	605 "
2·56	2·46	6·27	605 "
2·54	2·43	6·17	625 "
2·60	2·58	6·49	647 "
2·51	2·51	6·31	661 "
	Average	6·30	630 cc.

$$\text{Whence } L = \frac{6 \cdot 3 \times \cdot 24 \times 30}{630 \times \cdot 00130} = 55 \text{ calories per gm.}$$

The number quoted in the Smithsonian tables is 51 calories per gm.

The experiment was repeated with liquid methane at a temperature of $-160°$ on our pentane thermometer. The wastage per minute was first determined. It was about 160 cc. The graduated cylinder being placed in position, wastage was collected for 5 seconds, then the current was on for 30 seconds and the wastage allowed for another 25 seconds, making the total time of collection 1 minute. By running the experiment in this way we get over any error caused in the lag of the escape of the methane from the thermos bottle.

The readings were as follows:

Amperes	Volts	Watts	Gas collected allowing for wastage
2·63	2·71	7·15	543 cc.
2·53	2·70	6·85	517 "
2·53	2·66	6·77	513 "
2·56	2·66	6·81	549 "
2·56	2·70	6·90	560 "
2·48	2·64	6·57	521 "
	Average	6·68	534 "

The density of methane gas at the time of the experiment was ·000664 gm. per cc. hence the latent heat of vaporization

$$L = \frac{6 \cdot 68 \times 30 \times \cdot 24}{534 \times \cdot 000664}$$

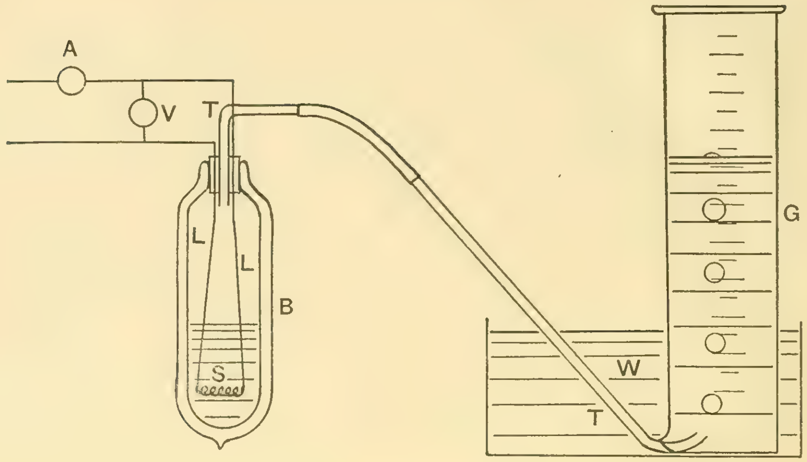
$$= 136 \text{ calories per gm.}$$

The experiment was repeated on a later occasion; unfortunately, the temperature of the methane was not read. The following results were obtained:

Amperes	Volts	Watts	Gas liberated by the current per half minute
2·44	2·60	6·34	491 cc.
2·48	2·65	6·60	450 "
2·42	2·61	6·31	482 "
	Average	6·42	474 "

This gives L = 147 calories per gm.

Method II. In the other method the stopper of the bottle now carries only the tube TT. A piece of copper rod is attached to a thread and at a given instant the copper is lowered into the liquid



and the stopper instantly inserted in the bottle. The gas liberated is collected as above. In one experiment the following readings were taken:

Temperature of liquid $-158°$C.

Mass of copper rod $8 \cdot 92$ gm.

Temperature of copper before insertion $17 \cdot 5°$C.

Volume of gas liberated 1500 cc.

Density of methane at time of experiment $= \cdot 00070$ gm. per cc.

If s = average specific heat of copper from $17\frac{1}{2}°$C. down to $-158°$C. then $8 \cdot 92 \times s \times (17\frac{1}{2} + 158) = 1500 \times \cdot 00070 \times L$.

To get s, the copper rod was quickly removed from the liquid methane and immersed in a weighed quantity of water in a copper calorimeter. From the resulting temperatures, s can be calculated. The value of s was found to be about $\cdot 087$ calories per gm. per degree.

$$\text{Hence } L = \frac{8 \cdot 92 \times \cdot 087 \times 175}{1500 \times \cdot 00070} = 130 \text{ calories per gm.}$$

The specific gravity of the liquid methane in this case was measured by a U-tube arrangement such as is used on liquefaction machines and found to be $\cdot 41$. The figure given in the Smithsonian tables is $\cdot 416$, thus our liquid was fairly pure.

The average of the three results is 138 calories per gm. which should not be more than 5% out.

The latent heat of liquid ethane (temperature = $-90°$C. by a pentane thermometer) was determined by the copper rod. When the rod at 17°C. was lowered into the liquid 270 cc. of gas was evolved. The density of ethane gas at the time of the experiment was ·00126 gm. per cc.

$$\text{Hence } L = \frac{8 \cdot 9 \times 087 \times 107}{270 \times \cdot 00126}$$

$$= 244 \text{ calories per gm.}$$

As a check the experiment was repeated with a narrow calorimeter weighing 74·4 gm. The room temperature was 17°C. This calorimeter was attached to a string as before and lowered into the liquid ethane (at −90°C.) contained in the thermos bottle, 1920 cc. of ethane being evolved. The calorimeter was then quickly withdrawn, emptied of ethane and 40 cc. of water at 18·5°C. was poured in. The final temperature of the water was 4°C. Hence we have the following equations:

$$74 \cdot 4 \times s \times (17+90) = 1920 \times \cdot 00126 \times L$$
$$74 \cdot 4 \times s \times (4+90) = 40 \times 1 \times (18 \cdot 5 - 4 \cdot 0)$$

where s = average specific heat of the metal from room temperatures down to −90°C.

Combining these, we get

$$L = \frac{107 \times 40 \times 14 \cdot 5}{94 \times 1920 \times \cdot 00126}$$

$$= 273 \text{ calories per gm.}$$

Hence the mean value for the latent heat of ethane is about 260 calories per gm.

The above results do not pretend to be within less than 5% of the correct values, but, such as they are, they have proved useful in designing machinery for future liquefaction purposes.

University of Toronto.

The Study of the Advance of the Ripple in Front of the Surface of an Ascending Column of Liquid

By J. C. THOMPSON, B.A.

Presented by JOHN SATTERLY, D.Sc., F.R.S.C.

(Read May Meeting, 1919.)

Many searching investigations have been carried out in respect to waves and ripples. J. Scott Russell was one of the earliest to make a thorough study of the subject. He carried out many researches in respect to the waves on rivers, canals, and artificial reservoirs[1]. His work was continued by Lord Kelvin and others. Lord Kelvin developed the theory of minimum wave-velocity[2], by which the velocity, v, of a wave propagated under the influence of surface tension as well as gravity, is given by the equation

$$v=\sqrt{\frac{\lambda g}{2\pi}+\frac{2\pi T}{\rho\lambda}}$$

where λ is the wave-length; T is the surface tension; ρ is the density; and g is the acceleration due to gravity. The velocity is a minimum when the two terms under the root sign are equal; hence, in the case of water for which $T=75$ dynes per cm.

$$\lambda=1\cdot 7 \text{ cm. and } v=23 \text{ cm. sec.}$$

Hence, no waves or ripples can travel over the surface of water with a smaller velocity than 23 cm. per second. Lord Rayleigh[3] and later Dr. Dorsey[4] made use of this equation to find the surface tension of various liquids and solutions.

A ripple, different from those referred to, was noticed by Dr. John Satterly. In carrying out some experiments[5] in which he had water repeatedly ascending a tube, a well-defined ripple was observed on the wetted wall of the tube slightly in advance of the moving surface of the column of liquid (see AA in Figs. 1 or 2). It was early noticed that the advance of this ripple varied as the velocity of the moving surface varied, which observation gave rise to this research.

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[1] J. Scott Russell, "Report on Waves," Brit. Ass. Rep., 1844.

[2] Lord Kelvin, "Hydrokinetic Solutions and Observations," Phil. Mag. (4), XLII, p. 375, 1871.

[3] Lord Rayleigh, Phil. Mag. (5), XXX, p. 386.

[4] Dr. N. E. Dorsey, Phil. Mag. (5), XLIV, p. 369.

[5] Satterly, Trans. R.S.C. 1919, p. 110, Fig. 1, supra.

To obtain the ripple, apparatus as shown in Fig. 1 was used. By means of a filter pump (V, a tube leading to filter pump), the reservoir R was exhausted and when the tap E was opened, keeping tap F closed, the water ascended the tube T. By opening F, it could be lowered again. P is a pressure gauge and B is a barometer; by means of these, the pressure in the reservoir could be kept constant, thus, ensuring the same velocity of the liquid surface in tube T. To vary the velocity of the surface, a number of capillary tubes in parallel were introduced, these being connected by means of rubber tubing to the larger distributing tubes C and D. By means of clips, each or all of these could be shut off. The velocity could further be altered

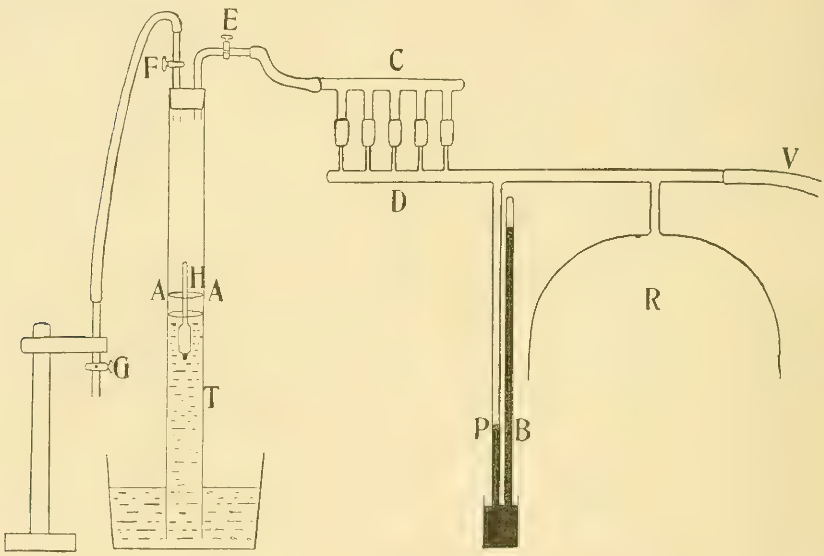


Figure 1

by changing the pressure in the reservoir. To measure the advance of the ripple, an instrument, H, similar to a hydrometer but calibrated in millimetres was used. This was allowed to ride on the surface of the liquid as it ascended the tube and thus, the advance of the ripple was measured directly.

The relation between the advance of the ripple and the velocity of the moving surface was first studied. The liquid was allowed to ascend to the top of the tube each time, measurements were taken as the surface passed a selected point, and its velocity measured by taking the time for it to pass from one point to another, these points being equidistant from the selected point. Using a constant velocity, the advance of the ripple varied to a great extent. This was found to be due partly to shaking, or slightly jarring the tube T, and was eliminated to a large extent by connecting the opening through a tap F by rubber tubing to a tap G fastened to a clamp separate from those holding tube T. The velocity was now varied and the advances of the ripple measured. The diameter and length of the tube used were 2·95 and 90 cms. respectively. The selected point was 17 cm. above the level of the water in the dish. The results are tabulated below and a graph is plotted as shown in Fig. 4. The advances used are the averages of five readings with deviations of 1 millimetre, approximately.

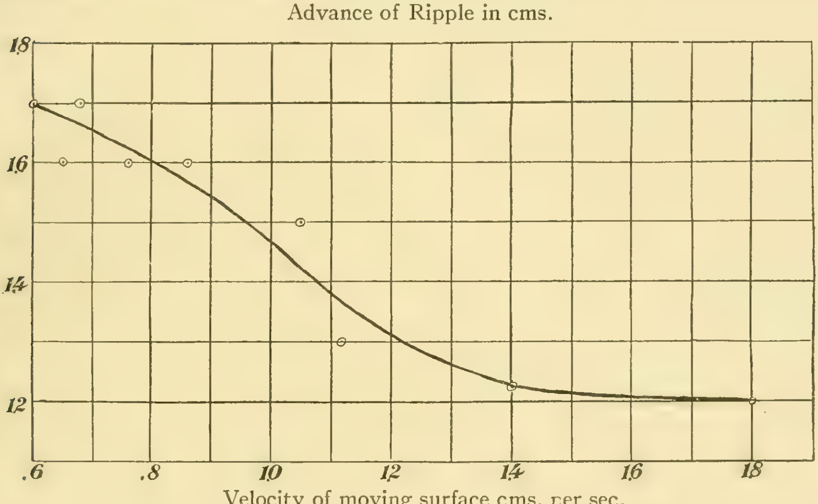


Figure 4—Relation between the advance of ripple and the velocity of moving surface.

TABLE I—RELATION BETWEEN THE ADVANCE OF RIPPLE AND THE VELOCITY OF MOVING SURFACE

Velocity of Moving Surface. (Cms. per sec.)	The Advance of the Ripple (Cms.)
1·80	1·2
1·40	1·25
1·16	1·3
1·05	1·5
·86	1·6
·76	1·6
·68	1·7
·65	1·6
·60	1·7

For greater velocities than those used, it was impossible to make measurements, and for lesser, the ripple disappeared due to the water draining from the sides of the tube. Tap water was used.

As the water ascends the tube the advance of the ripple increases, and as it nears the top it lengthens out very rapidly and finally disappears. This seems to be due to the draining away of the water from the walls of the tube and thus changing the thickness of the layer of liquid on the wetted wall. To study this, the water was allowed to ascend the tube at a definite velocity of 20 cm. in 25 seconds. This time varied somewhat but never more than ·4 seconds. The tube was 90 cm. long and had a diameter of 2·5 cm. The water was allowed to rise 80 cm. in the tube and measurements were taken at a point 17 cm. from the starting point or lower surface. The tube was allowed to drain for a definite length of time before commencing each operation. The results of readings taken on three different occasions are tabulated below and graphs (1, 2 and 3) are plotted as shown in Fig. 5. The advances used are the averages of five readings with deviations of 1 millimetre, approximately. Fresh tap water was used on each occasion.

TABLE II—RELATION BETWEEN TIME TO DRAIN AND THE ADVANCE OF THE RIPPLE

Time to Drain (Secs.)	Average Advance of Ripple (cms.)
First set of readings	
0	1·5
5	1·6
10	1·7
15	1·75
20	1·8
25	2·0
30	2·06
35	2·1
40	2·1
45	2·16
50	2·1
60	2·37
70	2·45
Second set of readings	
50	2·0
60	2·1
70	2·1
80	2·27
90	2·3
105	2·32
120	2·6
135	2·4
165	2·5
180	2·6
Third set of readings	
0	1·8
5	1·9
10	1·92
15	2·15
20	2·4
30	2·45
40	2·5
50	2·54
60	2·6
70	2·6
80	2·95
90	3·17
100	3·4
110	3·45
120	3·5
135	3·57
150	3·67
165	3·65
180	3·9
210	3·87

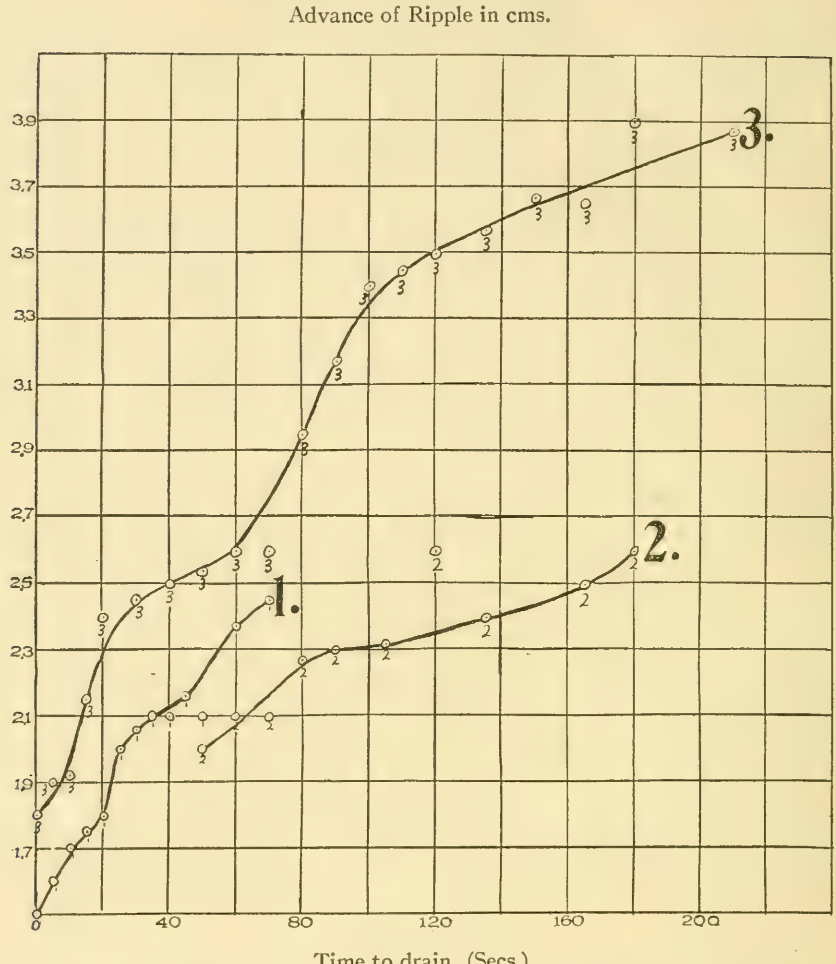


Figure 5—Relation between time to drain and the advance of the ripple.

The first and second set of readings were taken on successive days and there is a chance that a slight alteration in the purity of the water (Toronto water is often chlorinated) is responsible for the change in the position of the curves.

The following liquids, *viz.*, methylated spirits, kerosene, petrolatum oil, glycerine, aniline oil, toluene and soap solution have been tested. No trace of the ripple was found, but, in the case of water diluted with methylated spirits, the ripple began to appear when the water was diluted to 50 per cent, or when the specific gravity of the resulting solution was ·93. In the case of vinegar, strong sulphuric acid and strong solutions of sodium and calcium chloride, there was a distinct ripple; in fact, it appears that the phenomenon is more definite with the strong salt solutions than with tap water or vinegar or sulphuric acid.

In order to obtain a more accurate method of measuring the advance of the ripple, a photograph was taken as the ripple was passing an intense source of light, as shown in Figs. 2 and 3. This source, MM, is due to a mercury vapour arc in a Torricellian vacuum within a quartz tube. It was extremely difficult to obtain negatives from which prints might be obtained, yet from them the advance of the ripple could be easily measured.

Using the method just mentioned for measuring the advance of the ripple, the relation between the velocity of the moving surface and the advance of the ripple was studied for a strong solution of sodium chloride (specific gravity 1·195). The results are tabulated below and a graph (1) was plotted as in Fig. 6. For the same velocity, the advances varied by not more than one millimetre. An average of four readings was used. The diameter and length of the tube used was 2·20 and 80 cm. respectively. The selected point was 30 cm. above the level of the liquid in the dish.

TABLE III—RELATION BETWEEN THE ADVANCE OF THE RIPPLE AND VELOCITY OF THE MOVING SURFACE FOR THE STRONG SALT SOLUTION

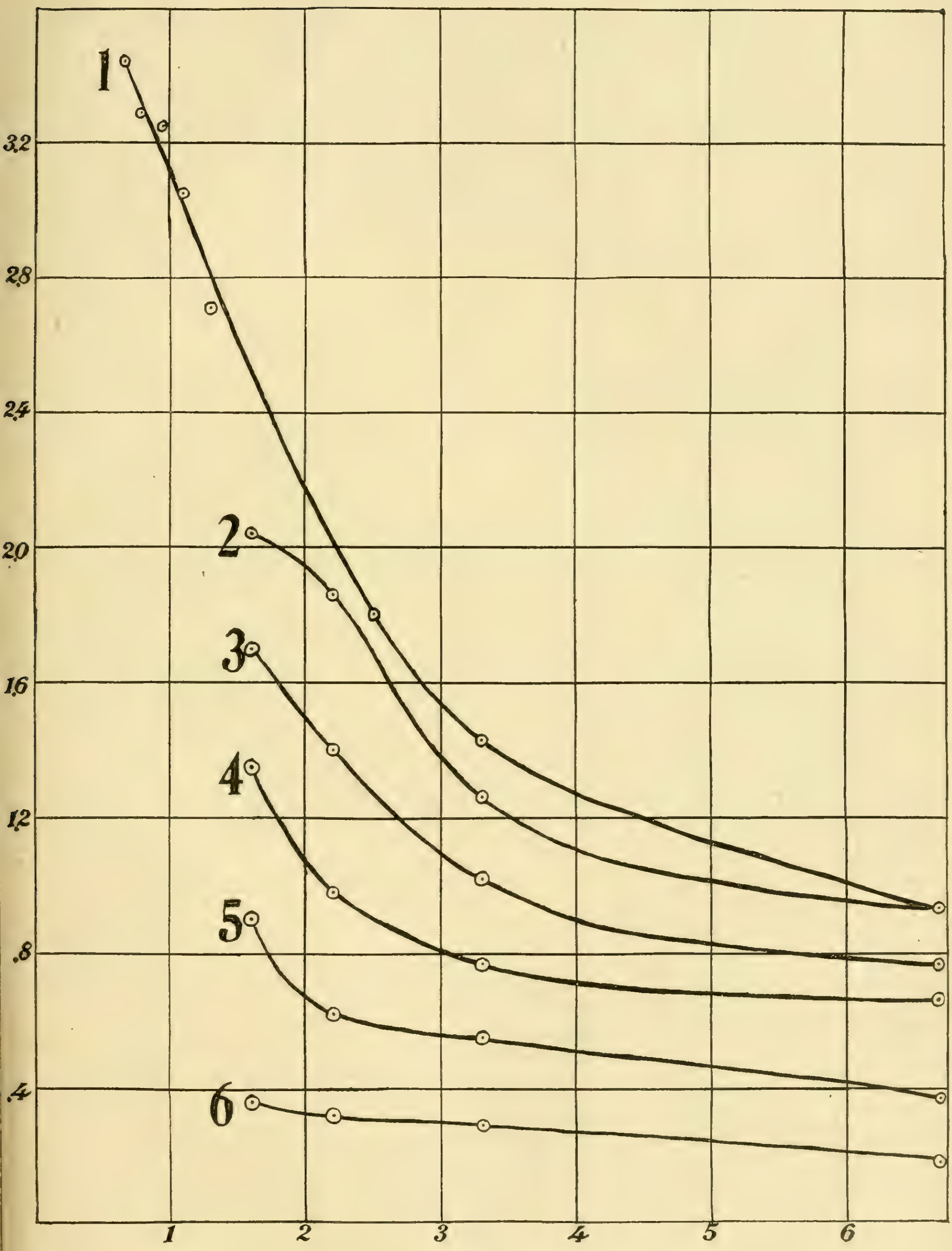
Velocity of Moving Surface (Cms. per sec.)	Average Advance of Ripple (Cms.)
6·7	·93
3·3	1·43
2·5	1·80
1·3	2·71
1·1	3·05
·95	3·25
·79	3·29
·67	3·44

The previous experiment was repeated, using solutions of varying specific gravities and also water. The results are given in Table IV and graphs (2, 3, 4, 5 and 6, representing respectively five solutions of specific gravities 1·195, 1·150, 1·100, 1·050 and 1·000) are plotted as in Fig. 6.

TABLE IV—RELATION BETWEEN THE ADVANCE OF THE RIPPLE AND VELOCITY OF MOVING SURFACE FOR SALT SOLUTIONS OF VARYING SPECIFIC GRAVITIES AND FOR WATER

Specific Gravity	Velocity of moving surface (Cms. per sec.)	Average advance of ripple (Cms.)
1·195	1·6	2·04
	2·2	1·86
	3·3	1·26
	6·7	·93
1·150	1·6	1·70
	2·2	1·40
	3·3	1·02
	6·7	·77
1·100	1·6	1·35
	2·2	·98
	3·3	·77
	6·7	·66
1·050	1·6	·90
	2·2	·62
	3·3	·55
	6·7	·37
1·000	1·6	·38
	2·2	·32
	3·3	·29
	6·7	·18

In order to learn whether the diameter of the tube played any part in the phenomenon, two smaller tubes of diameters ·8 and 1·2 cm. were placed within a large tube and it was observed when the water was allowed to ascend that there were five ripples, three being within the tubes and one on the outside of each of the smaller ones. Considering only the ripples on the inner surfaces, the advances were in the order of their diameters. Considering one small tube the advance of the outside ripple was greater than that of the inside one when the liquid was near the bottom of the tube but as it neared the top, the inside ripple overtook and passed the outside one. This operation was repeated with strong salt solution. All the ripples had the same advance. The two inner tubes were now replaced by a single tube and a narrow strip of plane glass and the experiment again repeated with water and with the salt solution. There was a ripple on



Velocity of moving surface (cms. per sec.)

Figure 6—Relation between the advance of the ripple and velocity of moving surface for salt solutions of varying specific gravities and for water.

the strip of glass as well as on the tube. For the salt solution all the ripples had the same advance, but in the case of water the inner ripple of the small tube was shorter than the others.

A battery of tubes of various diameters was fitted up so that the ripple in each tube was under the same conditions. The diameters of the tubes varied from ·6 to 3 cm. For the strong salt solution the advance of the ripple was the same in each case but for water there was a slight variation.

From the graphs on Figs. 4 and 6, it is shown that the advance of the ripple decreases with an increase of velocity. For the faster velocities, the ripple is more distant and a better definition of it was obtained on the photographic plate; hence, it appears that the ripple has a greater thickness, or tends to heap up for the faster velocities. It is further shown in Fig. 6 that the advance of the ripple varies as the specific gravity of the solution varies.

From the graph in Fig. 5, it is shown that the time given to the tube to drain, effects the advance of the ripple, such that it increases as the time to drain is increased, but the relation between the two has not yet been arrived at, but it seems likely that the advance of the ripple depends on the thickness of liquid clinging to the walls of the tube.

The work is still in progress and it is hoped that, with the introduction of more refined methods of measurement, the knowledge of the conditions attending this ripple will be greatly advanced.

This work was carried out under the direction of Dr. John Satterly.

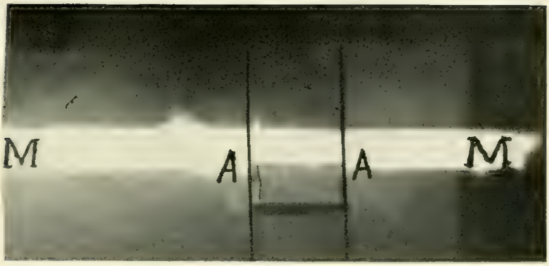


Figure 2

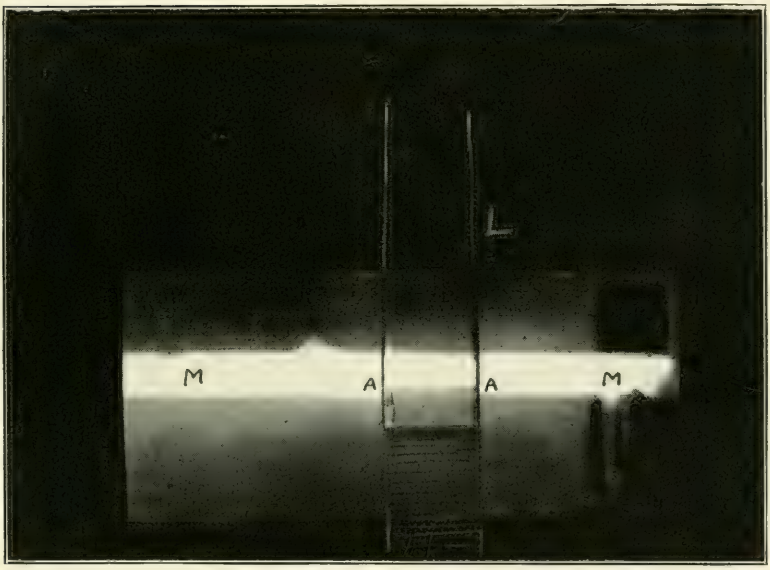


Figure 2

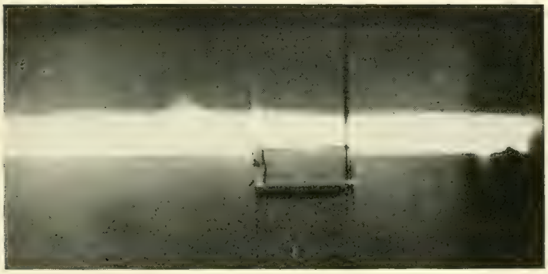


Figure 3

The Analysis of Simple Periodic Curves by a Projection Method, with Special Reference to Estuary Tidal Problems

By A. NORMAN SHAW, D.SC. and VIOLET HENRY, M.SC.

with an Introduction by

DR. BELL DAWSON, F.R.S.C., SUPERINTENDENT OF TIDAL SURVEYS FOR CANADA

Presented by Dr. Bell Dawson, F.R.S.C.

(Read May Meeting, 1919.)

§1. *Introduction* (by W. B. D.) The question discussed in this introduction is the problem of dealing with estuary tides by the method of harmonic analysis. This analysis is now very generally adopted as the best means of arriving at the tidal constants by which the tides of a future year can be calculated and published as a tide table. The importance of estuary tides is evident, as a large number of the principal harbours of the world are situated in estuaries, owing to the fact that ocean traffic may penetrate further inland on account of these tides. The tides in an estuary have features of their own, which necessitates special treatment in the analysis in a way that is entirely empirical; and the present endeavour is to improve upon this.

Characteristics of Estuary Tides. On an open coast of the ocean, the tide consists of an undulation which is fairly symmetrical in form, and has a period of about 12½ hours; the summit of the undulation occasioning high water, and the trough, low water. When this undulation enters an estuary, it is opposed by the outflow of the river; and in consequence the rise of the tide becomes more rapid and the fall longer.

In the outer part of the estuary, the undulation occasions an inflow and outflow alternately; but further up the river a point is reached where the river-flow overcomes this, and the current is always in one direction with only a fluctuation. But the river volume meeting the incoming undulation still causes a rise and fall. Gradually however, the river slope, up which the undulation has to travel, together with bottom and side friction, combine to reduce the amount of the undulation till its amplitude falls to nothing.

In the actual analysis, all these physical and hydraulic features of the progress of the tide up the estuary, as well as the horizontal movements known as tidal streams, are left out of account. The analysis deals exclusively with the form of the undulation, where it passes any given point in the estuary; as represented by a curve with time and height for its co-ordinates. The form of the curve can be obtained automatically with great precision, by means of a registering tide gauge.

If a series of such tide gauges are established in the estuary, the curve at the mouth will be practically symmetrical; but the gauges farther up will give a curve which becomes steeper on the rise and flatter and longer on the fall; the summit being rounder and the trough sharper. The variation in amplitude along the estuary will depend upon its geographical shape; but usually the amplitude will increase as the estuary becomes narrower, and will then decrease as it is cut off by the river slope and the opposing forces already referred to. The chief harbour in an estuary is usually situated where the tidal amplitude reaches its maximum; and the analysis for tide tables has thus to deal with the curve of maximum amplitude.

The Present Harmonic Analysis. In the harmonic analysis, the tide curve of an open coast is represented by a series of sinusoids which have periods related to the movements of the sun and moon; and the recompounding of these sinusoids gives the actual tide curve as observed or recorded by a registering instrument. The periods involved are the lengths of the solar and lunar day and half day, the half lunar month, the periods of the variation in the distance of the moon and sun, and of their variation in declination. All these are natural periods, astronomical in character; and in addition to these terms, a few others are introduced which represent lines of attraction along the resultant direction of the moon and sun combined, all of which have a direct physical interpretation, that is to say they are not merely empirical constants of an arbitrary character.

We need only mention six of the harmonic constants, as they are required for comparison later. In the notation, M stands for moon and S for sun; and we thus have M_2 for the lunar semi-diurnal component of the tide, and S_2 for the solar semi-diurnal; and, similarly, M_1 for the lunar diurnal and S_1 for the solar diurnal. These do not make up the whole, however; as there are two components which represent their combined influence in the direction of their resultant attraction; for which K_2 is the semi-diurnal and K_1 the diurnal term.

To represent the special or unequal form of the tide curve in an estuary, a series of components are introduced which are termed "overtides." This name is taken because the terms are similar to those representing the "overtones" in the analysis of musical sounds.

But in music the overtones are actual vibrations, such as the fifth or the octave above the primary tone; whereas in the case of the estuary tides the periods are *quite arbitrary, and do not correspond individually to separate physical factors.* These overtides have periods of one-third, one-fourth, one-sixth, and one-eighth of the lunar day, one-fourth of the solar day, and in the notation, the corresponding constants are M_3, M_4, M_6 and M_8, with S_4 for the solar term. The unequal form of an estuary tide gives these terms quite a large amplitude, relatively to such primary components of the tide as the lunar semi-diurnal and the solar semi-diurnal; as the following table will show, in which a comparison is given for a few leading harbours of the estuary type. As to the St. Lawrence tide stations, Father Point is in the open estuary and Quebec is not far from the maximum amplitude of the tide.

OVERTIDES COMPARED WITH LEADING SEMI-DIURNAL COMPONENTS
(Semi-amplitudes of sinusoids, in feet)

Locality	Luni-solar	Lunar					Solar	
	K_2	M_2	M_3	M_4	M_6	M_8	S_2	S_4
Liverpool......	0·936	9·975	9·109	0·691	0·196	0·068	3·161	0·057
London........	0·450	8·313	..	0·821	..	..	1·640	...
Havre.........	0·846	8·745	0·039	0·786	0·574	..	2·888	0·006
Dover.........	0·563	7·203	0·035	0·740	0·173	0·073	2·070	..
Calcutta.......	0·447	3·634	0·037	0·740	0·154	0·070	1·502	0·092
Father Point. .	0·412	4·145	0·011	0·056	0·015	0·010	1·353	0·009
Quebec........	0·463	5·897	0·041	0·897	0·230	0·153	1·400	0·052

An entirely different method of dealing with the problem by an oblique projection of the open-water or original oceanic tide curve will now be discussed. It was suggested to the Superintendent of Tidal Surveys by the shadow of suspended chains on the ground; as these approximate to half-sinusoids, and the oblique shadow line was strikingly like an estuary tide curve. By forming a sinusoid with a bent wire, it was found that the change in the form of the tide curve in its progress up an estuary, could be represented by a more and more oblique projection of the symmetrical sinusoid of the original oceanic tide curve.

§2. *The Method of Projection.* The photograph of the apparatus shown in Fig. 7, and discussed again in a subsequent paragraph, illustrates the method of projection. A graph cut out of stiff cardboard is mounted on a frame which may be inclined to any position, and by means of a beam of light a projection is made on to a rigid glass plane where paper may be placed and a tracing of the shadow readily obtained. The line of projection is at right angles to the glass plane which may conveniently be called *the plane of reference*. This plane is parallel to the initial position of the frame, or *initial plane*, when the two defining angles of inclination (θ and ϕ) between the frame and the plane of reference, each become equal to zero. (See §4.)

In such an arrangement it will be seen that these defining angles of projection do not each have the same degree of freedom in the adjustment, although all possible inclinations of the plane as a whole, may be produced. The plane in which lies some graph plotted with rectangular axes x and y, may be pivoted about the origin into any position, but in the cases discussed here, the arrangement is such that all the possible positions of the x axis lie in a plane at right angles to the *initial plane* (and obviously also to the *plane of reference*). For this reason the projection, x', of the x axis always lies along its initial direction, while the projected y axis may make any angle with x', depending upon the position of the inclined plane.

Let θ = the angle between the x axis and its projection, the x_1 axis.

ϕ = the angle between the y axis and y', the initial position of the y axis before rotation.

ϕ' = the angle between the y axis and its projection on the initial plane.

ϵ = the angle between y' and the projection of y on the initial plane.

Observe that θ and ϕ are the angles recorded on the apparatus.

Let us determine the equation of the projection of the graph of $x=f\ (y)$ with reference to the axes x' and y'. This is equivalent to transforming the co-ordinates for a rotation of axes, and then making the z co-ordinates which arise, equal to zero. It can easily be shown that $x=l_1x'$ and $y=l_2x'+m_2y'$ where $l_1=\cos\theta$, $l_2=\sin\theta\sin\phi$, and $m_2=\cos\phi$; thus curves of the type $y=f(x)$ and $x=f(y)$ become $m_2y'=f(l_1x)-l_2x'$ and $l_1x'=f(l_2x'+m_2y')$ respectively.

It is often convenient to take as axes of reference, y'', the projection of y, and x'' at right angles to it (y'') in the initial plane and thus making an angle equal to ϵ with x'. If this is done the transformation is made by using

$$x=L_1x''+M_1y'', \text{ and } y=M_2y''$$

where $L_1=l_1\cos\epsilon$, $M_1=-l_1, \sin\epsilon$, and $M_2=m_2\cos\epsilon-l_2\sin\epsilon$

In finding a "parent curve," that is to say, one which will project into a given one, the problem arises to determine what angles of θ and ϕ are required, and what magnitudes of intercepts on x and y will produce the given values on x′ and y′.

If A and B are intercepts on the x and y axes, which project into a and b on the x′ and y″ axes respectively, then it can be shown that the required projection constants are given by

$\theta = \theta_1$ where θ_1 is the solution of

$$b^2\cos^2\epsilon \cdot \cos^2\theta - (r^2a^2 + b^2)\cos\theta + r^2a^2 = 0$$

$$\phi = \cos^{-1}(b\cos\epsilon / ra\cos\theta)$$

$$A = a/\cos\theta$$

B = rA, where r is the ratio between B and A as they are drawn, and includes the effect of any difference in scale units between the abscissa and the ordinate. It is thus necessary only to measure a, b and ϵ on the given graph, and to adjust r, to be able to construct a parent curve, which will project into the given one, provided that the character of the parent curve is known. In this way many "trial and error" tests may be avoided. In the case of the estuary tidal curves, it will be seen that the ordinary sine or cosine curves might be expected to give, upon suitable projection, fair approximations, at least if the tides are considered one at a time. It will also be apparent that a series of curves of similar design but with amplitudes and axial inclinations which vary in a systematic manner, should for certain classes of similarity, be projectable as a whole, one into the other.

In Fig. 1, two curves are shown which are each a projection of the graph of $x = A\cos py$, where $p = \pi/2B = \pi/2rA$, A and B being the semi-axes of each loop, in this case the intercepts on the axes of reference (x is vertical, y is horizontal). The vertical semi-axis, or amplitude, A = 4 cm., and r = ·79.

Curve (a), in which the inclined amplitude a = 2·82 cm. (equal to A cos θ), is a sample projection when $\theta = 45°$ and $\phi = 14°45'$. (It should be remembered that the inclined axis of each loop is parallel to the x' axis, and that the horizontal axis is the y'' axis which is the projection of the y axis on the initial plane, and which makes the angle ϵ with the y' axis.)

Curve (b) in which a = 3·91 cm. is a projection of the same graph, with $\theta = 13°$ and $\phi = 60°$.

In order to test the usefulness of the formulæ for predetermining θ, ϕ and A when the projection is given, and also to test the sensitiveness of the apparatus, the two curves (a) and (b) with others, were measured, and in each case the values of θ and ϕ which had been used

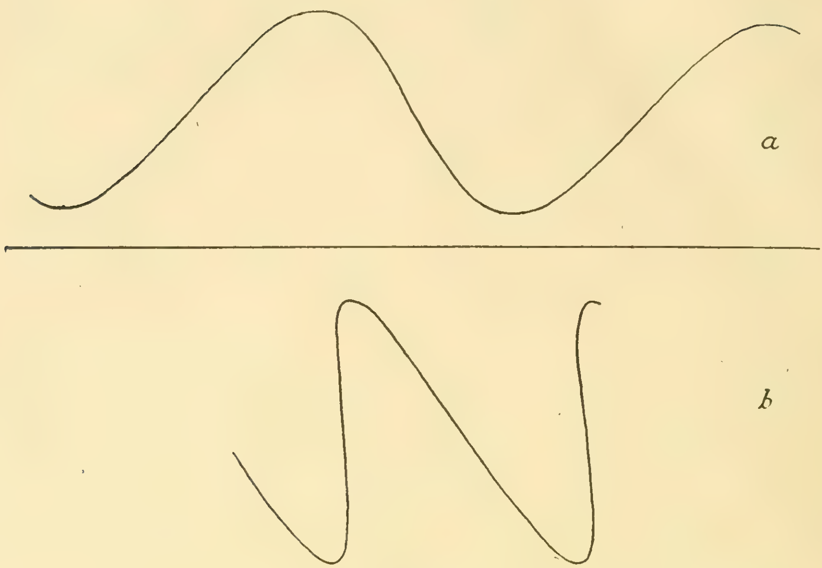


Figure 1

in their production were re-obtained by calculation to within 30′ of the correct value, and A to within ·05 cm. These errors could obviously be reduced with a finished piece of apparatus.

The question whether it is of interest to treat estuary tidal curves by this method of analysis depends upon the closeness with which a desired curve may be obtained, upon the number of constants involved, and upon the character of the parent curve. It will be observed in the subsequent figures that the lack of agreement usually represents differences only of the same order as those which may be the result of wind or local pressure disturbances. The long series of constants which arise in the harmonic method, and which are quite arbitrary in the case of estuary tides, are absent; and it is apparently possible to find suitable parent curves.

In some of the estuary tidal curves it is difficult to determine a, b and ε, owing to a lack of symmetry, but if they are chosen so that the high water and low water points are correctly derived, a fairly satisfactory projection usually may be obtained.

In the consideration of this method of analysis it should be noted that no criticism of the ordinary harmonic method is implied for those legitimate applications where each constant refers to a given physical component, as in the case of open sea tides (or, for example, sound waves).

Before proceeding with an account of the experimental tests on tidal records, it is perhaps desirable to submit a list of a few elementary relations, which may save the time of any reader desiring to consider the scope of the method, or to check any actual cases.

List of Useful Direction Cosines

(z' is the direction of projection)

For x axis with reference to x' y' z': $l_1=\cos\theta$, $m_1=o$, $n_1=\sin\theta$.

For y axis with reference to x' y' z': $l_2=-\sin\theta.\sin\phi$, $m_2=\cos\phi$, $n_2=\cos\theta.\sin\phi$.

For z axis with reference to x' y' z': $l_3=-\sin\theta.\cos\phi$, $m_3=-\sin\phi$, $n_3=\cos\theta.\cos\phi$.

For x'' axis with reference to x' y' z': $\cos\epsilon=m_2/\sqrt{(1-n_2^2)}$, $\sin\epsilon=-l_2/\sqrt{(1-r_2^2)}$, 0.

For y'' axis with reference to x' y' z': $-\sin\epsilon=l_2/\sqrt{(1-n_2^2)}$, $\cos\epsilon=m_2/\sqrt{(1-n_2^2)}$; 0.

For x axis with reference to x'' y'' z'': $L_1=\sqrt{[(1-n_1^2)/(1-n_2^2)]}$, $M_1=-n_1n_2/\sqrt{(1-n_2^2)}$, $N_1=n_1$.

For y axis with reference to x'' y'' z'': $L_2=0$, $M_2=\sqrt{(1-n_2^2)}$, $N_2=n_2$.

For z axis with reference to x'' y'' z'': $L_3=-n_1/\sqrt{(1-n_2^2)}$, $M_3=-n_2L_1$, $N_3=n_3$.

These and other *direction cosines* of possible interest in a quantitive examination of the method, can be deduced at once from the properties of direction cosines, and the definitions of θ, ϕ and ϵ. It is useful to note that $\cos\epsilon=\cos\phi/\cos\phi'=\cos\psi/\cos\theta=m_2/\sqrt{(1-n_2^2)}$ where ψ is the angle between the x and x'' axes; also that $\sin\phi'=n_2$.

§3. *The Application of the Method to Estuary Tidal Curves.* In Fig. 2, curve (*a*) shows a tidal curve for Nelson, Hudson's Bay, copied from the tide-gauge record. Curve (*b*) shows the form of this curve when projected with $\theta=54°$ and $\phi=27°$, and the superimposed broken line shows part of a pure sinusoid plotted with $r=2\cdot52$.

It will be seen that the possibility of expressing a wave length of this curve in terms of a sinusoid and three constants is clearly demonstrated. Several other samples were tested, and in each case an approximate projection of this kind was obtained. Although this is a quicker way to handle the curves experimentally, it will be seen that the converse process to which the previous notes refer is preferable, because it is desirable to produce the tidal graph in the same form that it assumes on the gauge.

It has been pointed out that the chief application of this method to tidal prediction probably lies in the case of the estuary tides. If

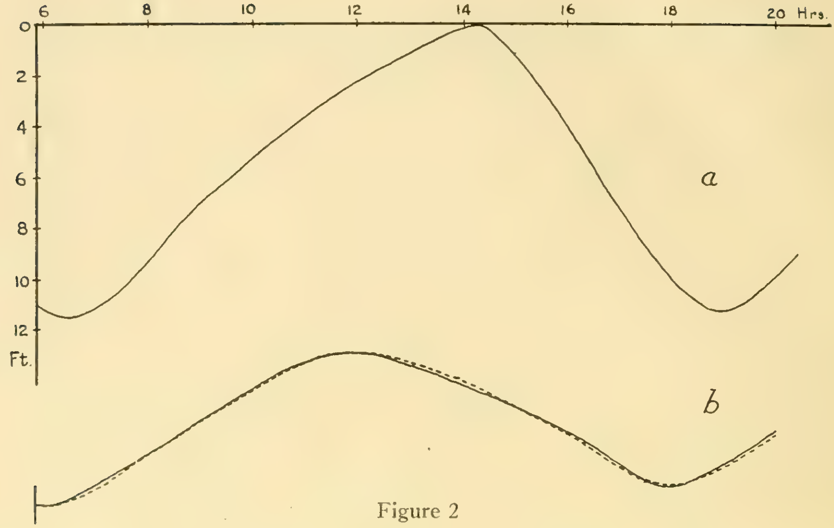


Figure 2

the tide is known at any one spot on an estuary it is suggested that a practical development of this analysis would lead to the prediction of the tidal record at any other place on the same estuary, when at least one comparison of previous tides with those at the reference station were available. A further reference may be possible to a set of basic sinusoids, but this idea is not quite so promising.

In Fig. 3 the agreement is not very good. We have attempted to express one of the extreme forms of estuary tidal curves as a projection of pure sines. The broken line represents the tidal graph for Levis, on June 23rd, 1917, and the continuous line from a to b represents the projection of a sine curve with $A=3$ cm. and $r=\cdot 54$ at the

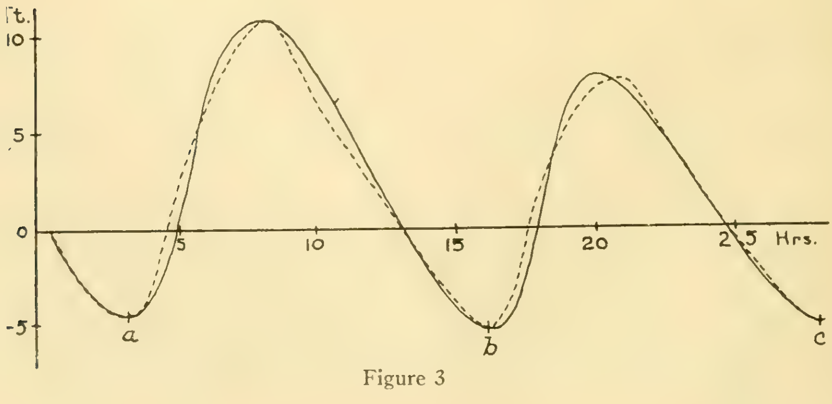


Figure 3

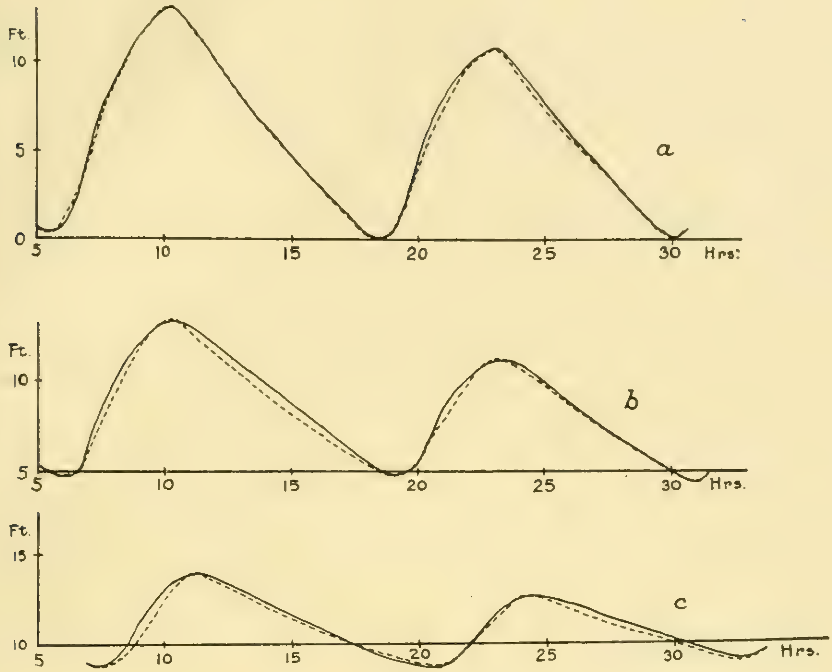


Figure 4

angles $\theta = 9°$ and $\phi = 50°\ 30'$; while from b to c the projection was obtained with the angles $\theta = 13°$ and $\phi = 44°\ 50'$ from the projection of a sine curve with $A = 2 \cdot 5$ cm. and $r = \cdot 84$. In the figure the scale for 1 hour corresponds to $\cdot 53$ cm. in the original copy of the projection. By varying r other fair adjustments could be obtained.

In Fig. 4, however, we have a satisfactory and remarkable agreement. The Levis curve of Fig. 3, has been projected into the curves for other places higher up the St. Lawrence, and it has been projected successfully *as a whole*, the angles being the same for each tide. In curve (*a*) of Fig. 4 the continuous line represents the projected Levis graph, at $\theta = 7°\ 45'$ and $\phi = 34°$, while the dotted line represents the actual record at *Platon*[1] on the same day.

In (*b*) the continuous line shows the projection of the Levis curve at $\theta = 55°$ and $\phi = 2°$, while the dotted line gives the correct graph for *Richelieu*[1] on the same day.

Similarly in (*c*) the continuous line gives the Levis record after projection at $\theta = 75°$ and $\phi = 10°$, while the dotted line gives the actual

[1] Platon, Richelieu and Cap à la Roche are respectively 30, 40 and 50 miles approximately, above Levis.

tide at *Cap à la Roche*[1] on the same day. (The angle θ, in this last case could only be obtained approximately, owing to a limitation in the apparatus when large angles were used.)

Other combinations of θ and ϕ with a different scale of plotting, were found also to give a good agreement, but this range in adjustment has not yet been considered. It is, however, apparent that if we have the tides at Levis, and also some previous sets for other stations, together with the usual tidal information sufficient to fix an origin with reference to time and height, that a method for predicting the tides at the other stations and tracing the changes up the river should be capable of development.

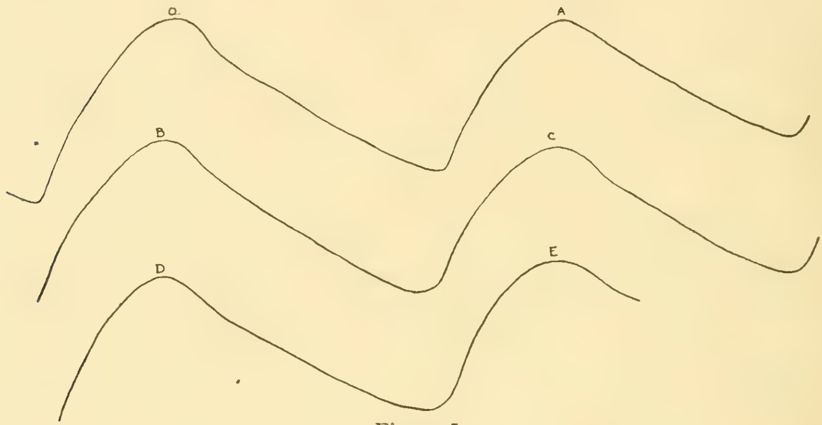


Figure 5

It was of interest to note whether any one or more of the constants of projection could be associated with any physical tidal constants, and thus give this method a further advantage. The expression $y=f(ax+by)$ in relation to $y=f(cx)$, is quite compatible with a possible dynamical significance for the constants of projection in a case such as that of our estuary tides.

Figs. 5 and 6 show the results of one test which was performed with this idea in view. The converse method of projection as in Fig. 2, was, for convenience, adopted again. Six consecutive tides at Quebec for June 7, 8 and 9, 1917, are given in Fig. 5. In Fig. 6, the continuous line represents the projections of the successive tides at the angles given below, and the broken line gives the corresponding pure sinusoids in which r' varies from loop to loop. The following table shows how adjustment can be made so that most of the variations can be associated mainly with a change in ϕ, and a change in r'; A' and r' refer to the sinusoid produced by projection and are analogous in meaning to A and r.

[1]Platon, Richelieu and Cap à la Roche are respectively 30, 40 and 50 miles approximately, above Levis.

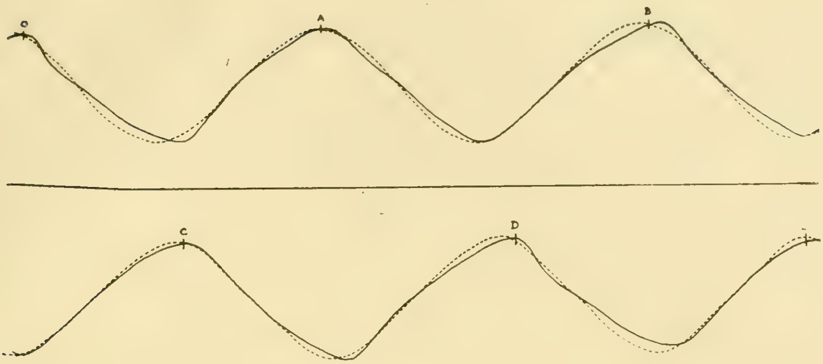


Figure 6

	θ	ϕ	A′	r′
From O to A..............	31°	37°	2·0 cm.	1·35
From A to B..............	31	34	2·0	1·38
From B to C..............	31	40	2·0	1·35
From C to D..............	31	37 30′	2·0	1·39
From D to E..............	31	36 30′	2·0	1·37

Three of these variables are ordinarily independent, but this number is reduced to two here, where there is a constancy in some of the physical factors, and it is reasonable to associate ϕ and r′ with such tidal constants as vary with the time. The fact that θ can be kept constant, while approximately the same value of A′ is obtained in each case, suggests further that the tidal change from day to day may also be associated with the inclination of the axes of approximate symmetry (measured by ε) and some one other variable, determinable from the graphs for consecutive tides. A series of comparisons along these lines with an examination of the variation of ε with the usual solar and lunar constants might lead to further simplications in tidal analysis.

It is considered that the perfecting of any method of analysis of this general type should be taken up in some laboratory where there are available, the apparatus, the methods and the experience which are associated with constant work in tidal prediction and allied forms of analysis. The writers have aimed to indicate the possible feasibility of Dr. Dawson's suggestion, but do not feel that a complete demonstration of its utility can be made without an extended analysis and further consideration of a large number of tides in the light of the special requirements of hydrographers. The results illustrated in Fig. 4 alone appear to have justified the work; they are most suggestive and apparently fit the particular difficulty which led to these projection experiments, but it is apparent that in the development of the technique and practical directions for analysing estuary tidal curves in this manner, and in the possible association of the new constants with some physical factors, most of the work remains to be done.

§4. *The Projection Apparatus.* The apparatus which was assembled for these tests was of a very simple character. The main part of the apparatus, shown in Fig. 7, was constructed from part of the framework and stand designed for an adjustable mirror. The rotation of the supporting stand as a whole gave the angle θ, while the inclination of the frame about its axis which was fixed in direction with reference both to the frame and its stand, gave the angle ϕ. In an improved instrument, the size of the frame should be increased and its solid parts should be reduced to minimum dimensions in order to avoid the shadows which interfere seriously when the angles of projection are large.

Behind the tilting frame lies the "projection plane" or "plane of reference," which is parallel to, and will receive the same projections as the imaginary "initial plane." It is conveniently made with a plate of glass, to which paper may be stuck ready for the tracing of the projected shadows.

An ordinary magic lantern is suitable for the production of the beam of light, but a large and very good lens must be employed in order to get a satisfactory parallel beam giving sharp definition to the shadows. In our case the objective of a large telescope was used, in such a way that the various parts of any given figure could in turn be projected by the central part of the beam.

The graphs were cut out of thin, stiff cardboard, and held in place by drawing pins and thin metal supporting strips as shown in the photograph.

A telescope and distant mirror were also tried instead of the beam from the lantern, but the accuracy obtained in tracing the curves by this method was inferior, and the process very tedious in comparison.

In conclusion the writers desire to express their thanks and to record their indebtedness to Dr. Dawson, who suggested the problem, and who has very kindly written the introduction (§1.) to these notes.

SUMMARY

The arbitrary character and the undesirability of the customary methods of analysing estuary tidal curves are pointed out, and a "projection" method is suggested. The elementary theory and the procedure of this method are outlined, also a description is given of a simple apparatus for such analysis. It appears probable from a series of projection experiments, that any tidal graph for one tide may very approximately be obtained by projection from one wave length of a pure sinusoid, the transformation involving three parametres; also that the tidal graphs for any place on an estuary may, in some cases, be obtained *as a whole* by the projection of the tidal graphs at some other place on that estuary, only two parametres being required. The importance of this relationship, and its possible application to tidal prediction is emphasized. The association of the parametres which are needed in the projection method, with the physical tidal factors, is also discussed.

McGill University.

Figure 7

The Mutual Potential Energies of Circular Coils and Small Magnets.

By A. NORMAN SHAW, D.Sc.

Presented by PROF. L. V. KING, D.Sc., F.R.S.C.

(Read May Meeting, 1919.)

§1. INTRODUCTION.

While determining certain small corrections in connection with the use of the Weber type of electrodynamometer for absolute measurements,[1] the writer had to consider the mutual potential energies of the dynamometer coils and the magnets of a small magnetometer; and the following notes, arising from this, are reported with the hope that they may be of service in connection with any problem which requires the accurate consideration of the magnetic potential due to small magnets. It will be observed that a number of points are raised in the paper without reference to any authority; this is due to the fact that the general method was derived from the lecture course on the theory of electrical measurements given by Dr. G. F. C. Searle at the Cavendish Laboratory, and apart from the well known sections in Maxwell[2] and in Gray[3] which deal with the application of Zonal Harmonics to problems in potential, no other authorities were consulted. A search in the literature on these subjects has been made since, and led to the conclusion that these notes might be of nterest.

The main points of the paper are to show (1) that even in some null methods it may be necessary to consider the influence of the characteristic constants of a magnetometer, and (2) that these constants may be determined with the aid of standard coils, in a comparatively simple manner.

§2. *The Significance of the Characteristic Constants of a Thin Magnet.*

The chief difficulty in the theory of electrical instruments which involve the use of coils and magnets, lies in the exact calculation of the couple on the moving system. In the usual symmetrical instruments the axes of the two systems intersect, and the couple tending

[1]A. N. Shaw, *Phil. Trans.*, A, Vol. 214, pp. 147-198, (1914).

[2]Maxwell, *Electricity and Magnetism* (third edition), Vol. 2, Ch. 14.

[3]Gray, *Absolute Measurements in Electricity and Magnetism*, Vol. 2, Ch. 1-6, also Appendix, Vol. 2, pt. 2.

to decrease θ, the angle between the axes, is equal to $\frac{dW}{d\theta}$ where W is the mutual potential energy of the two systems. W depends upon the current in the coils, upon the shape and size of the coils, upon the strength of the magnets, upon the distribution of magnetism, and upon the space included between the two systems and straight lines joining their boundaries. It is the presence of this last factor which is responsible for any difficulty in the matter, and it obviously resolves itself into a question of solid angles. By expressing the required solid angles in terms of Zonal Harmonics, a very convenient way of defining and determining the constants of the magnetic system can be developed.

Let us take M, L_1, and L_2, as the chief constants for a thin magnetic system, where M is the magnetic moment, L_1 is the "active" or "effective" length, and L_2 another unknown constant. It is on the significance and evaluation of these quantities that we shall centre our attention. In null methods which involve the simultaneous use of coils of different sizes with a magnetometer, a correction factor comes in, which includes these constants (see equation (7)), and in direct magnetic measurements they become of fundamental importance. M is well known, L_1 is frequently discussed, somewhat erroneously, under the title "equivalent length", and L_2 is generally ignored along with other constants of a lower order.

If m is the pole strength at a point in a thin magnet, and l is the distance of the point from the centre of the magnet, we have for the whole system, $M = 2\Sigma ml$; also $L^2_1 = {}^{(2\Sigma ml^3)}/M$; and $L^4_2 = {}^{(2\Sigma ml^5)}/M$. The difference of each of L_1 and L_2 from $M/_{\Sigma m}$ should be noted, because the latter quantity which is not required in this analysis, is sometimes taken as the equivalent length and used for L_1 and L_2 in approximate formulae. The expression below shows at once how these values arise. The potential, V, at a point r, θ due to a thin magnet, can be shown to be given by

$$V = \frac{(\Sigma 2ml)P_1}{r^2} + \frac{(\Sigma 2ml^3)P_3}{r^4} + \frac{(\Sigma 2ml^5)P_5}{r^6} + \dots$$

$$= \frac{MP_1}{r^2} + \frac{ML^2_1P_3}{r^4} + \frac{ML^4_2P_5}{r^6} + \dots\dots\dots \quad (1)$$

where P_1, P_3, P_5, etc., are zonal harmonics for cos θ of the orders 1, 3, 5, etc., respectively.

§3. *The Mutual Potential Energy of a Coil and a Small Magnet.*

It can be shown that if the point potential of a system of revolution, X, on its axis *at a distance*, x, from the origin is expressed in the form

$$\frac{a_0}{x}+\frac{a_1}{x^2}+\frac{a_2}{x^3}+\frac{a_3}{x^4}+\ldots\ldots$$

where a_0, a_1, a_2, etc., are constants, and if the point potential of a system of revolution, Y, on its axis *near* the origin is expressed in the form

$$b_0+b_1x+b_2x^2+b_3x^3+\ldots\ldots$$

where b_0, b_1, b_2, etc., are constants, then, if the axes of X and Y are inclined at an angle θ, the origin being chosen at the point of intersection, the mutual potential energy of the two systems will be given by

$$W=k(a_0b_0P_0+a_1b_1P_1+a_2b_2P_2+\ldots.) \quad \ldots\ldots (2)$$

where k is a constant.

If X is our magnetic system we see from equation (1) that

$$a_0=a_2=a_4=\ldots.=0$$

and equation (2) becomes

$$W=k(a_1b_1P_1+a_3b_3P_3+\ldots) \quad \ldots\ldots (3)$$

where

$$a_1=M,\ a_3=ML^2_1,\ a_5=ML^4_2,$$

and the series is so rapidly convergent in almost all practical cases that further terms amount to magnitudes affecting W by much less than one part in a hundred thousand.

If Y is the electrical system and consists for example of a plane circular coil of radius r, with its centre at a distance y from the origin and if N is the number of turns assumed to occupy a channel of, infinitesimal dimensions (corrected below), then it can be shown that

$$b_n=2\pi n(r^2+y^2)^{-n/2}\{\cos\phi\,.\,P_n(\cos\phi)-P_{n-1}(\cos\phi)\} \quad \ldots\ldots (4)$$

where $\cos\phi=y(r^2+y^2)^{-1/2}$, an if there are several coils we have merely to consider each pair of reacting systems separately and then superimpose the effects. From equation (4) we note the familiar

$$b_1=-2\pi Nr^2/(r^2+y^2)^{-3/2}$$

$$b_2=-4\pi Nr^2(y^2-r^2/_4)\,/\,(r^2+y^2)^{7/2}$$

$$\text{and } b_5=-6\pi Nr^2\left(y^4-\frac{3}{2}r^2y^2+\frac{r^4}{8}\right)/(r^2+y^2)^{11/2}$$

It will be seen that if the centre of Y is placed at a distance $y=r/2$ from the point of intersection of the axes, the value of b_3 is reduced to zero. (This is the case in the double tangent galvanometer, in the electrodynamometer, and in the method to be suggested for the determination of L_1 and L_2.) In this case our value for W reduces to

$$W = k(a_1 b_1 P_1 + a_5 b_5 P_5) \qquad (5)$$

The correction for the finite dimensions of the windings in a coil is such that b_1 should be multiplied by

$$1 + \frac{1}{24}\left(\frac{2}{r^2} - 15\frac{y^2}{(r^2+y^2)^2}\right)\epsilon^2_1 + \frac{1}{8}\,\frac{4y^2 - r^2}{(r^2+y^2)^2}\,\epsilon^2_2 + \text{(terms usually negligible)}$$

where ϵ_1 and ϵ_2 are respectively the depth and breadth of the windings. This value is obtained by integrating our expression over the given cross section of the windings (See §700, Maxwell, *loc. cit.*). In the case $y = r/2$, this reduces to

$$\left(1 - \frac{1}{60}\,\frac{\epsilon^2_1}{r^2}\right) + \text{(terms usually negligible)}$$

and is thus practically independent of ϵ_2, the breadth of the coil winding. The corresponding correction for b_5 is negligible in all practical cases.

§4. *The Determination of M, L_1, and L_2.*

The methods of determining M are well known and it is sufficient to point out that the presence of L_2 with L_1 in the equations cannot always be neglected. Kohlrausch's method for determining L_1 is perhaps the best standard method,[1] and is suitable provided again that the value of L_2 may be neglected or estimated.

The following method of determining these quantities is suggested. Two (or more) carefully measured circular coils of quite different sizes are set up in such a way that the intersection of their axes is at a distance of half a radius respectively from each coil. A small magnet to be tested is placed so that its axis intersects at the same point. For convenience in calculation and measurement the most suitable

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[1]In Kohlrausch's method two concentric coils are placed in the meridian and connected in parallel. If a current is sent through them and supplementary resistances are adjusted until there is no effect on a *very small* magnet at the centre, we have $n_1 i_1/a_1 = n_2 i_2/a_2$ where n, i and a represent the number of turns, the current and the radius in each case. The magnet to be examined is then substituted for the small testing magnetometer, and the current is reversed. If $H \cos\theta$ is the couple due to the earth's field, it can be shown (if the terms containing L_2 may be neglected or otherwise determined), that

$$L^2_1 = (2a_1 H \cot\theta)/3\pi n_1 i_1 (5\cos^2\theta - 1)\left(\frac{1}{a^2_2} - \frac{1}{a^2_1}\right).$$

arrangement is to place the coils so that they have a common axis and are at a distance apart equal to half the sum of their radii, and to put the magnet with its centre at the origin, the whole being arranged so that the magnet and the planes of the coils lie in the meridian. If the currents i_1 and i_2 in the two coils are adjusted so that the magnet is balanced, we have

$$\frac{dW_1}{d\theta} = \frac{dW_2}{d\theta}$$

where θ is equal to $\pi/2$, and W_1, and W_2 are respectively the mutual potential energies of each coil and the magnet. We have from equation (5) which holds for this arrangement,

$$W_1 = i_1(Mb_1P_1 + ML^4{}_2b_5P_5)$$

and $$W_2 = i_2(Mc_1P_1 + ML^4{}_2c_5P_5)$$

where c_1 and c_2 for the second coil, correspond to b_1 and b_2, for the first. Hence

$$\frac{dW_1}{d\theta} = i_1\left(Mb_1\frac{dP_1}{d\theta} + ML^4{}_2b_5\frac{dP_5}{d\theta}\right) \quad \ldots\ldots\ldots\ldots (6)$$

and similarly for W_2,

but $\dfrac{dP_1}{d\theta} = \sin\theta$, and $\dfrac{dP_5}{d\theta} = \dfrac{15}{8}\sin\theta(21\cos^4\theta - 14\cos^2\theta + 1)$

therefore when $\theta = \dfrac{\pi}{2}$

$$i_1\left(Mb_1 + \frac{15}{8}ML^4{}_2b_5\right) = i_2\left(Mc_1 + \frac{15}{8}ML^4{}_2c_5\right) = K \quad \ldots\ldots (7)$$

therefore $L^4{}_2 = (i_2c_1 - i_1b_1) \Big/ \dfrac{15}{8}(i_1b_5 - i_2c_5) \quad \ldots\ldots\ldots\ldots (8)$

Now i_1, i_2, b_1, b_5, c_1, c_5, can be determined with great accuracy, but unfortunately the quantities separated by the minus signs are usually very nearly equal. It is, however, possible to determine the couple K (equation (7)), mechanically and also to use more coils, and with the aid of these extra quantities the accuracy can be improved.

It will be seen that M can be determined at the same time from equation (7) if K is known, and if we move our coils to new positions such that the b_3 and c_3 terms are not zero, we can obtain L_1 from the equations which contain these terms.

It will be apparent from considerations based on equations (3) and (7) that the use of a null method in magnetometric tests does not necessarily eliminate the constants of the magnetometer from the required calculations.

§5. *Three Examples of the Magnetic Constants in Common Formulae.*

(*a*) In the ordinary tangent galvanometer, the formula for the couple, namely $\frac{2\pi niM \sin\theta}{r}$, becomes at length

$$\frac{2\pi niM \sin\theta}{r}\left(1-\frac{3}{4}\frac{L^2{}_1}{r^2}(5\cos^2\theta-1)+\right.$$
$$\left.\frac{45}{64}\frac{L^4{}_2}{r^4}(21\cos^4\theta-14\cos^2\theta+1)+\ldots\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots(9)$$

(*b*) The formula for the double tangent galvanometer follows at once from equation (6). The correction, if expressed as in (9) has the obvious advantage that the second term containing L_1 vanishes under the conditions already mentioned.

(*c*) The complete formula for the couple in magnetometric tests where x is the distance apart of the centres of two magnets with constants M, L_1, L_2, and m, l_1, l_2 respectively, is, in the case of the "sine" or "side-on" method given by

$$\frac{2Mm}{x^3}\left(1+\frac{2L^2{}_1-3l^2{}_1}{x^2}+\frac{24L^4{}_2-120L^4{}_2l_2{}^4+4l^4{}_2}{8x^4}+\ldots\right)\ldots\ldots(10)$$

SUMMARY.

This paper discusses the significance of the characteristic constants of small magnets and points out that the use of Zonal Harmonics leads to an expression of their value in a determinable form. The calculation of mutual potential energy in a special case is reviewed, and an application is made to the experimental determination of the magnetic constants. The details of the procedure are outlined, and the paper concludes with a brief reference to the occurrence of these constants in common formulae.

In conclusion the writer desires to repeat his indebtedness to Dr. G. F. C. Searle for the general method of treatment, and to express his thanks most heartily.

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Absorption of Light by Thin Films of Rubber

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Presented by E. F. BURTON, F.R.S.C.

(Read May Meeting, 1919.)

Considerable work on the influence of light on rubber has been done by Victor Henry. In his investigations he experimented with pure unvulcanized rubber, and with vulcanized rubber cured in different ways.

The pure rubber as obtained from Para sheets was exposed to the rays of a mercury vapour lamp for several hours. The samples exposed in this manner showed considerable change in colour and lost their elasticity, being readily torn. The change in the rubber appeared to depend on the colour of the original sheet, the dark brown sample being altered at the surface only, while the "yellow plantation" was changed through a considerable thickness. The vulcanized samples had to be left for a much longer period than that of the unvulcanized before any apparent change was noted.

An effort was also made to determine what particular part of the spectrum was most injurious to the rubber. He arrived at the conclusion that the rays below 3000 A. are the most active in this respect. Some of the rays between 4000 and 3000 A. were strongly absorbed, but the most refrangible rays are the particular agents which alter the rubber, the unvulcanized samples being altered most.

The foregoing results were confirmed during the course of the preliminary work in the present investigation, and prove conclusively that light has a very great influence on rubber and that certain wave lengths are more active than others in this respect. Beyond ascertaining the effect of light on rubber in changing its appearance, elasticity and general physical properties, no attempt was made, by previous investigators, to obtain in a quantitative way the absorption of light for different parts of the spectrum.

The purpose of this investigation was to ascertain in a quantitative manner the amount of light absorbed by rubber and how it varied for different wave lengths.

Pure Para rubber sheets were obtained, light brown in colour and several millimetres thick. Efforts were made to cut the sheets into thinner ones, for this purpose a microtome being used, but owing to the great elasticity of the rubber this method had to be abandoned as also an attempt made with a freezing microtome. Thin slices were ultimately obtained by freezing the rubber in liquid air and then cutting it with a sharp knife or razor. Slices obtained in this way were still too thick for satisfactory work and it was necessary to obtain sheets which had been rolled out by mechanical means. These were quite thin and could be readily used in all experimental work.

Preliminary tests were made to determine whether there were any absorption bands produced in a continuous spectrum. A quartz uviol spectrograph was used for this determination. As a source of light, a Nernst lamp was used, and also an arc in which different metals could be inserted as terminals. A photograph of the spectrum produced by the Nernst was first obtained and directly below it a photograph of the spectrum after it had passed through a thin sheet of rubber mounted directly in front of the slit of the spectrograph. In this way the two spectra could be readily compared and their characteristics noted.

The photographs obtained show that rubber absorbs light and that the more refrangible rays are more readily absorbed, so that any change or alteration in the characteristics of the rubber must be due principally to these rays. These results are, however, not sufficiently quantitative in nature to warrant any definite assumption as to the amount of light that is being actually absorbed.

The second stage of the experimental work was undertaken with the object of determining more definitely in a quantitative way a measure of this absorption. A suitable method of investigation is afforded by the photo-electric cell. The cell used in this work was of the round bulb type, about 5 cm. in diameter and made of glass. The arrangement of the apparatus was as shown in the following diagram. (Fig. 1.)

The source of illumination (A) was a Nernst lamp, the filament of which was focused by a quartz lens (L) on the slit of a monochromatic illuminator (M). The light on emerging from (M) fell on the photo-electric cell (C), the silvered surface being charged to a potential of 6 volts by a battery (B). The filament of the cell was joined through insulated connections to one pair of quadrants of a quadrant electrometer (Q), the other pair of quadrants being earthed. The quadrants joined to the cell could be earthed by the earthing needle (N). The needle of the electrometer was charged to a constant high potential by a Tucker Hydroscopic Battery (H). The electrometer when adjusted had a sensibility of 330 divisions per volt. The sensibility curve is shown in Fig. 2.

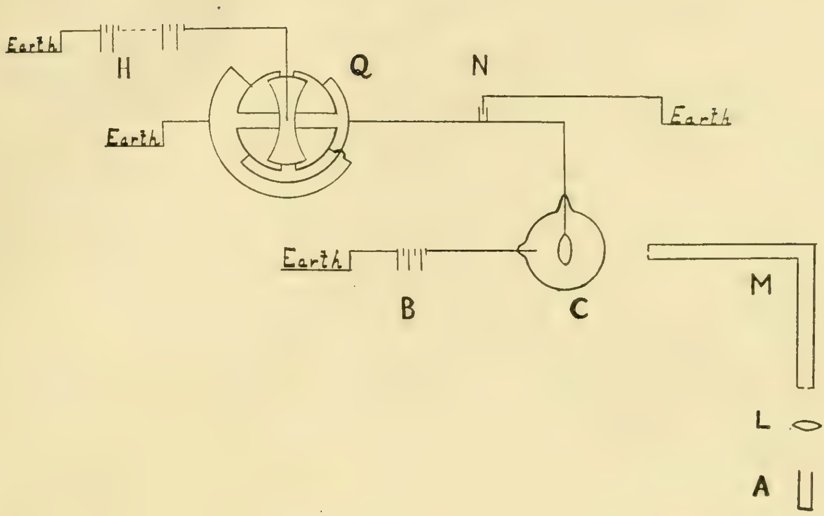

Figure 1

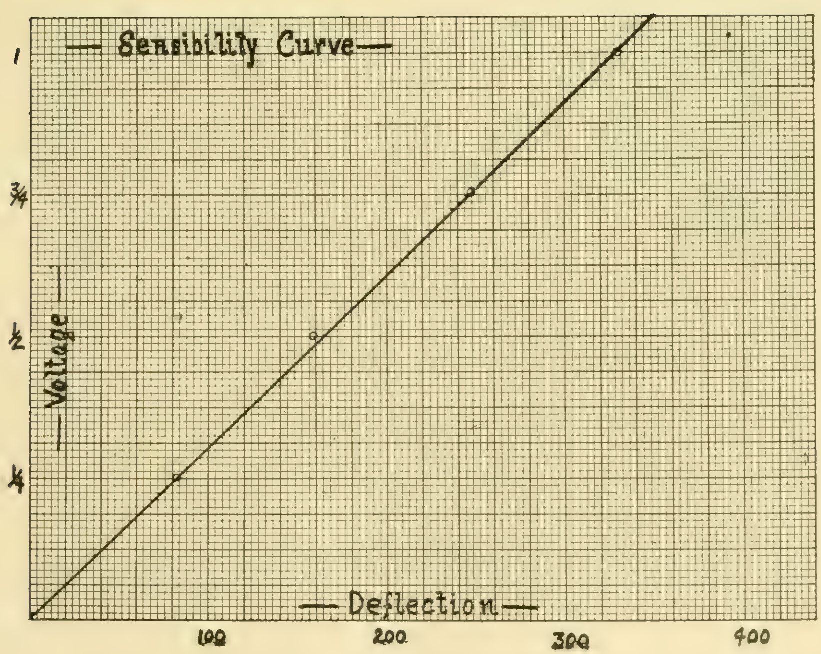

Figure 2

Light of any desired wave length could be introduced into the cell and the rate of drift of the needle noted on a scale suitably mounted in front of the electrometer. The wave length of the light introduced into the cell was altered from 7260 A.U. to 3140 A.U., by successive stages, and the rate of drift taken for each particular stage. This was repeated for each set of readings taken. The intensity curve for the variation of the deflection with the wave length for the different sets of readings varied but slightly, a typical curve being that shown in Fig. 3. In this curve we see that the maximum drift was obtained at

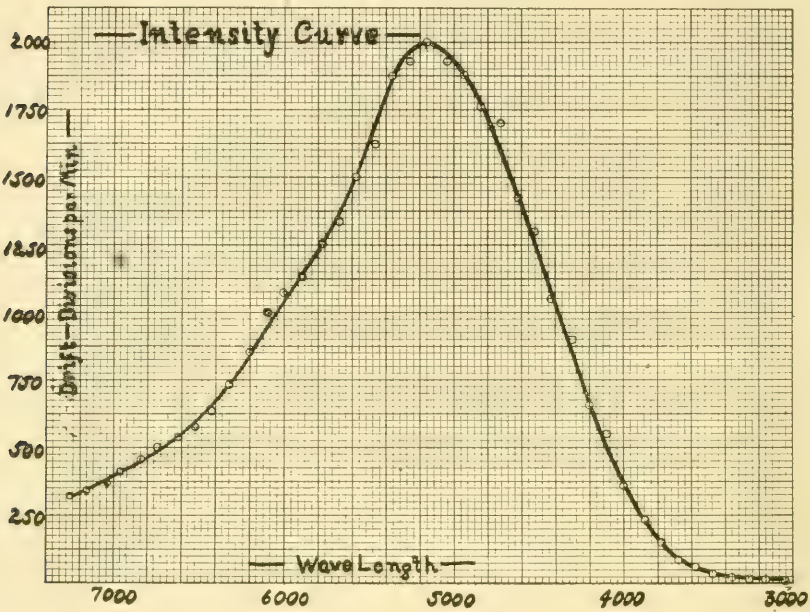

Figure 3

a wave length of 5160 A. After a set of readings as indicated were taken the rubber was placed directly in front of the slit of the spectrograph. The thin sheet of rubber was held between brass plates about 8 cm. by 5 cm., in the centre of which had been cut a small rectangular opening about 1 cm. long and ·3 cm. wide. The brass plate cut out all the extraneous light and only that passing through the rectangular opening where the rubber was exposed, was permitted to fall on the slit of the instrument. Readings for the rate of drift of the needle were again noted. In this way two sets of readings were obtained for any particular wave length, the first due to the effect of the light direct, the second due to the effect of the light after passing through the rubber, from which the percentage absorption can be readily calculated.

The following tables show the results obtained from four sets of readings. Table V shows the percentage absorption as obtained in each of the four separate sets and an average of the four sets is shown in Column No. 5 of Table V, from which an average curve was plotted and is shown in Fig. 4.

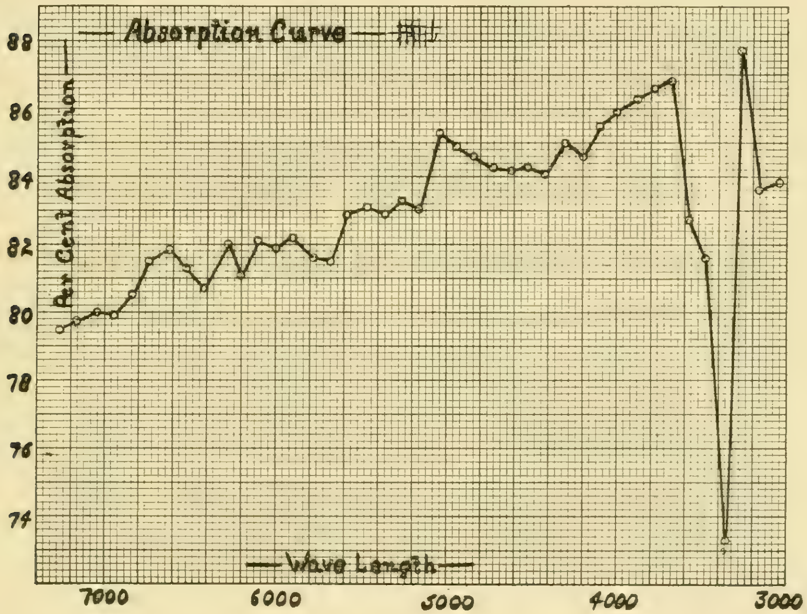

Figure 4

In each of the following tables, Column No. 1 gives the wave length in Angstrom Units; Column No. 2 gives rate of drift, light falling direct; Column No. 3 gives rate of drift, light passing through rubber; Column No. 4 gives percentage absorption.

TABLE I

1 Wave Length	2 Rate of Drift (Direct)	3 Rate of Drift (through rubber)	4 Absorption
7260	304	70·5	76·8
7160	331	76·2	77·1
7050	364	79·2	78·2
6950	426	88·4	79·2
6840	460	99·3	78·4
6740	515	112·0	78·2
6620	598	120·0	79·9
6520	611	132·0	78·4
6420	665	158·2	76·2
6320	855	174·5	79·6
6200	822	206·1	76·6
6100	1032	234·2	77·4
6000	1089	268·1	75·4
5900	1198	298·0	75·0
5780	1361	330·6	75·8
5680	1427	366·0	74·4
5580	1620	382·4	76·4
5460	1716	398·0	76·8
5360	1620	398·3	75·4
5260	1765	398·0	77·4
5160	1620	372·5	76·0
5040	1578	279·5	82·3
4940	1461	298·0	79·8
4840	1275	281·0	78·0
4720	1175	269·4	77·2
4620	1019	222·7	78·6
4520	855	176·6	79·4
4420	644	133·6	79·4
4300	506	96·1	81·0
4200	378	68·3	81·9
4100	273	47·3	82·7
4000	181	29·8	83·5
3880	121	18·6	84·6
3780	74·5	12·2	83·6
3680	45·6	7·5	83·5
3580	31·2	4·6	85·3
3480	20·8	3·5	83·2
3360	14·8	2·6	82·6
3260	11·3	1·8	84·0
3160	8·4	1·6	80·9
3040	5·9	1·2	79·6

TABLE II

1 Wave Length	2 Rate of Drift (Direct)	3 Rate of Drift (through rubber)	4 Absorption
7260	344	52·3	84·8
7160	379	57·6	84·8
7050	422	63·0	85·1
6950	461	68·0	85·3
6840	492	75·4	84·7
6740	535	82·6	84·6
6620	600	93·0	84·5
6520	660	102·8	84·4
6420	760	118·2	84·4
6320	870	135·4	84·4
6200	984	150·0	84·7
6100	1090	168·7	84·6
6000	1175	190·2	83·9
5900	1305	211·3	83·9
5780	1500	231·5	84·6
5680	1875	255·6	86·4
5580	2000	274·4	86·3
5960	2075	292·0	85·6
5360	2212	325·3	85·3
5260	2212	328·6	85·2
5160	2310	325·4	85·9
5040	2400	325·4	86·5
4940	2400	332·4	86·2
4840	2212	310·1	86·1
4720	2000	299·2	85·1
4620	1875	271·8	85·5
4520	1430	230·0	83·9
4420	1200	201·6	83·3
4300	1015	162·2	84·1
4200	845	128·5	84·8
4100	618	98·6	84·1
4000	462	69·8	84·8
3880	312	45·1	85·6
3780	208	27·3	86·8
3680	126	16·0	87·3
3580	79·6	9·4	88·3
3480	50·3	5·8	88·7
3360	34·1	4·1	88·3
3260	24·2	3·1	87·6
3160	18·6	3·0	83·9
3040	14·0	2·0	85·7

TABLE III

1 Wave Length	2 Rate of Drift (Direct)	3 Rate of Drift (Through Rubber)	4 Absorption
7260	242	70·0	71·1
7160	254	77·4	71·5
7050	292	83·5	71·4
6950	300	91·4	69·6
6840	364	96·2	73·6
6740	426	100·3	76·5
6620	463	110·0	76·4
6520	500	122·8	75·5
6420	548	134·7	75·6
6320	635	148·5	76·5
6200	665	166·3	75·1
6100	756	173·1	77·1
6000	935	190·0	79·7
5900	1070	209·1	81·2
5780	1000	230·4	77·0
5680	1090	241·6	76·2
5580	1200	249·9	79·2
5460	1250	250·2	80·0
5360	1300	261·0	79·8
5260	1330	278·0	78·9
5160	1330	300·0	77·4
5040	1460	278·0	81·0
4940	1460	263·0	82·0
4840	1430	241·6	83·0
4720	1330	220·0	83·3
4620	1110	205·0	81·9
4520	1090	179·6	83·7
4420	951	160·0	83·2
4300	782	130·0	83·4
4200	553	103·0	81·4
4100	453	74·0	83·6
4000	333	53·0	84·1
3800	238	39·0	83·6
3780	162	25·0	84·6
3680	94·1	14·0	85·1
3580	54·4	19·0	65·2
3480	32·5	11·8	63·4
3360	12·0	8·3	31·0

TABLE IV

1 Wave Length	2 Rate of Drift	3 Rate of Drift (Through Rubber)	4 Absorption
7260	320	47·6	85·2
7160	339	50·0	85·3
7050	364	53·1	85·4
6950	413	60·0	85·5
6840	455	60·8	85·3
6740	500	65·9	85·8
6620	533	71·3	86·6
6520	575	76·4	86·7
6420	637	84·6	86·7
6320	730	91·3	87·5
6200	855	101·0	88·2
6100	1000	108·7	89·2
6000	1070	121·1	88·7
5900	1130	129·2	88·6
5780	1250	138·9	88·9
5680	1332	150·0	88·8
5580	1550	155·0	88·7
5460	1620	160·2	90·1
5360	1872	162·2	91·3
5260	1936	165·9	91·5
5160	2000	168·9	91·6
5040	1936	168·0	91·4
4940	1872	162·2	91·4
4840	1764	152·2	91·5
4720	1712	143·3	91·7
4620	1428	130·2	90·4
2520	1200	115·3	90·4
4420	1051	100·0	90·7
4300	907	80·0	91·4
4200	665	65·0	90·2
4100	554	48·0	91·8
4000	363	34·0	91·3
3880	242	23·5	91·4
3780	155	16·0	91·3
3680	88·4	10·0	91·4
3580	57·2	7·0	91·9
3480	34·8	5·5	91·2
3360	24·0	4·5	91·2
3260	19·0	4·0	91·5
3160	15·0	4·5	86·0
3040	13·0	4·4	86·2

TABLE V

Wave Length	No. 1	No. 2	No. 3	No. 4	No. 5
7260	76·8	84·8	71·1	85·2	79·5
7160	77·1	84·8	71·5	85·3	79·7
7050	78·2	85·1	71·4	85·4	80·0
6950	79·2	85·3	69·6	85·5	79·9
6840	78·4	84·7	73·6	85·3	80·5
6740	78·2	84·6	76·5	86·8	81·5
6620	79·9	84·5	76·4	86·6	81·8
6520	78·4	84·4	75·5	86·7	81·3
6420	76·2	84·4	75·6	86·7	80·7
6320	79·6	84·4	76·5	87·5	82·0
6200	76·6	84·7	75·1	88·2	81·1
6100	77·4	84·6	77·1	89·2	82·1
6000	75·4	83·9	79·1	88·7	81·9
5900	75·0	83·9	81·2	88·6	82·2
5780	75·8	84·6	77·0	88·9	81·6
5680	74·4	86·4	76·2	88·8	81·5
5580	76·4	86·3	79·2	88·7	82·9
5460	76·8	85·6	80·0	90·1	83·1
5360	75·4	85·3	79·8	91·3	82·9
5260	77·4	85·2	78·9	91·5	83·3
5160	76·0	85·9	77·4	91·6	83·0
5040	82·3	86·5	81·0	91·4	85·3
4940	79·8	86·2	82·0	91·4	84·9
4840	78·0	86·1	83·0	91·5	84·6
4720	77·2	85·1	83·3	91·7	84·3
4620	78·6	85·5	81·9	90·4	84·2
4520	79·4	83·9	83·7	90·4	84·3
4420	79·4	83·3	83·2	90·7	84·1
4300	81·0	84·1	83·4	91·4	85·0
4200	81·9	84·8	81·4	90·2	84·6
4100	82·7	84·1	83·6	91·8	85·5
4000	83·5	84·8	84·1	91·3	85·9
3880	84·6	85·6	83·6	91·4	86·3
3780	83·6	86·8	85·1	91·3	86·6
3680	83·6	87·3	65·2	91·4	86·8
3580	85·3	88·3	63·4	91·9	82·7
3480	83·2	88·7	31·0	91·2	81·6
3360	82·6	88·3		91·2	73·3
3260	84·0	87·6		91·6	87·7
3160	80·9	83·9		86·0	83·6
3040	79·6	85·7		86·2	83·8

On examining the intensity curve (Fig. 3), it will be noted that for wave lengths in the region of 6500 A. and all above that wave length the instrument is not very sensitive, similarly, for very short wave lengths (from 4000 A. down) it is much less sensitive, so that for the two ends of the spectrum the results will not be as accurate as for the region about 5000 A. in which the rate of drift is fairly rapid.

The absorption curve (Fig. 4) indicates that we were wrong in assuming that very little light was being absorbed in the red region. Even if the results are not reliable above 6500 A. we see that there is a large percentage of the light being absorbed which increases as the wave length decreases, but does not become complete at any point as we were led to suppose in our first investigation. The points group themselves in a more or less regular curve with an abrupt change in the percentage absorption. This abrupt change is characteristic of all the curves for the particular wave length at which the change occurs. The curve becomes very irregular as the wave length decreases, owing to the rate of drift being very slow, hence accurate or reliable results are difficult to obtain. Throughout the visible part of the spectrum the proportion of light absorbed is a large fraction of the incident light and increases as the wave lengths decreases till about 3800 A. is reached. Beyond this point nothing definite can be concluded since the glass of which the photo-electric cell is made may be absorbing an appreciable amount of the ultra-violet rays that are emitted by the Nernst lamp and so their action is not recorded by the apparatus.

This work was done under the direction of Professor E. F. Burton.

The Effects of Ageing in Standard Weston Cells of a Modified Type

By A. NORMAN SHAW, D.Sc., and H. E. REILLEY, M.Sc.

Presented by DR. L. V. KING, F.R.S.C.

(Read May Meeting, 1919.)

§1. INTRODUCTION

The investigations on standard cells at the Macdonald Physics Building, McGill University, were commenced by Prof. H. L. Callendar, F.R.S., and Prof. H. T. Barnes, F.R.S., in 1896, and a large number of the older types of cells were constructed and examined.[1] In 1908, the investigation was resumed by Dr. H. L. Bronson and one of the present writers (A.N.S.), at the suggestion of Prof. Barnes, in order to equip the laboratory with a set of modern standards, and to provide means of completing some experiments which were in progress at that time. The opportunity was taken to consider thoroughly the general questions of reproducibility and constancy of standard cells and the relationship to one another, of the various existing types[2]. In 1910 and 1911, an investigation was conducted by one of the writers on the absolute measurement of the electromotive force of the international normal Weston standard cell[3], and at this time further observations were made on the behaviour of the various cells.

The present notes refer to the continuation of these tests in the summer of 1912 and during the winter of 1918–19. They deal especially with the effects of ageing in Weston standard cells of various types. It has been found that the constancy and accuracy of certain types of Weston cell, which may be constructed in any laboratory, compare favourably with those made according to elaborate and more costly specifications. The assurance with which an absolute value of voltage may be determined from a batch of old cells is discussed, and some objectionable characteristics of old cells are noted, together with simple methods of treatment for their improvement.

It should be pointed out that this laboratory is in a fortunate position to discuss the international mean value of the e.m.f. of the

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[1] Callendar and Barnes, *Proc. Roy. Soc.*, Vol. 62; p. 117 (1897); also Barnes, *Phil. Trans.* A, Vol. 199, p. 159 (1902).

[2] Bronson and Shaw, *British Association Report*, Vol. 79, p. 396, (1909); Bronson and Shaw, *The Electrician*, Vol. 66, p. 698, (1911).

[3] A. N. Shaw, *Phil. Trans.* A, Vol. 214, pp. 147–198.

normal Weston standard. Not only have a number of cells been constructed and compared, but the following series of direct comparisons have made it possible to check with great accuracy for any given batch of cells, the calculated value of the deviation in voltage from the international mean value.

1. Six Weston cells carried *from* Bureau of Standards, Washington, in 1908.

2. Three Weston cells carried *to* Bureau of Standards, Washington, in 1909.

3. Three Weston cells carried *from* Bureau of Standards, Washington, in 1909.

4. Three Weston cells carried *from* the National Physical Laboratory, Teddington, in 1909.

5. Three Weston cells mailed *from* the National Physical Laboratory, Teddington, in 1909.

6. Four Weston cells carried *to* National Physical Laboratory, Teddington, in 1911.

7. Two Weston cells carried *from* the National Physical Laboratory, Teddington, in 1912.

8. Two Weston cells carried *from* the Bureau of Standards, in 1919.

It is with much pleasure that we record our indebtedness and thanks to Dr. Glazebrook and to Dr. Stratton for this kind help from the National Physical Laboratory and the Bureau of Standards, and especially to Dr. F. E. Smith and to Dr. Wolff who were respectively in charge of the cell investigations at these institutions.

§2. The Constancy of Normal and of Modified Standard Weston Cells During a Period of Ten Years

The following table shows the constancy of two of our standard batches, one composed of our normal, and the other of our modified cells, during a period of ten years. The results are expressed in microvolts, and with the exception of the lowest row of values, give the differences from the international mean value as determined with the aid of the various comparisons already enumerated. The last line is expressed in terms of our own normal cells and illustrates the remarkable confidence with which independent workers may rely upon standards constructed in their own laboratory according to modified specifications. An average drop of six microvolts per annum is assumed in the latter estimation.

THE ELECTROMOTIVE FORCE OF STANDARD BATCHES OF NORMAL AND OF MODIFIED WESTON CELLS DURING A PERIOD OF TEN YEARS

(Expressed as differences in microvolts from the international mean value).

		Nov., 1909	June, 1910	Sept., 1911	July, 1912	May, 1919
Normal Cells. (Batch II)	A	+ 3	+11	−12	−20	− 72
	B	+ 5	+13	−9	−14	− 70
	N	+ 3	+10	−28	−28	− 32
	Q2	−12	−36	−62	−54	− 52
	Q3	−28	−47	−71	−46	− 45
Modified Cells. (Batch IV)	C2	−11	− 6	−25	. .	− 38
	P1	−19	−11	−44	−45	− 50
	P2	−18	−11	−41	. .	−103
	P3X	+30	−15	−97	. .	−117
	P4X	+ 5	+ 6	−37	−44	− 88
Exchange cells of same age as the above batches. N.P.L.	S20	− 2	+16	−43	−48	− 95
	1·6	. .	. .	. .	−10	− 5
	1·8	. .	. .	. .	−10	− 15
B. of S.	197	. .	. .	. .	. .	− 62
	198	. .	. .	. .	. .	− 47
					Mean	− 45
Means of Batch II		− 6	−10	−36	−32	− 54
Means of Batch IV		− 3	− 7	−49	. .	− 79
Means that would have been assumed for a standard batch if there had been no direct comparisons		− 6	−10	−17	−22	− 63

It should be observed that the constancy of such cells is equal to that of good resistance coils. Much electrical precision work depends upon the comparison of accurate resistances, involving methods which could be replaced by potentiometer measurements and based, instead, upon the accuracy of standard cells. It should be noted that a standard cell can be made more easily, more cheaply and more rapidly than any resistance coil which could be expected to remain constant for several years with a similar degree of accuracy.

The records of several exchange cells of the same age have been included in the table in order to emphasize the remarkable reproducibility of these cells by independent workers, as well as the constancy of given types.

Further details concerning the construction and early records of our cells may be found in the paper by Bronson and Shaw *loc. cit.*

§3. Suggested Rules With Reference to the Construction and Use of Modified Standard Cells for Precision Work.

If an accuracy of at least two or three parts in a hundred thousand is to be expected from a small batch of standard cells, it will be found useful to follow the regulations suggested below:

1. *In Construction* (*a*) prepare the mercurous sulphate paste either chemically or electrolytically with great care, dry it and cover with a special solution to prevent hydrolysis; and make it slightly basic. If possible, however, obtain at least this one ingredient from a "standards" laboratory,[1] as slightly impure or acidic mercurous sulphate leads to subsequent variations in e.m.f. which are both progressive and variable in their development. (*b*) One distillation of mercury, bought as c.p., will be found to be sufficient. It should be noted that if the mercury is slightly impure, the resultant variation in e.m.f. is usually of a constant character, and after comparison the cell is as useful as others. (*c*) The cadmium sulphate should be the best quality commercial product c.p., rendered slightly basic with cadmium oxide. The exceptionally tedious recrystallizations specified for its purification do not appear to be necessary. (*d*) Cadmium is prepared in sticks of exceptional purity by many firms, and the commercial c.p. product has been found quite satisfactory.

2. *In choosing standards for reference* a batch of at least five cells should be chosen and of these there should be representatives of at least three separate constructions, each from different samples of ingredients.

3. Any cell the e.m.f. of which differs from the mean of the remainder by more than 100 microvolts should be rejected and replaced by a satisfactory substitute. It has been found that a cell which changes its e.m.f. some time after its construction to an amount exceeding 100 microvolts, usually becomes considerably worse. Unless they have had that value from the date of their construction, appar-

[1] The distribution of ready-made Hg_2SO_4, purified carefully by one of the best recognized methods, dried with alcohol and sent out in hermetically sealed tubes to various laboratories, is a very simple method of avoiding the chief source of trouble in standard cell construction.

ently few cells maintain a value of about 100 microvolts difference from the mean.

§4. Notes on the Repairing of Bad Cells

The remarks recorded in this last section are based in some cases upon the observation of only a few cells, and are mentioned therefore with some reserve. As other bad cells were not available and as there seemed to be no immediate probability of supplementing these observations, it was thought of sufficient interest to add these conclusions in their present form. The following list enumerates what loosely may be termed some of the main "diseases" of standard cells with their "symptoms" and "treatments."

1. *High Internal Resistance* (*a*) *With Hard Packing.* If the internal resistance becomes much greater than 1000 ohms, it is found that the sensitiveness of a potentiometer circuit in which the cell is used, is obviously lowered. This trouble is due to the hard packing of the crystals and paste during a period, or repeated periods, of prolonged slow cooling (*e.g.*, in a thermostat after use at 25°C. in a cool room). A gentle application of heat at a temperature not higher than 30°C., followed by rapid cooling while being slightly shaken, has proved an effective treatment in several cases. The shaking must not be violent enough to dislodge the paste. (*b*) *With Gas Bubbles.* These are rare in the Weston, but very common in the old Clark. The same treatment as in (*a*) was found effective in the only Weston cell in which this defect occurred.

2. *Results of Short-Circuiting.* The e.m.f. is lowered, but if it has not been affected by more than a certain limiting amount which appears to vary with different cells, a long period of charging with a current of approximately the same magnitude as that obtained on the occasion of the short circuit, will remove the trouble.

3. *Results of Exposure to Higher Temperatures.* If the e.m.f. has changed appreciably from this cause it does not seem possible to repair the cell. Apparently a permanent inversion has taken place.

4. *Acidity.* This is due to some contamination at the time of construction, the effects of which often remain latent for months. Possibly the acid is included in the crystals or localized in part of the paste, and thus has at first no appreciable influence on the behaviour of the cell. Green feathery streaks often appear in the paste and occasionally in the packed part of the crystals. The cell should be opened and made more basic. If the $CdSO_4$ is to blame, a cure may be effected, but if it develops that the whole of the paste is affected, the trouble cannot be remedied unless the cell is practically remade.

Summary

The effects of ageing on some Standard Weston Cells of a modified type have been examined and it has been found that the constancy and accuracy of these cells, which may be constructed in any laboratory, compare favourably with those made according to elaborate and more costly specifications. The assurance with which an absolute mean value of voltage may be determined from a batch of old cells is discussed. Also some objectionable characteristics of old cells are noted, and a simple treatment for their partial elimination is outlined.

The Macdonald Physics Building,
McGill University.

The Variation of the Coefficient of Viscosity of Gases with Temperature (Abstract).

By ROBERT CLARK, B.A.

Presented by DR. LOUIS V. KING, F.R.S.C.

(Read May Meeting, 1919.)

It was suggested to the writer by Dr. L. V. King, that it would be desirable, with a view to the further development of the Dynamical Theory of Gases, to measure the variation of the viscosities of the principal gases over as extensive a range of temperature as possible. The experiments described were undertaken to ascertain the possibilities of a comparative method of determining this variation.

The coefficient of viscosity of air has been very accurately determined by Millikan for the temperature 23.0° C.[1] and it was evident that this value might be employed to calibrate a capillary tube, without resorting to a careful calibration by means of a mercury thread, an operation which is somewhat difficult and always more or less uncertain. Further as it is intended to extend the investigation to the highest temperature at which fused silica will remain gas-tight and as the difficulty of maintaining a uniform high temperature increases very rapidly with the size of the furnace the apparatus was made as small as possible consistent with the accuracy that was desired.

The present paper is an account of an investigation undertaken to test this type of apparatus. It will be seen below that the method is feasible. A larger apparatus has been constructed which should give fairly accurate results over a range of about 200° C., and it is hoped in the near future to construct an apparatus in fused silica and measure viscosities at temperatures up to 600° C.

If two vessels of known volumes, be connected by a capillary tube, any pressure difference between them will gradually disappear, in consequence of flow through the capillary. This flow can be calculated in terms of the rate of change in pressure difference, and the volumes of the two vessels; from the dimensions of the capillary tube the coefficient of viscosity may be determined. If the rate of change of pressure be observed when the apparatus is maintained at different temperatures, the values of the coefficient of viscosity corresponding to these temperatures may be obtained.

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[1]Millikan, R. A., *The Electron*, Chicago 1917, p. 92.

Let v_1, v_2 and p_1, p_2 be the volumes and pressures in the two vessels at any instant. Let the density of the gas under the standard pressure p_0, be ρ_0; at any other pressure, p, it is $\rho = p \dfrac{\rho_0}{p_0}$. Now the rate of flow of gas leaving the first and entering the second vessel is, supposing $p_1 > p_2$,

$$-\frac{dM}{dt} = -\frac{d}{dt}\left(p_1 \frac{\rho_0}{p_0} v_1\right) = \frac{d}{dt}\left(p_2 \frac{\rho_0}{p_0} v_2\right) \qquad (1)$$

The rate of flow through a capillary tube whose length is l, and radius r, is,

$$-\frac{dI}{dt} = \frac{P}{l} \cdot \frac{\pi r^4}{8\mu}$$

where P is the difference in pressure between the ends, and μ is the coefficient of viscosity.[1]

The rate of change of mass is $-\dfrac{dM}{dt} = -\rho \dfrac{dI}{dt}$ so that

$$-\frac{dM}{dt} = -\frac{\pi r^4}{8\,\mu}\,\rho\,\frac{dp}{dx},$$

whence

$$\int_0^l \left(-\frac{dM}{dt}\right) dx = -\frac{\pi r^4}{8\mu} \cdot \frac{\rho_0}{p_0} \cdot \int_{p_1}^{p_2} p\,dp.$$

Thus

$$-\frac{dM}{dt} = \frac{\pi r^4}{8\mu l} \cdot \frac{\rho_0}{p_0} \cdot \frac{p^2_1 - p^2_2}{2} \qquad (2)$$

Combining this with equation (1) we get

$$\left.\begin{aligned} v_1 \frac{dp_1}{dt} + \frac{K}{2\mu}(p^2_1 - p_2^2) = 0 \\ v_2 \frac{dp_2}{dt} - \frac{K}{2\mu}(p^2_1 - p^2_2) = 0 \end{aligned}\right\} \qquad (3)$$

in which $K = \dfrac{\pi r^4 \rho_0}{8 l p_0}$.

These equations give, on simplifying,

$$\frac{p_2 dp_1 - p_1 dp_2}{p^2_1 - p^2_2} + \frac{K}{2\mu}\,\frac{p_1 v_1 + p_2 v_2}{v_1 v_2}\,dt = 0.$$

[1]Lamb, H., *Hydrodynamics*, Cambridge 1916, p. 578ff.

and on integration, since from (1) $p_1v_1+p_2v_2=c$, a constant,

$$\log \frac{p_1+p_2}{p_1-p_2} = \frac{1}{2} \frac{KCt}{2\mu v_1v_2} + A$$

where A is a constant of integration. If p'_1, p'_2 be the initial pressures $p_1=p'_1$; $p_2=p'_2$ when $t=0$. Thus,

$$t = \frac{4\mu v_1v_2}{KC} \cdot \log \frac{(p_1+p_2)\ (p'_1-p'_2)}{(p_1-p_2)\ (p'_1+p'_2)} .$$

The value of the last expression may be calculated for each experiment. It varies with the atmospheric pressure, but the variation is small. If the pressure differences are small we have, very approximately, for the time T, in which the pressure difference decreases to half its initial value,

$$T = \frac{4\mu}{KC} \cdot v_1v_2 \cdot \log 2.$$

The apparatus employed consisted of two glass tubes placed side by side in an oil bath. They were connected by a capillary tube which was immersed in the oil. Small tubes, 1 mm. in internal diameter, led to the manometer, and two others served to lead in the gas.

The oil in the bath was well stirred, explorations with a thermometer showing no appreciable variation in temperature. Two regulators were employed, one a toluol tube, with copper turnings to reduce the lag, otherwise quite appreciable, which was used for most of the observations, the other an electrical arrangement which was more sensitive. These regulators shunted the resistance coils which heated the oil. When the current was adjusted so that the temperature varied at the rate of half a degree per hour, the shunt was opened and closed again about once in every 3 minutes. The temperature was taken as the mean of the indications of two mercurial thermometers. Their fixed points were determined and the proper corrections applied.

Pressure differences were read on a manometer tube of U-shape, mounted in front of an engraved scale and read through a telescope. As only one meniscus could be observed, the manometer was calibrated, and a correction applied for the amount of liquid adhering to the walls. Certain divisions on the scale were selected, and the time of transit of the meniscus across them was recorded on a chronograph.

The gases whose viscosities have been determined at different temperatures between 0° C. and 110° C. are carbon dioxide, hydrogen and dry air. The following values were obtained for the exponent n, in the formula

$$\mu = \mu_0 \left(\frac{T}{273.1} \right)^n ,$$

those in the second column of the table, were obtained by the writer; those in the third column are added for comparison. They are taken from Jeans' "Dynamical Theory of Gases" (2nd edition).

Gas	Observed Values	Values for Comparison
Air	.750	.754[1]
CO_2	.965	.98[2]
Hydrogen	.700	.681[1] .700[2]

It will be seen that the present determinations agree fairly well with previous ones, so that the method appears feasible, although the apparatus is very small. A determination of the viscosity of air, from the measured dimensions of the apparatus gave the result

$$\mu = 184.0 \times 10^{-6} \text{ at } 23.0^\circ \text{ C.}$$

Probably the best determination of this quantity, gives the value[3]

$$\mu = 182.26 \times 10^{-6} \text{ at } 23.0^\circ \text{ C.}$$

In conclusion, the writer desires to express his thanks both to Dr. King, for suggesting the problem, and for assistance while the work was being carried out, and to the Advisory Council for Scientific and Industrial Research under whose auspices the experiment was undertaken.

McGill University,
May 12th, 1919.

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[1]Lord Rayleigh, *Proc. Roy. Soc.*, LXVI., p. 68.

[2]Von Obermayer, *Wiener Sitzungsberichte*, LXXIII. (2), p. 433.

[3]Harrington, E., *Physical Review*, December 1916.

Experiments on Acoustic Depth Sounding Carried Out in the Gulf of St. Lawrence, September, 1915

By LOUIS V. KING, D.Sc., F.R.S.C.

(Read May Meeting, 1919.)

Proposals have been made from time to time to measure the depth of the sea by recording the time interval elapsing between the generation of a submarine sound wave from a ship and the reception of a possible echo from the sea floor. Experiments were carried out in 1915, from the C. G. S. "Cartier" with a Fessenden Sound Generator, with a view to determining if an appreciable echo could be obtained by means of an ordinary microphone receiver from the clay and ooze sea bottoms characteristic of the Gulf of St. Lawrence. It was shown that any echoes which might exist were not detectable by ordinary means, and, if appreciable at all, would require for their detection the use of the extremely sensitive microphones and thermionic amplifiers developed since the date of the experiments described.

On the Theory and Design of Electrically Operated Aerial and Submarine Sound Generators and Receivers

BY LOUIS V. KING, D.SC., F.R.S.C.

(Read May Meeting, 1919.)

The mathematical theory of diaphragms vibrating in elastic media, such as air or water, is developed at some length to afford a rational basis for the practical design of submarine sound generators and receivers. The results are applied to the construction of standard submarine sound generators and receivers for the purpose of measuring under-sea sound waves and studying the laws governing their propagation. The data thus obtained are intended ultimately to serve in the design of submarine fog alarm equipment.

On the Design of Continuously Tunable Diaphragms

By LOUIS V. KING, D.Sc., F.R.S.C.

(Read May Meeting, 1919.)

In order that submarine sound generators may radiate efficiently, theory indicates that the diaphragm should be tuned to the frequency of the alternating current operating the apparatus. Similarly, in all forms of sound receiving apparatus, the response to submarine sound waves is most marked when its fundamental pitch is in resonance with the frequency of the incident waves. In many applications of the ordinary telephone receiver it is important that the diaphragm be capable of tuning over a considerable range of frequency. The present paper describes how this result is achieved, and describes experiments on a submarine microphone receiver fitted with a continuously tunable diaphragm.

The Adsorption of Gases by Carbonized Lignites

By STUART McLEAN, M.A.

Presented by PROF. E. F. BURTON, F.R.S.C.

(Read May Meeting, 1919.)

The term "adsorption" is applied to that property possessed by charcoals, lignites and other porous bodies of absorbing gases that are in contact with them. For charcoal[1], the phenomenon has been shown to consist of a condensation of the gas upon its surface, which takes place rapidly, requiring only a few minutes to reach the maximum, and a slow diffusion of the gas into the interior. Some authorities[2] claim that, in a few cases, they have found evidence that chemical action accompanies the process or that some of the gas is adsorbed permanently.

The object of the first series of experiments to be described below was to investigate the amount of gas adsorbed by a sample of carbonized lignite and how that amount varies with the pressure of the gas and the temperature of the lignite. A second series of experiments was undertaken to determine the nature of the process, especially to find out whether, or not, any chemical action or permanent adsorption takes place.

The lignites for these experiments were prepared by Mr. E. Stansfield of the Department of Mines, Ottawa, Ontario. Their densities were found by the volumenometer method[3], the apparatus being filled with helium because that gas is not adsorbed at ordinary temperatures. Before each experiment the samples of lignite were heated to a temperature sufficient to free them from any previously absorbed gas and while hot, the apparatus containing them was exhausted.

A diagram of the apparatus used in the first experiments is shown in Fig. 1. The lignite is contained in the tube X which may be shut off from the rest of the apparatus at B. The gas used was measured in the graduated tube K and admitted at E. The mercury reservoir N was so arranged that it could be easily raised, thereby forcing all the gas in the tube K into the apparatus. The stop-cock B was then

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[1] McBain, Phil. Mag. 18, 1909. Page 916.

[2] Arrhenius: Theories of Solutions.
Rhead and Wheeler, J. Chem. Soc. 103, 1913. Page 641.

[3] McLean: Proc. Roy. Soc. of Canada. 1919.

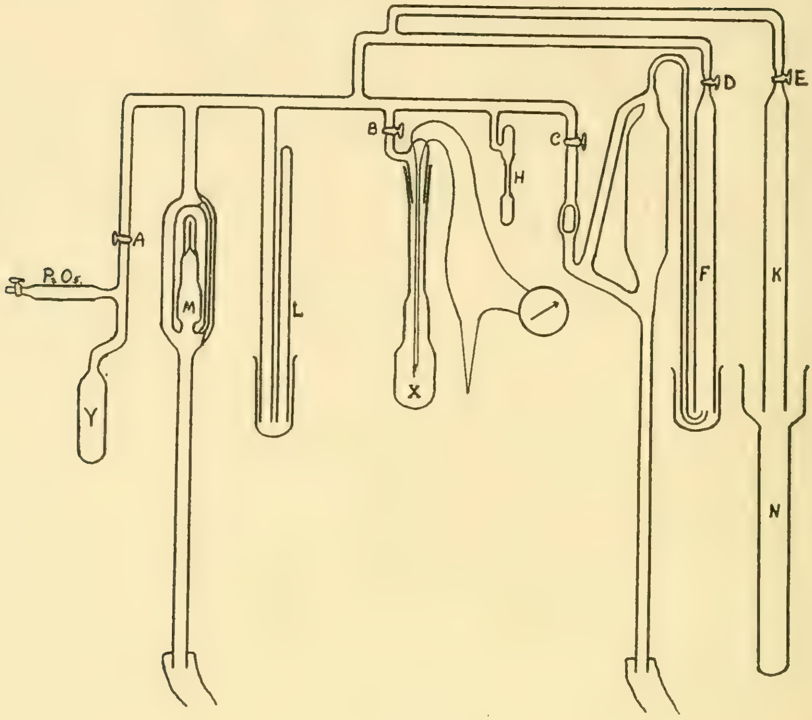

Figure 1

turned and the lignite exposed to the gas until the pressure, read on the manometer L, became constant. Since its density had been determined, the volume of the lignite in the tube X could be calculated. Subtracting this from the volume of the empty apparatus, which had been previously determined, the volume of the unadsorbed gas in the apparatus is found which, together with the pressure will give the amount not absorbed. The difference between this amount and the amount of gas admitted was considered to be the amount adsorbed.

In all measurements given below, the volumes of gas are reduced to standard temperature and pressure.

1. Time Required for Equilibrium

In order to obtain some idea as to the time required for equilibrium between the adsorbed and unadsorbed gas to be attained, a measured amount of dry air was admitted to the apparatus and allowed to be in contact with the lignite which was kept at a constant temperature (20°C.).

The pressure readings given by the manometer, L, were taken at intervals for the three succeeding days. The amount adsorbed was calculated, the results being given in Table I.

TABLE I

	Amount admitted	Time (t)	Pressure	Amount adsorbed (x)	t/x
1..........	161·4 cc.	0·0 hrs.	344·0 mm.	24·8 cc.	0
2..........		·05	312·5	37·4	·0014
3..........		·25	294·0	44·8	·0056
4..........		·5	288·2	47·0	·011
5..........		1·0	284·0	48·7	·021
6..........		2·0	280·0	50·3	·039
7..........		5·0	275·5	52·1	·096
8..........		7·0	273·0	52·9	·132
9..........		10·0	269·5	54·5	·183
10..........		12·0	268·0	55·0	·218
11..........		15·0	265·5	56·3	·266
12..........		20·0	262·2	57·3	·349
13..........		25·0	258·0	59·1	·423
14..........		30·0	255·0	60·2	·498
15..........		35·0	254·5	60·5	·578
16..........		40·0	253·5	60·8	·658
17..........		50·0	252·0	61·5	·813
18..........		60·0	251·5	61·6	·974

The curves for the relation between the amount adsorbed (x) and the time (t) are shown in Fig. 2. The part of the curve between A and B shows that at first the adsorption takes place very quickly and represents the condensation of the gas upon the surface of the lignite. The other part, between B and C represents the slower diffusion into the interior of the lignite. Thus the process is much the same as for coconut charcoal.

The curve plotted between t and t/x approximates a straight line showing that the equation for the curve for x and t is of the form:

$$t/x = a + bt$$

where a and b are constants.

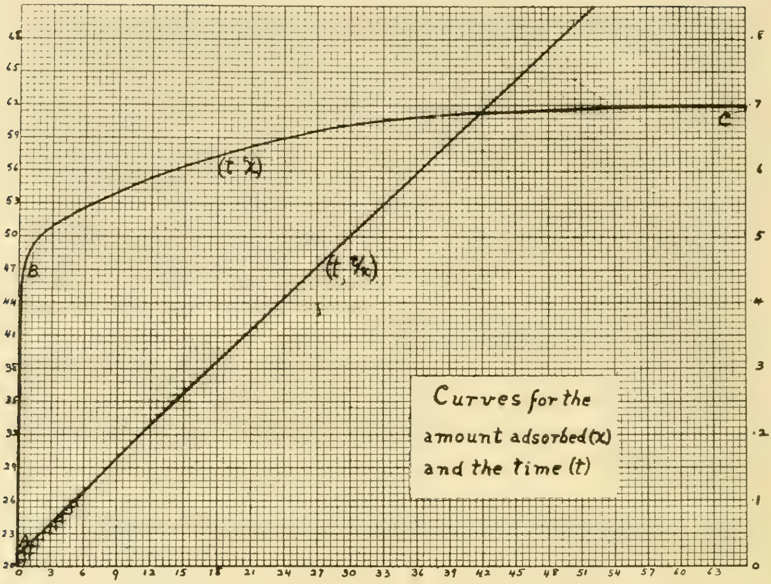

Figure 2

2. Influence of Temperatures on the Adsorption of Gases

Experiments on the adsorption of air were carried out at three temperatures: 20°C., −78°C. and −190°C. The first temperature was obtained by immersing the lignite tube in a water bath contained in a liquid air flask and kept constant at 20°C.; the second, by using a mixture of solid carbon dioxide and ether, the carbon dioxide being added at intervals to keept it at the same temperature, and the third, by using liquid air. Before it was admitted to the apparatus, the air was carefully dried by phosphorous pentoxide.

The following table gives the results of the experiment with the lignite at 20°C.:

Table II

Amount admitted	Time for saturation	Amount adsorbed (x)	Log x	Pressure (p)	Log p.
76·8 cc.	50 hours	29·5 cc.	1·470	119 mm.	2·076
156·8		60·4	1·781	243·0	2·386
236·6		89·6	1·952	370·5	2·569
279·0		106·4	2·027	435·0	2·639
321·9		122·7	2·089	502·0	2·701
363·2		137·1	2·137	570·0	2·756
397·9		147·9	2·170	630·0	2·799

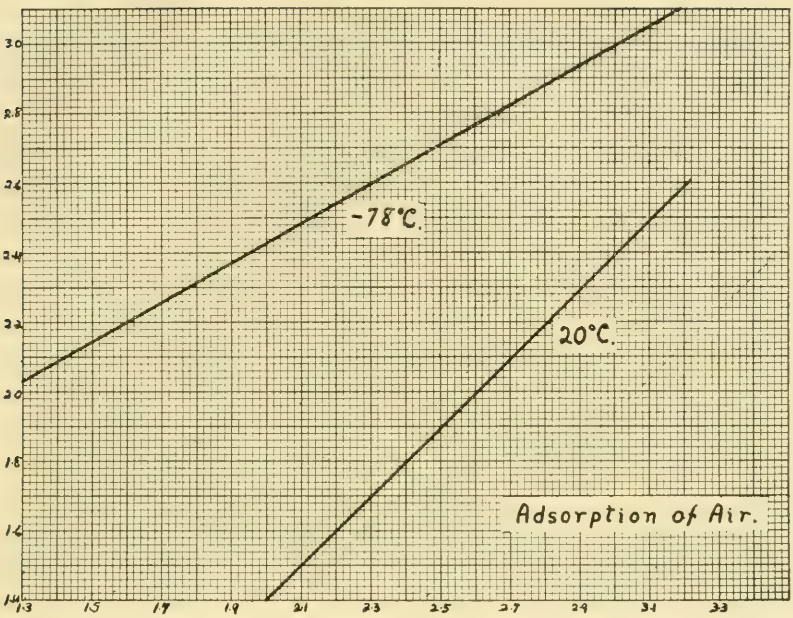

Figure 3

If log x be plotted against log p, the curve obtained is a straight line (see Fig. 3), which shows that the equation giving the relation between the amount and the pressure is of the form:

$$x = ap^6$$

where a and b are constants. Substituting the above results in this equation, it becomes:

$$x = \cdot 43p^{\cdot 9}$$

When the temperature of the lignite was much below the temperature of the room, a correction had to be made for the fall of pressure in the apparatus due to the cooling of the lignite tube. The amount of this correction was determined experimentally. The lignite was removed and the tube filled with an equal volume of a non-absorbing material (copper). The cooling agent was then applied and the fall of pressure noted. A series of readings showed that the fall of pressure is proportional to the initial pressure. This correction has been applied to all the pressure readings given for the other two temperatures.

The following results were obtained with the lignite at $-78°$C.:

Table III

Amount admitted	Limit for saturation	Amount adsorbed	Log. x	Press. p	Log. p
126·5	36 hours	116·3 cc.	2·066	234 mm.	1·369
541·1		450·4	2·654	207·1	2·316
826·4		645·3	2·810	413·8	2·617

The equation for x and p for this temperature is of the same form as before (see Fig. 3)

$$x = 17\cdot 7\ p^{86}$$

One reading was made with the lignite at liquid air temperature:

Table IV

Amount admitted	Time for saturation	Amount adsorbed	Log. x	Press.	Log. p.
939·6 cc.	60 hours	888·0 cc.	2·948	81·6 mm.	1·912

The Adsorption of Carbon Dioxide

An experiment on the adsorption of carbon dioxide was made with the lignite at 20°C. The gas used was that which is manufactured commercially and it was dried by bubbling it through strong sulphuric acid before it was put into the apparatus.

The following results show that carbon dioxide is adsorbed much more readily than air:

Table V

Amount admitted	Time for saturation	Amount adsorbed (x)	Log x	Pressure (p.)	Log p.
420·6 cc.	10 hours	375·2 cc.	2·574	114 mm.	2·057
631·4		537·2	2·730	237·0	2·375
758·8		626·7	2·797	332·0	2·521
886·9		711·7	2·852	438·5	2·642
1051·1		810·4	2·909	602·5	2·780

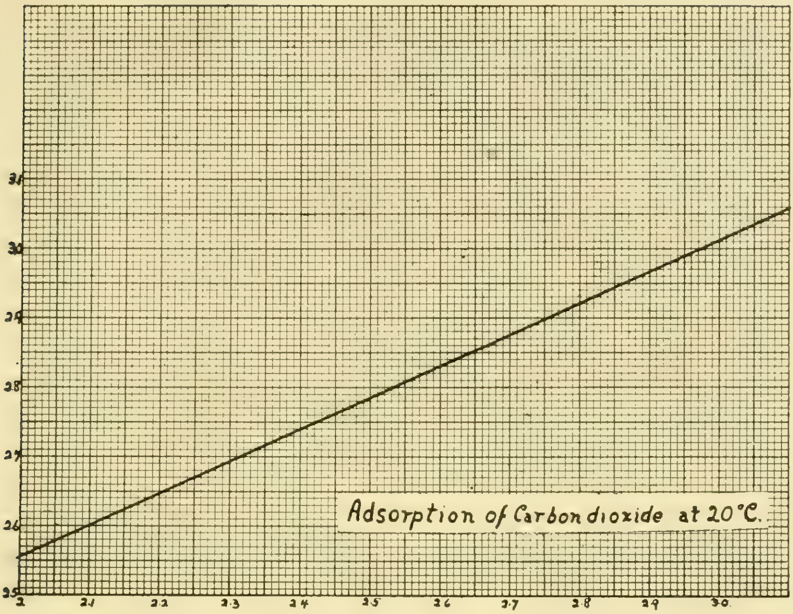

Figure 4

The adsorption-pressure equation for carbon dioxide with the lignite at 20°C. was found to be: (see Fig. 4).

$$x = 42 \cdot 7\ p^{\cdot 46}$$

The Adsorption of Hydrogen

With the lignite at 20°C., very little hydrogen is adsorbed. The following results were obtained but they do not conform to those obtained for other gases:

Table VI

Amount admitted	Amount adsorbed (x)	Log x	Pressure (p)	Log p.
99·4 cc.	2·8 cc.	·447	243 mm.	2·386
141·1	5·2	·716	342	2·534
182·4	7·4	·869	440	2·644
224·6	13·6	1·134	535	2·728

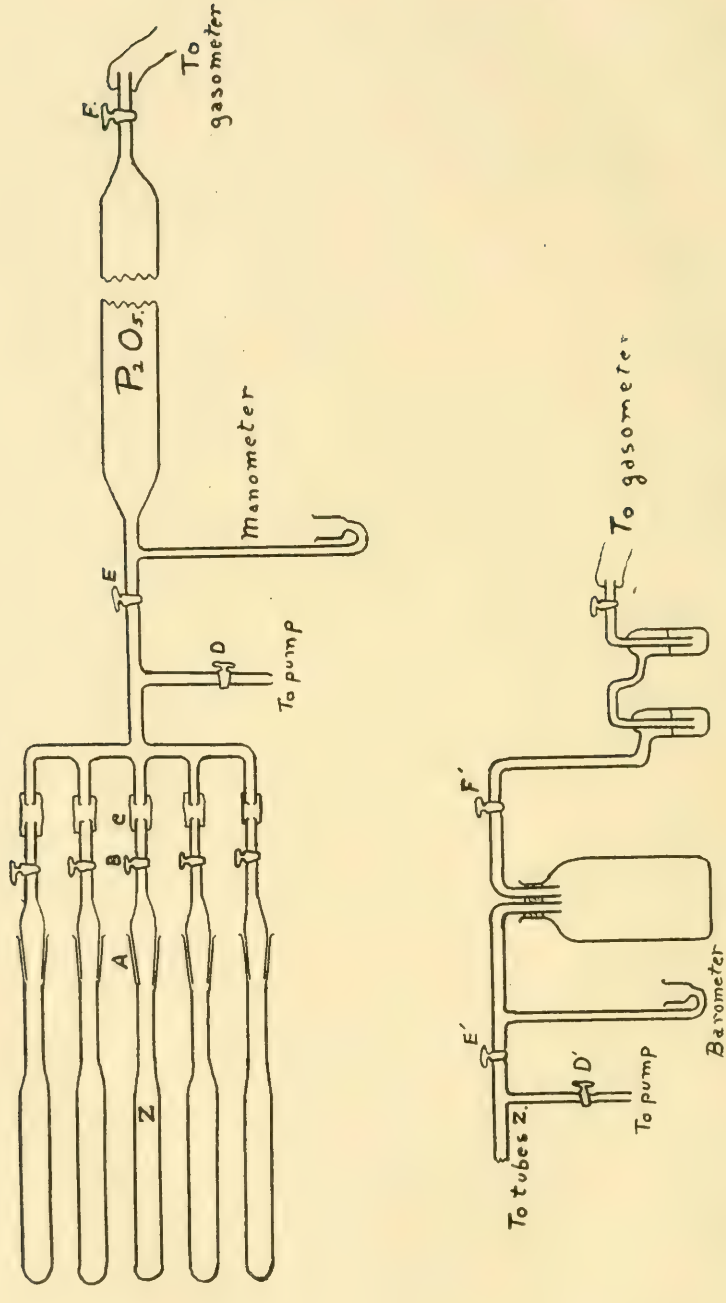
To gasometer
F.
P_2O_5.
Manometer
E
D
To pump
B
e
A
Z
To gasometer
F'
Barometer
E'
D'
To pump
To tubes Z.

Figure 5

3. Test of Possible Chemical Combination of Lignite and Gases

To find out whether any chemical action or permanent adsorption takes place, the apparatus shown in Fig. 5 was set up. Five samples of lignite carbonised at different temperatures were put in the tubes at Z. These samples were: raw lignite and lignite carbonised at 105°C., 350°C., 450°C. and 550°C. They had not been exposed to the air since carbonisation except where they were transferred to these tubes and then they were immediately heated to their respective temperatures and each tube exhausted.

The weight of each tube was found and the lignite exposed to the gas for a time sufficient for saturation to take place. The tubes were then weighed, heated out, exhausted and weighed again. If the last weight was appreciably different from the first, then chemical action or permanent adsorption must be taking place.

Readings were made for three gases: dry nitrogen, dry oxygen and moist oxygen. The results are given in Tables VII, VIII and IX. In the first column is given the temperature at which the lignite was carbonised; column 2 gives the net weight of the lignite and column 3 the weight after the lignite was saturated with the gas at atmospheric pressure, the difference denoting the gas absorbed is given in the next column. Column 5 repeats column 2, and column 6 gives the final net weight of the lignite after it had been heated and exhausted. The last column gives the difference between the initial and final weights of the samples, and consequently shows the net gain or loss in weight during the whole operation.

Table VII

Dry Nitrogen

Sample	First Weight	Second Weight	Difference	First Weight	Last Weight	Difference
Raw	58·7174	58·7090	·3196	58·7174	58·3904	−·3270
105°C	57·5468	57·5872	·0404	57·5468	57·5486	+·0018
350°C	51·6405	51·6832	·0246	51·6406	51·6360	−·0046
450°C	47·9974	48·0266	·0294	47·9974	48·0042	+·0078
550°C	43·6116	43·6276	·0160	43·6116	43·5985	−·0131

Table VIII

Dry Oxygen

Sample	First Weight	Second Weight	Difference	First Weight	Last Weight	Difference
Raw	58·3904	58·4095	·0181	58·3904	57·9922	+·3982
"	57·9976	58·0158	·0182	57·9976	57·9474	−·0502
105°C	57·5486	57·6048	·0562	57·5486	57·5572	+·0086
"	57·5580	57·6100	·0520	57·5580	57·5594	+·0014
350°C	51·6360	51·7812	·1452	51·6360	51·6336	−·0024
"	51·7546	51·9074	·1528	51·7546	51·7158	−·0388
450°C	48·0042	48·1636	·1594	48·0042	47·9964	−·0074
"	47·2041	47·4244	·2203	47·2041	47·1508	−·0533
550°C	43·5985	43·7154	·1169	43·5985	43·5732	−·0253
"	42·5328	42·6366	·1038	42·5328	42·4222	−·1106

Table IX

Moist Oxygen

Sample	First Weight	Second Weight	Difference	First Weight	Last Weight	Difference
Raw	57·9474	57·9681	·0207	57·9474	57·9025	−·0451
105°C	57·5594	57·6126	·0532	57·5594	57·5670	+·0076
350°C	51·7158	51·8690	·1532	51·7158	51·7098	−·0060
450°C	47·1508	47·3561	·2053	47·1508	47·1156	−·0342
550°C	42·4222	42·5870	·1648	42·4222	42·4238	+·0016

From the above tables, the following conclusions may be drawn:

1. Oxygen is adsorbed much more readily than nitrogen.

2. The presence of water vapour decreases the amount of gas adsorbed. This is shown from the last two tables. The weight of the amount adsorbed is not increased and the weight includes that of the water vapour taken up by the samples.

3. No permanent adsorption takes place since there are but few cases where the last weight is greater than the first, and these may be due to experimental error.

4. Chemical action may be taking place in the case of oxygen. The fact that in most cases the last weight is less than the first indicates that the oxygen combines with the lignite forming carbon dioxide, which is given off when the lignite is heated, making the sample lighter.

This work was done under the direction of Professor E. F. Burton.

The Density of Adsorbing Materials

By STUART McLEAN, M.A.

Presented by PROF. E. F. BURTON, F.R.S.C.

(Read May Meeting, 1919)

The density of adsorbing materials has usually been found by means of a pyknometer as follows: A tube containing the sample under test is heated to expel the adsorbed gas, evacuated and sealed up. The tube is then weighed and the sealed tip broken off under boiling water which rushes in, filling the pores of the material. After cooling, the tube is placed in a pyknometer and the usual procedure followed.

The following results for coconut charcoal have been obtained by this method:

Richardson[1]	1·6
Miss Homfray[2]	1·67
" "	1·68

The object of this experiment was to apply the volumenometer method to determine these densities. The gas used in the volumenometer was helium because it is not adsorbed at ordinary room temperature.

A diagram of the apparatus is shown in Fig. 1.

The sample under test was placed in the tube X. It was heated to a temperature sufficient to expel all the adsorbed gas and the apparatus was evacuated. Pure helium was then admitted through the Travers siphon T. Let V be the volume of the apparatus above the point M. The mercury in the tube MN was raised to this point and the pressure of the gas measured. Let it be P_1.

The mercury was then lowered to N, increasing the volume from V to V+v. If the resulting pressure is P_2, then by Boyle's Law

$$P_1V = P_2(V+v)$$

$$\text{and } V = \frac{P_2v}{P_1 - P_2}$$

w ence V may be found, if v is known.

Thus if V_1, the volume with the tube X empty, and V_2, the free volume when the material is in it, are determined, the volume of the

[1] Richardson: J. Amer. Chem. Soc., 1917.

[2] Miss Homfray: Zs. f. phys. chem. 74, 1910, p 152.

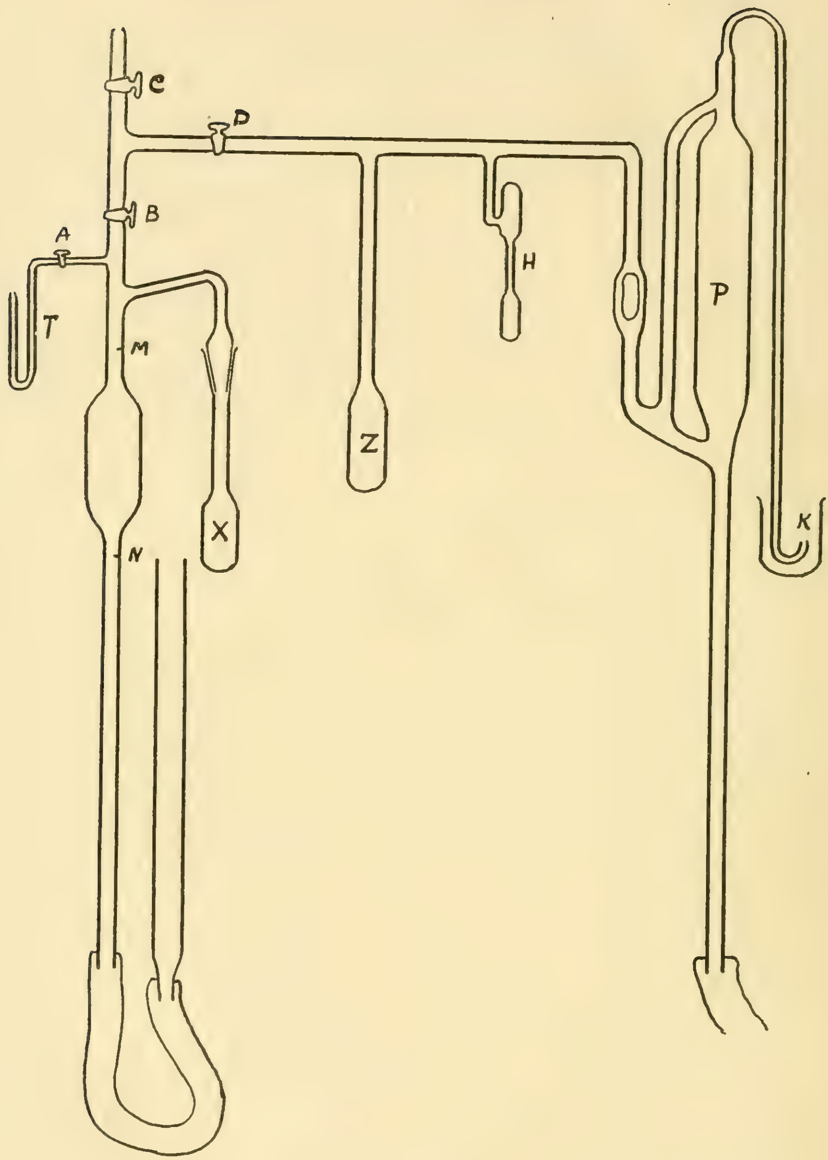

Figure 1

sample is V_1-V_2. If M is the mass of the sample, the density will be:

$$\frac{M}{V_1-V_2}$$

The following results were obtained:

Sample	Mass in grams	Heated to temperature	V_1	V_2	V_1-V_2	Density
1. Coconut Charcoal	24·4575	400°C	77·38 cc.	61·42 cc.	15·96 cc.	1·48
	25·4324	"	"	61·33	16·05	1·58
	25·5079	"	"	60·65	16·73	1·52
2. Lignite carbonised at 350°C	9·8511	350°C	"	69·99 cc.	7·39 cc.	1·33
	9·9007	"	"	69·89	7·49	1·32
	7·2393	"	"	72·04	5·34	1·35
3. Lignite carbonised at 450°C	9·0903	450°C	"	71·11 cc.	6·27	1·45
	9·0599	"	"	71·21	6·17	1·47
4. Lignite carbonised at 550°C	8·5915	550°C	"	71·56	5·82	1·47
	8·5219	"	"	71·47	5·91	1·44
	8·4933	"	"	71·34	6·04	1·42

This work was done under the direction of Professor E. F. Burton.

Use of Analogy in Vector Analysis.

PROFESSOR ALFRED BAKER, M.A., LL.D.

(Read May Meeting, 1919.)

It is a commonplace to say that no system of geometry is the best for the solution of all problems. Problems which are quite simple under one system are sufficiently difficult under another. Thus demonstrations which flow most readily from the very nature of, say, geometry of position or reciprocal polars, may be very laborious when attacked by Cartesian analysis. The extensive use made of Cartesian forms shows that they constitute undoubtedly the system of most general applicability. Next in general usefulness comes vector analysis. In working with vector forms it is interesting to observe the complete parallelism which often exists between them and Cartesians: they appear as two languages expressing the same thoughts, often employing the same idioms. If difficulties present themselves when working under one system, it is frequently sufficient to observe how the difficulties have been overcome in the other.

I proceed to illustrate this:

Suppose we are finding in the case of a conicoid the locus of the intersection of three tangent planes mutually at right angles:

Let them be $S\pi\phi\alpha=1$, $S\pi\phi\beta=1$, $S\pi\phi\gamma=1$, where α, β, γ are semi-diameters. Then $\phi\alpha$, $\phi\beta$, $\phi\gamma$, being perpendiculars to the planes, are perpendicular to each other; so that $S\phi\alpha\phi\beta=0=S\phi\beta\phi\gamma=S\phi\gamma\phi\alpha$.

Now $\phi\alpha=\dfrac{iSi\alpha}{a^2}+\dfrac{jSj\alpha}{b^2}+\dfrac{kSk\alpha}{c^2}$

$$\therefore Si\phi\alpha=-\frac{Si\alpha}{a^2},\ Sj\phi\alpha=-\frac{Sj\alpha}{b^2},\ Sk\phi\alpha=-\frac{Sk\alpha}{c^2}\ \ldots\ldots\ldots\ldots(1)$$

and $a^2(Si\phi\alpha)^2+b^2(Sj\phi\alpha)^2+c^2(Sk\phi\alpha)^2=\dfrac{(Si\alpha)^2}{a^2}+\dfrac{(Sj\alpha)^2}{b^2}+\dfrac{(Sk\alpha)^2}{c^2}$

$$=S\alpha\phi\alpha=1\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Let $i=x\phi\alpha+y\phi\beta+z\phi\gamma$

$\therefore Si\phi\alpha=x(\phi\alpha)^2$, etc., and

$$i=\phi\alpha\frac{Si\phi\alpha}{(\phi\alpha)^2}+\phi\beta\frac{Si\phi\beta}{(\phi\beta)^2}+\phi\gamma\frac{Si\phi\gamma}{(\phi\gamma)^2}.$$

So also $\quad j = \phi\alpha \dfrac{Sj\phi\alpha}{(\phi\alpha)^2} + \ldots + \ldots$

$$\therefore 0 = Sij = \frac{Si\phi\alpha Sj\phi\alpha}{(\phi\alpha)^2} + \frac{Si\phi\beta Sj\phi\beta}{(\phi\beta)^2} + \frac{Si\phi\gamma Sj\phi\gamma}{(\phi\gamma)^2}.$$

$$\left.\begin{aligned} 0 &= \frac{Si\phi\alpha Sj\phi\alpha}{(T\phi\alpha)^2} + \ldots + \ldots\ldots \\ \text{So also}\quad 0 &= \frac{Sj\phi\alpha Sk\phi\alpha}{(T\phi\alpha)^2} + \ldots + \ldots\ldots \\ 0 &\ \frac{Sk\phi\alpha Si\phi\alpha}{(T\phi\alpha)^2} + \ldots\ldots + \ldots \end{aligned}\right\} \ldots\ldots\ldots\ldots (3)$$

Again

$$i = \phi\alpha \frac{Si\phi\alpha}{(\phi\alpha)^2} + \phi\beta \frac{Si\phi\beta}{(\phi\beta)^2} + \phi\gamma \frac{Si\phi\gamma}{(\phi\gamma)^2}.$$

$$\therefore -1 = i^2 = \frac{(Si\phi\alpha)^2}{(\phi\alpha)^2} + \frac{(Si\phi\beta)^2}{(\phi\beta)^2} + \frac{(Si\phi\gamma)^2}{(\phi\gamma)^2}$$

$$\left.\begin{aligned} \text{or } 1 &= \frac{(Si\phi\alpha)^2}{(T\phi\alpha)^2} + \frac{(Si\phi\beta)^2}{(T\phi\beta)^2} + \frac{(Si\phi\gamma)^2}{(T\phi\gamma)^2} \\ \text{So also}\quad 1 &= \frac{(Sj\phi\alpha)^2}{(T\phi\alpha)^2} + \ldots + \ldots\ldots\ldots \\ 1 &= \frac{(Sk\phi\alpha)^2}{(T\phi\alpha)^2} + \ldots + \ldots\ldots\ldots \end{aligned}\right\} \ldots\ldots\ldots\ldots (4)$$

Then tangent plane is

$$S\pi\phi\alpha = 1, \text{ or } \frac{S\pi i Si\alpha}{a^2} + \frac{S\pi j Sj\alpha}{b^2} + \frac{S\pi k Sk\alpha}{c^2} = 1$$

or $S\pi i Si\phi\alpha + S\pi j Sj\phi\alpha + S\pi k Sk\phi\alpha = -1$, from (1).

$$\text{or } S\pi i \frac{Si\phi\alpha}{T\phi\alpha} + S\pi j \frac{Sj\phi\alpha}{T\phi\alpha} + S\pi k \frac{Sk\phi\alpha}{T\phi\alpha} = -\frac{1}{T\phi\alpha}$$

$$= -\sqrt{a^2\left(\frac{Si\phi\alpha}{T\phi\alpha}\right)^2 + b^2\left(\frac{Sj\phi\alpha}{T\phi\alpha}\right)^2 + c^2\left(\frac{Sk\phi\alpha}{T\phi\alpha}\right)^2} \text{ from (2).}$$

$$\text{So also } S\pi i \frac{Si\phi\beta}{T\phi\beta} + S\pi j \frac{Sj\phi\beta}{T\phi\beta} + S\pi k \frac{Sk\phi\beta}{T\phi\beta}$$

$$= -\sqrt{a^2\left(\frac{Si\phi\beta}{T\phi\beta}\right)^2 + \ldots + \ldots}$$

$$S\pi i \frac{Si\phi\gamma}{T\phi\gamma} + \ldots + \ldots = -\sqrt{a^2\left(\frac{Si\phi\gamma}{T\phi\gamma}\right)^2 + \ldots + \ldots}$$

Squaring and adding, observing result (3) and (4)

$$(S\pi i)^2 + (S\pi j)^2 + (S\pi k)^2 = a^2 + b^2 + c^2.$$

The complete parallelism between the above and the ordinary method in Cartesian geometry will be perceived in noting that the results in (3) correspond to $lm+l'm'+l''m''=0$, etc.; and the results in (4) correspond to $l^2+l'^2+l''^2=1$, etc.

In the following treatment of the same proposition the analogy with Cartesians is even more complete:

Let $\overline{ON}=p\alpha$ be the perpendicular from the origin on any plane, and $\overline{OP}=\rho$ any vector to the plane. $T\alpha=1$. Then

$$\alpha=-iSi\alpha-jSj\alpha-kSk\alpha, \text{ and } 1=(Si\alpha)^2+(Sj\alpha)^2+(Sk\alpha)^2.$$

$$\rho=-iSi\rho-jSj\rho-kSk\rho.$$

$$\rho=p\alpha+\overline{NP}$$

Operating with α, and taking scalars

$$Si\rho Si\alpha+Sj\rho Sj\alpha+Sk\rho Sk\alpha=p,$$

which is the equation of the plane.

Comparing this with the equation of the tangent plane at the extremity of the semi-diameter β, $S\rho\phi\beta=1$, or

$$\frac{Si\rho Si\beta}{a^2}+\frac{Sj\rho Sj\beta}{b^2}+\frac{Sk\rho Sk\beta}{c^2}=1,$$

we get as the equation of the tangent plane

$$Si\rho Si\alpha+Sj\rho Sj\alpha+Sk\rho Sk\alpha=\sqrt{a^2(Si\alpha)^2+b^2(Sj\alpha)^2+c^2(Sk\alpha)^2}.$$

Similarly for the two other tangent planes. Squaring and adding, remembering the relations between $Si\alpha$, $Sj\alpha$, etc., and between $Si\alpha$, $Si\alpha'$, etc., we obtain the equation of the locus, $(Si\rho)^2+(Sj\rho)^2+(Sk\rho)^2=a^2+b^2+c^2$.

If the question be the determination of the axes in the central section $S\alpha\rho=0$ of the conicoid $S\rho\phi\rho=1$, the finding of the maximum and minimum values of ρ, when subject to the above conditions, is not apparent. Converting, however, ρ into the form

$$\rho=-iSi\rho-jSj\rho-kSk\rho,$$

the equations become

$$0=Si\alpha Si\rho+Sj\alpha Sj\rho+Sk\alpha Sk\rho,$$

$$r^2=-\rho^2=(Si\rho)^2+(Sj\rho)^2+(Sk\rho)^2,$$

$$1=\frac{(Si\rho)^2}{a^2}+\frac{(Sj\rho)^2}{b^2}+\frac{(Sk\rho)^2}{c^2}.$$

Differentiating and using arbitrary multipliers A and B, we have

$$\left.\begin{aligned} Si\alpha + ASi\rho + B\frac{Si\rho}{a^2} &= 0 \\ Sj\alpha + ASj\rho + B\frac{Sj\rho}{b^2} &= 0 \\ Sk\alpha + ASk\rho + B\frac{Sk\rho}{c^2} &= 0 \end{aligned}\right| \begin{aligned} &Si\rho \\ &Sj\rho \\ &Sk\rho \end{aligned}$$

$$\therefore Ar^2 + B = 0$$

$$\left.\begin{aligned} \frac{Si\alpha}{1-\frac{r^2}{a^2}} &= -ASi\rho \\ \frac{Sj\alpha}{1-\frac{r^2}{b^2}} &= -ASj\rho \\ \frac{Sk\alpha}{1-\frac{r^2}{c^2}} &= -ASk\rho \end{aligned}\right| \begin{aligned} &Si\alpha \\ &Sj\alpha \\ &Sk\alpha \end{aligned}$$

$$\frac{(Si\alpha)^2}{1-\frac{r^2}{a^2}} + \frac{(Sj\alpha)^2}{1-\frac{r^2}{b^2}} + \frac{(Sk\alpha)^2}{1-\frac{r^2}{c^2}} = 0.$$

Thence finding r_1 and r_2 for axes, we have for the equations of the axes

$$\frac{Si\rho}{\dfrac{Si\alpha}{1-\frac{r_1^2}{a^2}}} = -\frac{1}{A} = \ldots$$

In the above the differentiated equations, if α be a unit vector, are evidently $0 = lx + \ldots + \ldots$, $r^2 = x^2 + \ldots + \ldots$, $1 = \frac{x^2}{a^2} + \ldots + \ldots$; and the final equation is $\dfrac{l^2}{1-\frac{r^2}{a^2}} + \ldots + \ldots = 0.$

The general scalar equation of the second degree may be written

$$a(Si\rho)^2 + b(Sj\rho)^2 + c(Sk\rho)^2 + 2fSj\rho Sk\rho + 2gSk\rho Si\rho + 2hSi\rho Sj\rho$$
$$-2uSi\rho - 2vSj\rho - 2wSk\rho + d = 0.$$

The term ρ^2 is included in the above since $\rho = -iSi\rho - jSj\rho - kSk\rho$.

Evidently this equation is obtained from the usual Cartesian form by writing $-Si\rho$ for x, $-Sj\rho$ for y, and $-Sk\rho$ for z.

If we wish to find the centre of the conicoid, suppose it at the term of δ, and write $\rho+\delta$ for ρ. Then that the term involving the first power of ρ may vanish we must have

$$aiSi\delta+bjSj\delta+ckSk\delta+f(jSk\delta+kSj\delta)+g(kSi\delta+iSk\delta)$$
$$+h(iSj\delta+jSi\delta)-ui-vj-wk=0.$$

To solve this for δ, let $\delta=xi+yj+zk$, and

$$-aix-bjy-ckz+f(-zj-yk)+g(-xk-zi)+h(-yi-xj)$$
$$-ui-vj-wk=0.$$

Whence

$$ax+hy+gz+u=0$$
$$hx+by+fz+v=0$$
$$gx+fy+cz+w=0,$$

the ordinary forms for the centre in Cartesian coördinates. Thence δ is found, and the surface is referred to its centre as origin.

In reducing the general equation of the second degree to the various forms which permit us to recognize the character of the surface, we may first find the locus of the bisections of parallel chords having, say, direction α. Let $\rho=\pi\pm x\alpha$; then the locus required is

$$S\pi\{i(aSi\alpha+hSj\alpha+gSk\alpha)+j(hSi\alpha+bSj\alpha+fSk\alpha)$$
$$+k(gSi\alpha+fSj\alpha+cSk\alpha)\}-uSi\alpha-vSj\alpha-wSk\alpha=0.$$

That this plane may be perpendicular to α, *i.e.*, to $-iSi\alpha-jSj\alpha-kSk\alpha$, we must have

$$\frac{aSi\alpha+hSj\alpha+gSk\alpha}{Si\alpha}=\frac{hSi\alpha+bSj\alpha+fSk\alpha}{Sj\alpha}=\frac{gSi\alpha+fSj\alpha+cSk\alpha}{Sk\alpha}=X, \text{ say,}$$

Eliminating $Si\alpha$, $Sj\alpha$, $Sk\alpha$, we obtain the usual discriminating cubic in X, with real roots. Supposing one of these roots to give the plane of (ij), f, g and w will disappear, and the equation becomes

$$a(Si\rho)^2+b(Sj\rho)^2+c(Sk\rho)^2+2hSi\rho Sj\rho-2uSi\rho-2vSj\rho+d=0.$$

Next turn the axes i, j through an angle θ, so becoming i', j',— for this purpose operating with $\cos\theta-k\sin\theta$. Then

$$i=(\cos\theta-k\sin\theta)i'=\cos\theta\ .\ i'+\sin\theta\ .\ j'$$
$$\text{or } Si\rho=\cos\theta Si'\rho+\sin\theta Sj'\rho$$

$$j=(\cos\theta-k\sin\theta)j'=\cos\theta\ .\ j'-\sin\theta\ .\ i'$$
$$\text{or } Sj\rho=-\sin\theta Si'\rho+\cos\theta Sj'\rho$$

Making these substitutions, a value can be found for θ that will make the term $Si\rho Sj\rho$ vanish, and the equation takes the form

$$a(Si\rho)^2+b(Sj\rho)^2+c(Sk\rho)^2-2uSi\rho-2vSj\rho+d=0$$

which may be further reduced to the usual forms

$$\frac{(Si\rho)^2}{A^2} + \frac{(Sj\rho)^2}{B^2} + \frac{(Sk\rho)^2}{C^2} = 1, \text{ etc,. etc.}$$

In particle dynamics, when the force is central, the differential equation, in the case where the acceleration varies as the inverse distance squared, is usually solved by converting

$\frac{d^2\rho}{dt^2} = -\frac{\mu U\rho}{(T\rho)^2}$ into the form $\frac{d^2\rho}{dt^2}\gamma = \mu\frac{dU\rho}{dt}$, whence the integration proceeds. The following obvious treatment will appear more straightforward:

Starting with $\rho = r\alpha^{\frac{2\theta}{\pi}}\beta$, we obtain

$$\frac{d^2\rho}{dt^2} = \left\{\frac{d^2r}{dt^2} - r\left(\frac{d\theta}{dt}\right)^2\right\}\alpha^{\frac{2\theta}{\pi}}\beta + \frac{1}{r}\,\frac{d}{dt}\left(r^2\,\frac{d\theta}{dt}\right)\alpha\alpha^{\frac{2\theta}{\pi}}\beta.$$

In central orbits, the acceleration perpendicular to the radius vector being zero, $r^2\frac{d\theta}{dt} = h$, a constant. Whence $\frac{d\theta}{dt} = hu^2$,

$$\frac{dr}{dt} = -h\frac{du}{d\theta},\ \frac{d^2r}{dt^2} = -h^2u^2\frac{d^2u}{d\theta^2}, \text{ and } \frac{d^2\rho}{dt^2} = -h^2u^2\left(\frac{d^2u}{d\theta^2} + u\right)\alpha^{\frac{2\theta}{\pi}}\beta,$$

for any central law of force. When the force varies as the inverse distance squared this equals $-\mu u^2 U\rho$, giving the differential equation of the orbit, which is readily solved.

On a Derivation of an Equation of a Ruled Surface.

By CHARLES T. SULLIVAN, PH.D., D.SC., F.R.S.C.

(Read May Meeting, 1919).

When a non-developable surface is referred to its asymptotic lines as parametric curves, so that in terms of the variables u, v the equations of the asymptotic lines are $u=$const. and $v=$const., the Gauss equations of the surface take the form

$$(A)\quad \begin{cases} (1)\quad \dfrac{\partial^2\theta}{\partial u^2}=\Gamma\dfrac{\partial\theta}{\partial u}+\Delta\dfrac{\partial\theta}{\partial v} \\[2ex] (2)\quad \dfrac{\partial^2\theta}{\partial v^2}=\Gamma''\dfrac{\partial\theta}{\partial u}+\Delta''\dfrac{\partial\theta}{\partial v}. \end{cases}$$

(The symbols Γ, Δ, etc., used in these equations and the symbols A, D, etc., used below are defined as in Forsyth's Differential Geometry, pp. 45, 190, 192). If the asymptotic lines $u=$const. are plane curves, they must be straight lines. In short, if the curves $u=$const. lie in the planes

$$a(u)x+b(u)y+c(u)z=1,$$

then

$$ax_2+by_2+cz_2=0,$$
$$(3)\quad ax_{22}+by_{22}+cz_{22}=0$$

where $$x_1=\frac{\partial x}{\partial u},\quad x_2=\frac{\partial x}{\partial v},\quad x_{22}=\frac{\partial^2 x}{\partial v^2},\ \text{etc.}$$

These equations combined with $(A-2)$ lead to the relation

$$\Gamma''(ax_1+by_1+cz_1)=0,$$

The expression in brackets cannot vanish; because if it did, we should conclude that

$$ax_1+by_1+cz_1=0,$$
$$(4)\quad ax_2+by_2+cz_2=0,$$
$$ax_{12}+by_{12}+cz_{12}=0,$$

and, therefore, that $MV=0$. But this result is inconsistent with the supposition on which the system (A) is based. We therefore infer that Γ'' must vanish. Now for the asymptotic lines the invariant A vanishes and the invariant D vanishes along $u=$const., since Γ'' vanishes. Hence $\gamma=\rho=\rho'=\infty$; and the curve $u=$const. is a straight line.

Let x, y, z be three independent solutions of (A), and let us effect the following transformation on (A):

$$x=x(u, v), \quad y=y(u, v), \quad z=\theta(u, v).$$

The relations between the two sets of variables and their derivatives of the first and second orders are:

$$(5) \quad \begin{aligned} &\frac{\partial\theta}{\partial u}=x_1p+y_1q, \quad \frac{\partial\theta}{\partial v}=x_2p+y_2q, \\ &\frac{\partial^2\theta}{\partial u^2}=x^2{}_1r+2x_1y_1s+y^2{}_1t+x_{11}p+y_{11}q, \\ &\frac{\partial^2\theta}{\partial u\partial v}=x_1x_2r+(x_1y_2+x_2y_1)s+y_1y_2t+x_{12}p+y_{12}q, \\ &\frac{\partial^2\theta}{\partial v^2}=x^2{}_2r+2x_2y_2s+y^2{}_2t+x_{22}p+y_{22}q, \end{aligned}$$

where $p=\dfrac{\partial z}{\partial x}$, $q=\dfrac{\partial z}{\partial y}$, $r=\dfrac{\partial^2 z}{\partial x^2}$, $s=\dfrac{\partial^2 z}{\partial x\partial y}$, $t=\dfrac{\partial^2 z}{\partial y^2}$.

If these values be substituted in (A), we find the relations:

$$(6) \quad \begin{aligned} &x^2{}_1r+2x_1y_1s+y^2{}_1t=0, \\ &x^2{}_2r+2x_2y_2s+y^2{}_2t=0. \end{aligned}$$

On differentiating the second of these with respect to v there results the relation:

$$(7) \quad \begin{aligned} &x^3{}_2\frac{\partial^3 z}{\partial x^3}+3x^2{}_2y_2\frac{\partial^3 z}{\partial x^2\partial y}+3x_2y^2{}_2\frac{\partial^3 z}{\partial x\partial y^2}+y^3{}_2\frac{\partial^3 z}{\partial y^3} \\ &+2(x_2x_{22}r+x_2y_{22}+x_{22}y_2.s+y_2y_{22}t)=0. \end{aligned}$$

Now for a ruled surface in which $u=$const. are the generators, Γ'' vanishes. Hence in virtue of equations (5) and (A-2):

$$(x_2x_{22}r+x_2y_{22}+x_{22}y_2.s+y_2y_{22}t)=\Delta''(x^2{}_2r+2x_2y_2s+y^2{}_2t)=0.$$

Thus for a ruled surface we have the equations:

$$(8) \quad \begin{aligned} &\frac{\partial^2 z}{\partial x^2}+2\lambda\frac{\partial^2 z}{\partial x\partial y}+\lambda^2\frac{\partial^2 z}{\partial y^2}=0, \\ &\frac{\partial^3 z}{\partial x^3}+3\lambda\frac{\partial^3 z}{\partial x^2\partial y}+3\lambda^2\frac{\partial^3 z}{\partial x\partial y^2}+\lambda^3\frac{\partial^3 z}{\partial y^3}=0, \end{aligned}$$

where $\lambda=\left(\dfrac{y_2}{x_2}\right)$.

The Sylvester eliminant of equations (8) is:

$$
\text{(B)}\qquad
\begin{vmatrix}
\dfrac{\partial^2 z}{\partial x^2} & 2\,\dfrac{\partial^2 z}{\partial x\partial y} & \dfrac{\partial^2 z}{\partial y^2} & 0 & 0 \\[2ex]
0 & \dfrac{\partial^2 z}{\partial x^2} & 2\,\dfrac{\partial^2 z}{\partial x\partial y} & \dfrac{\partial^2 z}{\partial y^2} & 0 \\[2ex]
0 & 0 & \dfrac{\partial^2 z}{\partial x^2} & 2\,\dfrac{\partial^2 z}{\partial x\partial y} & \dfrac{\partial^2 z}{\partial y^2} \\[2ex]
\dfrac{\partial^3 z}{\partial x^3} & 3\,\dfrac{\partial^3 z}{\partial x^2\partial y} & 3\,\dfrac{\partial^3 z}{\partial x\partial y^2} & \dfrac{\partial^3 z}{\partial y^3} & 0 \\[2ex]
0 & \dfrac{\partial^3 z}{\partial x^3} & 3\,\dfrac{\partial^3 z}{\partial x^2\partial y} & 3\,\dfrac{\partial^3 z}{\partial x\partial y^2} & \dfrac{\partial^3 z}{\partial y^3}
\end{vmatrix} = 0,
$$

which is the equation given by M. V. Jamet for a ruled surface (Nouvelles Annales De Mathématiques, Vol. X, p. 500).

A conclusion arrived at above provides a more direct method than that employed by Jamet of demonstrating that an integral surface of (B) is a ruled surface. In short, equation (B) expresses the condition that the equations

$$
\text{(9)}\qquad
\begin{aligned}
&\frac{\partial^2 z}{\partial x^2} + 2\lambda\,\frac{\partial^2 z}{\partial x\partial y} + \lambda^2\,\frac{\partial^2 z}{\partial y^2} = 0,\\
&\frac{\partial^3 z}{\partial x^2} + 3\lambda\,\frac{\partial^3 z}{\partial x^2\partial y} + 3\lambda^2\,\frac{\partial^3 z}{\partial x\partial y^2} + \lambda^3\,\frac{\partial^3 z}{\partial y^3} = 0.
\end{aligned}
$$

may have a common root. From the first of these we find by differentiating with respect to x and y:

$$
\text{(10)}\qquad
\begin{aligned}
&\frac{\partial^3 z}{\partial x^3} + 2\lambda\,\frac{\partial^3 z}{\partial x^2\partial y} + \lambda^2\,\frac{\partial^3 z}{\partial x\partial y^2} + 2\left(\frac{\partial^2 z}{\partial x\partial y} + \lambda\,\frac{\partial^2 z}{\partial y^2}\right)\frac{\partial\lambda}{\partial x} = 0.\\
&\frac{\partial^3 z}{\partial y^3} + 2\lambda\,\frac{\partial^3 z}{\partial x\partial y^2} + \lambda^2\,\frac{\partial^3 z}{\partial x^2\partial y} + 2\left(\frac{\partial^3 z}{\partial x\partial y} + \lambda\,\frac{\partial^2 z}{\partial y^2}\right)\frac{\partial\lambda}{\partial y} = 0.
\end{aligned}
$$

If cognizance be taken of the second of (9), the equations (10) show that

$$
\text{(11)}\qquad
\left(\frac{\partial^2 z}{\partial x\partial y} + \lambda\,\frac{\partial^2 z}{\partial y^2}\right)\left(\frac{\partial\lambda}{\partial x} + \lambda\,\frac{\partial\lambda}{\partial y}\right) = 0.
$$

If the factor $\left(\dfrac{\partial^2 z}{\partial x\partial y} + \lambda\,\dfrac{\partial^2 z}{\partial y^2}\right)$ vanishes, the expression

$\left[\left(\dfrac{\partial^2 z}{\partial x\partial y}\right)^2 - \dfrac{\partial^2 z}{\partial x^2}\,\dfrac{\partial^2 z}{\partial y^2}\right]$ must vanish and the corresponding surfaces are developable—a class not contemplated in (A).

The alternative possibility is: $\frac{\partial\lambda}{\partial x}+\lambda\frac{\partial\lambda}{\partial y}=0.$

This is Lagrange's linear equation; its solution is:

$$y=\lambda x+f(\lambda). \tag{12}$$

From (12) and the first of (9) we derive:

$$\left(\frac{\partial^2 z}{\partial x^2}\right)dx^2+2\left(\frac{\partial^2 z}{\partial y\partial x}\right)dxdy+\left(\frac{\partial^2 z}{\partial y^2}\right)dy^2=0.$$

This equation shows that the curves cut from an integral surface of (B) by the planes (12) are asymptotic lines on the surface. The surface must therefore be ruled.

The Combustibility of Mixtures of Hydrogen and Helium

By JOHN SATTERLY, D.SC., M.A., F.R.S.C.,
and E. F. BURTON, PH.D., F.R.S.C.

(Read May Meeting, 1919.)

These experiments were performed at the request of the British Admiralty in November and December of 1917. In connection with the use of helium in balloons it is of interest and importance to find out how far the helium may be diluted with hydrogen before the mixture becomes combustible. The addition of hydrogen to helium increases the bouyancy. It also lessens the cost so that it pays on both accounts to add hydrogen until the limit for safety is reached.

In the following experiments the helium was obtained from natural gas by the well-known methods of getting rid of all other ingredients by condensation with liquid air and absorption by cocoanut charcoal. The hydrogen was obtained from water by electrolysis, using pyrogallol to take out any oxygen that had diffused over to the hydrogen side of the voltmeter, and phosphoric pentoxide to dry it. The quantities of gases used in the experiments were measured in an apparatus devised by the late Dr. T. G. Brodie. In it, a Travers' siphon communicates to a chamber or pipette where the volume can be adjusted by mercury to be exactly 10 cc. and the pressure of the gas at that instant can be read off by a mercury column in a barometer tube. More gas can be passed in the mercury adjusted and the new pressure read. The increase of pressure bears to the first pressure the same ratio as the volume of gas passed into the volume of gas already in the apparatus.

In the first set of experiments the helium was passed into the pipette and the pressure read, then a certain quantity of hydrogen was passed in and the pressure again read. Then the mixture was expelled through the Travers' siphon, a white hot platinum spiral (heated electrically) being held in position just above the jet. We looked for a flame as the gases issued into the air. The following readings were obtained:

Pressure Readings			Per cent H. in the mixture	Remarks
Helium	Helium and Hydrogen	Hydrogen (by subtraction)		
mm.	mm.	mm.		
442	849	407	48	Burns.
429	553	124	22	Does not burn.
386	624	238	38	Burns.
400	479	79	16	Does not burn.
306	414	108	26	Suggestion of burning.
427	602	175	29	Does not burn.
357	536	179	33	Burns.
251	465	214	46	Burns.
609	797	188	24	?
717	919	202	28	Burning uncertain.
505	706	201	$28\frac{1}{2}$	Burning.
479	640	161	25	Suggestion of burning.
507	668	161	24	Does not burn.
456	673	217	32	Burns.

Our first experiment therefore gives a figure of about 26% above which it would not be safe to dilute with hydrogen.

We next mixed helium, hydrogen and air in known proportions, and expelled the mixture into an eudiometer tube standing over mercury and sparked. Sometimes an explosion occurred. After sparking, the mixture was passed back into the Brodie apparatus and its volume measured. It was hard to decide on the amount of sparking. Varying the percentage of air within wide limits did not seem to have much effect upon the results. Thirty or forty experiments were tried with the eudiometer method. The results, however, were indecisive, though it seems as if the first spark causes no perceptible combustion (as measured by a contraction of the total volume), if the hydrogen is not greater than 10% of the mixture, but if sufficient air is present a continued sparking burns up practically all the hydrogen and also some of the nitrogen, though much seems to depend on the relative proportions of the gases.

Mixtures of hydrogen and helium were next used to blow soap bubbles upon a tube to be described presently, and a white hot spiral was used to burn a hole through the film but these experiments used up too much helium and were not continued.

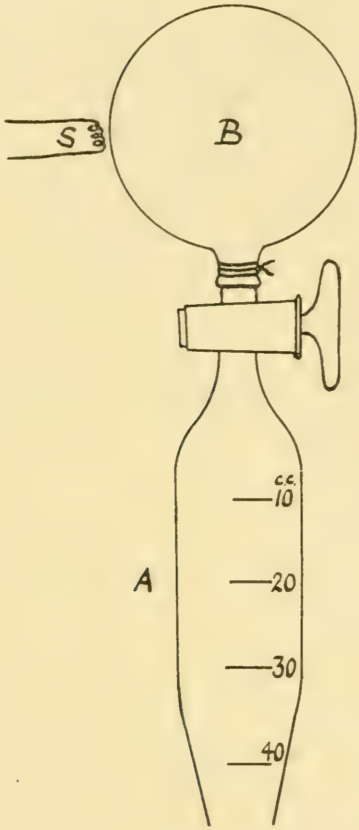

Figure 1

The soap bubbles were now replaced by thin india-rubber balloons, such as are sold at the common drug stores for twopence apiece. The balloon was tied to the glass apparatus shown in the figure. The volume of the glass tube was 44 cc. All the air was first removed from the balloon and the tube partially filled with helium. On depressing it in mercury and opening the tap, the helium was sent into the balloon B. A measured quantity of hydrogen was now delivered into the tube, and by depression this also was sent into the balloon. The balloon was now nearly a sphere of about 2½ inches in diameter. A lighted match or a white hot platinum spiral, S, was now brought up to the thin walled fabric, the wall burnt through and the action of the gases issuing through the vent observed. The temperature of the spiral would be above that of the match. The fabric itself did not burn.

I.—Preliminary Experiments with Mixtures of Hydrogen and Air, Results obtained on Applying a Lighted Match to the Fabric

Air	Hydrogen	% Hydrogen	Result
2 vols.	1 vols.	33	Loud explosion.
3 "	$\frac{1}{2}$ "	14	Just a pop.
3 "	$\frac{1}{4}$ "	8	Just a pop.
3 "	$\frac{1}{8}$ "	4	Very gentle sound.
3 "	..	0	Just a gentle flow of gas through hole in fabric.

II.—Experiments with Mixtures of Helium and Hydrogen; Results obtained on Applying a Lighted Match

Helium	Hydrogen	% Hydrogen	Results
44 cc.	5 cc.	10	Nothing.
44 cc.	10 cc.	17	Nothing.
44 cc.	22 cc.	33	Just a puff, flame hardly visible.
..	44 cc.	100	Burns, no explosion.

III.—Experiments with Mixtures of Hydrogen and Air; Results obtained on Applying a White hot Platinum Spiral

Air	Hydrogen	% Hydrogen	Result
44 cc.	44 cc.	50	Burns at the orifice made in balloon
0	88 cc	100	Prominent flare up.
55 cc.	22 cc	29	A decisive pop.

IV.—Experiments with Mixtures of Helium and Hydrogen; Results on Applying a White Hot Platinum Spiral

Helium	Hydrogen	% Hydrogen	Result
44 cc.	30 cc.	43	Gentle, but decisive burning.
44 cc.	17 cc.	28	Burns.
44 cc.	15 cc.	25	Does not burn.
60 cc.	20 cc.	25	Does not burn.
54 cc.	20 cc.	27	Indecisive.

As a result we concluded that under the conditions of the experiment the percentage of hydrogen could be raised to twenty-six per cent before the mixture become inflammable, but that if the percentage exceeded twenty-eight the mixture would burn. This result was communicated to the Admiralty on December 20th, 1917.

University of Toronto

Possible Economies in the Electric Smelting of Iron Ore

A PRELIMINARY NOTE

By Dr. ALFRED STANSFIELD, F.R.S.C.

(Read May Meeting, 1919.)

The electric smelting of iron ores was first undertaken about twenty years ago, and is now in regular commercial operation in Sweden and to a small extent elsewhere. The merits and limitations of this process can be visualized by comparing it with the corresponding process in the iron blast furnace.

Speaking generally, iron ores can be smelted in the blast furnace with the expenditure of one ton of fuel (coke or charcoal) for each ton of pig iron produced. In the electric furnace, on the other hand, the fuel needed is replaced in part by electrical energy, and the production of one ton of pig iron in this furnace is found to require about four-tenths of a ton of fuel (usually charcoal) and about four-tenths of an electrical horse power year.

In view of the comparative costs of coke and electrical energy, it is clear that the saving of six-tenths of a ton of coke will usually be insufficient to pay for four-tenths of an electrical horse power year, although where charcoal is used in the blast furnace and where electrical energy is exceptionally cheap, the saving in fuel may pay for the electrical power.

The use of charcoal in the blast furnace was, at one time, very general, but at present, owing to its higher cost and the other limitations of its use, charcoal smelting is only practised to a small extent.

In Sweden magnetite iron ores of unusual purity have for a long time been smelted with charcoal, in blast furnaces, for the production of a special quality of white pig iron which commands a high price. Under these conditions the electric furnace has been found to be more economical than the blast furnace and is therefore replacing it to a large extent. In other countries, such as Canada, electric power is in general more costly than in Sweden. As a rule, the ores are not pure enough for the production of the finest iron, and, in addition to this, there is not a large enough market for a high-priced pig iron of special quality.

There are many districts in Canada where iron ores and water power can be obtained near together and where coke, suitable for blast furnace smelting, is too costly for use; but the cost of smelting these ores in electric furnaces is too high for satisfactory commercial operation. The question naturally arises whether any improvement can be made in the furnace whereby any considerable economy can be effected.

The possibility of increased economy can be studied from two points of view. The first of these is the actual efficiency of the electric furnace, and the second is the wider consideration of the whole problem of the reduction of iron ores. The electric smelting furnace is wasteful, as regards fuel and electrical energy, because the gaseous product of the reduction of the ore is largely carbon monoxide instead of carbon dioxide. In the Swedish furnace, which is the most efficient type, the carbon monoxide is utilized to some extent for the reduction of the ore, but even in this furnace only one-fourth of this gas is utilized and the gas that still goes to waste contains as much potential energy as the net heat requirements of the furnace, or about three-fourths that of the electric power supply. It follows therefore that if the carbon monoxide could be completely utilized, the consumption of fuel and of electric energy would both be very materially reduced. So far, however, no satisfactory way of doing this has been arrived at.

The problem can be viewed, however, from a different and a wider point of view. In smelting iron ores in the electric furnace, a large amount of electric energy is needed—about 0·4 E.H.P. year per ton of pig iron—and this is the most serious item of cost in the operation. As the fusion of the pig iron and the slag only accounts for one-fourth of this amount, it is clear that by far the largest item in electric smelting is the energy requirement of the chemical reduction of the ore. So long ago as 1872 Sir Lothian Bell showed that the reduction of iron ores to the metallic state took place in the shaft of the blast furnace at temperatures considerably below the fusion point of the ore or the resulting iron or slag. This circumstance renders it probable that it will be more economical to carry out the reduction of the ore by means of fuel-heat, at moderate temperatures, and to leave for the electric furnace the smaller but more appropriate task of melting the metallic product and of reducing from the silica in the ore the required amount of silicon.

The smelting of iron ores in the blast furnace has been in operation for hundreds of years, and iron ores have been reduced in the solid condition to the so-called "iron sponge" for a number of years, but we have not as yet in metallurgical literature any definite information with regard to the speed and completeness with which iron ores can be reduced to the metallic state at various temperatures and with various reducing reagents. We have the information needed for calculating the equilibrium curves of the reduction, but there is not enough information available to show at what rate the reduction can practically be effected.

Several years ago when designing an electric furnace process for the production of steel from iron ore, I made experiments on the reduction of titaniferous magnetites, which were crushed, mixed with charcoal and briquetted with pitch and tar. I found that these briquettes must be heated to a temperature of at least 900°C. before any large proportion of the iron was reduced to the metallic state, and this circumstance made it very difficult to secure the efficient reduction of the ore in any practicable kind of preheating apparatus. Those who are familiar with furnace construction will recognize that a difference of as little as 100° C. in the operating temperature of such an appliance may make the difference between commercial success and failure.

In view of the lack of exact knowledge of this subject, I applied to the Advisory Research Council in March, 1918, for a grant to assist me in making a series of experiments to secure the needed information. Owing, however, to the extreme difficulty, during the war, of securing skilled assistance, I was unable to begin work until January, 1919, when I obtained the help of Mr. G. R. Kendall, B.Sc., who has carried on the work up to the present time. It seems inadvisable to state our results in any detail in their present incomplete condition; but I may say that we have aimed at obtaining definite information of a scientific character that would be useful in designing a process and have resisted fairly well the temptation to make guesses at a process before we had the information needed for designing it.

In my earlier process for the production of steel from iron ores[1] I depended on the gases from the electric smelting furnace for heating and partly reducing the ore. The reduction of the ore, in this appliance, could never be complete because it was carried out by the gases arising from the reduction of the *unreduced portion*. Another difficulty was met with in view of the relatively large size of the reduction part of the furnace which prevented a satisfactory design of the smelting portion.

In view of these difficulties, I came to the conclusion that the reduction of the ore and the fusion of the reduced ore should be carried out in separate appliances, and that the first thing to do was to study practically the conditions essential for the reduction, in the solid condition, of hematite and magnetite ores.

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[1] Stansfield, "The Electric Furnace." 1914 Ed. p. 258.

As stated above, I applied to the Advisory Research Council in March, 1918, for funds to help me in this research and made a partial statement of my ideas as set forth on p. 32 of the Report of the Advisory Council for the year ending March 31st, 1918. I considered, subsequently, the question of patenting, but came to the conclusion that as the reduction of iron ores to a metallic sponge was well known, and as the electric melting of metallic iron was well known, it would be impossible to patent them in combination. About a year later, however, I learnt that Mr. J. W. Moffatt of Toronto had actually patented in the United States and in Canada the particular combination I had in view; Mr. Moffatt's application being made about a month or six weeks after my own statement before the Advisory Council.

Recent experimental work on the reduction of iron ores, in preparation for electric melting, has been done by Messrs. Trood and Darrah, at Heroult, California, and by Mr. A. T. Stuart of Toronto. Mr. F. T. Snyder of Chicago has devised a process along similar lines, but does not appear to have tested it practically. Information with regard to these processes will be found in Appendix XII of my recent report on the possibility of smelting iron ores electrically in British Columbia[1].

While the experiments of Mr. Kendall and myself are still too incomplete for publication, I may state that they will furnish an important addition to our exact knowledge about the reduction of iron ores, and that it seems quite likely that we may ultimately arrive at some practical process that will be more economical than existing methods.

[1] "The Commercial Feasibility of the Electric Smelting of Iron Ores in British Columbia." British Columbia Department of Mines, Bulletin No. 2, 1919.

The Analysis of Maple Products

PAPER II. THE COMPOSITION OF MAPLE SYRUP AND OF MAPLE SUGAR SAND AND THE DETECTION OF ADULTERATION OF THE SYRUP

By J. F. SNELL, PH.D.

Presented by FRANK T. SHUTT, M.A., D.SC., F.R.S.C.

(Read May Meeting, 1919.)

Six years ago a first paper[1] under the above general title was presented to this Society. In the interval the electrical conductivity test therein described has been applied to a considerable number of pure syrups and to maple sugars and comparisons have been made between that test and others as to their effectiveness in detecting adulteration with pure and raw cane sugars. The directions for the test have been revised but not materially altered.[2] An electrotitrametric test using lead subacetate solution has been published[3] and further work upon it is in progress. Some miscellaneous observations on maple syrup[4] and some analyses of maple sugar sand[5] have also been made public.

The purpose of the present paper is to summarize some of the results of our own investigations and those of others in the same field, dealing first with the composition of the products of maple sap, and afterwards with the question of adulteration of the syrup and sugar.

MAPLE SUGAR SAND

This material, precipitated from the evaporating sap, has been shown to consist mainly of calcium malate, silica being the next most abundant ingredient. Table I gives the per cent of ash and the percentage composition of the ash of six samples analysed by Mr. A.

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[1] These Transactions 1913, Section III, pp. 165–182.

[2] Snell and Scott, Journ. Ind. Eng. Chem. 5 (1913) 993–7, 6 (1914) 216–22; Snell, Journ. Soc. Chem. Ind., 33 (1914) 507–15; Journ. Ind. Eng. Chem. 8 (1916), 331–3; Van Zoeren, Journ. Amer. Chem. Soc. 38 (1916) 652–3; Snell and Van Zoeren, Journ. Ind. Eng. Chem. 8 (1916), 421–2.

[3] Snell, MacFarlane and Van Zoeren, Journ. Ind. Engin. Chem. 8 (1916), 241–3.

[4] Snell, Journ. Ind. Eng. Chem. 8 (1916), 144–8.

[5] Snell and Lochhead, Journ. Ind. Eng. Chem. 6 (1914), 301–2.

Grant Lochhead in 1911[1], two by the author in the previous year and one by Prof. W. H. Warren[2]. Table II gives results derived from these ash analyses and the determinations of malic acid made by Messrs. Lochhead and Warren respectively. There is a reasonable agreement between the two estimates of calcium malate—that calculated from the calcium and that from the malic acid—the differences being sometimes positive, sometimes negative. In only three of the seven samples do the two estimates vary by more than two per cent.

The nature of the undetermined matter has not yet been ascertained. Water of crystallization, retained at 100–110° suggests itself as a possibility, though Prof. Warren tells me the hydrate, $CaC_4H_4O_6 \cdot 2H_2O$, loses its water at that temperature. Possibly it may be water retained by the silica. That it may be some complex carbohydrate, has been suggested by Warren.[3]

Results so far obtained point to malic acid as the only organic acid present in material quantity.

Von Lippmann[4] has reported the discovery of d-tartaric acid and of small quantities of tricarballylic acid in a sample sent him from Montreal some years ago. Mr. Van Zoeren, attempting to confirm Von Lippman's results, obtained sufficient tartaric acid to identify microscopically as acid potassium salt but was unable to isolate tricarballylic acid. Warren found a trace of calcium oxalate (identified microscopically), but could not detect any other organic acid.

The seven samples of washed sugar sand in which malic acid was determined show an average content of about 70 per cent of calcium malate, corresponding to 55 per cent of malic acid, $H_2C_4H_4O_5$. In thirteen samples received from farmers in 1914, an average content of 47·4 per cent of malic acid was found. In converting the sand into calcium bimalate in lots of 50 to 200 grams we recover about 75 per cent of the acid indicated by the analysis. Warren recovered 96 per cent in one experiment, but the calcium bimalate crystals obtained were naturally not very pure.

No very accurate estimate of the annual production can be made at present. Practical men say that the yield varies from year to year and from bush to bush. In 1912, Mr. Lochhead weighed the sugar sand produced by twenty-one Quebec farmers and obtained information as to the number of trees tapped and the number of gallons of syrup made by each. Samples of each farmer's sand were ashed.

[1] *Loc. cit.*

[2] Journ. Am. Chem. Soc. 33 (1911) 1205–11.

[3] Vermont Maple Sugar Makers' Association, Twentieth Annual Report (1913), p. 43.

[4] Ber deutsch, Chem. Gesell, 47 (1914), 3094–5.

The results showed an average of 56·2 oz. sugar sand ash per 1000 trees. This corresponds to 100 oz. washed sugar sand of the average composition indicated by Mr. Lochhead's analyses of samples of the previous season, or to 70 oz. anhydrous calcium malate or 55 oz. malic acid. If the 19 million trees tapped in the United States in 1909 yielded in the same proportion, they would produce 30½ tons malic acid, of which 24 tons could be recovered on a 75 per cent basis. Canada's production of sugar in 1910 being five-ninths of that of the United States in 1909, her possible production of malic acid from this source would be 18 tons total, or 13½ tons 75 per cent recovery.

Reasoning from the ratio of malic acid to sugar—probably a more reliable basis—we reach a higher result. Per 1000 lbs. sugar these twenty-one farmers produced sugar sand yielding 35·3 oz. ash, equivalent to 62·4 oz. washed sugar sand, 43·7 oz. calcium malate or 34·3 oz. malic acid. Canada's production of sugar in the last census year amounted to 26 million pounds. The corresponding amount of malic acid is 28 tons total or 21 tons recoverable.

Prof. Warren[1] has estimated the production of Ontario and Quebec at 127,200 lbs. sugar sand. On the basis of 47·4 per cent malic acid this would contain 30 tons malic acid.

It is not improbable that a better recovery than 75 per cent would be accomplished on the manufacturing scale. On the other hand, it is scarcely probable that nearly all the sugar sand produced could be collected, inasmuch as the amount produced by individual farmers is small and many of them could hardly be induced to take the trouble to wash and dry what they are in the habit of throwing away. As a matter of fact, however, some of them have been saving sugar sand for several years and shipments of some hundreds of pounds have been made from Canada to chemical manufacturers in Europe.

The Non-Sugar Components of Maple Syrup

Since the commercial value of maple syrup depends upon the content of non-sugar compounds—flavouring and colouring matters—and since most of the adulteration tests depend directly or indirectly upon non-sugar components—chiefly salts—a more exact knowledge of the nature and amount of these components is desirable. As yet but little is known. The flavouring material has not been isolated or in any way identified. Sy[2] made an unsuccessful attempt. Wiley[3]

[1] Vermont Maple Sugar Makers' Association, Twentieth Annual Report, 1913, p. 45.

[2] Sy, Journ. Franklin Inst. Oct., Nov., and Dec., 1908, p. 29–32 of reprint.

[3] U.S. Dept. Agr., Bureau Forestry Bulletin 59 (1905), p. 47.

and Warren[1] have made vague conjectures, and I have been told that a Canadian chemist once satisfied himself as to the constitution of the flavouring material but did not publish his work. The identification of this substance and the invention of a quantitative test for it would be a notable achievement.

Syrups skilfully made from fresh maple sap are very light-coloured and there is no definite evidence that the sap contains any specific pigment. Deterioration of the sap by micro-organic action,[2] caramelization of sugar in the evaporator and the action of adventitious tannin[3] on the iron of untinned evaporators may be the true sources of the light yellow to deep red and brown colours observed in the less carefully made syrups and sugars.

Ash analyses[4] indicate clearly that potassium and calcium salts of organic acids are the leading non-sugar constituents of maple syrup, with magnesium and sodium salts and silica also fairly prominent and some sulphur compound usually present.[5]

The only complete ash analyses as yet published are four by Hortvet and one of a composite of 60 syrups made by Mr. J. M. Scott in this laboratory. Mr. Van Zoeren has analyzed the ash of five syrups about which we have very full information as to origin, analytical values, etc. Averaging these five analyses with Hortvet's four and then averaging the result with Mr. Scott's on equal terms we get: K_2O, 29·45; Na_2O, 2·99; CaO, 23·24; MgO, 4·29; Fe_2O_3, 1·31; Mn_3O_4, 0·90; CO_2, 32·08; SiO_2, 2·75; P_2O_5, 0·63; SO_3, 1·46; Cl, 1·05. Sum − O-equiv. of Cl (= 0·24), 100·21 − 0·24 = 99·97.

Jones[6] has published determinations of lime, potash and sulphuric acid in ten samples with results averaging nearly the same as the above. Bryan[7] determined the same three constituents and phosphoric acid in 100 syrups, obtaining decidedly higher results on potash and phosphoric acid than have been found by the other analysts.

With what organic acid the metals are combined has not been clearly elucidated. Mr. Van Zoeren has made some attempts to

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[1] Vermont Maple Sugar Makers' Association, Twentieth Annual Report (1913), p. 50–1.

[2] Edson, Vermont Agr. Expt. Station, Bulletin 167 (1912).

[3] Bryan, U.S. Dept. Agr., Bureau Chem. Bull. 134 (1911), p. 66; U.S. Dept. Agr. Bull. 466 (1917), p. 34–5.

[4] Horvet, Journ. Am. Chem. Soc., 26 (1904), 1541: Jones, Vermont Agr. Expt. Station, Eighteenth Annual Report (1904–5) 331: Bryan, Bureau of Chem., U. S. Dept. Agr. Bull. 134 (1910), 82–89; Snell, Journ. Ind. Eng. Chem., 8 (1916), 146.

[5] Seven of Bryan's 100 ash samples were sulphate-free.

[6] Vermont Agr. Expt. Station Eighteenth Annual Report (1905), p. 331.

[7] U.S. Dept. Agr. Bull. 134 (1911), p. 82–89.

separate the acids precipitated by calcium salts and alcohol (as in the analytical determination of malic acid value) but his results are reserved for corroboration by further experiments.

Malic acid is probably the leading acid, however. Assuming the four leading bases of the above ash analysis average to be present in the syrup as malates, we derive an average salt content of 1·54 per cent. The equivalent amount of malic acid is 1·00 per cent, which corresponds closely to the average malic acid value obtained by Bryan on 843 samples of syrup and sugar, using the Cowles method of analysis, *viz.* 0·98 per cent malic acid, $H_2C_4H_4O_5$[1]. This agreement between two estimates of the amount of malic acid represented in the salts, remarkable as it is, does not exclude the possibility of the presence of a considerable amount of other acids having calcium salts insoluble in 85 per cent alcohol.

Detection of Adulteration

Adulteration of maple syrup with refined sugar leaves the sucrose content unchanged but reduces the percentage of every non-sugar component. For the detection of such adulteration we are necessarily dependent upon measurements of analytical values based upon the content of one or more of the non-sugar components. Of these components the salts are the most abundant and it is doubtless upon these that all our current methods are mainly dependent. Table III is a summary of the results which a number of investigators have obtained by applying these methods to syrups and sugars known to be genuine. Table IV gives a comparison of the range of variation which these various analytical values show in genuine maple products. In deciding whether a given sample is adulterated with refined sugar or not, the minima of these values are, of course, the significant figures, but in comparing the usefulness of methods, the range of variation of the values in genuine products is important. Other things being equal, that method whose value shows least variation in genuine syrups will be the most useful in detecting adulterations with refined sugar. Judged by this criterion, the conductivity method is shown by Table IV to be superior to any of the others, except the volumetric lead method, to which reference will be made later. This assertion is subject to the qualification that the conductivity results included in the summary have all, or practically all, been obtained upon syrups and sugars of Canadian origin, while those of the ash values, Winton

[1] Bryan, U.S. Dept. Agr., Bureau of Chem. Bull 134 (1911) pp. 91–2; U.S. Dept. Agr. Bull. 466 (1917), p. 34.

lead number and malic acid value refer to samples collected over the whole range of maple sugar production.

Last year in connection with the collaborative work of the Association of Official Agricultural Chemists, Prof. A. G. Woodman, of the Massachusetts Institute of Technology, applied the conductivity method to seven syrups, upon which measurements were also made by Mr. Van Zoeren and myself. For this purpose two sets of directions were issued: First, those of the seventh paper of the series published in the Journal of Industrial and Engineering Chemistry,[1] being essentially the original method in which the dilution of the syrup is roughly made; second, the following:

Weigh out the quantity of syrup containing 22 grams dry matter. Transfer to a 100 cc. volumetric flask with warm water, cool and make up to the mark. Measure 60 cc. of the solution into a 100 cc. beaker, insert a Van Zoeren or other dipping electrode, bring to 25°C. ($+0 \cdot 1$) and measure the electrical resistance. Divide the constant of the cell by the observed number of ohms and multiply the result by 10^5.

The results of this collaborative work, which are given in Table V, suggest that closer agreement might be obtained by use of the second and more precise set of directions, though the results included in Tables III and IV refer to the first and more rapid method.

The volumetric lead number results are obtained by titrating 6 cc. syrup, diluted to 60 cc., with a dilute solution of lead subacetate (sp. gr. 1·033), using electrical resistance measurements to detect the end point. The lead number represents the number of cubic centimeters of lead subacetate corresponding to a break in the curve of resistances. The method has given good results in the hands of both Mr. McFarlane and Mr. Van Zoeren. Using it, Mr. McFarlane has succeeded in discriminating between three pure and four adulterated samples, which all gave normal results by all the other methods. The weakness of the method at present consists in the difficulty of deciding on the manner of drawing the curves. The breaks in the curves of genuine syrups are not always as distinct as could be desired. Further work upon this method is in progress and we entertain hopes that in some form it may prove useful.

The "Canadian" lead method which originated in the Laboratory of the Inland Revenue Department (now the Foods and Drugs Laboratories of the Department of Trade and Commerce) has proved a very useful one and some investigations are in progress in Ottawa and in our own laboratory which may lead to its further improvement.

[1] Journ. Ind. Eng. Chem. 8 (1916), 333.

They have already led to the recognition that the lead subacetate solutions prepared by dissolving Horne's salt in water are not identical with those prepared by boiling lead subacetate solution with litharge, even when the directions given in the methods of the Association of Official Agricultural Chemists are closely adhered to and do not give identical results in the determination of Canadian lead number. Details of this work will be published in due time.

Macdonald College,

May 20, 1919.

TABLE I

Ash Analyses of Maple Sugar Sand

	Sample Number								
	1	2	3	4	5	6	7	8	9[1]
% Air-dry Ash......	55·37	60·24	59·02	60·15	58·67	56·32	54·26	52·22	..
Ignited Ash.........	..	..	..	..	..	..	33·45	32·08	32·26
Carbon Dioxide.....	36·14	25·27	30·94	29·81	34·07	30·68	..	..	..
Carbon.............	..	2·09	2·49	2·40	2·29	2·23	0·92	0·78	..
Sand and Silica.....	11·14	30·81	22·24	24·98	18·15	24·54	15·00	11·64	7·74
Lime (CaO)........	46·49	37·57	41·12	40·00	43·17	40·95	18·28	19·30	24·03
Magnesia (MgO)....	..	..	0·47	1·40	0·76	1·56	0·34	0·34	0·05
Potash (K_2O).......	..	..	..	..	..	..	0·06	0·06	..
Iron oxide (Fe_2O_3)..	tr	tr	tr	tr	tr	tr	..	..	0·39
Manganese oxide (MnO)...........	3·38	2·30	3·06	2·71	2·55	..	..	..	..
Phosphoric acid (P_2O_5)..........	..	1·64	1·19	1·37	0·57	0·52	0·65	1·30	0·05
Summation.........	97·15	99·68	101·51	102·67	101·56	100·48	35·25	33·42	32·26
Moisture[2]...........	3·36	3·60	1·87	3·28	2·85	2·86			
	100·51	103·28	103·38	105·95	104·40	103·34	..	..	..

[1] Warren, Journal Amer. Chem. Soc. 33 (1911), 1205–11. The figures given above are those of the first of two very similar analyses.

[2] The gain in weight upon exposure to air. This may have consisted partly of carbon dioxide.

TABLE II

Percentage Composition of Washed Maple Sugar Sand

	1	2	3	4	5	6	9
Minor mineral constituents Fe_2O_3, MnO, MgO, P_2O_5, and CO_2	1·87	2·37	2·77	3·29	2·27	1·17[1]	1·13
Extraneous organic matter	..	..	..	..	..	..	2·35
Invert sugar	..	..	..	..	..	..	2·31
Cane sugar	..	..	..	..	..	..	3·46
Ether-soluble matter	..	..	..	..	..	..	0·37
Moisture lost at 100°	0·21	0·69	0·69	0·57	0·17	0·11	2·60[2]
Calcium malate—from malic acid determination	79·67	68·91	69·87	65·73	75·25	66·56	67·08
(Excess over calculation from Ca	3·45	1·88	−2·01	−5·55	0·42	−1·72	−6·61)
Silica	6·16	18·55	13·74	15·03	10·65	13·82	7·74
Undetermined[3]	12·09	9·48	12·93	15·38	11·66	18·34[4]	12·96
$2H_2O$ per mol $CaC_4H_4O_5$	16·68	14·43	14·63	13·76	15·75	13·93	14·04

[1]MnO determination lost.
[2]Lost at 100–110°.
[3]100-sum of determined items using the percentage of calcium malate calculated from the malic acid determination.
[4]Including MnO.

TABLE III

Analytical Values in Genuine Maple Syrups and Sugars

Value	No. of Analyses	Max.	Min.	Average
Total Ash	1151[1]	1·70	·56	·95
Soluble Ash	1151[1]	1·23	·27	·60
Insoluble Ash	1151[1]	1·01	·12	·37
Ratio Soluble : Insoluble Ash	1036[2]	4·07	·43	1·78
Alkalinity—Soluble Ash	1034[3]	1·40	·34	·74
Alkalinity—Insoluble Ash	1034[3]	2·08	·31	·95
Ratio Alk. soluble: Alk. insoluble ash	1034[3]	2·29	·21	·84
Canadian Lead No.	155[4]	7·55	1·74	3·43
Winton Lead No.	891[5]	4·95	1·05	3·23
Malic Acid Value, Hortvet method.	620[6]	2·68	0·30	0·82
" with blank	481[7]	1·60	0·29	0·84
Cowles method	844[8]	1·82	0·21	0·98
Conductivity Value	319[9]	230	96	141
Volumetric Lead Number	139[10]	6·6	4·9	5·65

NOTES TO TABLE III

[1] Jones	48	syrups—Vermont Agr. Expt. Sta. Eighteenth Annual Report (1905), 315–339. Summary on p. 320.
Bryan	481	syrups—U.S. Dept. Agr., Bureau Chem. Bull. 134 (1910), 76.
McGill	115	syrups—Lab. Inland Rev. Dept., Canada, Bull. 228 (1911).
Snell and Scott	126	syrups—Journ. Ind. Eng. Chem: 6 (1914), 217.
Bryan	363	sugars—U.S. Dept. Agr., Bull. 466 (1917), 26.
McFarlane	9	Quebec syrups of the season of 1914—unpublished.
Van Zoeren	7	Quebec syrups of the season of 1915 do.
	2	Quebec sugars of the season of 1913 do.
Total	1151	

The 43 sugars analyzed by Jones (*l.c.*) are not included because these were analyzed without reconversion into syrup.

Hortvet's 22 syrups—Journ. Am. Chem. Soc. 26 (1904) 1528—might have been included without altering the maximum or minimum or appreciably affecting the average. His 19 sugars must be excluded on the same grounds as those of Jones. Jones—Vermont Agr. Expt. Sta. Bull. 167 (1912), 419–474—has published analyses of 228 syrups prepared from the sap of a few trees of a single orchard in three successive seasons. On account of the narrow limits of origin and the inconvenience of averaging the results, it has been thought inadvisable to include these.

[2] Same results as on total ash, omitting McGill's 115 samples, for which the ratio is not calculated. One of these syrups (No. 241) has 5·25 times as much soluble as insoluble ash, the insoluble ash (0·12 per cent) being much lower than has been found in any other genuine syrup, except No. vii of the same collection (0·14 per cent). This latter syrup shows a wider ratio of soluble to insoluble ash (4·00) than any of Bryan's syrups but a sugar of Bryan's from Lancaster Co., Penn., with an insoluble ash content of 0·25 per cent shows an equally wide ratio (4·00), while one from Delaware Co., N.Y. (No. 6640) has a ratio even wider (4·07).

[3] In addition to McGill's 115 analyses, two of Mr. McFarlane's are omitted here on account of inconsistencies in our records.

[4] Snell and Scott 126 syrups, (*l.c.*) McFarlane 9 syrups, (*l.c.*) Snell and Van Zoeren 20 syrups—Journ. Ind. Eng. Chem. 8 (1916), 242.

McGill's results on 456 syrups (*l.c.*) are not included, because these analyses were made upon 5 grams syrup and calculated to the dry basis, a procedure which does not give the same result as direct determination upon the quantity of syrup containing 5 grams of dry matter. See Snell and Scott, Journ. Ind. Eng. Chem. 5 (1913), 993–997.

[5] Bryan	481	syrups.
McGill	47	"
Bryan	363	sugars
Total	891	

The results of Snell and Scott are not included, since their analyses were made on the quantity of syrup containing 25 grams of dry matter.

[6] Hortvet	17	syrups—Journ. Am. Chem. Soc. 26 (1904), 1525–45.	
	16	sugars	*ibid.*
McGill	452	syrups	*l.c.*
Snell and Scott	126	"	*l.c.*
McFarlane	9	Quebec syrups 1914—unpublished.	
Total	620		

[7] Bryan 481 syrups.

[8] Bryan 481 syrups and 363 sugars.

[9]1911..... 30 Quebec syrups—Snell. Roy. Soc. Canada, 1913, III, 165–182.
13 Ontario syrups *ibid.*
1912..... 2 Quebec syrups (actually 22 from the sap of ten trees.)
3 Vermont syrups *ibid.*
1913..... 126 Ontario and Quebec syrups—Snell and Scott, *l.c.*
16 Sugars—Snell and Van Zoeren—Journ. Ind. Eng. Chem. 8 (1916) 421–2.
1914..... 9 Quebec syrups—McFarlane.
1915..... 61 Quebec syrups.
1916..... 53 Canadian syrups.
1917..... 3 Canadian syrups.
1918..... 3 Quebec syrups—Prof. A. G. Woodman.
Total..... 319 analyses.

[10] 16 sugars 1913; 8, 62, 53 syrups 1914, 1915 and 1916 respectively.

TABLE IV

Range of Analytical Values in Genuine Maple Sugars and Syrups
Revised to May 1st, 1919

Value	No. of Analyses	Range in % of Average	Range in % of Minimum
Total Ash	1151	120	202
Soluble Ash	1151	160	355
Insoluble Ash	1151	241	742
Ratio Sol. Ash: Insol. Ash	1036[1]	204	846
Alk. Soluble Ash	1034	143	312
Alk. Insoluble Ash	1034	186	571
Ratio Alk. Sol. Ash: Alk. Insol. Ash	1034	248	990
Canadian Lead No.	155	169	335
Winton Lead No.	891	122	371
Malic Acid Value: Hortvet method	620	290	793
Malic Acid Value: Hortvet method with blank	481	156	452
Malic Acid Value: Cowles method	844	164	767
Conductivity Value	339	95	140
Volumetric Lead No.	139	32	38

[1] If McGill's 115 analyses were included the total number of analyses would be 1151 and the range of variation would be 1121 per cent of the minimum.

TABLE V

Collaborative Measurements of Conductivity Value on Syrups issued as A.O.A.C. Samples in 1918

Syrup No.	Using 20 cc. Syrup			Using the quantity of Syrup containing 22g. dry matter.	
	Woodman	Snell	Van Zoeren	Woodman	Snell
1	165	173	171	166	167
2	171	179	180	173	173
3	171	177	178	171	172
4	123	132	..	128	131
5	148	153	154	149	152
6	137	144	145	139	141
7	192	202	203	191	195

The "Alkali" Content of Soils as Related to Crop Growth

(A REPORT OF PROGRESS)

By FRANK T. SHUTT, M.A., D.SC., and E. A. SMITH, M.A.

(Read May Meeting, 1919.)

In a paper presented to this Society last year, the writers outlined the work being carried on by the Division of Chemistry of the Dominion Experimental Farms for the Reclamation Service of the Department of the Interior, towards the classification of certain areas in Southern Alberta into irrigable and non-irrigable lands.[1] The chief feature in the analytical work involved is the determination of the so-called alkali, its nature and amount, on soil samples collected in suspected areas, at depths as follows: $A = 0' \cdot 0 - 0' \cdot 5$, $B = 0' \cdot 5 - 1' \cdot 5$, $C = 1' \cdot 5 - 3' \cdot 0$ and $D = 3' \cdot 0 - 5' \cdot 0$.

In the interpretation of the data so obtained and their application to the lands in question, certain standards or limits of toxicity as proposed by American investigators in alkali problems have been largely used. Since, however, in a large number of instances the nature of the "alkali" found in Canadian territory differs markedly from that which has formed the basis of the American standards, it is obvious that the latter are not in all cases strictly applicable to the soils now being classified. The results and examples presented in our paper last year constituted the first contribution towards the establishment of standards more particularly adapted to Canadian conditions. The present paper will give the results of the second years work on this problem and may be considered as a report of progress in this important matter.

The previous paper recorded the results of the analysis of five series of soil groups, each series consisting of three groups representative of land upon which (1) there was a fair or good crop, the concentration of the alkali being apparently and for practical purposes, negligible; (2) upon which there was poor growth, the crop evidently being distressed by alkali, and; (3) upon which there was no growth due to excess of alkali. Each series represented a separate tract of land or field, the three groups being collected within a comparatively short distance of one another in the same field or area. The same plan and procedure have been followed in the collection of

[1] The Alkali Content of Soils as related to Crop Growth, by Frank T. Shutt, D.Sc., and E. A. Smith, M.A., Transactions of Royal Society of Canada, 1918, pp. 83–97.

WHEAT

GOOD GROWTH

Series 6. Irrigated

Amounts of Ingredients in 100 of Air dried Soil

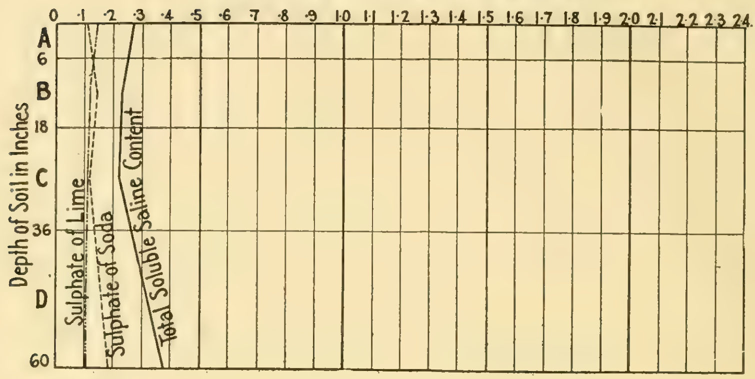

Fig. 6.

POOR GROWTH.

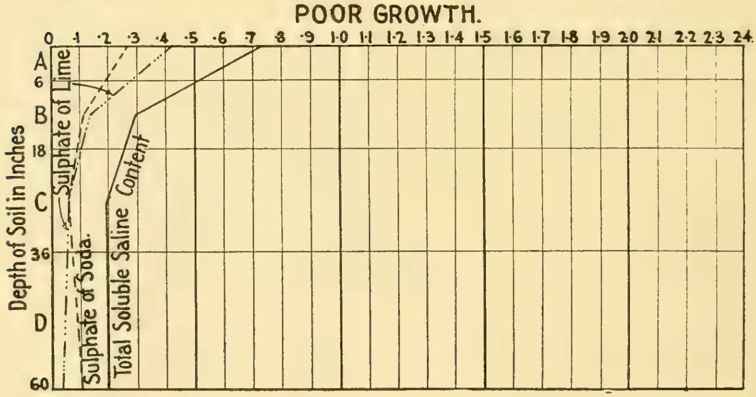

Fig. 6.

NO GROWTH.

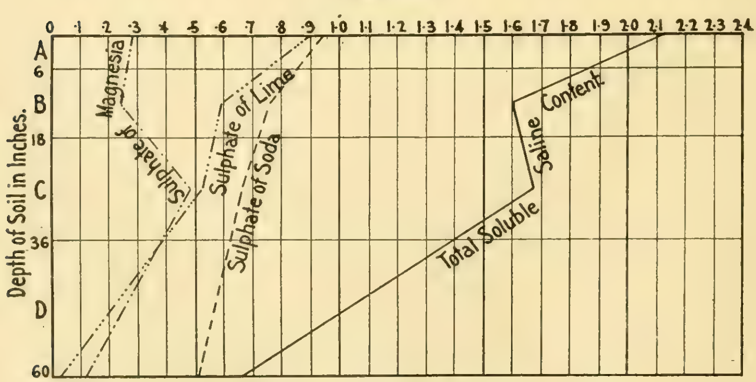

Fig. 6.

Distribution of Alkali Salts in Soil
in Section 7. Township 7. Range 22. W. of 4th M.
Samples taken 23rd July 1918.

the groups now reported on. The crops involved in the work presented last year were: Western Rye Grass, Native Prairie Grass, Oats, Wheat, Onions; those now considered are two series of Wheat and one each of Western Rye Grass and Oats.

Wheat

Series VI, Section 7, Township 7, Range 22, West of the 4th Meridian.

The samples of this series were collected in a wheat field one mile north-east of Gleichen, Alberta. The area had been under irrigation for a number of years, during which time the bare alkali spots had increased in size very considerably. The wheat had been irrigated June 15th. The soil was a brown loam of good quality; sub-soil of heavier character, containing a considerable proportion of clay. The yield for the 70 acre field of wheat at date of this visit, July 23rd, 1918, was estimated at 40 bushels per acre. One group of samples was from a bare spot, the second in poor growth, 18 feet distant, and the third in the best growth, 48 feet from the same point of collection.

Wheat

Sec. 7, Tp. 7, R 22, W. of the 4th Mer.

Group No.	Depth	Growth	Na_2SO_4	$MgSO_4$	$CaSO_4$	Total soluble saline content
1662	0′·0–0′·5	Good	·119		·136	·260
	0′·5–1′·5		·142		·119	·228
	1′·5–3′·0		·119		·111	·220
	3′·0–5′·0		·160		·104	·320
1661	"	Poor	·231		·352	·620
			·113		·136	·292
			·059		·060	·194
			·090		·046	·200
1660	"	No	·900	·273	·826	1·999
			·760	·243	·597	1·600
			·664	·483	·527	1·674
			·568	·249	·211	1·028

Discussion of Results. The alkali of these groups is sodium sulphate, the characteristic salt of "white alkali," but magnesium sulphate is also present in Group 1660, characterized by "No Growth." Chlorides are absent throughout the series.

WHEAT

GOOD GROWTH

Series 7. Irrigated

Amounts of Ingredients in 100 of Air dried Soil.

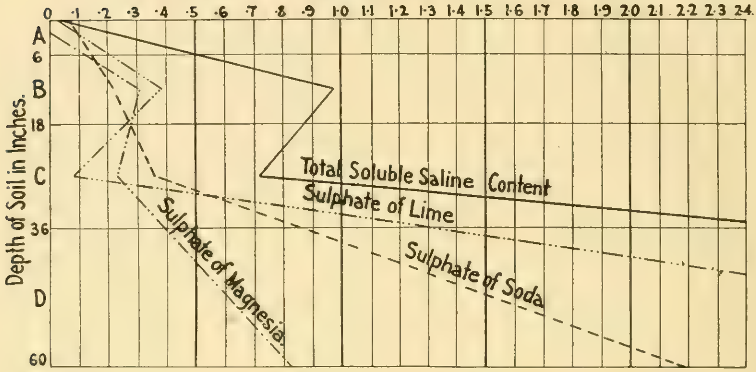

Fig. 7.

POOR GROWTH

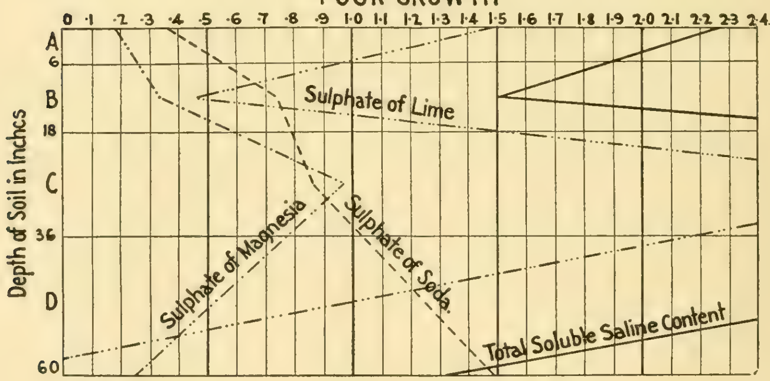

Fig. 7.

NO GROWTH

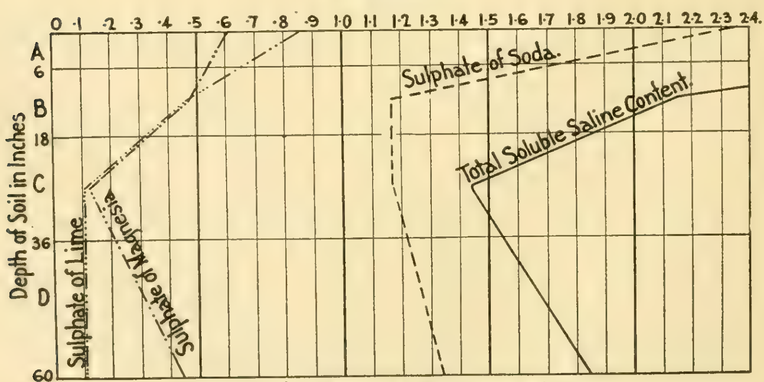

Fig. 7.

Distribution of Alkali Salts in Soil.
in Section 24. Township 22 Range 22. W. of 4th M.
Samples taken 24th July. 1918.

Group 1662. Good growth. The concentration of sodium sulphate throughout the members of this group is low and practically uniform.

Group 1661. Poor and meagre growth. The percentage of sodium sulphate in A (0′·0—0′·5) is considerably higher than in the corresponding member of Group 1662. The concentration decreases in the lower samples. Judging from the sparse appearance of the crop, the percentage of alkali in "A" probably represents the limits of tolerance for wheat under irrigation.

Group 1660. No growth, soil bare. In A (0′·0—0′·5) the concentration of sodium sulphate is ·900 per cent and magnesium sulphate ·273 per cent, an impregnation too high to permit of any growth. Throughout the members of this group the alkali remains between 1 per cent and 2 per cent.

Wheat

Series VII, Section 24, Township 22, Range 22, West of 4th Meridian.

These three groups were taken from a wheat field about six miles north-east of Gleichen, Alberta. The area was not under irrigation but obtained moisture from seepage from the irrigation canal. The yield of wheat on the best part of the field would be probably 30 bushels an acre. The samples were collected on July 24th.

Wheat

Sec. 24, Tp. 22, R. 22, W. of the 4th Mer.

Group No.	Depth	Growth	Na_2SO_4	$MgSO_4$	$CaSO_4$	Total soluble saline content
1665	0′·0–0′·5	Good	·103	·030	·114	·280
	0′·5–1′·5		·220	·306	·381	·974
	1′·5–3′·0		·359	·231	·085	·720
	3′·0–5′·0		1·521	·606	2·963	5·216
1664	"	Poor	·457	·225	1·248	2·080
			·740	·338	·461	1·508
			·861	·969	3·136	5·080
			1·260	·507	·927	2·692
1663	"	No	2·061	·576	·760	3·480
			1·167	·471	·461	2·148
			1·167	·129	·109	1·440
			1·276	·327	·109	1·700

Discussion of Results. The impregnation of this area is white alkali, the chief constituents being sulphate of soda and sulphate of magnesia. Sulphate of lime in considerable amounts is present in all the members of the three groups.

WESTERN RYE GRASS

GOOD GROWTH

Series 8 Irrigated.

Amounts of Ingredients in 100 of Air dried Soil

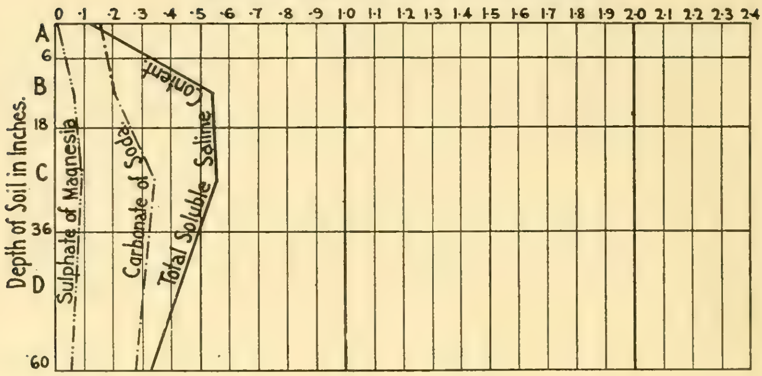

Fig. 8.

POOR GROWTH

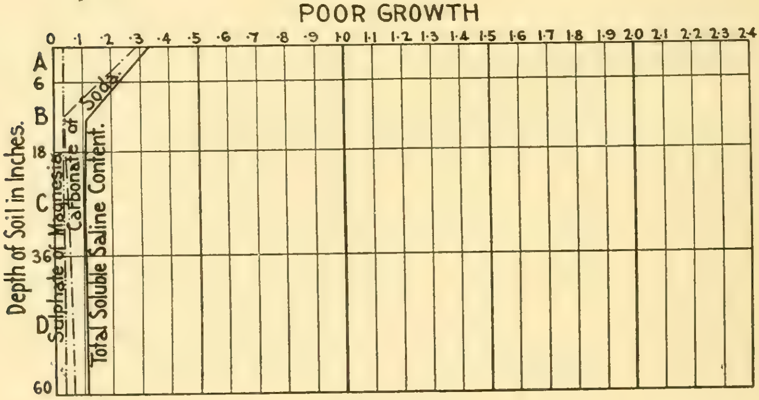

Fig. 8.

NO GROWTH

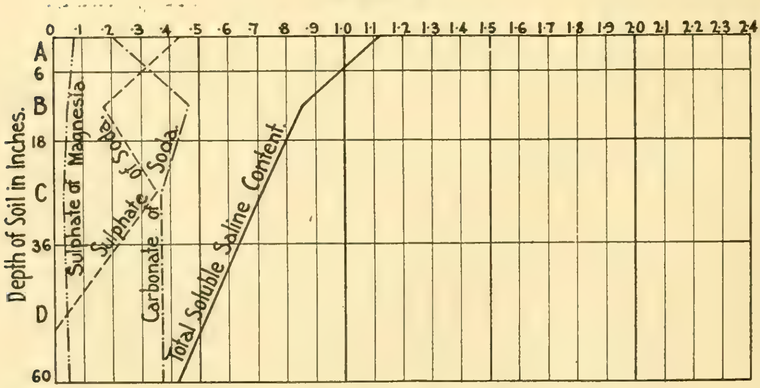

Fig. 8. Distribution of Alkali Salts in Soil in Section 11. Township 24 Range 25. W. of 4th M. Samples taken 20th July 1918.

Group 1665. Good growth. The sodium sulphate in A (0′·0–0′·5) is ·103 per cent and judging from the appearance of the crop, this amount in the surface six inches does not distress the crop. The concentration increases in the lower depths until in sample D (3′·0–5′·0) it is very heavy.

Group 1664. The results of analysis of this group show fairly heavy impregnation in all samples, increasing from approximately 0·5 per cent to 1 per cent in D (3′·0–5′·0). The crop was poor and distressed, probably not worth cutting. It was evident that the limits of tolerance had been passed. It is to be noted that marked percentages of magnesium sulphate occur throughout.

Group 1663. No growth. Alkali showing on the surface. The percentage of sodium sulphate throughout ranges from 1 to 2 per cent, the latter occurring in the surface 6 inches. This impregnation is too high to permit of any growth.

Western Rye Grasses

Series VIII, Section 2, Township 24, Range 25, West of the 4th Meridian.

On July 20th, 1918, three groups were taken from a field of Western Rye grass, one mile south of Strathmore, Alberta. The area had been under irrigation for a number of years. Water table from four to five feet, according to contour of land. Soil a very dark brown or black sandy loam of good quality, sub-soil of clay loam to clay, with some sand and gravel. Foxtail growing on the bare alkali spot. The crop was good on better part of the field.

Western Rye Grass

Sec. 2, Tp. 24, R. 25, W. of the 4th Mer.

Group No.	Depth	Growth	Na_2CO_3	Na_2SO_4	$MgSO_4$	Total soluble saline content
1659	0′·0–0′·5	Good	·168		·024	·232
	0′·5–1′·5		·207		·066	·544
	1′·5–3′·0		·345		·093	·560
	3′·0–5′·0		·301		·065	·412
1658	"	Poor	·227		·036	·280
			·038		·035	·106
			·053		·035	·104
			·061		·035	·110
1657	"	No	·272	·368	·066	1·054
			·466	·170	·048	·854
			·371	·355	·033	·714
			·371	·043	·042	·530

OATS

GOOD GROWTH

Series 9 Irrigated

Amounts of Ingredients in 100 of Air dried Soil

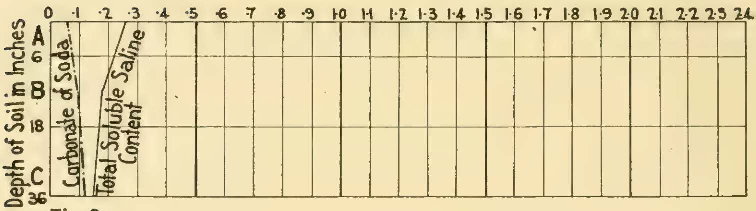

Fig. 9.

POOR GROWTH

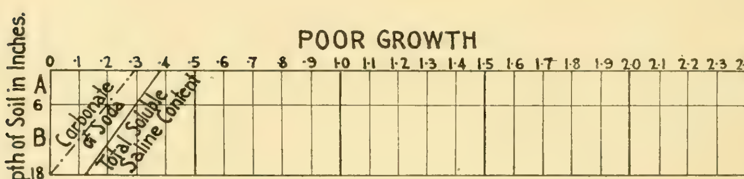

Fig. 9.

NO GROWTH

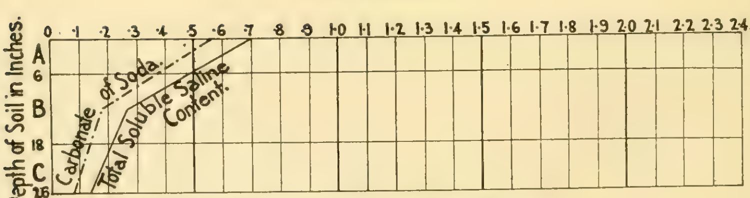

Fig. 9.

Distribution of Alkali Salts in Soil
in Lot 27-476 Summerland B.C.
Samples taken 27th July 1918.

Discussion of Results. The alkali of these groups presents a different case from the two series already discussed, the harmful salt being carbonate of soda, "black alkali."

Group 1659. Good growth. In parts of the field where a good crop was growing the concentration in the first six inches is ·168 per cent carbonate of soda, with a considerable heavier impregnation in the lower members of the group.

Group 1658. Poor and meagre growth. In A (0′·0–0′·5) the impregnation is ·227. The crop showed a very distressed appearance, and evidently the limit of tolerance had been passed.

Group 1657. No growth. In A (0′·0–0′·5) the carbonate of soda is ·272 and sulphate of soda is ·368. As is frequently the case with black alkali, the highest concentration is found in the surface soil.

It is interesting to note that when carbonate of soda is present very small changes in the percentage very materially affect the crop. Judging from these results 0·1 per cent to 0·15 per cent is the limit for Western Rye grass and it is generally conceded that this grass is more resistant to alkali than many other crops.

Oats

Series IX, Lot 27–476, Summerland, British Columbia.

A series of three groups was collected on July 27th, 1918, from an oat field about 4 miles south-west of Summerland, Okanagan Valley, B.C. The area has been under irrigation for a number of years. The surface soil is a brown loam of good quality. Sub-soil of clay loam with some gravel. The water table was from 2·0 to 2·5 feet from surface.

Series IX—Oats

Group No.	Depth	Growth	Na_2CO_3	Total soluble saline content
1668	0′·0–0′·5	Good	·066	·240
	0′·5–0′·5		·094	·180
	1′·5–2′·5		·111	·160
1667	0′·0–0′·5	Poor	·243	·340
	0′·5–1′·5		·100	·208
1666	0′·0–0′·5	No	·477	·600
	0′·5–1′·5		·181	·276
	1′·5–2′·2		·111	·180

Discussion of Results. In this irrigated district the harmful salt to be contended with is carbonate of soda.

Group 1668. Good growth. In A (0′·0—0′·5) the impregnation is ·066 per cent of carbonate of soda. From the appearance of the crop and these results and from analysis of corresponding samples taken in 1917 from good growth in an oat field at Strathmore, we might conclude that approximately ·05 per cent in the first 6 inches does not markedly affect growth.

Group 1667. Poor growth. In A (0′·0—0′·5) the impregnation is ·243 per cent in the surface soil and the crop was very scanty, probably not worth cutting. It was evident that this concentration was very distressing to the crop, only a small percentage of the seeds having germinated.

Group 1666. No growth. The percentage of carbonate of soda in A (0′·0—0′·5) is ·477, which is evidently much too high to permit of any growth.

This investigation, it is proposed, will be continued for a number of years and it is thought advisable to postpone the detailed discussion of the data and the establishment of limits of tolerance for the various farm crops until further evidence is obtained. It is, however, very satisfactory to note that the results here presented show a very fair agreement with those presented in our previous paper and we may therefore conclude that this work will in time afford a valuable basis for the classification of alkali-affected areas. It will also, incidentally, furnish very useful information as to the movement of alkali on lands both heavy and light under irrigation but without artificial drainage.

A Study of the Estimation of Iron and the Separation of Manganese from Iron by Notroso-phenylhydroxylamine Ammonium (Cupferron)

By E. H. ARCHIBALD, PH.D., F.R.S.C., and RUTH V. FULTON, M.A.

(Read May Meeting, 1919.)

INTRODUCTION

The use of cupferron as a reagent for the separation of iron from aluminium[1] has been the subject of a limited number of investigations. Several of the conditions which ensure a complete precipitation of the iron have, however, received little if any attention. The results thus far obtained for the separation of iron from manganese[2] would indicate that a complete separation can be obtained here as well, but the evidence on this point is not sufficient to warrant the conclusion that this method may be substituted for the older and very troublesome methods.

In view of these conditions, it seemed very desirable to make a study of the precipitation of iron and its separation from manganese, under varying conditions, by means of cupferron.

OTHER METHODS FOR THE SEPARATION OF IRON FROM MANGANESE

It will be sufficient to remember here four of the more reliable methods for the separation of iron from manganese. We have first the basic acetate method by means of which iron, aluminium, titanium, zirconium and vanadium may be separated from manganese, zinc, cobalt and nickel. By treatment with the proper reagents these several metals are converted into their acetates, the solution being slightly acid. The acetates of the first group of metals decompose on heating, forming insoluble basic acetates. The other group of metals remains in solution. Sodium acetate is added to reduce the ionization (and thus the dissolving power of acetic acid).

By means of Rothe's "Ether extraction method" iron can be separated from chromium, aluminium, manganese, cobalt, nickel and copper. In this case advantage is taken of the fact that ferric chloride can be completely extracted by ether from a hydrochloric acid solution

[1] Baudisch, Chem.—Ztg., 33, 1298.
Bilty and Hodke, Zeit. Anorg. Chem., 66, 426.
Fresenius, Zeit. Anal. Chem., 50, 35.

[2] Fresenius, *ibid*, Brown, Jour. Am. Chem. Soc. 39, 2358 (1917)

containing the above metals. Nitric acid, chlorine and more than small amounts of sulphuric acid must be absent. The solution should be cold lest ferric chloride be reduced by ether. All suspended matter must be removed by filtration.

A third method, known as Ford's method, depends upon the conversion of the manganese present, in strong nitric acid solution, to manganese dioxide by potassium chlorate. The dioxide is then separated from the iron and other metals which remain in solution, by means of an asbestos filtering medium. The manganese may now be estimated either by a gravimetric or volumetric process.

A rather interesting method for the separation of iron from manganese is that suggested by R. B. Moore and Ivy Miller[1]. Advantage is here taken of the fact that, if pyridine is added in slight excess to a solution of ferric chloride containing free hydrochloric acid, the iron is completely precipitated, while the manganese remains in solution.

Anyone acquainted with these several methods appreciates the fact that, with the exception of the last one, the processes involved are long and tedious and that considerable experience is necessary before reliable results can be obtained. A shorter and less troublesome method for the separation of iron from manganese is highly desirable.

Experimental Work

The flasks, burettes and pipettes used in this work were calibrated on the basis of the true litre (U.S. Bureau of Standards). The weights employed were compared the one with the other and all expressed as multiples of the 10 mg. weight, according to the suggestion of Richards.[2]

The nitroso-phenylhydroxylamine ammonia was material supplied for analytical work by Eimer and Amend. Samples were carefully tested for the presence of iron, aluminium and zinc. In the case of two samples supplied the material had to be further purified before using it in this work.

A solution of ferric chloride, approximately 1/30 N, was prepared. Sufficient hydrochloric acid was added to prevent an appreciable hydrolysis of the iron salt. This solution was standardized gravimetrically, precipitating the iron with ammonium hydroxide and weighing as ferric oxide.

[1] Journ. Am. Chem. Soc., 30, 593 (1908).

[2] Jour. Am. Chem. Soc., 22, 144 (1900).

A corresponding solution of manganese chloride of approximately twice the strength of the iron solution was prepared. This solution was standardized by weighing the manganese as pyrophosphate thrown down as phosphate from a measured volume of the solution. The average weight of pyrophosphate obtained from different 25 cc. portions of solution was 0·3522 gram. The solution therefore contained 12·496 grams of $MnCl_2$ per litre.

A series of determinations was now made to test the influence of of the volume of the mother liquor, and therefore the dilution of the acid upon the weight of precipitate obtained and the completeness of the separation of the manganese. For this purpose 25 cc. of the iron solution were measured off and to this was added 25 cc. of manganese solution and 20 cc. of concentrated hydrochloric acid. The solutions were then made up to the volumes set forth in the table below. For each precipitation 2¼ grams of cupferron were weighed out and dissolved in sufficient water to yield a 6% solution. These solutions were cooled and filtered in each case before using, and a fresh solution was prepared for each precipitation. The solutions of the chlorides were now cooled in water at 7°C. and the cupferron solution added slowly with constant stirring. The precipitate was reddish-brown, crystalline, rather bulky, but could be easily crushed with the stirring rod. The solutions were filtered almost immediately, the beakers meantime being immersed in the cold water. The precipitates were in each case washed with 75 cc. of cold water, twice with water containing ammonium hydroxide to remove the nitroso-phenylhydroxylamine, and twice with water. After the filter paper had been burned and all organic matter destroyed, the iron oxide was brought to constant weight with the Meker burner. In a number of cases the precipitate had been weighed, and in order to be sure that no iron had been reduced, it was treated with nitric acid, the excess of acid expelled, the precipitate again ignited and weighed. This treatment never made any difference in the weight.

Below are the results of experiments at four different dilutions. The weight of iron oxide found is the average, in each case, of two closely agreeing values.

TABLE I

Number of Experiment	Volumes of Solutions	Weight of Fe_2O_3 Taken	Weight of Fe_2O_3 Found
(1)	75 cc.	0·0613 gram.	0·0599 gram.
(2)	100 "	·613 "	0·0608 "
(3)	125 "	·613 "	0·0609 "
(4)	150 "	·0613 "	0·0611 "

From these results it would appear that the better results are obtained in the more dilute solutions. This may be due to the solvent action of the hydrochloric acid becoming less as it becomes more dilute. In any case, however, the weight of iron is lower than it should be, and the actual facts are probably worse than would appear from these values, because, as shown later, the precipitate probably contained some manganese. Some of the iron must be going through, either in the mother liquor or wash water.

It seemed necessary before making any more separations to determine whether the low values for the iron were due to the solubility of the precipitate in the mother liquor and wash water. With this point in view, the following series of estimations was carried out. The solution of iron used was about double the strength of the previous solution. From three 25 cc. portions the following weights of ferric oxide were obtained by precipitating the iron as ferric hydroxide with ammonium hydroxide.

0·1373g 0·1374g 0·1372g

The iron solution must have contained 11·154 grams of $FeCl_3$ to the litre. The following estimations were made with 25 cc. portions of this solution. In each case 20 cc. of conc. hydrochloric acid were added and the solution diluted to 150 cc. before adding the precipitating reagent. Approximately, 4 grams of cupferron were taken for each precipitation, this portion being made up to a 6% solution, filtered and cooled before using. The precipitate was washed with a constant volume (75 cc.) of water, containing a varying amount of hydrochloric acid, and finally with water (25 cc.) containing a constant amount of ammonium hydroxide.

The results were as follows:

Table II

Number of Experiment	Concentration of 75 cc. of Washing Solution	Weight of Fe_2O_3 Taken	Weight of Fe_2O_3 Found
(5)	Water only	0·1373	0·1324
(6)	10 cc. Conc. H Cl to 100 cc. H_2O	0·1373	0·1327
(7)	20 cc. Conc. H Cl to 100 cc. H_2O	·1373	·1338
(8)	30 cc. Conc. H Cl to 100 cc. H_2O	·1373	·1307

The solvent action of the acid wash is very apparent in the last determination. It seemed necessary now to make a more extended series of determinations, in which both the iron remaining in the mother liquor as well as that dissolved by the wash water should be determined. The iron solution used in this series contained, as estimated through the hydroxide and oxide, 11·402 grams of $Fe Cl_3$ per litre, yielding 0·1403 gram of $Fe_2 O_3$ for every 25 cc. taken. The iron in the wash water was determined by evaporating, adding a little nitric acid, precipitating the iron with ammonium hydroxide, filtering, igniting and weighing the oxide. In the case of the mother liquor this was evaporated almost to dryness, treated with nitric acid to destroy the excess of cupferron, finally diluted, and the iron precipitated with ammonium hydroxide and determined as before.

The acid concentration of the washing solution was varied as set forth in the table. The volume of this solution was 75 cc. for each estimation. Each result tabulated is the mean of two closely agreeing values.

TABLE III

Number of Experiment	Concentration of Washing Solution	Weight of Fe_2O_3 Taken	Weight of Fe_2O_3 Found	
				gms.
(9)	Water only	0·1403	Fe_2O_3 from main precipitate	0·1359
		gms.	Fe_2O_3 from wash water	·0011
			Fe_2O_3 from mother liquor	·0028
			Total wt. Fe_2O_3	·1398
(10)	5 cc. conc. H Cl to 100 cc. water	·1403	Fe_2O_3 from main precipitate	0·1367
			Fe_2O_3 from wash water	·0006
			Fe_2O_3 from mother liquor	·0029
				·1402
(11)	5 cc. conc. H Cl to 100 cc. water	·1403	Fe_2O_3 from main precipitate	0·1368
		·1403	Fe_2O_3 from wash water	·0004
			Fe_2O_3 from mother liquor	·0028
				·1400
(12)	5 cc. conc. H Cl to 100 cc. water	·1403	Fe_2O_3 from main precipitate	0·1362
			Fe_2O_3 from wash water	·0004
			Fe_2O_3 from mother liquor	·0035
				·1401
(13)	10 cc. conc. H Cl to 100 cc. water	·1403	Fe_2O_3 from main precipitate	·01360
			Fe_2O_3 from wash water	·0014
			Fe_2O_3 from mother liquor	·0026
				·1400
(14)	20 cc. conc. H Cl to 100 cc. water	·1403	Fe_2O_3 from main precipitate	0·1355
			Fe_2O_3 from wash water	·0016
			Fe_2O_3 from mother liquor	·0030

In experiments 9, 10, 13 and 14, 3 grams of cupferron made up to a 6% solution were used for each precipitation. In the case of 11 and 12 this amount was increased to 5 grams, but apparently without any effect upon the amount of iron remaining in solution.

The above results show that the low values for the weight of the iron precipitate are chiefly due to the iron remaining in the mother liquor, increased still further by the solvent effect of the wash water. The weight of iron remaining in the solution varies but little from the mean value of the several determinations, so that a legitimate correction might be applied to the weight of the main precipitate in the case of an experiment carried out under known conditions. With regard to the amount of iron compound dissolved by the acid wash water, this is surprisingly constant, for a given concentration of acid, and not too large, so that a correction could surely be applied here. For the three estimations in which the concentration of acid was 5 cc. conc. hydrochloric acid to 100 cc. of water, the greatest difference in the weight of iron oxide dissolved was only 0·0002 gr. so that the correction is here pretty closely defined.

It was thought worth while to try the effect of replacing the 20 cc. of hydrochloric acid in the main solution by an equal volume of sulphuric acid. This was done in the case of the three estimations which follow. The iron in the wash water and mother liquor was determined as before. The acid concentration of the wash water corresponded to 5 cc. of conc hydrochloric acid to 100 cc. of water. The volume of this solution used varied as set forth below. The final washing in each case was with 25 cc. of water containing ammonium hydroxide.

TABLE IV

Number of Experiment	Volume of Wash Water	Weight of Fe_2O_3 Taken	Weight of Fe_2O_3 Found	
				gms.
15	75 cc.	0·1403	Fe_2O_3 from main precipitate	0·1361
			Fe_2O_3 from wash water	·0007
			Fe_2O_3 from mother liquor	·0032
				·1400
16	100 cc.	0·1403	Fe_2O_3 from main precipitate	0·1353
			Fe_2O_3 from wash water	·0013
			Fe_2O_3 from mother liquor	·0029
				·1395
17	125 cc.	0·1403	Fe_2O_3 from main precipitate	0·1357
			Fe_2O_3 from wash water	·0014
			Fe_2O_3 from mother liquor	·0030
				·1401

The substitution of sulphuric acid for hydrochloric has apparently not rendered the precipitation any more complete. The increase in the amount of iron dissolved as the volume of wash water increases is worth noting.

It was now considered that sufficient data were available to enable one to correct the values for the iron obtained in its separation from manganese. The correction for the iron remaining in the mother liquor will of course vary with the volume of the solution from which precipitation took place. For a precipitation carried out under the usual conditions, *i.e.* for a volume of 100 cc. of solution, to which has been added 20 cc. of concentrated hydrochloric acid, this correction corresponds to 0·0030 gram of ferric oxide. In the case of the wash water the correction amounts to 0·0004 g. of ferric oxide, 75 cc. of washing solution being used, having an acid concentration corresponding to 5 cc. of conc. hydrochloric acid in 100 cc. of water. A series of separations were accordingly carried out with mixtures containing 25 cc. of iron solution (11·154 grams $Fe\ Cl_3$ per litre) and 50 cc. of manganese solution (22·304 grams $Mn\ Cl_2$ per litre). To these mixtures were added 20 cc. of conc. hydrochloric acid and enough water to give the volumes shown in the table.

TABLE V

Number of Experiment	Volume of Solution	Weight of Fe_2O_3 Taken	Weight of Fe_2O_3 Found	
18	100 cc.	0·1373 g.	Fe_2O_3 (Mn_3O_4) main precipitate	0·1337
			Mn_3O_4 in main precipitate	0·0005
				·1332
			Fe_2O_3 in wash water	·0004
			Fe_2O_3 in mother liquor	·0030
			Total Fe_2O_3 found	·1366
19	135 cc.	0·1373 g.	$Fe_2O_3(Mn_3O_4)$ main precipitate	0·1346
			Mn_3O_4 in main precipitate	·0012
				·1334
			Fe_2O_3 in wash water	·0004
			Fe_2O_3 in mother liquor	·0032
			Total Fe_2O_3 Found	·1370
20	175 cc.	0·1373 g.	$Fe_2O_3(Mn_3O_4)$ main precipitate	0·1348
			Mn_3O_4 in main precipitate	·0018
				0·1330
			Fe_2O_3 in wash water	·0004
			Fe_2O_3 in mother liquor	·0035
			Total Fe_2O_3 found	0·1369
21	200 cc.	0·1373 g.	$Fe_2O_3(Mn_3O_4)$ main precipitate	0·1361
			Mn_3O_4 in main precipitate	·0029
				·1332
			Fe_2O_3 in wash water	·0004
			Fe_2O_3 in mother liquor	·0035
			Total Fe_2O_3 found	·1371

The iron in the wash water and mother liquor was determined as in previous estimations. In the case of the manganese the main precipitate was fused with acid potassium sulphate, in a platinum crucible, the fusion dissolved, and the manganese determined, either by oxidizing it with sodium bismuthate and titrating with a standard solution of ferrous sulphate, according to the regular bismuthate method, or by oxidizing the manganese with lead peroxide in a nitric acid solution, and comparing the color developed with that obtained from a steel of known manganese content.

In regard to these results it is apparent that the amount of the manganese brought down with the precipitate varies with the concentration of the hydrochloric acid, the more dilute the acid the greater the weight of the manganese found in the precipitate. The best results will be obtained using the smaller volumes of solution, as both the manganese carried down will be lower and the iron remaining in the filtrate will be a minimum.

It should be pointed out that the precipitates obtained as set forth in Table I must have contained some manganese. The better agreement here between the amount of iron oxide taken and found must be largely due to this.

The following final values were obtained from solutions to which had been added 15 cc. of conc. hydrochloric acid and 5 grams of ammonium chloride. It was thought that this concentration of acid might be sufficient to keep the manganese in solution in the presence of this amount of ammonium chloride. The volume of solution from which precipitation took place was in each case 100 cc., prepared by mixing 25 cc. of iron solution containing 11·154 grams of $Fe\ Cl_3$ per litre, 50 cc. of manganese solution containing 22·304 grams of $Mn\ Cl_2$ per litre, 15 cc. of concentrated hydrochloric acid and 5 grams of ammonium chloride. The resulting volume was made up to 100 cc., cooled to 7°C. and to this was added the cupferron solution containing 4 grams of cupferron made up to a 6% solution. The washing liquid was 75 cc. of a hydrochloric acid solution containing 5 cc. of conc. hydrochloric acid to 100 cc. of water; this being followed with 25 cc. of very dilute ammonium hydroxide. The two results obtained for each experiment are included in the following table to show the character of the agreement.

TABLE VI

Number of Experiment	Weight of Fe_2O_3 Taken	Weight of Fe_2O_3 Found		
22	0·1373	Fe_2O_3 (Mn_3O_4) main precipitate	0·1362	0·1368
		Mn_3O_4 in main precipitate	·0004	·0004
			·1358	·1364
		Fe_2O_3 in wash water	·0004	·0003
		Fe_2O_3 in mother liquor	·0012	·0010
		Total Fe_2O_3 found	·1374	·1377
23	0·1373	Fe_2O_5 (Mn_3O_4) main precipitate	0·1264	0·1361
		Mn_3O_4 in main precipitate	·0002	·0002
			·1362	·1359
		Fe_2O_3 in wash water	·0004	·0004
		Fe_2O_3 in mother liquor	·0010	·0010
		Total Fe_2O_3 found	·1376	·1373
24	0·1373	Fe_2O_3 (Mn_3O_4) main precipitate	0·1360	·1362
		Mn_3O_4 in main precipitate	·0002	·0002
			·1358	·1360
		Fe_2O_3 in wash water	·0004	·0004
		Fe_2O_3 in mother liquor	·0011	·0011
		Total Fo_2O_3 found	·1373	·1375

It appears from these results that the presence of ammonium chloride is beneficial in lowering the solubility of the precipitate under the above conditions, only about 1 mg. of iron, reckoned as oxide, remains in the mother liquor.

SUMMARY

From the above experiments we can conclude:

1. That the cupferron precipitate of iron is slightly soluble in the acid solution from which it is precipitated. The solubility is apparently not affected by the substitution of sulphuric acid for hydrochloric. This solubility is appreciably lowered by adding ammonium chloride to the solution, from which precipitation takes place.

2. The precipitate is slightly soluble in the wash water.

3. If corrections are applied for these solubilities, the determination of iron by this method becomes very exact.

4. Iron can be separated from manganese in a solution containing four times as much manganese as iron, the amount of manganese carried along with the precipitate being inappreciable for most purposes. This amount increases with the acid dilution of the mother liquor. The presence of ammonium chloride to the extent of 5 grams in 100 cc. of solution is an advantage in this separation.

Chemical Laboratory, University of British Columbia, Vancouver, B.C.

The Synthesis of b-palmitodistearin and b-stearodipalmitin

By George Stafford Whitby

Presented by Dr. R. F. Ruttan, F.R.S.C.

Abstract

(Read May Meeting, 1919.)

The above-named substances have been synthesised by the following steps. First: the preparation of the acyl-dichlorhydrins by the interaction of *a*-dichlorhydrin and the acyl chloride. Second: treatment of the acyl-dichlorhydrins with two molecules of the silver salt of the appropriate acid.

(1) $\mathrm{CH_2Cl \cdot CH(OH) \cdot CH_2Cl + C_{15}H_{31}COCl = CH_2Cl \cdot CH(OC_{15}H_{31}CO) \cdot CH_2Cl + HCl}$.

$$\begin{array}{ll} \mathrm{CH_2Cl} & \mathrm{CH_2 \cdot OC_{17}H_{35}CO} \\ | & | \\ \mathrm{CH\ (OC_{15}H_{31}CO) + 2C_{17}H_{35}COOAg =} & \mathrm{CH \cdot OC_{15}H_{31}CO + 2\ AgCl} \\ | & | \\ \mathrm{CH_2Cl} & \mathrm{CH_2 \cdot OC_{17}H_{35}CO} \end{array}$$

(2) $\mathrm{CH_2Cl \cdot CH(OH) \cdot CH_2Cl + C_{17}H_{35}COCl = CH_2Cl \cdot CH(OC_{17}H_{35}CO) \cdot CH_2Cl + HCl}$.

$$\begin{array}{ll} \mathrm{CH_2Cl} & \mathrm{CH_2 \cdot OC_{15}H_{31}CO} \\ | & | \\ \mathrm{CH\ (OC_{17}H_{35}CO) + 2C_{15}H_{31}COOAg =} & \mathrm{CH \cdot OC_{17}H_{35}CO + 2AgCl} \\ | & | \\ \mathrm{CH_2Cl} & \mathrm{CH_2 \cdot OC_{15}H_{31}CO} \end{array}$$

Both steps took place without complications. The first was brought about by short heating on the water-bath; and the loss of HCl was theoretical. The second was brought about by heating at 155° for three hours; and the yield was practically theoretical. The physical constants of these glycerides are being studied; and the work is being extended to the synthesis of other mixed glycerides.

Note on the Preparation of the Silver Salts of the Fatty Acids and Their Behaviour Towards Ammonia

By GEORGE STAFFORD WHITBY

Presented by DR. R. F. RUTTAN, F.R.S.C.

ABSTRACT

(Read May Meeting, 1919.)

A simple and convenient method of preparing the silver salts of the fatty acids is found to consist in the addition of an aqueous ammoniacal silver solution to an alcoholic solution of the acid followed by the addition of water. The latter completes the precipitation of the silver salt. Silver palmitate, stearate, margarate and heptadecylate, and also silver salts of the lower fatty acids, have been prepared by this method.

If the mixed solution contains excess of ammonia, the silver salt remains in solution. Dilution with water then has the effect of throwing the salt out. A number of observations have been made with the object of ascertaining the reason for the precipitating effect of dilution, but hitherto have not led to the formulation of a satisfactory explanation.

The amount of water required to throw out the silver salts depends on the concentration of ammonia present. There is a marked quantitative difference between palmitic and stearic acids in relation to the concentration of ammonia necessary to hold them in solution.

The analytical applications of the above observations are being studied.

A Hydrate of an Oxonium Compound

By O. MAASS and J. RUSSELL

Presented by PROFESSOR R. F. RUTTAN, F.R.S.C.

(Read May Meeting, 1919.)

In the following paper it will be shown that there exists at low temperatures a termolecular compound between ether, hydrobromic acid and water, which may be termed a hydrate of the oxonium compound ether-hydrobromide[1].

It may be well to review in a few words the facts which suggested the investigation. It has often been noticed in the examination of binary systems that where combination between the components occurs, the substances are easily soluble in one another. For example, anhydrous hydrobromic acid dissolves quite easily in ethyl benzene and molecular compounds have been shown to exist in this system; while in benzene, with which the acid forms no compound, it is almost insoluble at atmospheric pressure. Also, it is well known, that, in general, water is insoluble in pure liquids at low temperatures. If ether, which is not quite anhydrous, is cooled to a low temperature (−78°C.; the temperature of solid carbon dioxide), all the water is precipitated as small crystals, even traces appearing in the form of a cloud[2]. Water is also found to be absolutely insoluble in liquid hydrobromic acid at the same temperature. But if water be added to a mixture of the ether and the acid it dissolves readily to form a clear solution. The behaviour of the hydrocarbons seemed to indicate that ease of solubility was accompanied by compound formation and it was therefore deemed possible that in this latter case some compound was formed between the three substances. This possibility lends itself to investigation by means of a freezing point curve in which the oxonium compound is treated as one component with water as the second.

The hydrobromic acid used was prepared by dropping bromine on red phosphorus immersed in water, passing the gas thus evolved through wash-bottles containing phosphorus to remove traces of bromine, and through phosphorus pentoxide tubes to dry it. It was finally condensed by means of solid carbon dioxide ether mixture.

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[1] J.A.C.S. 34, 1273 (1912).
[2] J.A.C.S. 34, 1275 (1912).

The ether was a pure sample carefully freed from alcohol by repeated washing with water, dehydrated by distillation over calcium chloride and finally allowed to stand for some days over sodium wire. This latter step removes even the last traces of water which will otherwise show themselves as a cloud in the ether when the latter is cooled.

The oxonium compound of ether and hydrobromic acid in mono-molecular proportions was prepared by addition of the correct amount of ether to a weighed quantity of the acid. This process required some care in manipulation owing to the heat of combination which tended to cause some of the acid to evaporate. Into a weighed dry test-tube, dry hydrobromic acid was distilled and the whole reweighed and thus the weight of acid obtained. To this ether was added drop by drop. At first, when the heat evolution was greatest, a long interval between the addition of drops was necessary for cooling, but as the correct proportions were approached the speed of addition could be increased. When the tube contained the required amount of ether it was reweighed to determine just how great had been the loss of acid in the process. The ether additions were made by means of a pykno-meter as also were the subsequent additions of water to the compound.

The freezing-point of the mixture was then determined and found to be $-40 \cdot 5$°C., agreeing well with the value -40°C. found by McIntosh.[1] A slight discrepancy was to be expected due to the difficulty in mixing the two components in exactly molecular proportions. Definite amounts of water were added and the freezing point of the system determined each time. The temperatures were found by means of a platinum thermometer which gave readings to $0 \cdot 1$°C. with ease. After the series the total contents were dissolved in a large excess of water and the hydrobromic acid estimated by standard alkali, the loss of acid during the determinations being distributed proportionately when calculating the percentages. After the first few points were determined the viscosity of the solution began to increase very rapidly, so much that the recognition of the exact freezing point became a matter of much difficulty. Finally at a composition of about 16% water, on attempting to freeze out solid by cooling, the mass became so viscous as to be correctly characterized as a glass and the curve could be continued no further. The values obtained are shown in Table I.

[1] J.A.C.S. 33, 70 (1911).

TABLE I

Percent Water	Freezing Temperature
0	−40·5°C.
·9	−42·5
2·3	−46·0
3·8	−49·5
5·4	−52·5
7·1	−57·5
9·4	−50·0
10·6	−50·0
12·1	−56·5
14·1	−61·5
16·2	−72·5

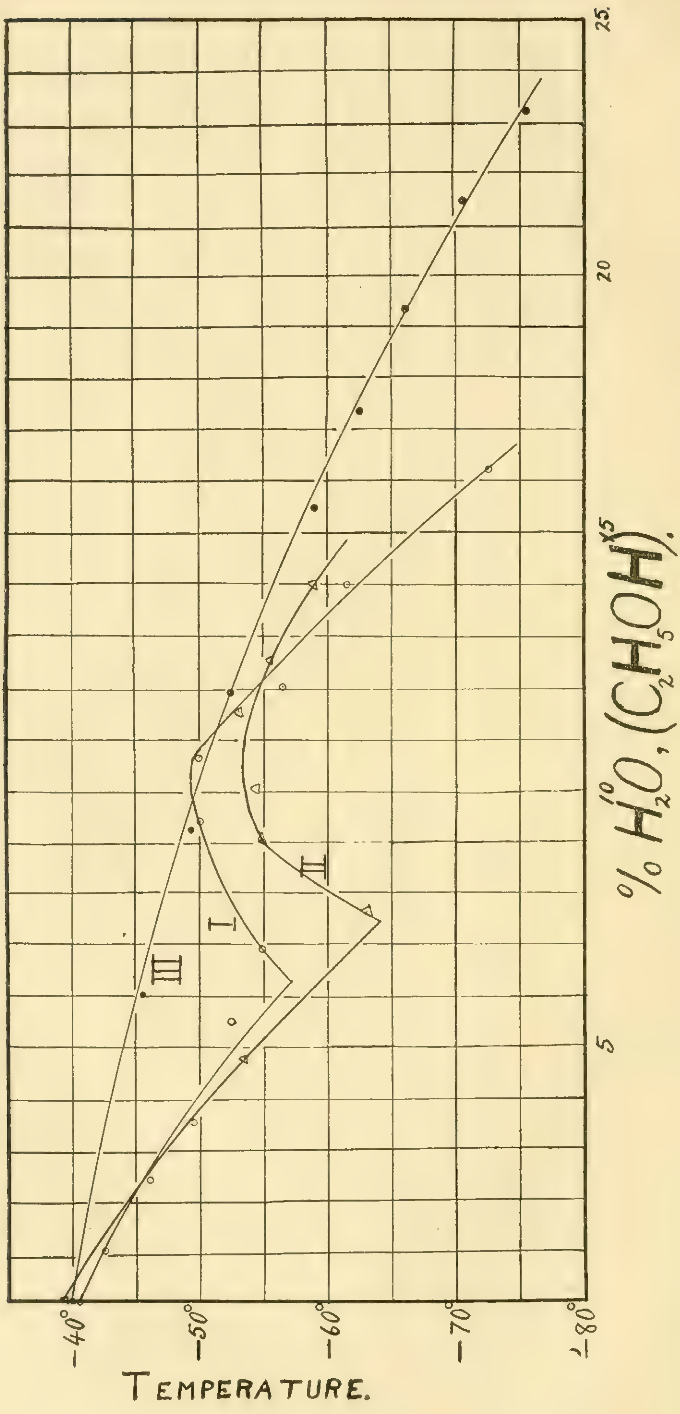
As a check the curve was repeated. The ether hydrobromic acid mixture this time was not quite identical with that previously used, the melting point being −39·5°C. instead of −40·5°C. The results obtained in this series are shown in Table II.

TABLE II

Percent Water	Freezing Temperature
0	−39·5°C.
4·8	−53·7
6·5	−56·2
7·7	−63·0
8·9	−54·7
10·1	−54·5
11·4	−53·2
12·6	−55·5
13·9	−59·0

It can be seen from the diagram that in both curves I and II, representing Tables I and II respectively, there is a well-defined maximum between 10 and 11 per cent, which corresponds with the monohydrate of ether hydrobromide, which would have the composition 10·4 per cent water. Thus it has been shown that here, too, solubility is accompanied by compound formation.

An attempt was made to determine the freezing point curve of the system ether-hydrobromide-ethyl alcohol, but the viscosity of the resulting solutions made it impossible to proceed more than a very short distance along the curve. The values obtained are given in Table III, plotted in Curve III of the diagram.



−40°
−50°
−60°
−70°
−80°
TEMPERATURE.
5
10
15
20
25.
% H₂O, (C₂H₅OH).
I
II
III

TABLE III

Percent Alcohol	Freezing Temperature
0	−40·0°C.
6·0	−45·4
9·2	−49·5
11·8	−52·5
15·4	−58·8
17·4	−62·6
19·3	−65·8
21·4	−70·5
23·4	−75·5

It can be seen that the curve is continuous and reaches a point representing a composition 23 per cent alcohol. Now, a compound ether-hydrobromide-alcohol would have a composition 22·9 per cent alcohol, and the continuity of the curve shows that it could not have been isolated here.

These results are in agreement with the recent ideas upon the relation which the formation of molecular compounds bears to chemical reactions, according to which the interaction of two substances is preceded by their association in a molecular complex. The example given by Baumé[1] is quite analagous in characteristics to the one observed above. He showed the probability that the catalysis of ester formation by the presence of an acid is due to the formation of a termolecular compound between the organic acid, the alcohol and the catalytic acid. By additions of methyl alcohol to the oxonium compound propronic acid-hydrochloric acid he obtained a freezing point curve having a definite maximum at a point corresponding to a compound propronic acid-hydrochloric acid-methyl alcohol. The propronic acid and the methyl alcohol do not combine, but each unites with the halogen acid, and the three together combine as a preliminary stage to a reaction between the two organic substances. The parallelism between the two is completed by recalling the reaction whereby, if ether be heated for some hours in a sealed tube with dilute hydrochloric acid, an equilibrium is established in the reaction represented by the following equation :

$$C_2H_5OC_2H_5 + H_2O = 2C_2H_5OH.$$ [2]

It is evident from this work that here, too, as in the reaction investigated by Baumé, the acid may function as an intermediary by

[1] Comptes Rendus 55426.

[2] Bernsthen, Organic Chemistry, pp. 84, 85 (Eng. Ed.)

linking the reacting substances in a molecular compound where opportunity is afforded for the radicals in question to interchange.

The fact that alcohol does not combine with the ether hydrobromide in the proportion one to one is to be expected since no reaction between ethyl alcohol and ethyl ether can be formulated representing an interchange of radicals in the manner of the two reactions discussed above.

A termolecular compound between ether, hydrobromic acid and water has been isolated. It has been pointed out that the explanation by intermediate compound formation of the assistance of a chemical reaction by the presence of an apparently non-reacting substance finds here a further illustration.

The Crystallization of Supersaturated Solutions and Super-Cooled Liquids

By D. McINTOSH, F.R.S.C.

(Read May Meeting, 1919.)

Few natural phenomena show so much beauty or appear so wonderful as the formation of crystals. From a homogeneous solution, the molecules, in an instant, rush into position and form well defined bodies of various sizes and figures. It is not strange then, that for many years the formation of crystals has been studied, and that amongst other problems, chemists and physicists have attempted to define the conditions and explain the causes of crystallization from supersaturated and supercooled liquids. To give any extended account of this work is unnecessary; those interested will find an excellent account in Ostwald's Lehrbuch.

Many molten substances may be cooled far below their melting-points without solid matter appearing; and many solutions may be made which remain liquid although they hold in solution far more of the solute than would dissolve at that particular temperature. Mechanical shocks, treatment with foreign substances, changes of pressure, of temperature within certain limits, produce no crystallization. But precipitation is induced by the smallest crystal of the substance in solution. And this fact has been made the basis for a "germ" theory, which has been extended by Ostwald.

Ostwald recognises two fields in his supersaturated or super-cooled system—a labile and a metastable. In the former, crystallization may occur through mechanical shocks, etc.; in the latter, only by the action of a crystal of the material in solution, or isomorphous with it. For instance, in a supersaturated solution of sodium sulphate crystallization of the heptahydrate may be brought about by mechanical means at 10°C. The decahydrate, however, can be precipitated only by the decahydrate crystals. On cooling the solution to -5°C., the decahydrate passes from the metastable to the labile field, and at that temperature can be precipitated by mechanical means.

This theory, accepted by chemists for a decade, was proven untenable by Young. For a great mechanical shock can be shown to be more effective in inducing crystallization than a weak one; the greater the shock the more the metastable field is narrowed.

Young was able to show that the product of the degree of super-cooling and shock (measured in some mechanical units) was roughly a rectangular hyperbola, and that, therefore, for a small degree of super-cooling or of supersaturation, the necessary mechanical shock must be very great. Since the shock need be given at one point only, it would seem that this might be tested by means of minute amounts of explosives.

However the metastable theory is, for many systems a very satisfactory one. For supersaturated solutions of sodium sulphate or super-cooled salol I have never succeeded in causing crystallization by mechanical shock, by an electric spark, by a small arc playing below the surface, by radium in solution, by radium A, B and C deposited on a needle and held near the surface, or by cathode rays. As shown by Violette and Gernez, crystallization in a sodium sulphate solution is caused by the particles in the air. If the air be "sterilized" by bubbling through water, or drawn through cotton wool, or through a tube heated above the melting point of sodium sulphate decahydrate, crystallization never results. DeCoppet has preserved tubes for thirty years, and in only a few cases has crystallization occurred.

That crystallization is brought about by a crystal, and stops when the crystals are removed, can be shown with supersaturated sodium thiosulphate. A hair which has touched a crystal induces crystal formation, and as these adhere to the hair they may be removed and crystallization stopped (Ostwald). I have frequently been able to perform this experiment with sodium sulphate. A crystal placed in the bottom of a supersaturated solution of sodium chlorate precipitates the solute and leaves a supersaturated solution in the upper portion of the vessel.

The analogy to the phenomena of bacteriology is so striking that Gernez, Pasteur's assistant, was thus led to a study of supersaturated solutions; and the technique developed in these investigations is so similar that it is convenient to use the terms "infection," "sterilization," etc.

It is worth while here mentioning a phenomenon similar in many respects to that met with in cultures containing spores, that is, the spontaneous crystallization of many solutions, which have not been properly "sterilized."

I may cite one example from many:

Eleven tubes containing salol were fastened to a header in order to be exhausted. These were sterilized by heating to 78° (M.P. salol 48°) for 2 hours, and left over night.

Times, Heated	Remaining Liquid
1	1
2	2
3	5
4	7
5	9
6	9
7	10
8	10
9	10
10	all

A tube remaining liquid for a reasonable time could be depended on to remain liquid indefinitely. The 11 tubes mentioned had not crystallized after two months.

Size of Particles Inducing Crystallization

As far as I am aware, the only investigations of the size of particles necessary to cause precipitation in super-cooled or supersaturated solutions are those made by Ostwald. A brief description may not be out of place.

One gram of the crystals was mixed with 99 grams of an indifferent substance, such as silica, and ground for many hours, usually in a small ball-mill. A gram of this mixture containing 10^{-2} of the crystals was taken, mixed with 99 grams of silica and the grinding repeated, 1 gram contained 10^{-4} of the crystals. By further dilution mixtures containing any mass of crystals could be obtained. If a weighed amount of a mixture dropped into the supersaturated solution brings about precipitation, the mass of the added crystals may be easily calculated. The second method applies only to anhydrous salts and was used by Ostwald in his investigation of sodium chlorate solutions. A platinized platinum wire was dipped a certain distance into a very dilute solution of the chlorate. The solution adhering weighed approximately 10^{-4} gram, so the mass of the solute could be easily calculated. The platinum wire was carefully dried, and used to inoculate the supersaturated solutions.

The weakness of both methods is clear. It is by no means certain that many crystals were not present in the material used for inoculation, and that one of these might have produced crystallization. However, by these methods Ostwald found the size of particles necessary to cause precipitation to be:

For:	Sodium thiosulphate	10^{-12}
	Sodium chlorate	10^{-9}-10^{-10}
	Potassium alum	10^{-10}
	Rochelle salts	10^{-11}
	Borax	10^{-10}
	Salol	10^{-8}-10^{-10}

Particles of a mass of 10^{-12} are easily microscopically visible; but Ostwald expresses a view that the limiting size to induce crystallization is about 10^{-12}.

From both the theoretical and experimental sides this conclusion may be combated. There is no a priori reason why a perfect crystal, however small, should not bring about crystallization.

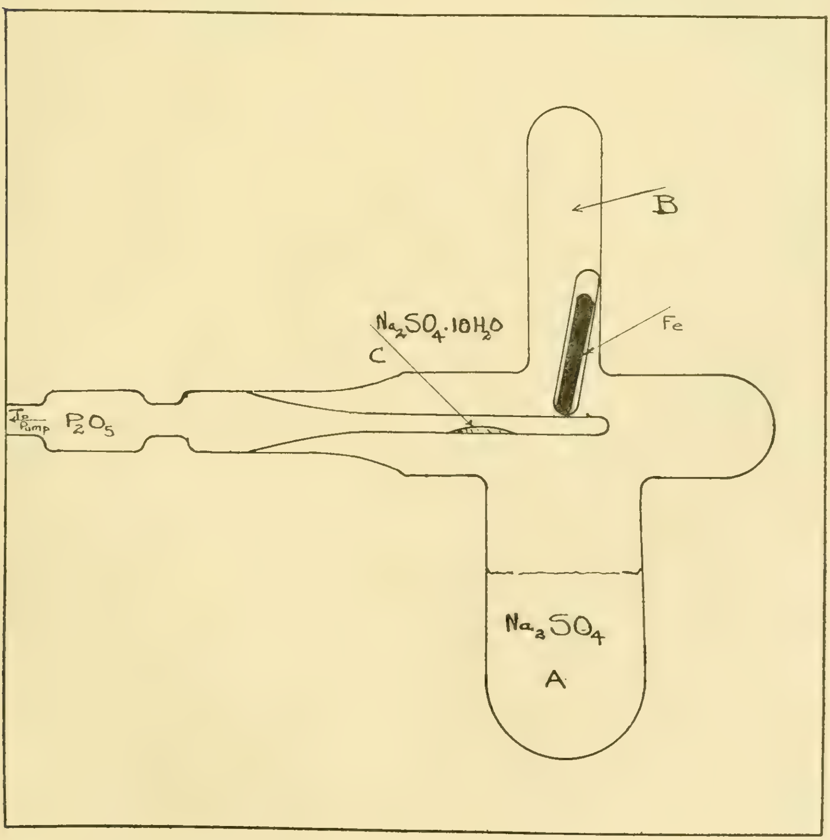
X-ray spectroscopy has shown that crystals are comparatively simple, and that a perfect crystal may be formed from only a few molecules. Barlow's views agree with this, and Professor Graham has informed me that he sees no reason why a perfect crystal of hydrated sodium sulphate should not be formed from four molecules. If this be so, the crystal particle bringing about precipitation need not be larger than $10^{-20}-10^{-21}$ gram.

It has been noticed that sodium sulphate decahydrate, which has effloresced, is as active in bringing about crystallization in supersaturated solutions as the perfect salt. Glass hairs, drawn lightly over sodium sulphate crystals, are sufficient to bring about crystallization, although the adhering matter probably weighs not more than 10^{-9} gram. These glass hairs with sodium sulphate, rochelle salts, sodium acetate, etc., have been kept in tubes, dried by phosphoric anhydride at a pressure of 1/1000 millimeter of mercury, for over a month and were still active. Two cases, ammonium acetate and salol, yielded negative results; as their vapour pressures were high the materials had quite disappeared. If we accept Morley's view that the vapour pressure of water is reduced to 1/40,000,000 of an atmosphere in the presence of phosphoric anhydride, one can calculate that the mass of the decahydrate present is not greater than 10^{-14}.

DeCoppet regards these dried particles as anhydrous crystals isomorphous with the original crystal. This appears unlikely, since it postulates at least three anhydrous forms; the true anhydrous, stable above 33°C., the anhydrous heptahydrate, and the anhydrous decahydrate. The fact that the sterilizing temperature for the dried decahydrate is exactly 33° indicates, if it does not prove, the presence of decahydrate crystals.

As it is difficult to avoid contamination in removing the glass hairs from the drying chambers, this question was tested in another way. Pieces of apparatus of the form shown in the diagram were constructed. The tube A was filled with the supersaturated solution; a piece of iron was sealed into a glass tube and placed in B, and the apparatus "sterilized" by heating to 45° for several hours. After standing for a week, a few grains of finely-powdered sodium sulphate were placed in C, a phosphoric anyhdride tube was sealed on and the system exhausted to one one-thousandth of a millimeter of mercury with a Toepler pump. The apparatus was washed out several times with dry air, and was finally exhausted and sealed. After standing for a month, F was raised with a magnet, the inner tube was broken, and the powder allowed to fall into the solution. In four experiments there was instant crystallization; in the fifth hesitation for an instant.

A note in Faraday's Researches on Electricity (392) explains, I think, why the crystals are not destroyed. Faraday observed that hydrated crystals, if perfect, *i.e.* with unruptured surfaces, could remain indefinitely in an atmosphere where the water vapour pressure



is far below the pressure of the crystal itself, while a scratched crystal effloresced at once. The affinity between the water molecules and the other atoms must be of considerable magnitude, and doubtless increases as the size of the particle decreases.

My own experiments on the size of particles necessary to induce crystallization may be briefly stated, since better results may be obtained in the future. The determinations were with sodium sulphate and salol.

Sodium sulphate. 35 grams of the anhydrous salts were dissolved in 100 grams of water. The solubility diagram shows that at 33° anhydrous salt separates. Below 18° the stable modification is the heptahydrate, and this separates out at 6° or 7°. When a solution containing crystals of the heptahydrate is inoculated with a crystal of the decahydrate, the clear heptahydrate crystals almost at once appear to effloresce; they turn, apparently, to the decahydrate and to the anhydrous salt. After a few months the change to the deca is complete, except for a few points of anhydrous salt.

These solutions may have air drawn through them for days without separation taking place if the air be sterilized. In general, the air in my laboratory contained one crystal germ in about 30 or 40 cc. If the air be drawn quickly through a tube bent at right angles, the small particles are usually retained at the bend, and crystallization only takes place when the liquid is forced up the tube through which the air passes. With a straight leading in tube, crystallization occurs quickly.

Size of Crystals.

Glass tubes, an inch and a half in diameter, and from 30 to 40 centimeters long were carefully cleaned, and in them to the depth of 5 centimeters the supersaturated sodium sulphate solution was placed. These were plugged with cotton wool and carefully "sterilized." After standing for two weeks, a large, wide-mouth bottle from which the bottom had been cut, was fastened over the tube, covered with a sheet of paper, and the whole fixed as nearly as possible perpendicular to the earth's surface. The cotton wool was then withdrawn by means of an attached wire, and the apparatus left until crystallization was noticed. From the length of tube, the velocity of the falling particle was obtained; and then by the aid of Stokes' Law, the size of the particle was calculated. Millikan's and Cunningham's results show the failure of Stokes' Law for particle small compared with the mean free path of gaseous molecules; and my results, for several reasons, I regard as little better than guesses. I have, however, obtained by this method numbers running from 10^{-13} to 10^{-18} gram.

In the second method the supersaturated solutions were covered with a sterilized layer of oil. Unfiltered air was bubbled slowly and carefully through the upper part of the oil, so that the lower layer was not disturbed. The solutions were then allowed to stand until crystallization took place. Stokes' Law holds exactly for liquids, and numbers from 10^{-12} to 10^{-14} were found. I do not regard these results with any confidence, and a method now being studied, where minute particles are got in suspension by shaking, and the larger particles removed by centrifuging would seem to lead to better figures.

Salol

Salol melts at 49°, and when properly sterilized remains liquid indefinitely at room temperatures. When cooled to about $-5°$ the solution crystallizes spontaneously, or on the slightest shock. I have, however, on a number of occasions cooled the liquid to $-80°$, when it appeared as a horn-like solid.

On warming to room temperature, the salol in some of the tubes still remained liquid; but in many cases was exceedingly sensitive to shock. I may point out again here that simple heating to a few degrees above the melting point is unlikely to give stable solutions. They must be properly "sterilized."

One gram of salol was taken and dissolved in 100 cc. of alcohol. A portion taken out on a platinized platinum wire and allowed to dry always induced crystallization (Mass $= 10^{-6}$ gm.). One cubic centimeter of the solution was made up to 100 cc. with alcohol. On applying the same inoculation method, crystallization was induced in about 20 per cent of the experiments.

One cc. of the 10^{2} solution was then added to 100 cc. of water. The salol separated, and gave a milky liquid. A pipette delivering a drop of 10 milligrams was made, and a single drop was allowed to fall into the super-cooled salol. The surface tension of the latter kept the drop beneath its surface and in a moment or two crystallization began, often from 5 or 6 different points on the drop. This is quite a pretty experiment, and the fact that the salol particles can penetrate the skin between the water and salol is worth study. A drop was then put on a microscopic slide, divided into sections and the number of crystals counted. Ten milligrams contained about 1000; so the mass of the particle was about 10^{-9}, a result approximating that obtained by Ostwald.

The solution was then placed in a long tube, and the particles allowed to settle. From time to time a small amount was pipetted off, the diameter of the particles measured by a microscope, and the salol was inoculated in the manner described. Although the solution was absolutely clear it produced crystallization invariably. Indeed, I have had a solution containing such fine particles that they had not fallen 5 centimeters after 40 days; but as my solutions were not in a constant temperature bath, this can in part be ascribed to temperature variation.

The results from the microscopic measurements were: after 24 hours, diam. 2ν, mass 4×10^{-12}; after 96 hours, diam. $0\cdot5\nu$, mass 6×10^{-14}; final results, diam. $0\cdot2\nu$, mass 4×10^{-15}, density of salol, $1\cdot27$.

While these results are only a first approximation, I have every confidence that the necessary mass to cause crystallization does not exceed this amount. Perrin, in his determination of the value of N, shows that a gamboge solution, (density $1\cdot2$) containing particles of a diameter of $\cdot42\ \nu$ comes to a stable state in a few hours, and that the number of the particles decreases to one-half for each $30\ \nu$ ascent in the liquid. In one millimeter the number of particles would diminish to $\frac{1}{2}^{33}$, or become vanishingly small. This leads me to believe that the particles were even smaller than I had estimated.

Finally, it may be noted that salts which readily give supersaturated solution with water fall into two principal classes: those containing water of crystallization, and organic substances. In both classes destruction of the crystal form is brought about by moderate heating, so that the solutions are easily "sterilized."

The anhydrous salts forming supersaturated solutions are mainly compounds such as the nitrates and chlorates which are easily destroyed by heat and whose crystals are therefore not likely to be present on the surfaces of the containing vessels.

In the case of anhydrous salts, the failure to form supersaturated solutions easily can be accounted for by the separation of the solid from drops on the sides of the vessels containing the solutions. These minute crystals fall into the solution and induce crystallization.

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SECTION IV.

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PRESIDENTIAL ADDRESS

The Palæo-Geography of Acadia

By L. W. BAILEY, LL.D., F.R.S.C.

(Read May Meeting, 1919.)

In addressing you to-day I wish, first of all, to thank you for the honour, which I very highly appreciate, of choosing me as your presiding officer on the occasion of this, the first meeting of Section IV as at present constituted, and in the performance of its duties must ask you to extend to me the indulgence always so readily granted to those of advanced years.

This is not the first time that I have occupied the position of President of Section IV, and in doing so now, my thoughts naturally go back to that occasion when the membership of the Section was so different from what it is to-day. At that time, twenty-nine years ago, biology was a word which had hardly come into existence, and the great majority of those who constituted the membership of the section were geologists. Among them let me recall the eminent services and genial personality of one of the founders and the first President of the Royal Society, Sir Wm. Dawson; Dr. T. Sterry Hunt, equally eminent for his chemical investigations mainly in connection with geological problems and the development of the mineral resources of Canada; Dr. Geo. F. Matthew, one of the three still surviving charter members of the Section, and whose long continued and successful study of the rocks and fossils of the Cambrian System was some two years ago recognized by the award to him of the Medal of the Royal Geological Society of Great Britain; Thomas McFarlane, well known among the mining geologists of the Dominion; Dr. Chapman, of Toronto University, a distinguished mineralogist; Dr. Geo. Dawson, one of the great explorers of the Northwest whose chief mining city bears his name, and who also occupied the position of Director of the Geological Survey; Dr. Robert Bell, who did such important work in the exploration of the more remote and at that time wholly unknown regions of Northern Canada; Dr. Frank Adams, who is still with us, now as the Dean of the Science Faculty at McGill University; Dr. A. R. C. Selwyn, F.R.S., for many years Director of the Geological Survey; Mr. J. F. Whiteaves, the distinguished Palæontologist of the same Survey; Dr. A. P. Coleman, of Toronto University, fortunately still with us and still active in geological research; Abbe LaFlamme of Laval University, and Edwin Gilpin, F.G.S., Inspector of Mines in Nova Scotia. Of the original charter members of Section IV, ten were geologists, and of these, two only, viz., Dr. Matthew and myself, remain.

While recalling these distinguished names I for myself cannot but regret that we are no longer to have as fellow members of the Section, the biologists who now constitute the new Section V. For most geologists are, to a greater or less extent, biologists also, and if the two Sections meet simultaneously, as will probably be necessary, many of us will miss the reading of biological papers which we would gladly hear. I fancy also that some of the biologists are interested in the discussion of geological problems. But the change will at all events have one good result, viz., that, with fewer members and papers, there will be much more time for the reading and discussion of such subjects as are brought before us.

The purpose of my Address to-day is to discuss the subject of the Palæo-Geography of Acadia, in other words of the Maritime Provinces of Canada. In attempting this I am aware that the subject is not altogether a new one, nor can I hope to add to it very much that is new, but it is one which may well be considered from different points of view and by different observers. Perhaps the most important of the papers treating directly upon the subject is one by Dr. G. F. Matthew, entitled "The Physical Evolution of Acadia," which appeared in the Bulletin of the Natural History Society of New Brunswick in 1908. But since that time further information, more particularly as regards northern New Brunswick and some portions of Nova Scotia, has been forthcoming, and questions have been raised with regard to the acceptance of the views at that time set forth as the basis of the conclusions arrived at. On the other hand in the volume of the Society's Transactions just issued, and which was read at our last Section, is a joint paper by Dr. Matthew and myself, in which these disputed points were considered at length, giving the natural and probably final views of that gentleman and myself upon the geology of New Brunswick. It would therefore seem to be an appropriate time now in which to review the geography of Acadia in the light of what is now known or thought to be most probable.

Pre-Cambrian

Unquestionably the oldest land to be found in New Brunswick is that which now constitutes the Southern Highlands, being a series of ridges of no great elevation which cross the St. John river at and above its mouth, and which, on either side of the latter, bound for the most part the present Bay of Fundy on its northern or northwestern side. Apart from certain overlying beds of much later origin, they consist of rocks which upon good grounds (mainly the fact that they are unconformably covered by fossiliferous Cambrian strata) were, as early as 1871, referred to the Laurentian and Huronian systems as then understood. The former embraces two principal members, of which the lower or Laurentian proper consists mainly of gneisses, with granitic and syenitic batholiths, while the upper includes heavy deposits of quartzites, limestones and dolomites. The supposed Huronian on the other hand also embraces two terranes of which the lower is represented by clastic rocks (argillites, magnesian schists and grits) and the upper largely by volcanic eruptives. Whether or not these formations are the exact equivalents of the resembling beds in Ontario which have been termed the Animikie and Hastings groups, their Pre-Cambrian origin cannot be successfully questioned, and from them some reasonable deductions may be drawn as to the geographic and climatic conditions which then characterized this part of America.

The lower division of the Laurentian rocks, owing to their highly disturbed and altered condition, afford but little satisfactory evidence, and the granites and other similar rocks which accompany them may be of much later origin. Even the gneissic structure of many of the beds may be no indication of ordinary sedimentation. But the strata which succeed, viz., quartzites, slates and limestones, are evidently sedimentary, and point unmistakably to the fact that the areas which they now occupy were in Pre-Cambrian times covered by the sea. The frequent changes in the character of the deposits, from arenaceous to argillaceous or to calcareous beds, give equal evidence of oscillations in the sea floor and variations in the depth of water, but no evidence exists which can be safely regarded as indicative of dry land. If such there was, it must have been destitute of any ordinary vegetation, though bacteria may already have been present and played some part in the disintegration of exposed surfaces. If the *Archæozoon* of Matthew, found in the limestone series, is really of organic origin, as believed by him, it is a probable inference that the seas in which reefs of the latter were growing were at least warm temperate.

In the Huronian era again we find no certain evidence of dry land over any portion of Acadia, the clastic portions of the system indicating a marine origin, while the eruptives, which constitute so marked a feature in its composition, were probably, in part at least, also submarine.

While, however, we have not, as stated, any satisfactory evidence of dry land during the eras under discussion, the nature of the sediments indicates that some such source of derivation could not have been far distant, while the structural relations of the Huronian to the Laurentian rocks render it probable that great physical disturbances occupied the interval between the two, and that as a result of such disturbance elevations of considerable extent and height may have been brought into view before the opening of the Cambrian Era. It is to the Cambrian strata that we must look for the first clear evidences of early Acadian geography.

Cambrian

The Cambrian rocks have been so long and so carefully studied by our colleague, Dr. Matthew, that it would be out of place to do anything more here than to indicate their bearing upon the geographical conditions existing at that time. They have already been alluded to as affording in southern New Brunswick indisputable proof of the age of the Pre-Cambrian rocks upon which they rest. Their distribution and characters also indicate that they were laid down in narrow troughs, four or five in number, and parallel to the Bay of Fundy, which were traversed by oceanic currents. The basal (Etcheminian) beds are coarse conglomerates, so coarse and holding such large boulders, derived from the subjacent beds, as to suggest bold shores and the undermining action of ice, but the higher beds are finer, chiefly grey and dark slates and quartzites, indicative of quieter waters, but these also from the occurrence of such physical markings as rill-marks, furrows, worm burrows, etc., clearly indicate a littoral origin. They are also in certain beds abundantly fossiliferous, the fossils (Trilobites, Brachiopods, Pteropods, etc.), being such as would naturally tenant muddy shores. From these facts we may infer that, whatever was the case during the greater part of Pre-Cambrian time, the close of the latter, or rather the opening of the Cambrian Era, found the region of the southern Highlands of New Brunswick represented by a massif of hard crystalline rocks, and that these stood above the sea-level, forming a series of island ridges between which flowed the currents of the Cambrian sea, the abode of the rich and somewhat varied fauna so fully described by Matthew.

In other words that portion of Acadia which now forms the southern part of the Province of New Brunswick was then in the condition of an archipelago, the currents traversing the latter being, as shown by Matthew, at times from the south and therefore warm, while at others they were from the opposite direction and therefore of lower temperature.

It will be in place to say here a few words further regarding the great series of strata which in Nova Scotia occupy the whole southern coast of that Province, and is well known for its auriferous contents. The series in question embraces two divisions or groups, of which the lower or Meguma Group consists mainly of grey quartzites with much thinner alternating beds of grey slates, while the upper or Halifax Group is made up almost wholly of black argillites, at times replaced by similar beds which are greenish, purplish or conspicuously rib-banded. The most noticeable features in connection with this formation are four in number, viz., (1) the enormous thickness of the deposits, estimated at 35,000 feet, (2) their uniformity over such great areas, stretching from Yarmouth to Canso, (3) the absence, except locally near Yarmouth of any conglomerates, and (4) the apparently entire absence of recognizable fossils. The first feature points to an equally enormous lapse of time and the depth to which the subsidence took place, the second to the continuance through like periods of conditions showing little change, *i.e.*, the accumulation of successive beds of sand and clay under waters which were at no time very deep, the third to the absence of strictly littoral deposits or of powerful currents, and partly the existence of conditions not suitable for the development of life. A comparison has been suggested between this series and parts of the Huronian of New Brunswick, but the two differ widely in most of their characteristics. The only rocks with which they come into contact are batholithic granites and these were of long subsequent origin.

It has been said that the Pre-Cambrian rocks of the southern Highlands in New Brunswick coincide, at least to a considerable extent, with what is now the northwest side of the Bay of Fundy. They thus evidently tended to fix what in all subsequent time was one of the distinctive features of Acadian geography. Their general northeasterly direction is in accordance with the system of trends which throughout Palæozoic time and later distinguished the orogenic movements affecting the whole of northeastern America, and from their hard and crystalline character, determining resistance to pressure, made them a barrier against which that pressure, coming from the Atlantic, was enabled to react.

But while the general position of the Bay of Fundy trough was thus fixed, we must not infer that this had either its present limits or its present character. For, if we look to the position of its southern side we find distinct evidence that its border in that direction was not where it now is. The present southern shore is bordered throughout by the trappean ridge of the North Mountains overlying red sandstones of Triassic age, and even if we go further back in the Nova Scotian peninsula we fail to find any rocks so ancient as are some of those of southern New Brunswick, unless it be those of the southern coast, the so-called Meguma series and Halifax formations, and these are undoubtedly of marine origin. The only other rocks to be found in the Nova Scotian peninsula west of Halifax are the Silurian (?) and Eo-Devonian rocks bordering the southern side of the Annapolis Valley, and the great granite batholiths which border and invade the latter.

We thus fail to find any evidences of land areas to mark the southern side of the Bay in early Palæozoic time. Possibly such areas existed to the eastward of the present limits of Nova Scotia over a region now submerged.

So much for the Bay of Fundy region and its borders. What about Northern New Brunswick? It was at one time supposed that large areas constituting the Northern Highlands were Pre-Cambrian and are so represented in the official Geological Survey map, but while we cannot deny that rocks of such high antiquity may actually occur there, in a region as yet very imperfectly explored, no definite proof of this exists at present while it has been certainly shown that a considerable part of the areas referred to consists of volcanic effusives which are at least as recent as Silurian. The oldest strata met with so far as the fossils show, are of Cambro-Silurian age.

Cambrian-Silurian or Ordovician

In the Geological Survey Map, published, as regards northern New Brunswick, in 1875-82, large areas in the northern central parts of the Province are represented as of Cambro-Silurian age, the rocks there met with consisting mainly of slates and quartzites, lying either side of and at many points penetrated by the great granitic batholiths which more or less interruptedly cross the Province from the western frontier at Macadam to the lower part of the Nepisiquit River near Bathurst. Prior to the publication referred to, the same group of rocks had by various authors (Gesner, Hind, Logan, Robb and others) been regarded as the probable equivalents of the so-called Quebec group, and to this view some support was given from the fact that at certain points portions of them are unequivocally overlaid by Silurian rocks. It was not, however, until 1880 that any definite evidence as to the age of any portion of the area thus referred to was found, when Matthew obtained from one of the branches of the Beccaguimee river, in Carleton, a series of fossils (Harpes, Lingullella, Leptaena, etc.) clearly indicative of a Cambro-Silurian (Trenton) or older Ordovician horizon[1]. Another locality yielding fossils was that of the Tattagouche river, a few miles from Bathurst, from which were obtained graptolites determined by H. M. Ami as homotaxial with those of Norman Kile near Albany, N.Y., or Lower Trenton. Still later the writer was fortunate in finding on Eel river, near Benton, in Carleton County, abundant remains of graptolites (*Dictyonema flabelliforme*) probably of Upper Cambrian age.

But while the above facts justify the conclusion that there are within the areas under discussion rocks of the high antiquity just assigned to them, there is equally strong evidence that there are also rocks of much more recent origin and that future editions of the map will require to be greatly altered. Thus Eo-Devonian rocks, containing plant remains were found by Reed in slates at Spring-Hill near Fredericton; Eo-Devonian marine fossils on a branch of the Nashwaak river (Chas. Robb); double graptolites at Seven Mile Brook on the St. John river above Fredericton (Bailey); in Waterville Settlement, York County (Bailey); and on Eel river below Benton (Wilson and Bailey). In fact the evidences in favour of a Silurian or Eo-Devonian age for a large part of the great tract under discussion is much stronger than for the view of their higher antiquity.

While the geology of northern New Brunswick is thus, to a considerable extent, involved in doubt, it is certain that strata of Cambro-Silurian age are to be found in southern New Brunswick. They are, however, of very limited extent and thickness, being found about the Falls of St. John river, being associated with Cambrian strata and forming a portion of the St. John Group of Matthew. The beds are argillaceous, and it is to be noted that nowhere in New Brunswick have we anything resembling in character or origin the heavy coral-bearing limestones which, alike in Canada and the eastern United States, are so marked a feature of the Cambro-Silurian era. At an earlier period the areas above the sea-level were confined to the pre-Cambrian ridge bordering the Bay of Fundy and some portions of King's and Queen's counties, and these in the form of scattered islands of no great size.

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[1]Compare Beekmantown limestone in New York and Arenig in western Great Britain.

In Nova Scotia rocks of Cambro-Silurian age have been reported by Fletcher, Ami and others as occurring at various points, such as the Arisaig region (mainly Silurian) the Mira river district in Cape Breton, and others. These beds are marine in origin and indicate submergence of the areas in which they occur, but no such deposits are found in peninsula Nova Scotia, where, excepting the Eo-Devonian of the Annapolis region and the batholithic granites, the only rocks are those of the Gold-bearing series of the Atlantic coast, of Pre-Cambrian age. These may have been above the sea-level in Ordovician time and far higher than at present, but there is no definite proof of this.

Silurian

The geographical conditions which characterized the Silurian Era in Acadia are much more clearly indicated than those of preceding eras—the rocks of this time being very widely distributed and giving much more direct evidence of their origin.

As in earlier periods a large part of the Acadian basin was below the sea-level. Not only was this true of what is now the St. Lawrence Gulf, but, to the westward of the latter, the waters spread over all northern New Brunswick, north of a line extending from near Bathurst to the Maine frontier, the depression thus indicated being a portion of what Dana long since termed "the Gaspe-Worcester trough." As indicated by the organic remains found on Anticosti Island in the Gulf, at Dalhousie in New Brunswick, in Aroostook county, Maine, and further west, the trough was occupied by a shallow coral-growing sea, abundantly tenanted by forms of life indicative of a warm temperature. In southern New Brunswick were other troughs such as have been already indicated in connection with the discussion of earlier periods, but here the waters were shallower and more turbid, limestones and corals are of rare occurrence and the deposits are mainly argillaceous or sandy, being, as further indicated by their fossils, such as would naturally accumulate where heavy sedimentation would be in progress and current action powerful. In both cases a noticeable feature is the presence and extent of volcanic action. Evidences of such action are especially noticeable around Passamaquoddy Bay, where they are now represented by such eminences as Chamcook mountain, Troaks mountain, McMasters island and Moose island (Eastport) and are so distributed as to indicate that the Bay referred to was at that time not only clearly differentiated, but was a focus of intense volcanic activity. Similarly in Northern New Brunswick the disposition of the volcanic rocks around the shores of the Bay Chaleur is such as to indicate that this depression also was clearly defined in Silurian time and nearly with its present limits. Lastly, the wide distribution of volcanics on the Northern Highlands, if of Silurian age, as is altogether probable, show that this portion of the Province also was at that time one of pronounced vulcanism.

In Nova Scotia, the only rocks of Silurian (or Eo-Devonian) age with which the author of this address is personally familiar are those which, at Bear River, Clementport and Nictor, border the southern side of the Annapolis Valley. They are sandstones and slates with beds of iron ore, and are abundantly fossiliferous, the fossils, consisting largely of Spirifers, indicating an horizon which is about that of the Oriskany formation. Being evidently marine, though of shallow water origin, we must look elsewhere for evidences of land areas, but, as already explained, these are wholly wanting in peninsular Nova Scotia, the only other formations being the great granite batholiths which by their invasion of the Eo-Devonian rocks show their later origin, and the Meguma and Halifax formations, which, though of great antiquity, can hardly be otherwise than of oceanic origin. As in the Cambrian era, we must look to a possible Atlantis to the eastward of the present Atlantic seaboard for such land as then lay above the sea-level in this region.

Another important area of Silurian rocks in Nova Scotia is that of Arisaig. In view, however, of the diversity of opinion entertained by different writers regarding these rocks it is not proposed to discuss them further here than to say that they indicate submergence at the time of their origination.

It will here be in place to consider a group of rocks found in southern New Brunswick as to the age of which there has been much controversy. I refer to what is known as the Little River group occurring on the coast of the Bay of Fundy, near St. John, where they include the well-known deposits of "the Fern Ledges," of Carleton. These, partly on palaeobotanical and partly on stratigraphical grounds were originally referred by Dawson, Hartt, Matthew and the writer to the Devonian, and later by Matthew to the Silurian, but have been claimed by White, Ami, Mrs. Stokes and others as equivalents of the Millstone Grit, or even as representing higher horizons in the Carboniferous system. Thus a wide divergence of opinion has developed as to their true position, but it is to be noted that the view that they are of Carboniferous age rests solely upon palaeobotanical grounds, which may be liable to change, while no one who has actually studied the ground has as yet reached any other conclusion than that they are really older than the formation last named. The question has been largely and somewhat acrimoniously discussed, but as the facts bearing upon it have been fully stated by Dr. Matthew and the writer in a paper contained in the last volume of the Transactions of the Royal Society, and more recently in other papers by the first-named author, I have not considered it necessary to discuss the subject further here.

The organic remains of the Little River group include those of Ferns, Conifers and Insects. They therefore show the existence of dry land near their place of burial and that this was covered by a terrestrial vegetation. Moreover, the Conifers (*Dadoxylon* or *Araucarites*) are in places in such numbers and so confusedly piled together as to indicate that they represent the driftage of considerable streams. The land therefore must have been of such extent as to make possible a system of drainage. The occurrence of beds carrying marine fossils to the north of the area occupied by the Little River rocks militates against the idea that any considerable tract of land lay at the time in that direction, and Dr. Matthew, who regards these rocks as of deltaic origin, has suggested the idea that they may have come, in part at least, from the Meguma series of Nova Scotia, which, there is reason to believe, was above the sea-level at the time and which has undergone enormous denudation.

The Devonian or Acadian Revolution

We come now to consider some events which wrought a tremendous change alike in the geography and physiography of Acadia. All authorities agree that towards the later part of the Devonian age there occurred a series of earth movements, accompanied by or resulting in mountain elevations, metamorphism, etc., to which the designation given above may very appropriately be applied. The evidence of this revolution is to be found in the uptilting and folding of all formations up to and including the Silurian, but which did not affect the Perry Group or Upper Devonian or the Lower Carboniferous —also in the intrusion of great granite batholiths, such as now form the cores of such ranges as the York County Highlands, the Nerepis range and the Caledonia range in New Brunswick, together with the Cobequids and South Mountains of Nova Scotia. At many points these granites are seen to penetrate and alter Siluro-Devonian rocks, and boulders of granite, rare in the conglomerates of older formations, abound in those of the Perry formation and Lower Carboniferous. These latter formations, like the Coal measures, also show no evidence of the metamorphism which is so conspicuous in all the groups of earlier age[1].

[1] *e.g.* The slaty structure of the mud rocks.

From the above observations it may be concluded that during a portion of the Devonian age the land areas of Acadia were both more extensive and of much higher elevation than was the case in any earlier period of their history. These land areas were clothed with vegetation and air-breathing types of animals, such as Neuropterous types of insects, Myriapoda and Snails tenanted the forests of the era[1]. Batrachian foot prints have also been found by Matthew, although they are not common.

THE PERRY GROUP

The rocks to which this name has been applied consist of coarse conglomerate and sandstones, of brownish red colour, resting unconformably upon Silurian and older strata and made up of their detritus. In places, such as Perry, Maine, on the shores of Passamaquoddy Bay, they contain plant remains which were regarded by Dawson as of Upper Devonian age, a view which has been confirmed by later observers. From their distribution around Passamaquoddy Bay, and their evidently marine origin, it seems obvious that this Bay, forming so considerable an indentation of the southern coast of New Brunswick, was in existence at the time and with nearly its present limits, while further east the occurrence of similar beds at Point Lepreau and on the Kennebecasis river near St. John, possibly also about St. Martins and on the Albert County coast, leads to like conclusions as regards the great Bay of Fundy trough. The interior of New Brunswick, now occupied by the great central coal field, was probably also submerged.

A feature of the Perry Group is the extent to which, as seen about St. Andrews, the stratified rocks of the latter are penetrated by basic volcanic rocks, dolerite, diabase, etc., occurring both as dykes and sills, but not of sufficient extent to affect materially the geography of the region.

LOWER CARBONIFEROUS

The line of separation between the Perry Group and Lower Carboniferous is not easily drawn. The lower beds of the latter are very similar to the former, are of similar origin, and hold similar relations to older formations. For these reasons the Perry rocks were, at the time of the publication of the Geological Survey maps, regarded as being also Lower Carboniferous age and were so represented. But above rocks of the Perry Group proper, with organic remains now accepted as Upper Devonian, is a very considerable thickness of strata

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[1] Little River group.

which must, with equal certainty, be referred to the Carboniferous system. The beds to which this conclusion applies embrace, in addition to volcanic rocks and bright red sandstones, often saliferous, limestones holding characteristic marine fossils (brachiopods, orthocerata and occasional corals), with which at some points, as about Hillsboro, N.B., and Windsor, N.S., are associated extensive deposits of anhydrite and gypsum.

These rocks are undoubtedly marine and their disposition in the maritime provinces is such as to make the drawing of conclusions as to the geography of the time comparatively easy. The Bay of Fundy trough must have been in existence, but as a strait rather than a bay, and opening freely at its head into the Gulf of St. Lawrence. Its southern shore also was formed not as now by the North mountains (volcanic traps of Jurassic age), but lay south of Annapolis basin, with considerable indentations about Windsor. In the interior of New Brunswick a long shallow valley traversed by marine currents lay between the Southern hills and the similar Pre-Carboniferous hills of King's county, while still further north a large part of central New Brunswick, later to be occupied by the swamps of the Coal measures, was beneath the sea level. Still further north, rocks of this age occupy limited areas in Victoria county and around the shores of the Bay Chaleur.

The period was evidently one of wide submergence, though only to shallow depths, and where conditions were favourable, considerable areas, shut off by barriers from the general oceanic circulation, became evaporating basins, in which were laid down the deposits of gypsum. It is also evident that the sinking of the land, resulting in such submergence, was to a considerable extent, as the marine deposits are now found at considerable elevations, and that it increased progressively eastward, as while near St. John they are not far above sea level west of that point they are wanting altogether. In the opposite direction they rise higher and higher on the underlying hills until at Shepody Mountain, overlooking the head of the Bay of Fundy, they cap the latter.

In Nova Scotia the Lower Carboniferous system is mainly represented by the Horton series, exposed along the shores of the Avon estuary, and the Windsor series, closely adjoining the former. The former consists of black argillaceous and calcareous shales, marked by evidences of littoral marine origin but holding the remains of numerous plants (especially Lepidodendron corrugatum and Aneimites Acadica) and the latter by reddish and greenish marls, with zones of gypsum and limestone, the latter abundantly fossiliferous.

Carboniferous

At the opening of the Carboniferous Period the main geographic and physiographic features of Acadia had already been determined. The existence of the latter as a distinct region, well styled the Acadian Basin, had been established, and through the orogenic movements constituting the Acadian Revolution, the position even of its principal hill ranges and intervening valleys had been fixed. But while in the preceding Lower Carboniferous Era these valleys were still below sea level and traversed, as already stated, by marine currents, in the Carboniferous Period they too, by emergence became for the most part, permanently added to the dry land of the continent. The change was gradual, and except for slight discordance of dip and evidence of erosion the one formation follows upon the other without evidence of great physical disturbance. The valleys within which the coarse red beds of the Lower Carboniferous, with their limestones and gypsums, had been laid down, now became occupied by extensive swamps over which, with imperfect drainage, grew the great forests of ferns and Conifers now represented by our coal beds. The largest of these swamp areas was in New Brunswick, that now occupied by the great central coal-field, embracing an area of about 6000 square miles, and eastward this was probably extended over the greater part if not the whole of what is now the Gulf of St. Lawrence, thus connecting this Province with Cape Breton and Newfoundland, while smaller areas, representing similar conditions, occur here and there among the southern hills and in the Bay of Fundy troughs. Oscillations of level must have been of frequent occurrence, as was necessary for the formation of successive coal beds and the aggregate subsidence, especially about the head of the Bay of Fundy, as indicated by the Joggins section, must have been enormous. Central New Brunswick with a thickness of coal strata probably nowhere exceeding 1000 feet as against that of the Joggins nearly 15,000 feet, must have been much more stable. The St. Lawrence river must have found its way to the sea by various channels traversing what is now the Gulf of St. Lawrence, and from this must have come to a large extent the materials, sandstones and pebble-beds, which now form the strata which alternate with the coals. Throughout the deposits there are no marine fossils, and the sea must have been wholly excluded. The higher lands were covered with coniferous forests and the lowlands by swamps with luxuriant growth of Ferns, Calamites, etc. The only air-breathing types of life were Insects, Myriapods and Amphibians. The climate was warm and moist, with probably an excess of carbon dioxide in the air.

Post-Carboniferous

Though the purpose of this Address is to consider the geographical conditions of Acadia in the Palaeozoic ages only, a few references to those of later times may help to give completeness to the subject.

Before the close of the Carboniferous age the land had already again subsided, the Gulf region was again under water, and sediments of marine origin were formed in what is now Prince Edward Island and the opposing shores of Westmoreland county, while the probable submergence of the Isthmus of Chignecto would connect the waters of the Gulf with those of the Bay of Fundy, leaving Nova Scotia as an island.

In the Trias-Jura period similar conditions prevailed, but during and at the close of the latter, remarkable changes took place through the extravasation of vast quantities of volcanic material in the Bay of Fundy trough. Such extravasation did not take place from separate localized vents or craters, but, as in the case of the Palisades of the Hudson, along extended cracks or lines, thus giving origin to long and well-defined ridges, though of no great elevation. Of these the most conspicuous is that which forms the North mountains of Nova Scotia, and which by its production determined for the first time the present south side of the Bay of Fundy trough. The island of Grand Manan, made up to a large extent of similar trappean and basaltic rocks, is of like origin, as is also Isle Haute and some of the hills about Parrsboro, while the occurrence of equivalent strata on the New Brunswick shores, though only of limited extent, and the existence of parallel ridges along the centre of the trough, as indicated by soundings, show that this was throughout an area of intense vulcanism. The extremely coarse character of some of the conglomerates of this age on the New Brunswick coast, especially about St. Martin's, show that the Bay was at that time swept by very powerful currents.

The events of the Cretaceous and Tertiary Periods are in New Brunswick without recognizable records. In Nova Scotia a very small area on the south shore of the Bay of Fundy and overlying the Triassic traps has been regarded as of probably Jurassic or Cretaceous age, but with this exception no rocks of Mesozoic or Tertiary age are to be found in any part of Acadia. Throughout the long period represented by these ages the land in this part of Acadia stood at higher level than at present, with higher ranges, and the coast lay considerably to the eastward along an area now submerged. It was a period of extensive peneplanation, though not effectually effacing the more dominant geographic features of the region, but any accumulations of detrital matter which may have been produced by aerial agencies or along the course of streams or rivers have since been wholly obliterated.

The facts regarding the Quaternary age may be briefly stated. Adopting the generally accepted Glacial Theory of Agassiz, we may picture to ourselves the greater part of Acadia in the Glacial Epoch as standing at a much higher elevation than now, and covered by an ice-cap which buried alike the two provinces of New Brunswick and Nova Scotia, as well as the Bay of Fundy trough which now separates them. The extent of the ice-cap was continental, and few, if any, of the higher elevations remained uncovered. The effects were those of enormous erosion, the formation or deepening of river channels and the formation of new ones, together with the origination and dispersion of enormous quantities of drift, mostly to the south of the place of origin. With the passing away of Arctic conditions, local centres of ice action for a time persisted, and to these were due the occasional transference of the drift, as in the Annapolis Valley, in directions the reverse of its previous transportation.

In the Second (or Champlain) Era, a subsidence followed the previous elevation and to such an extent as to carry much of the present coastal areas bordering the St. Lawrence Gulf and the Bay of Fundy below the sea-level, about 200 feet in the latter case and about 600 feet in the former, and thus leading to the drowning of numerous rivers and streams. At the same time, many lakes and ponds were formed through the damming of drift, and the soil covering of the region had its characteristics largely determined.

Finally, in the Terrace Period, still another upward movement took place, but not sufficient to restore Arctic conditions. The coast line became about what it is today. Lakes were drained more or less completely by the removal of their drift dams, river piracy, as in the case of such streams as the St. John and Miramichi, took place on a large scale, and the drainage systems of both New Brunswick and Nova Scotia, assumed for the most part their present aspect. Elevated beaches, like Pennfield Ridge in New Brunswick, were left bordering the coast, while along the river valleys, as illustrated in the case of the St. John, below the Grand Falls, these slopes were conspicuously fringed with terraces, sometimes four or five in number, marking successive periods of elevation.

Among other changes may be noted the separation from the mainland of the ridge of the North Mountains in Nova Scotia, as proved by the occurrence of marine fossils at Middleton; the similar separation of the ridge on which now stands the city of St. John; changes in the position and character of river outlets, as in the case of the St. John; and, as in many instances, the determination of waterfalls.

The Delta of the Little River Group and Some of its Peculiarities

By G. F. MATTHEW, D.Sc., F.R.S.C.

(Read May Meeting, 1919.)

This paper deals more at length with some peculiarities of a deltaic deposit described in a former article read before this Society and one communicated to the Natural History Society of New Brunswick[1]. In the following notes the subject is treated more at length, specially in relation to the source of the sediment which built up the Cordaite deposit. But as a preliminary to what is there stated, one may mention that the source and course of a river in the Cordaite period is not yet known; that a delta existed, however, may be inferred from what is stated below.

Very little is known of the history of land-deltas of this early time. The changes in the level of the land have been so great, and the erosion of the earth's surface so enormous during the ages that intervened between that time and the present, that seldom or never can the connection between the sources and the delta of a river of that age be found. Still, one should have clearly in his mind, the fact that a complete river system should have three principal parts.

There are *first*, the *sources* which are usually in some mountain system, or some high table-land; *second*, the *river valley*, usually eroded considerably below the chain of hills or ridges that bound the valley on either side; and *third*, the *delta* or terminal plain, where the river enters the sea.

In such cases as that here considered, only the *delta* remains to tell the history of past geological changes, and to give hints of conditions on the neighbouring emerged land, at least this delta is all that we have to tell of terrestrial conditions in Silurian times at St. John and its neighbourhood.

Whenever, because of pressure from the ocean abysses the continental border was raised, erosion of the land-area occurred, and the river valleys suffered from erosion not infrequently they were completely obliterated or disconnected, and in this way the source of the river could be entirely cut off from the delta which it had formed. This appears to have been the case with this old delta at St. John which in this way was completely cut off from the source of its sediment which may have come from the great Pre-Cambrian area, which then appears to have had a great extent in eastern New Brunswick

[1] Bull. Nat. Hist. Soc., N.B., No. XXXII, 1918.

and in the neighbouring province of Nova Scotia. The large area of these rocks in Nova Scotia has been called the Maguma series, and shows in its lower part an enormous mass of hard quartzites, without parallel among the Pre-Cambrian rocks of this region. In Newfoundland these rocks were called by the late Alexander Murray, the Intermediate series, I suppose, because they held an intermediate position between the old gneisses of that colony, and its Cambrian rocks. But neither there nor in New Brunswick do they exhibit the great masses of quartzites that are found in the Maguma series of Nova Scotia.

Northeastward of the Cambrian area of southern New Brunswick (in which lies the chief basin of the Cordaite deposits) on the highlands bordering the Bay of Fundy on its northern side, one comes on Pre-Cambrian rocks. There is a prominent belt of sericic mica schist and argillites that are in great masses and serve for an elevated border to the later deposits on the north side of the Bay of Fundy, as the Maguma quartzite do to those of the opposite shore of that bay. These may be of same age as the latter, but different in appearance owing to the deposit of sand of that age having ceased in this northerly direction[1].

Another peculiarity of this delta is that there is no marine intercalations near St. John to tell, by means of the organisms of the shallow seas, what the geological age of the delta really is. And so far as the creatures of the land are concerned we can have little help, as such for Silurian times are yet quite inadequate. But if we extend our survey of these rocks westward toward the broad area of marine Silurian strata that spread off in that direction, we do get some help. In that direction we find them cut up into several narrow basins that have portions of the Silurian sediments, none so complete as the Little River basin, but in this direction we soon find that we have reached the marine border.

One important factor in determining the true position of these sediments is the uncomformable superposition of the Devono-Carboniferous series, which though intimately connected with Little River sediments in its distribution is manifestly of later date, the flora of these later beds, first described by Sir J. W. Dawson and later by Mr. David White, is recognized as Upper Devonian. These plants were found in sandstone beds at Perry, near Eastport, in the State of Maine,

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[1] A similar reduction in bulk of the middle member of the St. John group (Cambrian) may be seen at the Kennebecasis Valley, where that member of the series has shrunk to about one-eighth of the bulk it has in the central area at the city of St. John; and yet there are only a few miles between the two basins of Cambrian strata.

where they overlie unconformably the more highly-disturbed strata of the Little River group.

Lowest among these Upper Silurian strata is the Bloomsbury effusive series which either in the form of unaltered lavas and ash rocks, or as reddish and greenish-grey, stratified rock, are found mostly at the margins of the basins, and tell of the way in which the accumulation of these rocks began. A large mass of these effusives forms the prominent hill on the west side of St. John harbour. Another volcanic mass is Partridge Island at the mouth of St. John harbour; another, the Manawagonish Islands, is on the same line of vents. Similar intrusives mark the southeastern side of the basin of these rocks.

The group which immediately overlies these volcanic strata are the quite dissimilar beds known as the Dadoxylon sandstone in which the oldest plant remains of the Silurian succession at St. John are found. The source, course and termination of the river courses of this set of beds is fairly well shown, but that of the overlying Cordaite slates and sandstones is not so apparent.

The Cordaite beds were laid down like their predecessors in what are now narrow parallel valleys of which that of the Little River basin is the principal one, and, so far as is at present known, were deposited in fresh water, since plant remains and denizens of the fresh-waters and the land are the only remains of living objects found in the slates and sandstones of the Cordaite series.

Assuming then, that the sources of the sediment which built up the Dadoxylon beds is fairly well known, there remains a consideration of the origin of that which has built up the many feet of strata which constitute the Cordaite group, so uniform in character, and so far as we know, in its most complete basin, quite devoid of marine strata. In this connection one may well consider the known Silurian deposits of this region and their characteristics. So far as known, we have no "abyssal" deposits, but there is a large area extending southwestward into New England, between Gaspé, in eastern Quebec on one hand and the main peninsula of Nova Scotia on the other, where extensive shallow-water marine deposits are known. At irregular intervals along the southern side of this tract are detached basins which by the presence of land plants, terrestial animals or fish remains, indicate the nearness or actual presence of emerged land. Farther to the southwest, we lose even these indications of the vicinity of the land to the sea margin, and there is nothing in the present condition of the earth's surface there to show whether the area beyond the present sea shore had emerged land or was beneath the sea. Jas. D.

Dana and other writers since him, have assumed that a part at least of this region was then emerged and in that way accounted for the production of the coal seams of Carboniferous time in the deltas of the rivers of Pennsylvania in that distant time. Such an area in the Maritime Provinces of Canada, would, with its highlands in what is now the coastal border of the sea and its maritime border toward the present interior plain, have afforded a gathering ground for the waters of rivers flowing northward and westward to the ocean sound that then stretched from the depression of the Gulf of St. Lawrence into the central part of New England affording an area where the fresh-waters from the hills could reach the ocean. In this area, now submerged, there would have been ample space on Cambrian and Pre-Cambriam rocks, for the sources and channels of rivers that have drained the southeastern highlands that existed here in Silurian times.

These conditions form the basis of the hypothesis which the author now puts forward as the most feasible in explanation of the unique conditions associated with the accumulation of the Cordaite slates (or shales) and sandstones.

1. There was an outburst of effusive rocks at the beginning of the period, leading to the production of masses of dolerites and ash rocks, that are found at the base of the plant—bearing beds in many places in this district.

2. The main basin containing the plant beds was separated from the sea to the northwest by a land barrier that lasted throughout the time the plant remains were accumulating. And the basin itself settled slowly and gradually allowing the regular and continuous accumulation of alternating sand and mud-beds in this area.

3. There is a connection and resemblance between the species of the basin of plants throughout the deposits from the base upwards. Some species of plants are found in all parts of the deposit.

4. Beside the plant remains there are several kinds of fresh-water animals, as Phyllopods, Ostracods and Fishes.

5. Also land animals, as Batrachians, Insects, Myriapods, Molluscs.

6. The land plants show a number of the Palaeozoic types, as Pteridoserms, Pteridophyta, &c.

7. The depression of the Bay of Fundy area, or other cause, eventually cut off the supply of freshwater, bearing plant remains; and the covering slates are those of the Mispec group, in which slaty cleavage is even more marked than in the earlier Cordaite slates.

8. These Mispec slates are all of a deep red colour, are based upon volcanic rocks, and at west are entirely separated from the Cordaite or plant-bearing slates.

9. At this time, or somewhat later, the pressure from the southeast, and the folding of the whole pre-Devonian series of Palaeozoic strata occurred, and the change from carboniferous to graphitized inclusions became manifest.

10. Connected with the folding and squeezing together of the whole deposit, ridges of granitic rocks appeared at the surface. Of these, the most notable is the range of the Nerepis hills of which the core consists of such granites. These granitic intrusions are specially notable along the southern border of the Coal Measures in Queen's county, beyond which, westward, while the granites continue their course to the southwest, the border of the coal field trends away to the North.

11. After the folding, hardening and partial metamorphism of the plant beds, further geological changes occurred, leading to the deposit of later series of strata—Palaeozoic and Mesozoic—none of which, however, show such strong pressure from the southeastward as those we have described, and none exhibiting that development of heat which graphitized plant remains of the St. John plant beds exhibits.

But the erosion of these ridges continued for many ages, as there are no traces of accumulative deposits again until the Glacial time is reached, and the erosive action of glaciers covered the surface of the land with till and the clay and sand beds which now conceal from view large areas of the older stratified rocks.

The Origin of the Purcell Trench, British Columbia (Kootenay Lake Valley)[1]

By STUART J. SCHOFIELD

Presented by WILLIAM McINNES, F.R.S.C.

(Read May Meeting, 1919.)

SUMMARY

1. Orogenic movements affected the Selkirk range in southern British Columbia for the first time in the late Jurassic period.

2. The first granodiorite intrusion of the West Kootenay (Nelson) batholith took place in the late Jurassic period.

3. This batholith was unroofed in the Upper Blairmore times.

4. The upland surface of the present Selkirk range was formed by erosion during the period from late Jurassic to early Tertiary. This period of erosion was brought to a close by the Laramide orogenic movements which built the Rocky Mountains and raised the upland surface of the Selkirk range to its present height.

5. The Purcell trench and similar valleys of the Selkirk range were cut into this upland surface during the Tertiary and Quaternary periods and hence are antecedent river valleys.

GEOGRAPHY

Everyone who crosses the Canadian Cordillera by way of the Crow's Nest pass or the southern route is struck with the great longitudinal valleys or trenches, not only on account of their beauty but also on account of their even continuity to the north and south. From east to west the trenches may be listed as follows, the Rocky Mountain trench (Kootenay River Valley) separating the Rocky Mountains on the east from the Selkirk mountains on the west, the Purcell trench (Kootenay Lake valley), the Selkirk valley (Columbia River valley), the Okanagan Lake valley and the Fraser River valley (Plate I).

The Purcell trench is situated in the Selkirk mountains[2] and crosses the International boundary line, longitude 116 degrees 30 minutes, (Plate II). It extends from this point in a northwesterly direction

[1] Published by permission of the Director of the Geological Survey of Canada.

[2] Nomenclature of the Mountains of Western Canada. Geographic Board of Canada, April 2 1918.

until it joins the Selkirk trench at the northern end of Upper Arrow lake, a drowned portion of the south-flowing Columbia River valley. Daly[1] considers the northern extension of the Purcell trench to be the Duncan and Beaver River valleys, while the writer considers the northern portion to be occupied by Lardo river, Trout lake and Beaton creek which flows into Upper Arrow lake and thus joins Selkirk valley and Purcell trench.

The following facts support the change in the delineation of the Purcell trench:—

1. The Purcell trench is a valley formed by an antecedent river and the northern extension occupied by Lardo river, Trout lake and Beaton creek is of similar origin.

2. The valley of the Duncan river parallels the strike of the rocks and is probably a subsequent river.

Kootenay lake occupies the central portion of the trench and is drained from a point near its centre by the west-flowing Kootenay river, which in turn empties into the Columbia river. The southern portion of the trench is occupied by the north-flowing Kootenay river.

Topography

In a view from one of the higher peaks of the Selkirk range, the most striking feature is the series of almost unbroken ridges, having an approximate elevation of 7,000 feet. The trend of these ridges is in all directions and bears no relationship to the underlying structure. These ridges evidently represent the remnants of an uplifted and dissected peneplain. Numerous peaks having an elevation from 8,000 to 9,000 feet project above this old land surface, while great valleys have been carved 6,000 feet below it. The ridges form convenient highways for exploration once this upland surface is reached. In marked contrast to the ridges of the Selkirk mountains, those of the Rocky Mountains to the east have a remarkably constant northwest trend and have a direct relationship to the structure of that system, in that the ridges represent great fault blocks whose trend is in a northwesterly direction.

Geology

The Purcell trench is carved in a series of sedimentary rocks ranging from the Beltian to the Carboniferous. This series is intruded by masses of granodiorite, offshoots of the west Kootenay batholith of Jurassic age (Plate II). The following is a condensed geological table:

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[1] Daly, R. A., Geol. Surv., Can., Mem. 38, 1912, p. 26.

Quaternary		Till, unconsolidated gravels and sands.
UNCONFORMITY		
Jurassic	West Kootenay Batholith (Nelson)	Granite.
INTRUSIVE CONTACT		
Carboniferous	Slocan Series (fossiliferous).	
Carboniferous or Pre-Carboniferous	Ainsworth Series	Mainly quartzites, argillaceous quartzites, limestones and their metamorphosed equivalents.

STRUCTURE

Viewing the geology of the whole trench as shown on the accompanying geologic map (Plate III), it will be seen that the sedimentary series forms a huge, almost symmetrical bow, the apex of the bow being to the east. The general dip is almost everywhere about 45 degrees towards the inside of the bow so that the rocks in the northern part of the trench strike northwest with a dip to the southward, bending gradually until the middle of the trench is reached where the strike is north and south with a dip to the west, and finally in the southern part of the trench where the strike is southwest with a dip to the northwest. The granite masses, the eastern fringe of the west Kootenay (Nelson) batholith, have had no effect on the general strike of the sedimentary series. Hence, it is seen that the Purcell trench is carved into the terrane with no reference to its structure.

ORIGIN

The origin of the Purcell trench has been described by Daly[1] in the following words: "The Rocky Mountain trench and the Purcell trench are likewise located on zones of profound faulting; in each case the constructional profiles may have been grabens as typical as that of the middle Rhine or that of the Dead Sea." The geology of the Purcell trench in the neighbourhood of the International Boundary line was carefully examined by the writer in 1913, and it was found that the faults marked by Daly on the geological map as occurring on each side of the Purcell trench were not present and that the valley in this locality was not a graben[2]. The area was again examined in 1915 and these results confirmed. In 1916, Drysdale[3] made

[1] Daly, R. A., Geol. Surv., Can., Mem. 38, pt. 2, 1912, p. 600.

[2] Schofield, S. J., Geol. Surv., Can., Sum. Rept., 1914, p. 41, Geol. Surv., Can., Mem. 76, 1915, p. 168.

[3] Drysdale, C. W., Geol. Surv., Can., Sum. Rept. 1916, p. 61.

an examination of the section in the neighbourhood of the International Boundary line and again confirmed these results. In 1915, the area in the vicinity of Proctor on Kootenay lake was carefully examined for evidence of faulting. This locality was specially favourable for geological field work since the formations cross the lake almost at right angles. The formations were followed from the high mountains on the east side of the lake across Pilot point and into the mountains on the west side of the trench. In fact a very persistent limestone band, dipping 45 degrees northwest, was used as a horizon marker. If any fault exists parallel to the trench it certainly would have offset this limestone band, where it crosses the band at right angles. At the north end of the trench Bancroft has found no faults. From the above facts, it is certain that faulting played no part in the formation of the Purcell trench. In 1915, the writer advanced the idea that the Selkirk mountains[1] were mountain-built for the first time at the close of the Jurassic. The following reasons were put forth:

1. The present drainage bears no relation to the underlying structure.

2. The products of the erosion of these Jurassic mountains are seen in the sedimentation of the Cretaceous of the neighbouring Rocky Mountains to the east. The following shows the geological succession of formations of the Rocky Mountains in tabular form:

Period	Formation	Condition of deposition	Lithological character
Tertiary	Paskapoo	Freshwater	Sandstones.
Upper Cretaceous	Edmonton	Brackish and freshwater	Sandstones and shales
	Bearpaw	Marine	Shales.
	Belly River Series	Brackish	Sandstones and shales.
	Colorado	Marine	Shales.
	Upper Blairmore	Subaerial	Sandstones, conglomerates (*granite* and chert pebbles).
Lower Cretaceous	Lower Blairmore	Subaerial	Shales and conglomerates (quartzite and chert pebbles).
	Kootenay	Subaerial	Sandstones and shales. Coal.
Upper Jurassic	Fernie shales	Marine	Shales.
Devonian and Carboniferous		Marine	Limestones and quartzites.
Lower Palaeozoic		Marine	Limestones and shales.
DISCONFORMITY			
Pre-Cambrian (Beltian)	Purcell Series; Galton Series	Continental	Mainly quartzites and argilaceous quartzites.

[1] Schofield, S. J., Geol. Surv., Can., Mem. 76, 1915, pp. 160–169.

From an examination of the above table it will be noticed that the conglomerates are first found in great amount at the base of the Lower Blairmore formation. The pebbles in these conglomerates consist of quartzites and chert derived from the quartzites of the Beltian rocks which make up the great part of the Selkirk range. Evidently in lower Blairmore times the Selkirk range was approaching the maximum of elevation and was undergoing rapid erosion. The upper Blairmore formation also consists of conglomerates and sandstones, but in addition to the pebbles of quartzite and chert, pebbles of granite occur for the first time and in great abundance. The presence of the granite pebbles at this horizon is interpreted to mean that the Selkirk range was unroofed during the upper Blairmore times and that the Nelson granite batholith which forms the core of the Selkirk range in southern British Columbia was exposed to rapid erosion and furnished the pebbles for the conglomerate. Hence, it is established that the first intrusion of granodiorite into the Selkirk range took place before the deposition of the Upper Cretaceous. The superposition of the marine Fernie shales upon the marine Devono-Carboniferous limestones suggests that the period of stability which prevailed throughout British Columbia until the Triassic was interrupted during the Upper Jurassic period. The Selkirk mountains received their initial form probably at the close of the Jurassic or in early Kootenay times. If mountain-building and igneous intrusion are contemporaneous, it may be concluded that the first intrusion of granodiorite in the Selkirk range commenced towards the close of the Jurassic and continued until the mountain-building reached its maximum in Kootenay times.

Tabular History of Selkirk and Rocky Mountain Systems in Southern British Columbia

Selkirk Mountains	Period		Rocky Mountains
Uplift of peneplain	Eocene		*Orogenic movements* (Laramide Revolution).
Peneplanation To Late Maturity (final) Batholith unroofed	Tertiary	Paskapoo	Freshwater sedimentation.
	Upper Cretaceous	Edmonton	Brackish and freshwater
		Bearpaw	Marine sedimentation.
		Belly River	Brackish sedimentation.
		Colorado	Marine sedimentation.
		Upper Blairmore	Subaerial sedimentation.
Early Matur ty Youth (initial)	Lower Cretaceous	Lower Blairmore	Subaerial sedimentation.
		Kootenay	Subaerial sedimentation.
Possible Initiation of Orogenic Movements	Upper Jurassic		Marine Sedimentation.
Stable Marine Condition	Devonian and Carboniferous		Marine sedimentation.
Stable Marine Condition	Lower Palaeozoic		Marine sedimentation.

In early Tertiary, the Laramide revolution took place, causing an uplift of the Selkirk mountains and the formation of the Rocky Mountains. The effect of this uplift in the Selkirks was to slowly raise the old land surface formed during the Cretaceous almost to its present height, with the natural result that the streams which meandered over the old surface were rejuvenated and cut their present valleys into the old peneplain. As these streams bore no relation to the underlying structures, the valleys cut by their rejuvenated descendents, the present main valleys of the range, bear no relation to structure. Thus the main valleys of the Selkirk range have been carved during the Tertiary and Quaternary out of a peneplain which was formed during the Cretaceous and early Tertiary periods. Such has been the origin of the Purcell trench which contains Kootenay lake.

Plate I

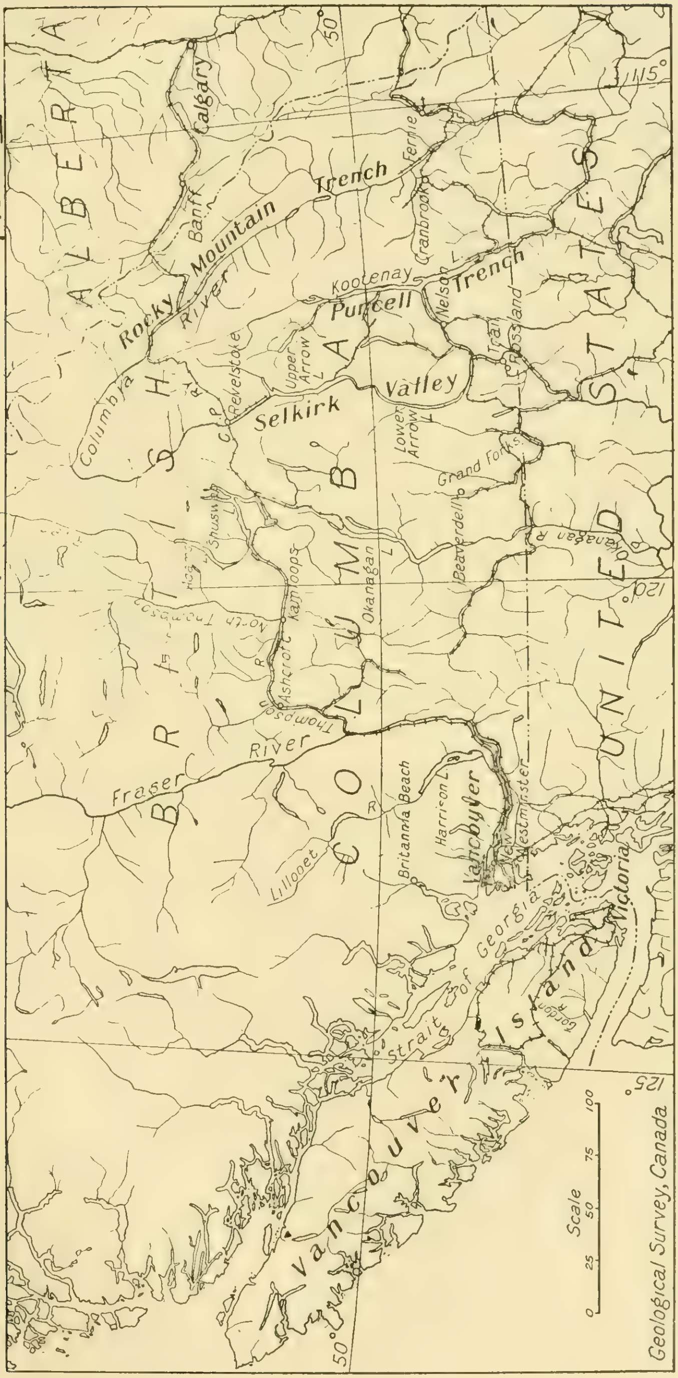
ALBERTA
BRITISH COLUMBIA
UNITED STATES
Rocky Mountain Trench
Purcell Trench
Selkirk Valley
Calgary
Banff
Fernie
Cranbrook
Kootenay
Nelson L.
Trail
Rossland
Upper Arrow L.
Lower Arrow L.
Revelstoke
Columbia
C.P.R.
Shuswap L.
Kamloops
North Thompson
Ashcroft
Thompson
Fraser River
Okanagan L.
Beaverdell
Grand Forks
Okanagan R.
Lillooet
Britannia Beach
Harrison L.
Vancouver
New Westminster
Strait of Georgia
Vancouver Island
Victoria
Gordon R.
50°
115°
120°
125°
Scale
0 25 50 75 100
Geological Survey, Canada

Plate II

Diagram showing the classification of the Mountains of Southern British Columbia

Scale of Miles

To accompany Memoir by S. J. Schofield

PLATE III

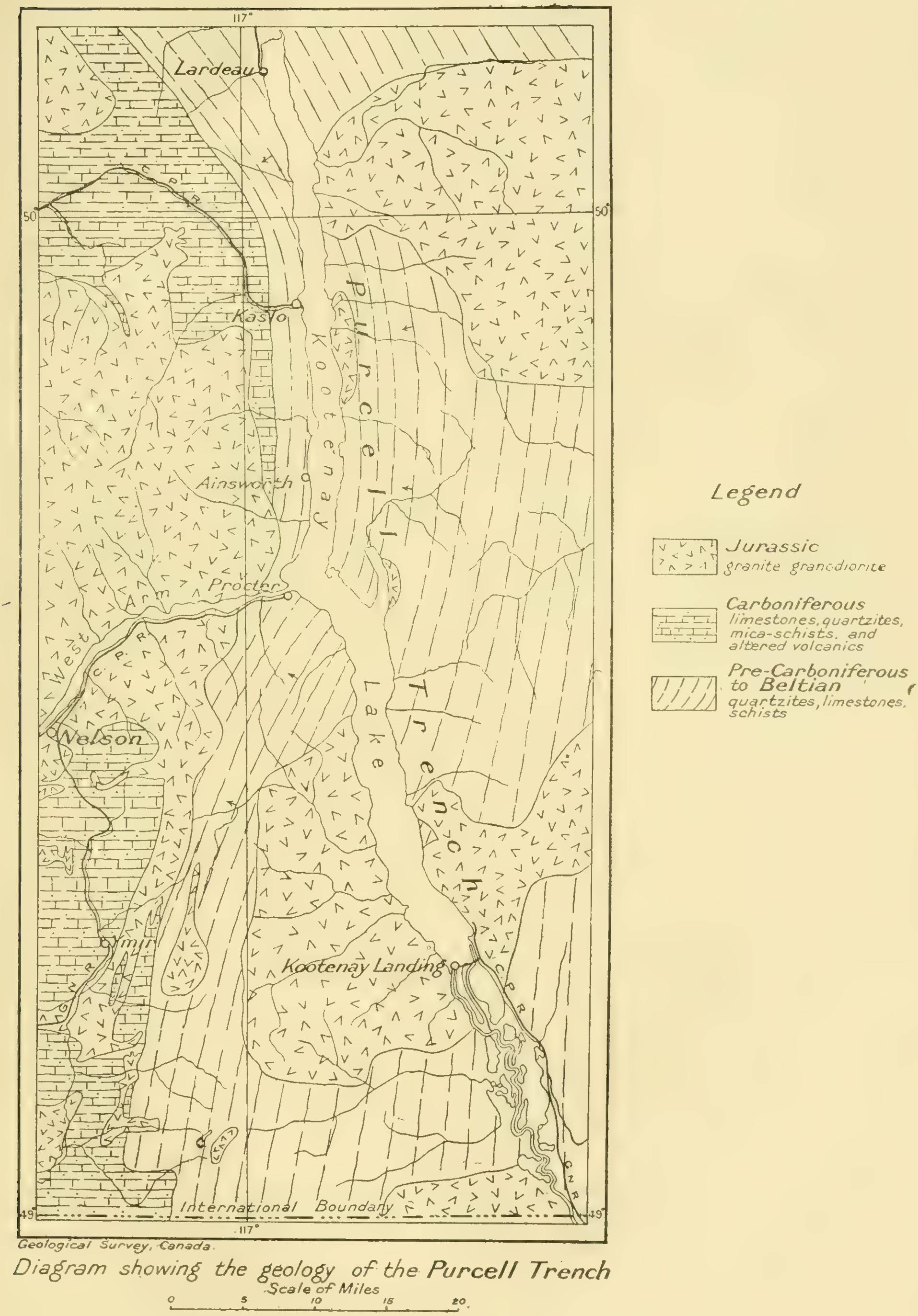

Diagram showing the geology of the Purcell Trench

The Glacial History of Prince Edward Island and the Magdalen Islands

BY A. P. COLEMAN, M.A., PH.D., F.R.S.C.

(Read May Meeting, 1919.)

The literature shows a considerable diversity of opinion as to how far Pleistocene land ice encroached on the shallow water of the Gulf of St. Lawrence, some believing that Prince Edward Island and the Magdalen Islands were not touched by it, and others, that the Labrador sheet swept across Gaspé and continued southeastwards to Cape Breton Island and the mainland of Nova Scotia. The most extensive description of the Pleistocene geology of the region is that of Chalmers in 1894. He states that the west end of Prince Edward Island was at least touched by ice from New Brunswick, but that the rest of the island was not covered by it. He thinks there may have been local glaciers upon parts of it and that floating ice deposited boulders on its lower shores during a time of depression at the end of the Ice Age. The Magdalen Islands he believes were never glaciated, though a few foreign boulders were deposited by floating ice on the northwestern shores[1]. In regard to the Magdalens, his conclusion that they were unglaciated is shared by Richardson and Clarke.

On the other hand, Goldthwait, in 1915, suggests that the Labrador ice sheet pushed southeast across the shallow floor of the gulf between Gaspé and Nova Scotia, leaving boulder clay on Amherst and other islands of the Magdalens and reaching Nova Scotia.

The present writer visited the islands in 1918 with the object of studying the superficial geology so as to settle the matter if possible; but no attempt was made to cover their Pleistocene features in detail.

PLEISTOCENE DEPOSITS OF PRINCE EDWARD ISLAND

A visitor landing on Prince Edward Island from the Tormentine ferry and going by rail to Charlottetown sees a red loamy soil free from boulders, resting on decaying red sandstones, as if residual; and no other features of the general landscape or the railway cuttings suggest the action of ice. In places rock comes close to the surface, there are no morainic forms visible, there is only one small lake on the island, and the rivers are mostly well graded; so that one is inclined to think that Prince Edward Island escaped glaciation. Very little that could be interpreted as proving ice action was found in the central parts of the island, but going northwestwards from Summer-

[1] Geol. Surv. Can., Vol. VII, New Series, 1894, pp. 39 M, etc.

side, a few small foreign boulders were encountered, chiefly granite and gneiss, a striated stone was seen, and a number of smoothed and polished pebbles looked glacial.

On a journey toward the northwest end of the island, near Northam, Ellerslie and Richmond, many granite boulders, some six feet in diameter, were seen; and at O'Leary there were gneisses and a large block of coarse conglomerate, suggesting a tillite, much like the Devonian boulder conglomerates of the southern side of Gaspé. An excursion from O'Leary to Pitt Island, on the sea to the northeast, disclosed red brown till with many Archaean-looking stones, especially greenstones and granites. The conclusion was reached that ice from New Brunswick and Gaspé had covered at least the lower lands of northwestern Prince Edward Island.

East of Emerald Junction, near the centre of the island, the country grows hilly, the railway reaching 311 feet at North Wiltshire station, and the red sandstone comes close to the surface with no hint of ice smoothing or of boulder clay, so that one would suppose the country to be unglaciated. At Souris, near the east end of the island, however, there is sandy till in a railway cutting close to the harbour, 15 or 20 feet in thickness and enclosing plenty of striated stones. In this section only local sandstones were found, but there are a few granite boulders in the fields nearby, one having diameters of 2 feet 9 inches, by 1 foot 9 inches. There are also smaller boulders of quartzite which must have come from a distance. As these foreign stones were found only at the lower levels they may have been carried by floating ice, since they seem not to occur in the till.

Three or four miles northwest of Souris on the road toward Gowan Brae, a surface of sandstone is smoothed, and well striated, in the direction 15° west of north, but whether the ice advanced from the north or the south was uncertain.

The results of the fieldwork done corroborate the conclusions reached by Chalmers[1] that only the northwest end of the island was actually overridden by an ice sheet coming from New Brunswick or Gaspé; that the rest of the island, especially the central part, was only very lightly touched by ice, if ever completely covered; that the till toward the east end contains only local materials; and that floating ice has distributed foreign boulders over the lower parts of the island.

Chalmers states that marine terraces reach about 75 feet above present sea level. They are by no means striking as compared with the impressive cliffs and widespread sand bars of the modern shore.

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[1] Ibid., p. 70. M.

The present sea level must have been permanent for a vastly longer time than any halt in the rise of land which preceded it.

Glaciation of the Magdalen Islands

The Magdalen Islands, near the middle of the Gulf of St. Lawrence, have until recently been considered unglaciated. Richardson, who reported on their geology in 1880[1], found no evidence of glaciation except a few drift boulders of granite, quartzite and schist, which might be accounted for by floating ice; and Chalmers, who visited the islands specially to study their Pleistocene geology, states positively that they are non-glaciated, referring particularly to the rotted rock immediately beneath the soil; though he thinks it possible that evidences might be found "of at least the impingement of floating ice against the slopes or coast borders of the islands."[2] J. M. Clarke also found that "the soil of the islands is essentially residual. The islands have never been subjected to glacial action;" though boulders have been brought by icebergs and floe ice[3].

In 1913, however, J. W. Goldthwait visited the islands, and during the twenty minutes stay of the steamer at Amherst Island, found a deposit of boulder clay with glaciated stones not far from the pier. He concluded that the deposit is glacial till and not formed by floating ice. Evidence obtained on the other islands of the group, though less conclusive, confirmed this view[4].

Sailing from Souris, I visited Amherst Island in June, 1918, and spent two days examining its surface features. The till described by Goldthwait as forming a cliff beside the inner basin was naturally visited first, and I can confirm, in the main, his account of the deposit. It consists of unstratified sand containing many small striated stones. None that I found were certainly of foreign origin, all being sandstones or green basic eruptives, such as might have come from the Demoiselle hills.

Similar till was found at various points along the road toward the west side of the island, which was followed for four miles. The cuttings for grading the road furnished shallow exposures of the soil, drift sand, and in places the sandy till. Striated stones were collected at several localities, the highest point at which they were observed being inland at about 105 feet above sea level. Among the stones

[1] Geol. Surv. Can., Vol. 1879–80, pp. 8 and 9 G.

[2] Geol. Surv. Can., Vol. VII, 1894, 48 and 9 M and 91 M.

[3] New York State Mus. Bull. No. 149, 7th Rep. of Director, 1910.

[4] Geol. Surv. Can., Mus. Bull. No. 14, 1915, pp. 6, etc.

collected there was one which had a flat striated base, while the upper part was distinctly a "dreikanter" with polished triangular faces caused by wind-blown sand.

It was very noticeable, however, that till was confined to the lower levels. Several hills which were climbed, one reaching 360 feet, showed no suggestion of ice action. The higher ones are "Demoiselle" hills, as described by Clarke, and consist of an agglomerate of some greatly weathered basic eruptive, probably basalt, only loosely coherent and yet with steep slopes, even reaching 30° or 40°. The soil upon them passes down into broken and weathered rock and is clearly residual. It seems improbable that these small hills of loose fragments, with fairly steep slopes, could have been crossed by an ice sheet without any visible effects; and the statements of the earlier observers seem quite justified when the higher parts of the island alone are considered. If an ice sheet ever crossed the island it must have touched it very lightly, or else have done its work so long ago that weathering has had time to remove completely the evidences of its work.

There is, however, another Pleistocene feature to be considered. The older observers all mention foreign boulders transported by ice when the sea stood at a higher level, and these may be found, in rather small numbers, along the present shore and at various points up to 160 or 170 feet above sea on the hill sides. On the south flank of the Demoiselle hill near the harbour, a number of small boulders were found, including undoubted foreign stones, such as quartzite, granite and porphyritic granite. The granites at the higher levels are very few in number. As these blocks rest upon a typical residual soil they must have been transported by floe ice during a higher stage of the sea. This higher sea level seems to have lasted only a brief time, however, since no well-marked beach was formed in spite of the abundant loose materials at hand for the formation of gravel. When one observes the lofty cliffs and miles of sandbars at the present sea level the lack of distinct beaches at these higher levels is very striking.

There still remains the problem of accounting for till at low levels with no indication of ice action on hills of loose volcanic materials rising only a few hundred feet higher. It is hard to imagine these hills of only 250 to 350 feet rising as nunataks above a continental ice sheet depositing boulder clay up to 105 feet; and the only alternative seems to be floating ice as the cause of the low lying till. Goldthwait's objection that the striae on the stones in the till are generally in the direction of the longest axis is not necessarily fatal to this theory, since icebergs are merely floating portions of glaciers which originate on the land and carry with them the debris acquired in their journey over land. On the other hand, the apparently local origin of the stones in the till seems to harmonise better with the idea of a thin ice sheet covering the low ground. The evidence at hand seems insufficient to decide finally between the two explanations.

No striated surfaces were found on the island, but the soft sandstones of the glaciated lower levels were not well adapted to retain such markings. In this respect the contrast is great with Prince Edward Island, where Chalmers has reported many striated surfaces, some of which he attributes to land ice and others to floating ice.

Both islands differ greatly from most other parts of eastern Canada in the small amount of glaciation they display, and in the frequent occurrence of residual soils passing down into rock in place. They were evidently little affected by the passage of land ice over them, if this ever really happened; and one would be tempted to account for the undoubted till deposits as the work of icebergs floating from the margin of the main sheet, if it were not the fact that the till and the striated stones contained in it are usually of local materials. If the ice sheet was so thin that low hills of 250 feet were not covered during its advance one can hardly imagine it capable of depositing boulder clay up to 105 feet. Is it possible that the thin edge of the continental ice was afloat, like the Ross Barrier ice of Antarctica, when the sea stood 75, or perhaps 150 feet higher than at present, and that the sandy till with its enclosed bits of sandstone was gathered from rocks on the bottom nearby and left when the ice grounded on the present lowlands of the islands, then shoals covered by shallow water?

The facts are apparently contradictory and are not easily accounted for by the action of land ice as illustrated in Quebec or Ontario; so that some modification of the glacial machinery, as generally imagined, seems to be necessary.

To an observer from Ontario, all the glacial deposits seen in the east, both on the mainland and on the islands, seem much more weathered and ancient than the glacial deposits north of Lake Ontario, and it may be that they were formed during an earlier and much more extensive glaciation than that of the Wisconsin sheet.

Description of a New Genus and Species (Panoplosaurus mirus) of an Armoured Dinosaur from the Belly River Beds of Alberta.[1]

By LAWRENCE M. LAMBE, F.R.S.C., VERTEBRATE PALÆONTOLOGIST TO THE GEOLOGICAL SURVEY, CANADA.[2]

(Read May Meeting, 1919.)

The first armoured dinosaur to be described from the Belly River Cretaceous of Alberta was *Euoplocephalus tutus*[3] Lambe, represented by the upper part of the skull and an arch of coossified, dorsal, neck scutes.

Another armoured dinosaur from the same geological horizon and locality, generically distinct from any hitherto described form of Stegosauria, is the subject of the present paper.

This new genus, for which the name *Panoplosaurus* is now proposed, is based on a complete skull and a considerable portion of the remainder of the skeleton, discovered in 1917 by Mr. C. M. Sternberg, in charge of the Geological Survey vertebrate palæontological field party of that year, 2¾ miles south of the mouth of Little Sand Hill creek, a tributary of Red Deer river, Alberta. The remains occurred in sandstone beds of the Belly River formation, 210 feet above the river level. The name *mirus* is given to the species represented.

The type specimen, Cat. No. 2759, consists of the following parts: The skull, practically complete, with teeth (Plates I-IV and Plate XI, figure 2).

About three feet of the vertebral column, found articulated to the skull. The atlas and axis are present with probably all of the other cervical vertebræ, and a few thoracic vertebræ; most of these in place in natural sequence. At least three cervical ribs are preserved.

Seven scattered thoracic ribs, more or less complete, in six of which the head is preserved.

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[1] This paper is printed in the incomplete form in which it was at the time of Mr. Lambe's death in March, 1919.

[2] Communicated with the permission of the Deputy Minister of Mines.

[3] Geological Survey of Canada, Contributions to Canadian Palæontology, vol. III (quarto), pt. II, On vertebrata of the Mid-Cretaceous of the North West Territory, 1902. Described in this publication as *Stereocephalus tutus* but later changed by the writer to *Euoplocephalus tutus* as the former generic name was preoccupied.

Humerus, ulna, and radius (displaced). Three complete digits of fore-foot (in proper relative position to each other) (Plate VIII).

Incomplete scapula, with coracoid.

Sternal bone.

Fragment of ilium, and part of sacrum.

One phalanx and two terminal phalanges of hind foot, and one metatarsal (Plate XI, figure 1).

About two hundred scutes of various sizes, with numberless ossicles. Of the scutes a number are in place, or in their proper relative position to each other over considerable areas; the remainder were scattered either in the matrix or at the surface (weathered out)(Plates V, VI, VII, IX, X, and XII).

In *Euoplocephalus* the armature, so far as known, consists of numerous polygonal plates on the head, and a semi-circle of high keeled scutes coossified in an arch over the neck. The skull of *Panoplosaurus* is protected above by a few plates of large size, and the neck dorsally by a longitudinal row of transversely paired plate-like scutes.

With the preparation and study of other Stegosaurian material in the Geological Survey's collections, it will probably be found that several distinct forms of armoured dinosaurs existed in Belly River times, although their diversity is hardly thought to have been as great as that of the contemporaneous hadrosaurs and horned dinosaurs.

The dinosaurian fauna of the Belly River formation, Alberta, as at present known, consists of the following genera:

Hadrosaurs	*Ceratopsians*	*Stegosaurs*
Stephanosaurus	Eoceratops	Palaeoscincus
Corythosaurus	Centrosaurus	Euoplocephalus
Gryposaurus	Styracosaurus	Panoplosaurus
Prosaurolophus	Brachyceratops	
	Chasmosaurus	

Panoplosaurus mirus gen. et sp. nov.

Generic and Specific Characters. Skull depressed, broad behind, ending narrowly and squarely in front; completely enclosed in bony plates and scutes. Superior head plates large; cheek plates present. Nostrils latero-terminal. Orbits placed far back. Infratemporal fossæ placed latero-posteriorly, directed backward. Teeth small, with a laterally compressed, moderately high, serrated crown, borne on a long sub-cylindrical root. Transversely twinned, low keeled scutes forming a longitudinal dorsal series on the neck. Principal lateral scutes of neck and trunk keeled, in longitudinal rows. Scutes of ventral surface small. Centra of cervical vertebræ slightly concave at the ends. Atlas, axis, and third cervical coossified.

Teeth. Eight maxillary teeth of the left side, showing more or less signs of wear, are in place. They are all of much the same size and shape, but whether these constitute the complement of one side of the maxillary bone is not known, although it is thought that if there were any more the number did not greatly exceed eight.

Of these teeth the one least worn and best preserved is here described and figured (Plate XI, figure 2).

The crown of this particular tooth is enamelled throughout, is but slightly deeper than broad, and has a strong, tumid cingulum constituting its base. This cingulum is less protrudent, and at a lower level on the inner side than externally, giving the base of the crown a decided obliquity of outline when viewed from the front or back. The portion of the crown below the cingulum, in the form of a short blade, has nearly the full breadth of the cingular part, and descends to a point with denticulated border, but is thin interno-externally in comparison with the thick base. The greater tumidity of the cingulum externally, and the fact that the blade does not descend fully in line with the axis of the root but is retired somewhat inward, gives a decided concavity to the external face of the crown which is absent internally, the inner face of the blade being flat or inclined to convexity below the shelf of the cingulum.

There are five denticulations on the crown's anterior border, and apparently three on the posterior one which is injured. The additional one, forming the point of the tooth, is larger than the lateral ones. Both externally and internally, the crown is marked longitudinally by fine anastomosing, discontinuous rugæ which are somewhat accentuated on the lower curve of the cingulum. The outline of the denticulated anterior border of the crown has a more decided curve than that of the posterior one, viewing the crown from within or without. The root of the tooth is long, smooth-surfaced, and subcylindrical with a broadly oval cross-section of which the fore and aft diameter is the greatest. A pulp cavity is present and occupies about one-third of the diameter of the root.

The tooth is worn on the inner side in a small surface above the apex toward the front and on the prominence of the cingulum near the front, proving that the upper teeth bit outside the lower ones, as would be expected.

Measurements of Maxillary Tooth of Type.

	mm.
External depth of crown, including cingulum	7.5
Internal depth of crown, including cingulum	6.0
External depth of blade (crown below cingulum)	5.5
Internal depth of blade (crown below cingulum)	4.5
Maximum breadth of crown (at cingulum)	7.0
Maximum thickness of crown (at cingulum)	4.5
Breadth of root	4.0
Thickness of same	3.0

The teeth of *Panoplosaurus* have the general characteristics of those of the known North American genera of armoured dinosaurs, in all of which the pointed crown is laterally compressed, has denticulated borders and a basal cingulum, and is borne on a long, more or less cylindrical root. This style of tooth is found in *Stegosaurus* and *Ankylosaurus*. *Palaeoscincus* is known only from teeth of this general shape. The teeth of *Euoplocephalus* have not been certainly recognized but they are no doubt represented by one of the different patterns of the numerous stegosauroid teeth found loose in the Belly River formation of Alberta.

In comparison with the teeth of *Stegosaurus* those of *Panoplosaurus* are larger, are proportionately higher in the crown, have a thinner blade, and a more pronounced cingulum, particularly on the outer side, and the denticles, although of about the same number are rather less conspicuous. Compared with *Ankylosaurus* they are of much the same size, but the crown is lower, with fewer denticles, and is externally concave with a very pronounced cingulum, whereas in *Ankylosaurus* it is strongly convex on the outer side and the cingulum is here absent.

The teeth of *Palaeoscincus*, although of the general stegosauroid pattern, differ in many particulars from those of both *Panoplosaurus* and *Ankylosaurus*. They are usually much larger, with a low crown and coarse denticulations, and can readily be distinguished at a glance. This is the most common form of tooth of the armoured dinosaurs of the Belly River formation and is found in large numbers on weathered rock surfaces. It is hoped that the teeth of *Palaeoscincus* as well as those of Troodon will be found in association with the skull at no distant date. Here may be mentioned *Palaeoscincus asper* of Belly River age, represented at present only by a tooth, with strongly-marked characters, described by the writer in 1902.[1]

Armature of the Neck and Trunk (Plates IX, X and XII). The protective covering of the body is different from that of the head in that it consists of integumental scutes, mostly distinct from each

[1] op. cit.

other and generally keeled. In their largest form they are plate-like and unite in pairs, but with a decrease in size they grade into small amorphus ossicles. Between these extremes there are many variations in shape, and every gradation in size, dependent on location.

In the type specimen many of the scutes are in their proper relative position to each other over very considerable areas. Some of these groups have been more or less displaced, others are preserved practically in situ and give their true location. The displacement of groups of scutes points to a post-mortem dislocation of the skin. In places there is a decided folding of the skin.

Some of the scutes belonging to the type individual were found separate in the matrix, and many had weathered out and were loose on the surface. Of these, some, through agreement in size and shape with those in situ, can be fairly well placed, but the position of others can be only surmised.

The principal types of scutes distinctive of definite areas are as follows:

1. Large plate-like scutes with a low keel, coossified in transverse pairs, forming a longitudinal dorsal, neck series from the head backward.

2. Scutes of various dimensions, but not attaining to the size of the above, strongly keeled, from broadly to narrowly suboval in outline, more or less pointed behind, and flat or somewhat excavated below, occurring laterally on the neck, and continuing backward on to the trunk.

3. Moderately small, keeled scutes with a thick, tumid base, occurring on the throat and passing forward in the midline towards the chin.

4. Small, somewhat rectangular scutes, arranged in close-set longitudinal rows with the greater diameter fore and aft, occupying a latero-ventral position on the trunk.

5. Smaller scutes with a polygonal outline, occurring along the ventral midline and grading outward into the latero-ventral rectangular ones of the trunk. These scutes are arranged after the pattern of, and resemble, the small polygonal scutes, between the limpet-shaped ones, of *Stephanosaurus*.

6. Rather small, thin, keelless scutes, apparently from the limbs. These scutes are suboval, or subtriangular, often irregular in outline, with a transversely concave lower surface. With these are classed also, as presumably from the limbs, thin scutes, generally quite small in size, and of an irregular, broadly suboval or subcircular outline, with a flat lower surface.

7. Irregularly shaped ossicles grading down to a very small size. Extensive aggregations of these occur ventro-posteriorly on the neck, and laterally on the throat, passing forward internal to the mandibular rami to the symphysis. These ossicles are also numerously distributed throughout the skin, filling the smallest interspaces between the larger scutes of definite shape.

The above-mentioned scutes, most typical of special integumental areas, grade more or less into each other, occasioning a great variety of transitional forms. It may be noted that the change from the flank scutes to the rectangular, ventro-lateral ones appears to be abrupt.

The larger-keeled scutes of the side of the neck and trunk are in longitudinal rows, with the scutes lengthwise in each row. The rows of scutes are near each other, and the scutes themselves in any particular row follow each other closely. So far as observed the rows are fairly regular, and apparently those of any row do not alternate with those of adjacent rows but have a transverse alignment. Smaller-keeled, suboval scutes occur in the interspaces, and any intervals left are filled by ossicles whose size and shape are governed by the extent of the gaps remaining to be filled.

The scutes occurring laterally on the neck and trunk have been already referred to as being strongly-keeled. In these scutes the keel, running lengthwise, in many cases somewhat obliquely and more or less curved, is generally sharply angulated along the crest and usually increases in height and basal breadth in its passage backward, ending posteriorly in a more or less decided spur which often overhangs the basal border of the scute. On either side of the keel the external surface of the scute slopes to its upper and lower border either flatly or with a varying amount of concavity, the latter depending largely on the extent to which the keel is developed. It appears to be the rule that the farther a scute is from the dorsal midline, the nearer the keel approaches the lower border of the scute. Thus in scutes high up on the flank the keel is nearly median, but in those forming the lower rows it rises close to the lower border, apparently even overhanging it in the lowermost row. These scutes are thickest posteriorly, and thinnest toward the border in their anterior half. The internal surface is flat, or slightly concave transversely, and posteriorly a marginal ridge is frequently developed, giving this surface at this end the appearance of being excavated.

The surface of the scutes throughout is usually roughened by irregularly disposed pits and depressions and externally, in addition, by numerous vascular groove markings. The external surface has a somewhat more glossy appearance, best seen in weathered specimens. In a number of scutes belonging to the type the spur or posterior termination of the keel is defective owing apparently to imperfect ossification.

In the type specimen two large keeled scutes, corresponding to each other in size and shape and belonging one to either side of the neck, have a length equal to 2⅔ the breadth at midlength. Length about 230 mm., breadth about 86 mm.

Also in the type three scutes with high keels are preserved following each other in natural sequence, and constituting part of a flank row of the right side. The posterior scute of these three has a length slightly over 1¾ its breadth at midlength. Length about 173 mm., breadth about 97 mm. The middle one is 162 mm. long, and 97 mm. broad, and the foremost one 115 mm. in length and 84 mm. across.

In *Panoplosaurus* the armature of heavy plates and scutes no doubt allowed a moderate flexion of the body, and a free motion of the limbs, but the movements of the animal must have been decidedly slow and deliberate.

Dorsal Neck Scutes (Plates V, VI, VII, and XII). Two of these scutes and half of a third are preserved. One, found immediately behind the skull, is referred to and described below as the nuchal plate. Another, supposed to be the second of the longitudinal row of the neck, on account of its similarity in size and shape to the nuchal plate, was about two feet to the right of this plate at about the same level. The remaining incomplete plate lay beneath the nuchal one and may be the third of the series.

The nuchal plate is rather thin, somewhat semi-circular in outline as seen from above, and broader than long, the length being about three-fourths the breadth. It is bilaterally symmetrical, curving down on either side so as to be transversely concave on the under surface. It is composed of two similar, subtriangular scutes which unite along their inner edge, the line of junction being marked by a deep, straight groove extending down the middle of the upper surface of the plate from the front to the back. Each scute, or half-plate, has a longitudinal, low but broad keel on either side of which the upper surface is transversely concave. These keels tend to disappear at the front border and are broadest and most elevated posteriorly. They are placed somewhat obliquely on the scute curving slightly outward in their backward course. The upper surface of the plate is in this manner divided into four nearly equal, longitudinally flat, transversely concave areas so as to have a shallowly fluted appearance. The whole of the upper surface is rough and marked by irregular, shallow vascular depressions and grooves. The lower surface is evenly concave from side to side and relatively smooth, and shows no trace of coossification along the midline. The plate throughout is moderately thin, attaining its maximum thickness alongside the groove at midlength, and its next greatest thickness at the middle of the lateral keels. It thickens along the side and front borders, but to a greater extent laterally than in front. The hinder border has an undulatory outline, comes to a comparatively thin edge, and is rugose on the under surface for a short distance forward in a marginal area defined in front by a broad, shallow, but clearly marked transverse sulcus reaching across the plate. The edge of the plate laterally and in front is channelled by a peripheral groove which is most strongly developed where the border is thickest.

Measurements of Nuchal Plate of Type.

	mm.
Maximum distance transversely between lateral borders........	272
Maximum breadth following curves of upper surface...........	330
Length at central groove marking line of coossification.........	203
Thickness at midlength adjoining central groove...............	31
Thickness at midlength of lateral ridge........................	27
Thickness along anterior border..............................	15
Thickness of lateral border in advance of maximum breadth....	23

This composite plate was found close behind the skull, slightly out of alignment but practically in place, with its front border about two inches from the hinder border of the occipital plate of the head. The front border of the nuchal plate and the back border of the occipital one conform to each other in general curvature. When in place the nuchal plate is nearly on a level with the top of the skull. It has almost the same breadth as the skull, and the transverse convexity of the upper surface in each is similar. The proximity of this large plate to the head, and the fact that the atlas, axis, and third cervical vertebra, covered by the plate, are coossified indicate that there could have been little lateral movement of the head.

The plate that is thought to have followed behind the nuchal plate resembles the latter in general appearance, and need not be commented on further than to say that it has practically the same length but is a little broader with less transverse curvature, and shows some slight differences of outline. Its transverse curvature has the appearance of being normal. In this plate also, the union of its two halves has left no trace on the under surface beyond a slight thickening of the bone beneath the groove of the upper surface.

The third plate preserved, presumably the third of the series, is represented by the right half only and indicates a plate which, when complete, was like those in front except that it was considerably shorter. Its exterior border is imperfect, but the full breadth of the plate was apparently much the same as that of the other two. The union of the two halves does not appear to have been fully complete.

These broad plates with low keels and a deep groove in the mid-line evidently followed each other in a longitudinal series on the neck from close behind the skull, but how many plates there were in the series and how far back the series extended is left for future discoveries to reveal.

Skull (Plates I, II, III, and IV). The skull of *Panoplosaurus* is depressed, and diminishes in breadth and height toward the front where it ends squarely, the outline as seen from above being nearly triangular, and in lateral aspect sub-ovate. The orbits are small and placed very far back. The narial openings are also rather small and open outward at the anterior end.

The whole of the exposed surface of the head, above, in front, and on the sides, consists of ossified plates covering and concealing the underlying bones of the cranium and mandible. On the under surface, between the mandibular rami, there is a close aggregation of small bony scutes and smaller ossifications.

The most prominent features of the skull of *Panoplosaurus* and those that arrest the attention on first viewing it are its breadth in comparison with its length; its compactness and breadth of surface curvature; the large size of most of its covering plates; the squareness of the muzzle; the posterior position of the orbit and the consequent recession of the lateral temporal fossa; the flatness and breadth of the lower surface of the mandibular rami; the withdrawal inward of the dentiguous border of the maxillary and dentary bones, causing a depressed buccal area of considerable extent; the presence in this area of a large cheek-plate, and in the nostril of small plates; and the direction of the occipital condyle which faces downward and slightly backward.

Dimensions of Skull of Type of Panoplosaurus.

	mm.
Maximum breadth behind orbits	294
Anterior breadth, in advance of external nares	121
Length, in a straight line, from occipital condyle to middle of anterior end (upper border of mouth opening)	355

	mm.
Distance between same points measured in a curve over the top of the skull	530
Height, from lower edge of mandible to level of centre of top of skull	204
Length of orbit	66
Height of same	47
Length of principal cheek-plate in maxillodentary space	104
Height of same	59
Length of mandibular rami	313
Length of curve of the upper border of the predentary	262
Width of the predentary posteriorly	142
Length of external narial opening	71
Height of same	58
Breadth of skull behind external nares	155
Greatest diameter (height) of lateral temporal fossa	59
Least diameter (width) of same	31
Height of occipital condyle	41
Breadth of same	58
Height of foramen magnum	26
Width of same	38

Mandibular Rami. The two halves of the lower jaw are short and spread widely backward. Posteriorly they have a strong inward curve. In front, they bend in to each other beneath the predentary, which is clearly recognizable in the type as a separate armoured bone. The angle of convergence of the rami is about 68 degrees, using the outer border behind the predentary contact as the line of their general direction. The outer and lower surfaces of the rami, except posteriorly, consist of a thick dermal covering of bone which conceals the mandibular elements, and in the type specimen, the inner surface, except at the back, is hidden by the ossicle and scute-bearing integument filling the space between the rami. The armour does not cover the posterior end of the rami, and here the hinder mandibular elements are seen; not, however, separately in the specimen as the sutures have not been preserved. In separate rami the principal bones would no doubt be recognizable from the inner side. In the type specimen, the cheek-plate of the left side is missing and the wide sweep of the dentary inward to the teeth is exposed to view.

The rami are heavier in the hinder than in the front half of their length. They are deepest at about one-third of their length from the back whence they narrow forward for a short distance, then expand upward to attain a moderate depth behind the predentary. In front they narrow rapidly from above, with a sharp curve inward beneath the predentary, to the symphysis. The outer surface of the rami at their deepest part slopes considerably outward to the lower border where it meets the lower horizontal surface at an angle of about 80 degrees. This sharp angulation ends suddenly near the hinder end of the jaw, but lessens gradually to the front where it merges into the horizontal inturn of the bone toward the symphysis. Posteriorly, a rapid contraction in the depth of the rami is continued inward and downward by a relatively slender projection or process providing the cotylus for the articulation of the quadrate and made up largely, no doubt, of the surangular, angular, and articular, although these elements have not been recognized separately in the type.

MEASUREMENTS OF MANDIBLE OF TYPE.

	mm.
Length of mandible, in a straight line, from middle of anterior border of predentary to posterior end of ramus	310
Length of ramus, approximately	280
Greatest depth toward the back	72
Greatest depth toward the front	50
Distance across mandible inferiorly near hinder end of rami	288
Distance from upper exterior border of ramus, below cheek-plate, in to alveolar border	46

Predentary. This element consists of an anterior median portion and two relatively slender, backwardly directed, slightly divergent lateral limbs which pass upward on the truncated anterior ends of the dentaries with little diminution in their exterior depth. As seen from above the outer contour is somewhat horseshoe-shaped, with the curve flattened across the front and along the sides. The posterior width (142 mm.) is considerably greater than the median length in about the proportion of 3 to 2.

The upper border of the bone throughout comes to a moderately sharp edge and is fitted closely within the upper border of the mouth opening (lower border of premaxillaries). The anterior middle part retreats rapidly backward beneath the mandibular symphysis, and terminates posteriorly in a pair of short, liguiform processes one on either side of the midline as in the Hadrosauridae. In *Stegosaurus* a single median process is described by Gilmore as "being interposed between the ends of the dentaries at the symphysis." The Hadrosauridae as a rule have three processes given off posteriorly from the central portion of the predentary, an inferior median pair and a superior median one, the former extending beneath the dentaries, the latter above the symphyseal contact. It is probable that the single superior process is present in *Panoplosaurus* above the median pair.

Although the predentary in the specimen is encased in armour externally its shape is clearly indicated by a groove where its bony covering meets that of the dentaries. Inferiorly a small part of the armour has been broken off, revealing the median pair of tongue-shaped processes. That portion of the anterior ends of the dentaries underlapped by the predentary is, as would be expected, devoid of armour.

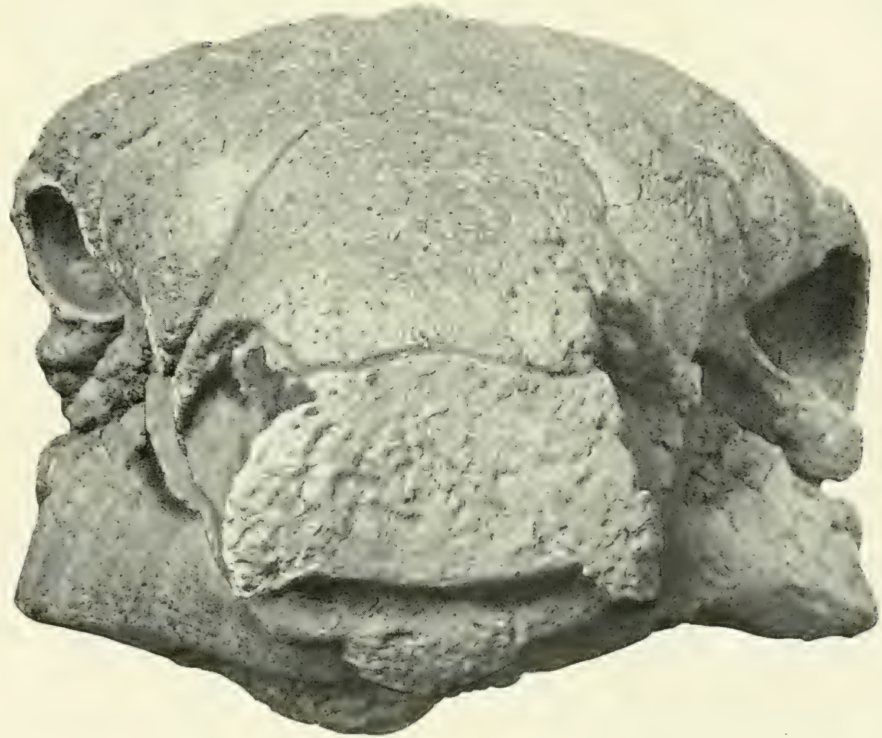
Occipital Condyle. The occipital condyle faces downward and slightly backward, and has a short thick neck. The articular surface is strongly convex, broader than high, reniform in outline with the greater curvature below. It is 58 mm. broad and 41 mm. high.

The head was evidently held much as in *Stegosaurus* but with a greater downward inclination. In the type when the skull is placed in position on the neck its axial line, from the floor of the foramen magnum to the anterior premaxillary border of the mouth, makes an angle of about 160 degrees with the direction of the neck.

The foramen magnum is elliptical in outline, with the greatest diameter transverse. It is 37 mm. wide and 25 mm. high.

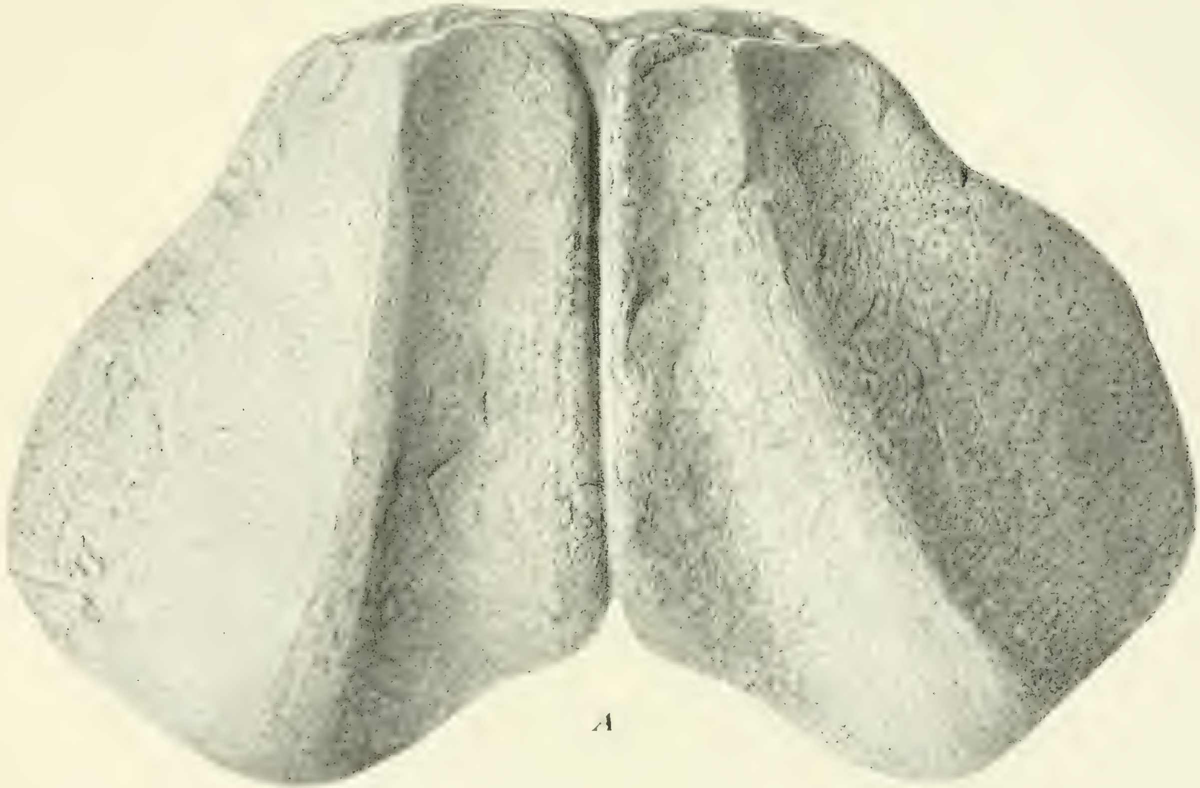
Panoplosaurus Mirus, skull. Superior aspect.
Two-fifths of natural size.

Panoplosaurus Mirus, skull. Inferior aspect.
Two-fifths of natural size.



Panoplosaurus Mirus, skull. Anterior aspect.
Two-fifths of natural size.

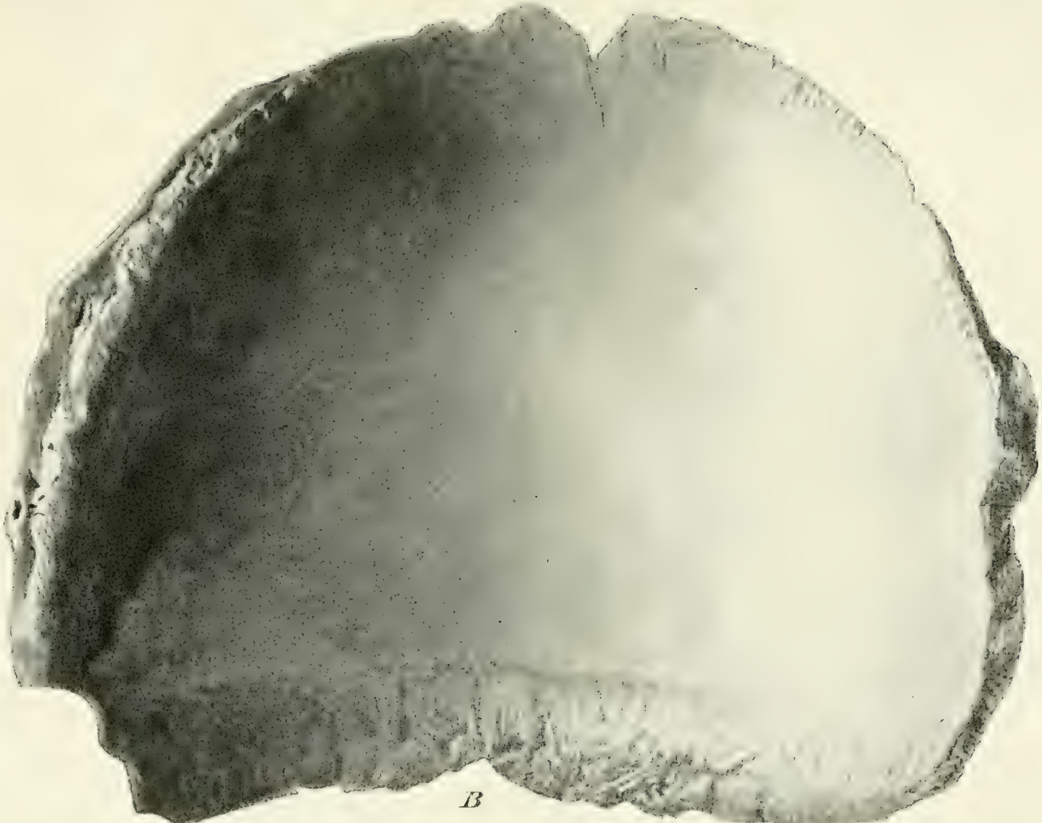
Panoplosaurus Mirus, skull. Lateral aspect.
Two-fifths of natural size.



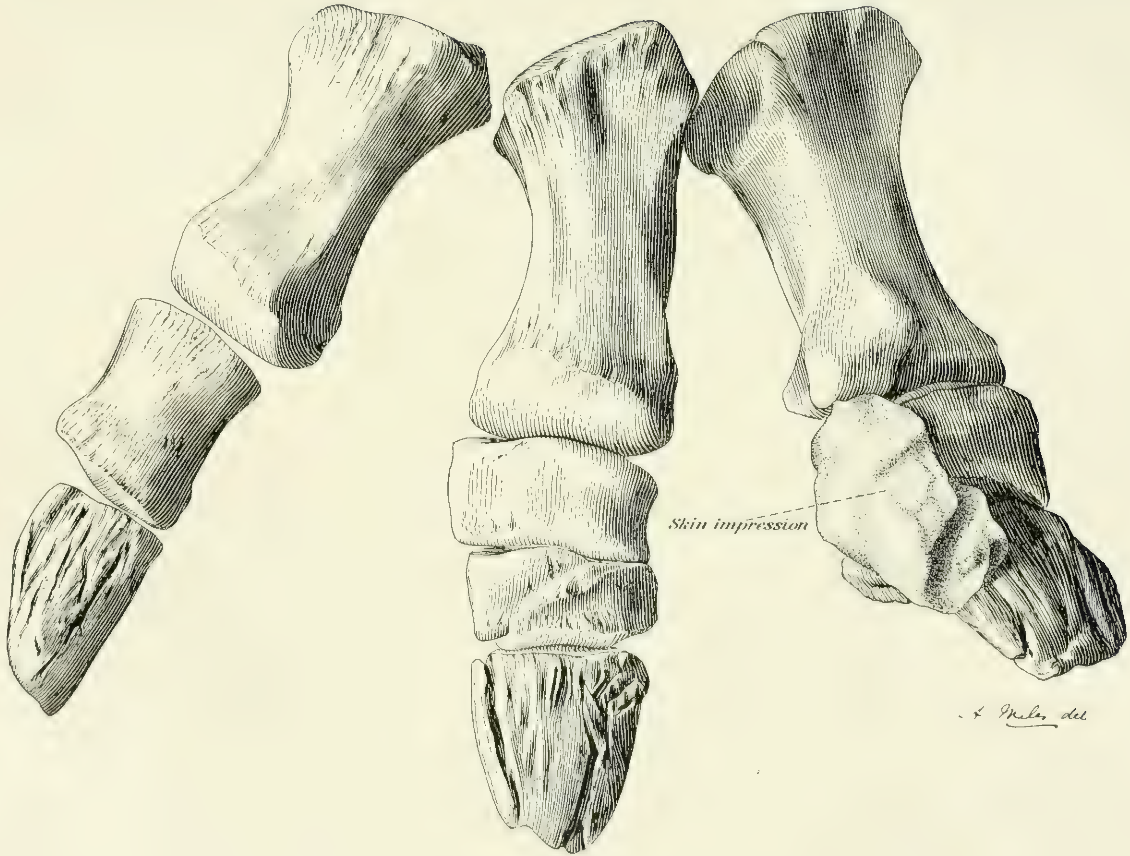
Panoplosaurus Mirus, dorsal neck scute. Superior aspect.
One-half natural size. (For section see Figure A, Plate XII).

PLATE VI.

Panoplosaurus Mirus. Superior aspect. One-half natural size.
(For Section see Figure B, Plate XII).

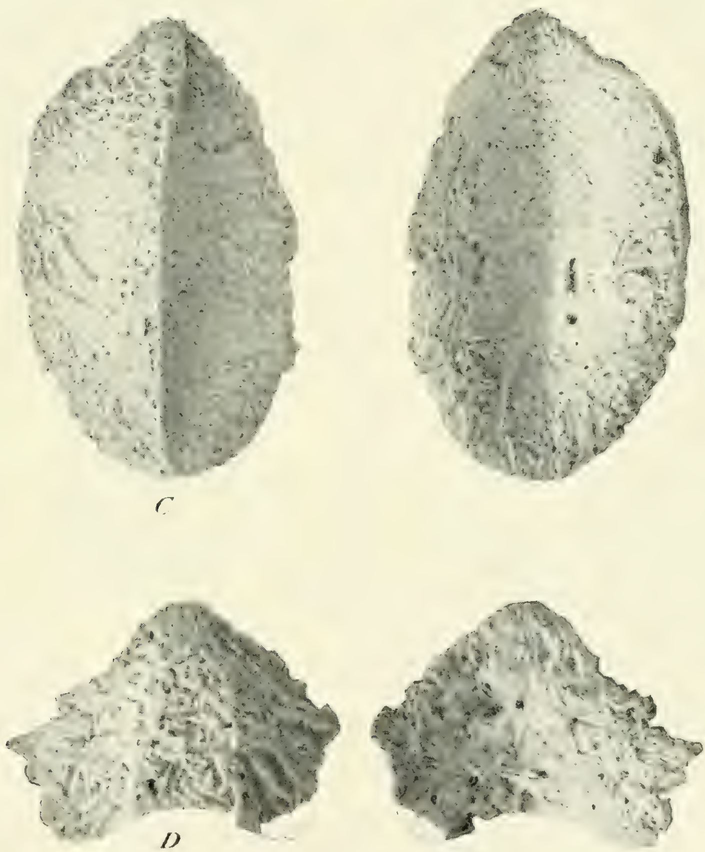


Panoplosaurus Mirus, dorsal neck scute. Inferior aspect.
One-half natural size.



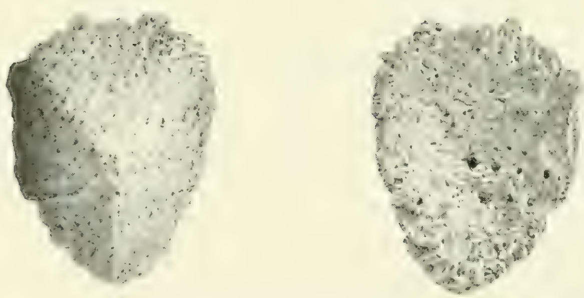
Panoplosaurus Mirus, digits of fore-foot. Superior aspect.
One-half natural size.

PLATE IX.

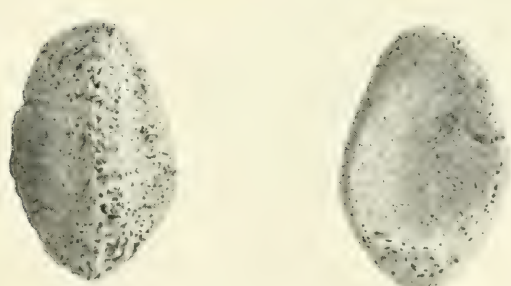


Panoplosaurus Mirus, two small scutes. Superior and inferior aspects. One-half natural size. (For sections see Figures C and D, Plate XII).

E

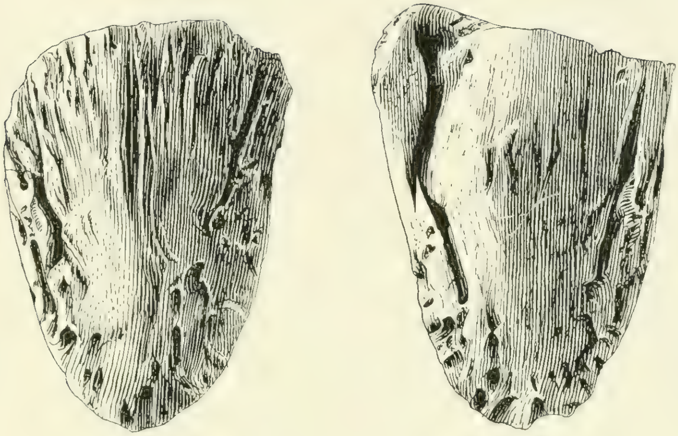


F



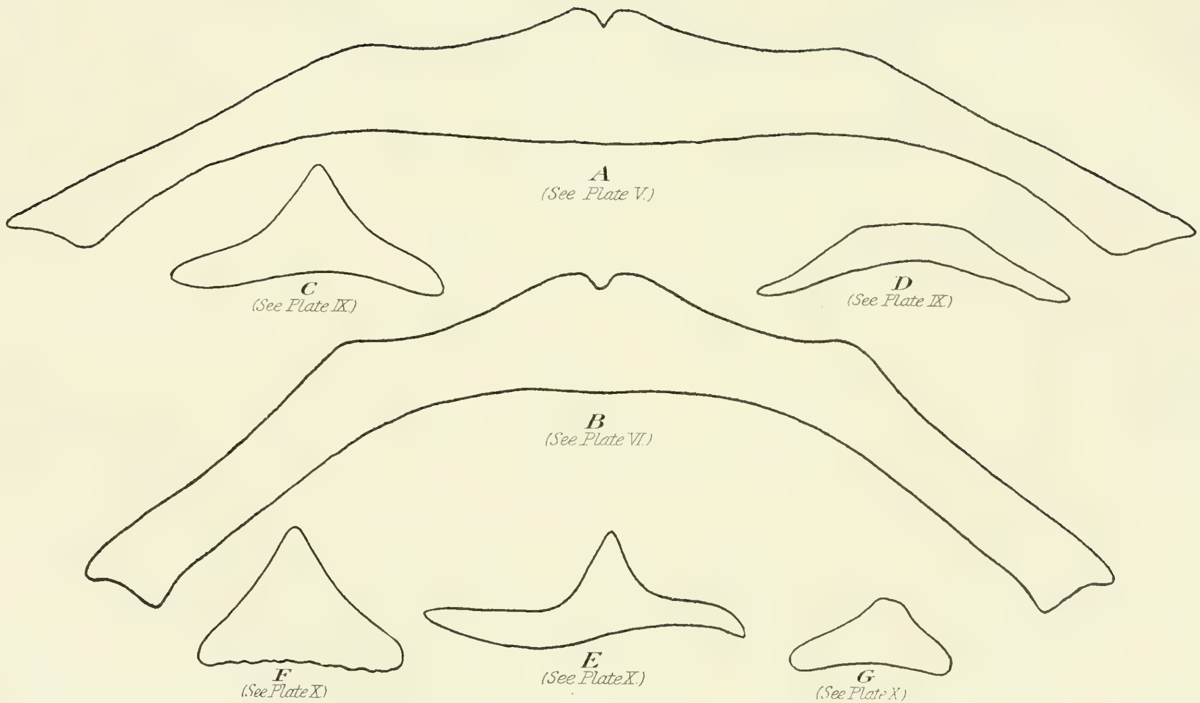
G

Panoplosaurus Mirus, three small scutes. Superior and inferior aspects. One-half natural size. (For sections see Figures E, F, and G, Plate XII).



Panoplosaurus Mirus, terminal phalange. Superior and inferior aspects.
Two-thirds of natural size

Panoplosaurus Mirus, tooth.
Four times natural size.



Panoplosaurus Mirus, sections of scutes.
One-half natural size.

Preliminary Description of a New Species of Trachodont Dinosaur of the Genus Kritosaurus. Kritosaurus incurvimanus.

By WM. A. PARKS, PH.D., F.R.S.C.

(Read May Meeting, 1919.)

In 1904, Mr. Barnum Brown, of the American Museum of Natural History, found near Ojo Alamo, in New Mexico, the head of a trachodont dinosaur which he described as *Kritosaurus novajovius*, gen. et sp. nov.[1] In 1914 Mr. Lawrence Lambe described a similar form from the Belly River beds of Alberta as *Gryposaurus notabilis*, gen. et sp. nov.

Brown's genus is described in part as follows: "Skull deep; muzzle narrow; frontals short, orbital portion reduced barely coming to the border of the orbit; nasals and premaxillaries very long; quadrate elongate; quadrato-jugal short antero-posteriorly, completely separating quadrate and jugal. Mandibular rami massive; edentulous portion decurved. Teeth spatulate in lower jaw."

Lambe defines *Gryposaurus* as follows: "Skull large, narrow and very deep, with highly arched nasals . . . . Quadrate high, partially separated from the jugal by a small quadrato-jugal. Mandible robust. Predentary expanded laterally and deflected in its hinder half, and posteriorly bifurcated below at the midline. Neural spines of the anterior dorsal vertebrae long. Ischia not expanded distally. Body covered with small, polygonal, non-imbricating, tuberculate scales of rather uniform size."[2]

Some authorities consider these two genera to be identical; it is not the purpose of this little article to discuss this question, but for the present their identity may be accepted, and as *Kritosaurus* has priority that generic name will be used.

In 1918, an expedition of the Royal Ontario Museum of Palæontology obtained the skeleton of a trachodont at a height of about 100 feet above the Red Deer river, in the bad lands of the Belly River formation on Sand Hill creek. The specimen was lying on its right side with the head, the ilium, and the diapophyses of the vertebrae exposed. The premaxillary and predentary bones were destroyed, and the extremity of the tail was later found to be absent. Work done on the specimen since it was taken to Toronto shows that the remainder of the skeleton is remarkably well preserved and that

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[1] Bull. Am. Mus. Nat. Hist., Vol. XXVIII, Art. 24, 1910.

[2] Ottawa Naturalist, Vol. XXVII, Feb., 1914.

the animal had been very quickly entombed, as a thickness of nearly two feet of rock lies between the ribs of the right and left sides, and the two sternal bones remain in their natural position at a high angle to each other. As the upper or left side has been somewhat affected by weathering, it has been decided to prepare the specimen as a panel mount, showing the under or right side. Preparatory to doing this the left shoulder girdle and fore limb have been removed; they reveal an unusual structure, particularly of the manus, which seems to justify a preliminary account which must be of some generic value even if the species is not new.

The Head

Figure 1.

The head shows conclusively that the specimen belongs to the genus *Kritosaurus*, an opinion which has been confirmed by Mr. Brown after the examination of photographs. The resemblance of our specimen to Lambe's *Gryposaurus notabilis* is very striking and it may yet prove to be another example of that species. There are, however, some points of difference which, in my opinion, are sufficiently marked to justify the creation of a new species. In the first place, the highly arched nasals, so characteristic of *Gryposaurus notabilis*, are not to be seen in our specimen. In Lambe's figure, a vertical line drawn from the anterior end of the lachrymal passes through the summit of the nasal prominence; a similar line in the new specimen cuts the superior aspect of the nasal at a point scarcely above the preorbital level. In the second place, the distinct emargination of the anterior border of the orbit, on which Lambe places especial stress in his description of *Gryposaurus notabilis*, is not seen in the specimen under examination. Other points of difference of less significance are the smaller size of the head, the more quadrangular form of the orbit, and the inward deflection of the proximal end of the mandible (possibly due to pressure).

The general anatomy of the head corresponds so closely to that of *Gryposaurus notabilis* that a further description is unnecessary here. The following measurements will serve to illustrate the general similarity but smaller size of the new species:

	Gryposaurus notabilis		Kritosaurus incurvimanus	
	Ft.	Ins.	Ft.	Ins.
Height of head from lower edge of dentary to highest point of squamosal	1	8	1	4¼ (415 mm.)
Breadth between upper rim of orbits		9⅜		7 (178 mm.)
Height of quadrate	1	4¾	1	1⅛ (345 mm.)
Length of supratemporal fossa		6		5½ (140 mm.)
Width of same		4		2⅞ (73 mm.)
Height (oblique) of lateral temporal fossa		11¾		8 13/16 (225 mm.)
Width (horizontal) of same		5½		4⅝ (118 mm.)
Height (oblique) of orbital opening		8⅜		6 5/16 (160 mm.)
Width (horizontal) of same		5		4 5/16 (120 mm.)
Length of frontal on median line				90 mm.
Length of lachrymal				100 mm.
Width of same on orbital edge				48 mm.
Premaxillary-lachrymal suture				65 mm.
Prefrontal-lachrymal suture				45 mm.
Width of lower part of occipital condyle				65 mm.
Width of same across the upper trifid portion				77 mm.
Height of foramen magnum				50 mm.
Width of same				34 mm.

The Neck

The head of the animal was so strongly thrown backward, either in the death throes or afterwards, that the neck is abnormally flexed, so much so that the zygopophysial facettes are pushed quite past one another. The total length, in this flexed position, of the thirteen cervical vertebrae is 3 ft. 6 in.

The atlas is composed of four pieces: a curved intercentrum, a sub-spherical odontoid, and two fairly stout neural arches laterally expanding into transverse processes and dorsally into a spine which is nearly as high as the crest-like spine of the axis. There is, apparently, no cervical rib. The axis is a normal vertebra except for the long and crest-like neural spine which is 170 mm. long and 55 mm. high. The cervical rib is very slender and thin, and longer than those immediately posterior to it (100 mm.).

The remaining cervical vertebrae are strongly opisthocoelous. The neural spines, from the third to the thirteenth vertebrae, gradually increase from 20 to 120 mm. in length, and the diapophyses from 20 to 140 mm. The cervical rib of the third vertebra is 80 mm. long and that of the eleventh 145 mm.

The Post-Sacral Region

The slab of rock containing the bones immediately posterior to the sacrum has been partly prepared. Sixteen vertebrae are exposed showing a length of 4 ft. 1½ in. The neural spine of the anterior is about 1 ft. 1 in. long, and that of the twelfth is 9 inches long.

Ossified muscle-tendons are developed in great perfection; of these there seems to be three distinct sets. The first set is closely applied to the sides of the neural spines; the tendons are inclined slightly upwards posteriorly, and stretch over 10 spines, reaching a length of 2 ft. 3 in. The second set underlies the first; the tendons pass backwards and downwards and occupy the space of from 3 to 5 spines. The third set has not been so well worked out as yet; the tendons are more slender and less regular; they seem to pass from the neural spines backwards to the diapophyses. It is confidently expected that a wonderful series of ossified tendons will be revealed when the main portion of the vertebral column is worked out.

The anterior chevrons are about one foot long. Impressions of skin are common and all show a uniformly tuberculated pattern, not differing from those observed in other parts of the specimen.[1]

The Pectoral Girdle and Fore Limb

Sufficient work has been done to show that both sides of the girdle and both fore limbs are completely preserved, including two sternal bones. The left side has been prepared and the bones completely removed from the matrix.

The scapula (Figs. 2 and 3) is broad in the blade, only slightly constricted in the shaft, and rather massive at the articular end; it does not differ markedly from the scapulae of other trachodonts. The external face is flat posteriorly and not so decurved as in Marsh's figure of *Claosaurus*. The ridge posterior to the articular surface is very prominent with a deep cavity below. The inner face is flat in the blade portion and slightly concave anteriorly. The articular face shows two distinct concavities, one for the coracoid and the other forming part of the glenoid cavity. The figures and the following measurements will sufficiently define this bone:

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[1] Later investigations have shown that the tuberculation of the skin is not uniform.

MEASUREMENTS OF SCAPULA

	mm.
Total length	793
Maximum width of blade	190
Minimum width of blade	120
Maximum width at articular end (oblique)	210
Thickness from external ridge to inner face	108
Scapular portion of glenoid cavity, length	130
Scapular portion of glenoid cavity, width	60
Articulation for coracoid, length	80
Articulation for coracoid, width	60

The coracoid (Figs. 4 and 5) is a roughly triangular bone with the apex situated antero-inferiorly. The anterior part is moderately thick and sharply inflected outwards about one inch a little above midheight. The articular portion is greatly expanded. The outer face is generally convex but with a sharp concavity infero-proximally owing to the great expansion at the margin of the glenoid cavity. The interior face is slightly concave. The surface for articulation with the scapula is evenly and strongly convex; it is not roughened for sutural union, and the bone was entirely separated from the scapula when removed from the matrix. This articular convexity is separated from the concave articular surface of the glenoid cavity by a deep foraminal notch. The foramen was evidently not closed as in other trachodonts. The structure of this region resembles that of *Camptosaurus* and *Iguanodon*[1].

MEASUREMENTS OF CORACOID

	mm.
Antero-inferior point to upper edge of scapular articulation	200
Edge of glenoid facette to highest point of anterior margin	115
Width of scapular facette parallel to foraminal notch	80
The same at right angles to the notch	65
Maximum width of glenoid facette parallel to foraminal notch	95
Maximum width of same at right angles to notch	78

The humerus (Figs. 6 and 7) is a stout bone with a slight twist, prominent radial crest, rounded head with inner and outer tuberosities, and inner and outer condyles distally. The radial crest extends more than half way down the bone and is continuous with the outer tuberosity which is sharply deflected backward and separated from the head, on the outer aspect of the bone, by a pronounced concavity. In the figure the crest may be somewhat too rounded, as the

[1] Osteology of the Jurassic Reptile Camptosaurus, Gilmore. Proc., U. S. Nat. Mus., Vol. XXXVI, April, 1909

bone was badly mashed along the edge. The head is strong and rounded and is extended downwards as a pronounced ridge on the posterior side of the bone. On the proximal end there is no depression between the head and the inner tuberosity.

Immediately below the radial crest the shaft is evenly elliptical but expands distally with a pronounced concavity, both anterior and posterior, continuing to the depression between the condyles. Both the external and internal faces of the distal end of the bone are conspicuously flattened above the condylar facettes. The facettes are strongly convex and sub-triangular in outline.

Measurements of Humerus	mm.
Length	630
Maximum thickness at proximal end	165
Maximum thickness at distal end	130
Minimum girth of shaft below radial crest	214
Thickness of head	78
Thickness at inner tuberosity	41
Inner condyle, width antero-post	82
Inner condyle, transversely	50
Outer condyle, width antero-post	80
Outer condyle, at right angles to above	52
Maximum width at radial crest (?)	125

The bones of the fore arm (Figs. 8 and 9) are similar in position and shape to those of other trachodonts. The relative length of these bones and that of the humerus is commonly regarded as a feature of generic value. In this case the ulna, over the olecranon process, is slightly shorter than the humerus, and the radius is considerably shorter; this condition maintains in *Trachodon* and *Hadrosaurus;* the radius and humerus are of equal length in *Saurolophus;* and in *Hypacrosaurus* the radius is much the larger bone.

The ulna is a shaft-like bone expanded proximally in two directions making the articular aspect L-shaped. There is a strong olecranon process. The distal end of the bone is but little expanded, narrow anteriorly and wider posteriorly, with a median concavity.

Measurements of Ulna	mm.
Total length over olecranon process (2 feet).	610
Length between articular surfaces	574
Greatest width of transverse expansion	104
Greatest width of antero-post expansion	75
Girth of shaft at midlength	158
Maximum thickness of distal end	80

The radius is a more slender bone than the ulna, cylindrical and gently expanding towards the distal end; proximally the expansion is more rapid to the edges of the articular facette. This bone was split longitudinally in the process of removal and the separated parts warped; in consequence, the swelling in the middle, as shown in the figures, is to be disregarded.

Measurements of Radius	mm.
Total length	555
Minimum girth	140
Proximal end, transverse (obliquely inwards and back)	83
Proximal end, transverse (obliquely inwards and forward)	60
Distal end, transverse (obliquely inwards and back)	70
Distal end, transverse (obliquely inwards and forward)	50

The carpals are apparently two: one is an irregularly triangular bone with a greatest edge of 40 mm. situated anteriorly, below the radius on the side towards the ulna. The other carpal is a much smaller, disc-like bone of a diameter of 28 mm. This bone was found on the posterior side directly behind and below the ulna. These bones are shown in Figures 8 and 9; the larger bone is almost certainly in place; the position of the smaller carpal is less certain and does not correspond with the relationship given by Brown for the typical trachodont.

The greatest interest attaches to the manus, every bone of which is excellently preserved. An anterior view of the bones, almost exactly in the position in which they lay in the matrix, is shown in Figure 10, and a posterior view in Figure 11. The relationship of these bones to the radius and ulna, in both this foot and on the right side, confirms the conclusions of Brown[1] and disproves Marsh's original arrangement.

There are four metacarpals, which, according to Brown, are to be considered as II, III, IV, and V. Metacarpals III and IV are very closely associated, II is somewhat less closely associated with III, and V is quite free and divergent.

Metacarpal II is a fairly straight bone, swollen in the middle, flattened proximally, and not so much distally, and with the outer side (towards axis of foot) flattened, more particularly distally, as if in close contact with metacarpal III. Length 185 mm. Metacarpal III is a much heavier bone, slightly twisted, flattened externally at

[1] The Manus in the Family Trachodontidae, Barnum Brown, Bull. Am. Mus. Nat. Hist., Vol. XXXI, Art. X, 1912.

both ends, and closely applied to metacarpal IV. Distal articular surface almost flat and sub-quadrangular. Length 225 mm.

Metacarpal IV is somewhat heavier than III and flattened internally for close union with the corresponding surface of III. Greatest width near proximal end transversely (65 mm.). The antero-posterior width here is 35 mm. Distally the greatest width is antero-posterior (50 mm.). Both articular surfaces are convex. Length, same as metacarpal III, 225 mm.

Metacarpal V is a much shorter and smaller bone, divergent, and with no trace of close approximation to metacarpal IV. It is somewhat twisted and greatly expanded proximally. The distal end is small and obliquely convex, indicating great power of flexion and possibly prehensile ability in this digit. The proximal articular surface is slightly concave and oval, 58 mm. by 40 mm. Length of bone, 83 mm.

The arrangement of the metacarpals presents no feature of striking difference from the generally accepted anatomy of the manus. The phalanges on the other hand are very remarkable and differ in important details from any manus hitherto described.

The phalangeal formula is as follows:

Digit II with three phalanges, the third a hoof.

Digit III with three phalanges, the third a hoof.

Digit IV with three phalanges, the last small and probably carrying a nail.

Digit V with four phalanges, the last a small evenly ovoid bone.

The first phalanges of digits II, III and IV are almost equal in length (55–65 mm.), and are expanded at both ends. Phalanx II^1 is excavated externally and closely applied laterally to the distal end of metacarpal III.[1]

The second phalanx in digits II and III is very remarkable, being in both cases a small triangular or wedge-shaped bone. The articular surface extends over the edge of the wedge. This fact, the position of the bones in the matrix, and the character of the articulating surfaces, point clearly to the position of these bones as external as shown in Figures 12 and 13. This disposition of these peculiar bones must of necessity throw the unguals inward. A wedge-shaped phalanx in one digit has been recorded previously; this seems to be the first instance of the occurrence of two.

[1] "External" and "internal" are used with respect to the axis of the body, not of the limb.

Phalanx IV^2 is normal, but of very irregular shape and with a proximal articular surface very much smaller than the apposed distal articular surface of IV^1.

The unguals of digits II and III are distinct hoofs, the ungual of digit II being longer and more pointed than that of digit III. Both bones show a lack of symmetry in accord with their inflected position. The ungual of digit II of the right foot has not yet been recovered, but that of digit III is exactly the same as the corresponding bone in the left foot, showing that the lack of symmetry is not due to distortion.

The first three phalanges of digit V are free, normal, transversely elliptical bones of gradually decreasing size. The last phalanx is a small, symmetrically ovoid bone 12 mm. long.

It is commonly thought that the loss of two hoofs in the manus is evidence that the race was in process of giving up the use of the fore limb for progression. If this is true, the present animal had advanced further in this respect than other members of the family. The inflection of the two hoofs and the development of the fourth phalanyx in the fifth digit point in this direction. On the other hand, the specimen was found fairly low in the Belly River beds and is evidently older than the trachodonts of the upper part of the Belly River and of the Edmonton formation in which this remarkable phalangeal arrangement is not shown.

FIG. 1.—*Kritosaurus incurvimanus.* The head, one-fifth natural size.

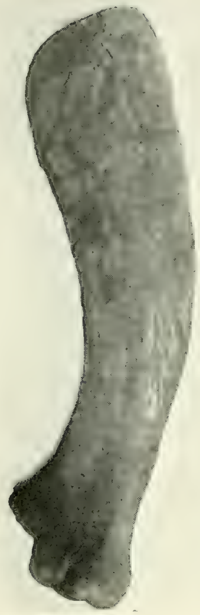


Figure 2. *Kritosaurus incuvimanus.* Figure 3.

The left scapula, internal view, about one-tenth natural size.[1]

The left scapula, external view, about one-tenth natural size.

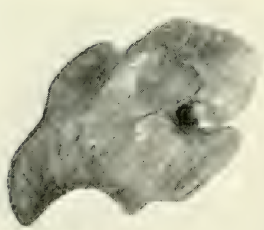


Figure 4.—*Kritosaurus incurvimanus.*

Left coracoid, external view, about one-fifth natural size.[2]

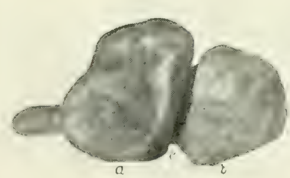


Figure 5 —*Kritosaurus incurvimanus*

Left corocoid, posterior or articular view. *a*, glenoid facette; *b*, scapular facette; *c*, foraminal notch. About one-fifth natural size.

[1] The better preserved right scapula shows the superior margin to be much less rounded.

[2] The indentation of the anterior border is abnormal as shown by comparison with the right coracoid which has been uncovered since going to press.

Figure 6.—Left humerus viewed from outer rear. *r*, radial crest; *c*, outer condyle; *o*, outer tuberosity. About one-tenth natural size.

Figure 7.—Left humerus, viewed from inner front. About one-tenth natural size.

Figure 6. *Kritosaurus incurvimanus.* Figure 7.

Figure 8.—Left radius and ulna, posterior view.

Figure 9.—Left radius and ulna, anterior view. *u*, ulna; *r*, radius; *c*, carpals. Both figures about one-tenth natural size.

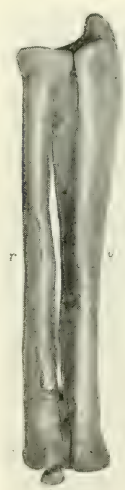


Figure 8. *Kritosaurus incurvimanus.* Figure 9.

Figure 10.
Kritosaurus incurvimanus.
Left manus, anterior view. One-fifth natural size.

Figure 11.
Kritosaurus incurvimanus.
Left manus, posterior view. One-fifth natural size.

Figure 12. *Kritosaurus incurvimanus.* Figure 13.

Dissociated phalanges of the left manus. Anterior view. About one-third natural size.

Dissociated phalanges, posterior view. About one-third natural size.

The Problem of the "Burn-out" District of Southern Saskatchewan

By J. STANSFIELD, B.A., M.Sc.

Presented by D. B. DOWLING, B.Sc., F.R.S.C.

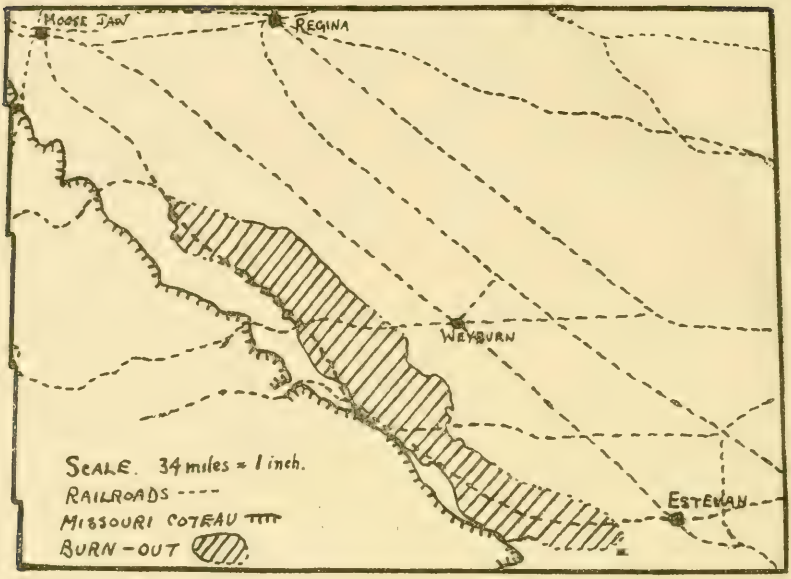
(Read May Meeting, 1919.)

The "burn-out" district of southern Saskatchewan comprises some 652,800 acres, forming an area approximately 100 miles long and ten miles in average width, and extending from the vicinity of Avonlea in a south-easterly direction to beyond Torquay. This area is served by the Avonlea branch of the Canadian National railway and the Neptune branch of the Canadian Pacific railway. The greater part of the area is more or less unsettled, notwithstanding the fact that immediately to the northeast lies one of the most fertile grain growing stretches in Canada and that the more hilly district to the southwest is more thickly settled. The chief reason for this thinly settled character is that many of the early settlers who came into the district with the wave of settlement about 1906–1910, were unable to make a sufficient success of farming to lead them to make their homes there permanently. Many of them left and the reputation of the district suffered in consequence, so that at the present time the question of its future settlement constitutes one of the important land problems of Canada and one which is worthy of having focussed upon it the best brains of the country. That the successful solution of this problem will greatly increase the national wealth of Canada can easily be understood, by consideration of the difference between an area of nearly two-thirds of a million acres, the greater part of which has never known the plough, as at present, and the same area enjoying an annual production of wheat, oats, barley, rye and flax which may not equal per acre that of the most highly favoured districts of the country, but which should equal the average for the prairie provinces.

The writer does not look for a speedy solution of the problem, but does expect that its solution will be a positive one.

THE "BURN-OUT"—WHAT IT IS

The name "burn-out" is given by the western farmers to those parts of the prairie which present a peculiar hummocky appearance (see Fig. 1), the higher parts of which possess a fine sandy loam soil and the lower parts of which, being some four inches below the higher



THE "BURN-OUT" DISTRICT OF SOUTHERN SASKATCHEWAN.

parts, have a peculiar sticky clay soil. In the typical "burn-out" the two types are very distinctly separated from each other, and the whole surface is dotted by the clay hollows which vary in size from three feet across to 150 feet or more across. The two soils appear to make up about equal parts of the surface, but probably the hollows constitute somewhat less than half the surface area.

The farmer has to cope with a two-soil farm instead of a uniform soil, as is more usual. The lack of uniformity is aggravated by the great dissimilarity between the two types of soil and also because after rain the water stands for a long time on the impervious clay in hollows, thus retarding growth at some periods of the year, or preventing germination in spring, or, on the other hand, increasing growth in certain dry seasons.

Beneath the four inches of fine sandy loam on the higher parts of the "burn-out", the sub-soil is similar to the soil as exposed in the hollows. So that it would appear that originally a uniform clay sub-soil was covered by a uniform fine sandy loam soil to a depth of about two or three inches; and that the latter has been removed in spots by the action of the wind so as to expose the clay beneath, and piled up in other spots.

The people of the district suppose that prairie fires swept over the country, and that here and there the vegetation smouldered longer than at other points, until the roots of the grasses were quite burned away leaving the soil light and loose, and that these parts were then blown away, the soil being left on the spots which were only just singed by fire. Wind action would appear to be a satisfactory explanation of the result, but whether this were preceded by fire or not, may be left open to doubt. The name "burn-out" is used here as a matter of convenience without accepting the idea involved to account for the formation of the two-soil land. By retaining the name the population of those parts have no hesitation in knowing what is being discussed.

The "burn-out" lies for the most part on the level or nearly level prairie, only a few miles northeast of the Missouri coteau, but southeast of Radville it also runs for some distance up the face of the coteau. It is also found on both sides of Long creek (Souris river), to the southeast of Radville. (This creek is instanced by the inhabitants as having stopped the prairie fire which is supposed to have caused the "burn-out," but this idea would appear to be untenable.)

Outside the main area of the "burn-out" as outlined above, there is also a small area southwest of Colfax, and occasional small patches are to be found here and there on other parts of the prairie in southern Saskatchewan.

Results in the Past

In the first wave of settlement of southern Saskatchewan a number of settlers entered the "burn-out" district. Some of these have stayed on and have made a success of farming there. Others have been unable to make a success and after a series of unsatisfactory seasons have left the district, so that in one instance, *i.e.* Webster, formerly a station on the Canadian Northern railway, a possible centre of progress has ceased to exist.

When the "burn-out" is ploughed and put under crop the ensuing growth is not uniform over the fields, as is usual with uniform soils, but the growth is patchy. The good growth is found on what were originally the high spots, but the low spots give rise to a very thin growth or none at all. So that where the "burn-out" is at its worst a field is marred by a series of bare spots which have no crop at all. Even the growth of weeds on summer fallow shows the same (see Figs. 2 and 3). The total effect of these bare spots on the yield of a farm can be readily understood. Yet the fact that some of the settlers have stayed on and are able to continue business successfully shows that the problem is not hopeless.

The cases of these settlers who have been successful are generally similar. They are records of dogged perseverance under conditions which would readily daunt the faint-hearted or the impatient. A particular case, chosen at random, will serve to illustrate. It is that of Mr. Lehaye, who is located two miles north of Neptune, where the characteristic features of the "burn-out" are about at their worst. Mr. Lehaye came from France about 1908 with a capital of somewhat less than $1000. He possesses the fortunate characteristic of being cheerful under all circumstances, is not easily overcome by obstacles, and can keep doggedly to a fixed purpose, as the present state of his farm shows. He owns three-quarters of a section. He has ploughed the soil deeply and in an endeavour to change his two-soil farm into one of uniform soil, he has put every available hour on the field, after ploughing, with team and plank drag moving the lighter soil from the high spots, so covering the heavy clay of the low spots with a dressing of the lighter soil. At the present day his crop shows little of the patchiness characteristic of the "burn-out." He has been enabled to put up the necessary barns and house, has horses sufficient to work the farm and is in a sound financial position.

Causes of Non-Success.

Among the causes which have operated in those cases of non-success, to which the unenviable reputation of the "burn-out" is ascribed, three classes may be recognized: psychological, financial and physical.

Psychological. Doubtless among the settlers coming to the district at first some would be found lacking the cheeriness and doggedness in the face of adverse circumstances, or lacking the patience required under those conditions. Such types would almost certainly be unsuccessful in the "burn-out" district.

Financial. The settler with sufficient capital to enable him to commence operations in the "burn-out" district with little or no outside help would be more liable to succeed than the one having to borrow capital at the outset. A time limit to the repayment of capital and the piling up of debts as a result of a series of poor seasons have doubtless operated in squeezing out some of the settlers.

Physical. The chief of these is the two-soil character of the land, which has been discussed above. The other important one is said to be the lack of adequate water supply. But according to the writer's investigations during the summers of 1917 and 1918, the "burn-out" district lies within an area in which a sufficient water-supply for a farm is obtainable at depths which may range from 100 to 400 feet or more[1]. Practically no tests as deep as these requirements have been made over the greater part of the area involved, so that the part of the problem which concerns the water supply may be regarded as of small difficulty once the necessary finances are available. The settler with capital would experience less trouble with regard to water-supply than the one who would have to make the money to pay for a well before being able to call in the driller.

Requirements for Successful Development of the "Burn-Out" District.

Type of Settlers. The qualities essential to success in the "burn-out" district have been indicated above, and it may be said that the most important part of the problem will be the careful choosing of the right types from the country's immigrants to take up farms in this district. In addition to the correct psychological characteristics, a certain amount of capital would be a great help along the road to success.

It is probable that some of the immigrants from Europe will do best under the circumstances to be found in the "burn-out" district.

Government Policy. An adequate government policy can only be arrived at by means of discussion of the problem from all angles. The problem should be recognized as one of national importance, the solution of which should be to the interests of all citizens irrespective of political faiths.

As contributions to the discussion, the writer will suggest the two following possible lines of action, *viz.*, aid to settlers and establishment of an experimental station.

Aid to Settlers. The question of the possible financial aid to settlers possessing the requisite human qualities for success, but lacking sufficient capital to start the heavy battle with little chance except that of being swamped by circumstances, is one that should receive due consideration. Government loans with extensions of time, without loss of title, when needed, along with considerate treatment, would lighten the burden in difficult cases, should such arise.

Experimental Station. The area of the "burn-out" district being discussed is sufficiently large to have an experimental station (if not more than one) devoted to its problems. Such an experimental station should be located where the "burn-out" conditions are at their worst, should include at least one section of land, and should be in charge

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[1] Summary Report, Geol. Surv. Can., 1917, p. 44 C., and also Summary Report, Geol. Surv. Can., 1918, p. 45 C.

of duly qualified operators with scientific training. Such an experimental station should carry out investigation of all the possible methods of soil treatment known to the agriculturist, should compile statistics relative to its own experiments and also the results obtained by the farmers working "burn-out" soils, and should publish its results and statistics, perhaps in the form of a "burn-out" bulletin, which could be calculated to interest at least those who are endeavouring to make a success of farming under those conditions.

"Burn-Out" Soils in Other Parts. The writer is credibly informed that the district under discussion is not the only one of its kind in the prairie provinces. The problem would become of still greater importance in accordance with the size of the area involved.

(THE "BURN-OUT" DISTRICT).

Figure 1.—"Burn-out", unploughed, showing unequal growth on high and low areas. South of Neptune, Sask.

Figure 2.—Summer fallow on "Burn-out", showing patchy growth of weeds. South of Yeomans, Sask.

(THE "BURN-OUT" DISTRICT).

FIG. 3.—Bare patches in flax crop, on "Burn-out", south of Yeomans, Sask.

Two plant associations from areas near Radville, Saskatchewan

By CARRIE M. DERICK, M.A.

Presented by D. B. DOWLING, B.SC., F.R.S.C.

(Read May Meeting, 1919.)

In the summer of 1918, Mr. John Stansfield, of the Department of Geology, McGill University, Montreal, was engaged in making a soil survey of part of southern Saskatchewan. Two collections of plants made by him near Radville, Saskatchewan, in August, were submitted to the writer for determination and description. The one was obtained from a characteristic area covered with sandy soil, approximately four inches in depth, overlaying a "peculiar sticky clay." The other was collected on one of the so-called "burn-outs" or shallow depressions, which often sharply break the general surface of the country. From these spots, about four inches lower than the higher levels, the sand has been completely eroded exposing the clayey sub-soil. Here, in the spring and after heavy rains, water stands long, although the adjacent sandy places are dry.

As is usual, the water relations are associated with marked differences in the plant life of the two types of land; and these differences themselves vary from year to year, in accordance with variations in the rainfall. Generally, however, the depressions are but scantily clad with vegetation and growth is greatly retarded. Thus, in the collections under consideration, many plants from higher levels had already gone to seed, while the same species from lower areas had only begun to bloom.

Both of these conditions are doubtless due to the injurious effects of water upon the seeds of land plants. As Shull[15] has shown, the long-continued flooding of land practically eliminates all but hydrophytic and ruderal species. So, too, Crocker and Davis[7] observed that, "The seeds of water-plants in general are capable of lying in water for years in the imbibed condition without losing their vitality. In contrast to this, seeds of land plants will stand such storage for a relatively short time." Probably the amount of oxygen necessary to each species for germination is the factor which determines death or survival, but the leaching out by the water of substances stored in the seed may sometimes play a part. It is easy to say that favourable conditions as to water, heat and oxygen are required for a viable seed to germinate. But, as Clements[5] has pointed out, with the exception of the seeds of forest trees and certain weeds, there is "practically no accurate knowledge of the germinability of native species. . . . . The normal period of viability under the usual conditions of natural sowing is unknown, as well as viability under extremely favourable and unfavourable conditions." It is, however, evident that the barrenness of the "burn outs" is not an indication of sterility of soil, but merely of a lack of drainage, which could be overcome by proper methods of cultivation. Therefore, if the flooding of parts were prevented, the necessary supply of oxygen for germination would be obtainable and normal development would ensue. The bearing of these conditions upon the culture of wheat, oats and flax should be carefully studied.

The reason, popularly assigned, for the origin of the depressed areas is the occurrence of prairie fires, varying locally in intensity.

Dacknowski[10] has observed that, after slight fires in the peat bogs of Ohio, new shoots arise at once from the rhizomes of ferns. If, however, all vegetation were completely destroyed, the succeeding growth is quite different in character and the marshes are changed into grassy prairies clothed with plants introduced from the surrounding country. So too, in Isle Royale, Lake Superior, Cooper[6] found that forest fires which completely destroyed the conifers spared the underground parts of birches. The latter then sprouted and produced almost a pure forest of birch. When, however, the humus was completely destroyed by fire, the re-establishment of the characteristic flora was brought about by invading plants from uninjured areas.

Pool[12] in his study of the sand hills of Nebraska notes that fires may lead to the eradication of the majority of the deeper-rooted species of the sandy uplands. Then, if the site is exposed to wind action, the almost invariable consequence is the generation of "blow-out" phenomena.

In the case of the Saskatchewan "burn-outs," wind alone might account for the unevenness of the surface. When depressions were established, water relations alone would determine the nature of the vegetation. But, as Cowles[9] has noted, the flora of a particular area is to be regarded "not as a changeless landscape feature, but rather as a panorama, never twice alike." In order, therefore, to give a satisfactory account of the plants of the district, it would be necessary to have collections made at different seasons and during successive years; to have records of the distribution and relative abundance of the various species; to ascertain the physical and chemical nature of the soil ; and to determine its water content at different periods of both wet and dry seasons. As Shantz[14] has proved for the Great Plains, one may regard the "natural vegetation as an indicator of the capabilities of land for crop production," but "the entire plant cover is a better indicator than the presence or condition of a single species."

Though the following lists may be imperfect, they suggest that a district, whose flora so closely resembles that of fertile areas further south, described by Shantz, might be profitably brought under cultivation.

(A) Plants From the Higher Sandy Areas

1. Cladonia pyxidata, (L) Fr. (Lichenes). A fragmentary specimen of a lichen which apparently occurs abundantly upon the depressed areas. It is described in connection with the latter.

2. Polytrichum piliferum, Schreber (Musci). A moss well represented in the depressions. Only one specimen was noted in the collection from the higher areas.

3. Selaginella rupestris, (L). Spring. (Lycopodiales). A form quite common, especially in the west, on sand, barren hills and rocks. Macoun reports it as ranging from Ottawa, on sand hills throughout the prairie region, to British Columbia.

It is a small Selaginella, growing in close tufts from 2 to 6 cm. high, with closely appressed leaves each tipped with a bristle. The sessile spikes are quadrangular, the sporophylls being somewhat broader than the foliage leaves.

4. Bouteloua gracilis (H.B.K.) Lag. (Bouteloua oligoslachya, (Nutt.) Torr.) (Gramineae). The Blue Grama, a grass characteristic of the prairies and found from Mexico to Manitoba. It is a shallow-rooted, tufted plant, which withstands fire well. The culms are slender and erect, 1·5-5 dm. high. The sheaths and leaf blades are smooth. At maturity the latter are convolute. The spikelets are sessile and crowded in two rows along one side of a flattened rachis. The fertile lemma is three-cleft with awned divisions, the sterile is two-lobed with two divergent awns and a tuft of hairs at the base. It blossoms from July to September.

5. Muhlenbergia gracillima, Torr. (Gramineae). This Ring Grass is a perennial found on the prairies and throughout the western United States. Shantz reports it as characteristically associated with Bouteloua. It may be recognized by its loose, long panicles; by the unequal, empty glumes, the second of which is awned, and by its long lemma with an awn 2-4 mm. long. It blooms in the late summer or autumn.

6. Pulsatilla ludoviciana, (Nutt). Heller (Ranunculaceae). The Pasque-flower, Blue Tulip, Wild Crocus, Lion's Beard or Prairie

Anemone, is a beautiful member of the Ranunculaceae which occurs in abundance on dry soil, from the eastern margin of the prairie region through the Rocky Mountains to the Coast Range, extending to Alaska and beyond the Arctic Circle. It is a perennial with a thick taproot, and leaf-blades repeatedly dissected into linear divisions, which are hairy, at least when young. The large, solitary flowers are purple or violet, seldom white, with sessile involucral leaves. The achenes are silky with plumose, persistent styles about 3 cm. long. According to Rydberg, the blossoms appear from March to the summer.

7. Potentilla bipinnatifida, Dougl. (Rosaceae). This perennial cinquefoil or five-finger occurs on plains and hills from Manitoba to Alberta and as far south as Colorado, in July and August. Its erect stems, about 1 ft. in height, and pinnate leaves are covered with fine white hairs. The styles of the yellow flowers are glandular and thickened at the base.

8. Cheirinia inconspicua, (S. Wats.) Rydb. (Cruciferae). The prairie-rocket is a biennial with an angled stem from 3 to 6 dm. high. The leaves are linear or oblanceolate, almost entire, and covered with fine grayish hairs. The flowers are pale yellow, the pods erect from 1·5 to 5 cm. long and about 2 mm. thick, containing one row of seeds in each locule. It occurs in dry soil from Minnesota to British Columbia, blossoming in July and August.

9. Solanum triflorum, Nutt. (Solanaceae). A spreading annual, about 2-9 dm. in length, with pinnatifid leaves, white flowers, and globose green berries. This Solanum grows on the prairies and in waste places from western Ontario to British Columbia and south to New Mexico and Arizona. Macoun says that it is very common near "badger" holes and along the railways throughout the prairie region, and Mr. Stansfield found his specimens only near gopher holes.

10. Achillea lanulosa, Nutt. (Compositae). The woolly yarrow is a silky perennial about 1-2½ ft. high, with deeply and finely lobed leaves and with white flowers in convex clusters. It grows in dry soils from Ontario to Saskatchewan and south to Mexico, flowering from May to September.

11. Artemisia frigida, Willd. (Compositae). The Pasture Sagebrush or Wormwood Sage is a perennial with finely divided leaves, covered with white hairs. The numerous small nodding heads of yellow flowers are arranged in a raceme. It blossoms from July to October, on dry plains and hills from Hudson Bay to Texas. The Sage-brushes are characteristic features of sandy regions, especially in successions following "blow-outs."

12. Artemisia gnaphaloides, Nutt. (Compositae). The Prairie sage, Western sage or Cud-weed Mugwort occurs on prairies and dry banks from Ontario to Alberta. It has oblanceolate, entire or serrate leaves, woolly on both sides, and numerous heads of flowers in large panicles.

13. Artemisia cana, Pursh. The Hoary Sage-brush is silvery-canescent with almost linear leaves, often with 2 or 3 teeth at the apex. The heads form a leafy cluster of yellowish flowers. It grows on plains and hills from Saskatchewan to Calgary and south to Colorado.

17. Aster Commutatus, T. & G. (Compositae). This aster has a coarsely hairy stem; hair linear leaves about 1-4 cm. long; and white ray-flowers. It is found in August, on river banks and plains from Saskatchewan to British Columbia.

18. Chrysopsis hispida, (Hook). DC. (Compositae). The Golden Aster is said by Macoun to be somewhat rare, but Rydberg states that it occurs from Saskatchewan to British Columbia in sandy river valleys, flowering from June to August. The stems are hairy and glanduliferous. The lower leaves are oblanceolate and petioled, the upper lanceolate and sessile, about 1-3 cm. long. The heads are showy, radiate and golden yellow.

19. Erigeron glabellus, Nutt. (Compositae). This fleabane has narrowly linear-lanceolate leaves, and purple heads in clusters of about three. The bracts are linear and pointed. This specimen is rather hairy. The plant is found quite commonly from Winnipeg to the Rocky Mountains, showing several varietal forms.

20. Gutierrezia Sarothrae (Pursh). Britt & Rushby. (Compositae). Gutierrezia, Broom-Weed or Rabbit-Brush, which is associated with Artemisiae after "blow-outs" in the Great Plains of the United States, occurs in Saskatchewan and Alberta. Its stems are from 1 to 3 dm. high and its linear leaves about ½ to 1½ inches long. The small, bright yellow heads are arranged in flat-topped cymes at the ends of the numerous branches.

21. Ratibida columniferae (Nutt.) Wood & Standl. (Compositae). This cone-flower is a perennial with a long taproot and pinnately-divided leaves. The yellow ray-flowers droop about the columnar grayish disc, which is three or four times as long as it is thick. The plant grows on dry prairies from Saskatchewan to British Columbia, flowering in the spring and summer.

22. Solidago glaberrima. Martens. (Compositae). The Missouri golden-rod grows on dry prairies from Manitoba to Alberta, flowering from July to September. The lowest leaves are spatulate

and petioled, the upper linear, entire or slightly serrate with ciliated margins. The heads are arranged on one side of the branches of the short but broad panicle.

(B) Plants from the Clayey, Depressed Areas

1. Cladonia pyxidata (L.) Fr. This is a grayish-green lichen, with short, thick ascending lobes. Macoun says that it is common everywhere throughout Canada on earth, rocks, logs and stumps. The brown apothecia are situated on the margins of the grayish-green stalked, open cups. Such lichens are the first plants to appear on exposed surfaces after slides and "blow-outs." In the Great Plains, as soon as soil has been prepared by them, Artemisia and Gutierrezia are apt to succeed. In this instance, the lichens formed expanded groups associated with Artemisia and clusters of Antennaria leaves.

2. Polytrichum piliferum, Schreber. This moss is found in the northern regions of both the old and the new world. The specimens in this case showing no inflorescences, the determination is only provisional. The leaves, however, were characteristic, bearing numerous lamellae and terminating in a long white awn. The lower half of the stem was naked.

3. Bouteloua gracilis (H.B.K.) Lag. It is shorter on the lower than on the higher ground, and shows the characteristic blue-green colour, whereas on the higher ground the colour is brownish because of approaching maturity.

4. Opuntia polyacantha. Haw. (Cactaceae). This is a prickly pear cactus with prostrate, conspicuously jointed stems, the internodes being obovate, and pale green. The stout spines, from 5 to 15 in number and from 1 to 5 cm. long, are either deflexed or spreading. In the late spring and summer, it bears yellow flowers, followed by spiny fruits. The range is from Saskatchewan to British Columbia and south to Missouri, on plains and prairies. Mr. Stansfield reports that it was common in the "burn-outs" of southern Saskatchewan, but not present on the higher sandy parts of the same district.

5. Astragalus, Sp. A fragment of one of the Leguminosae suggested a milk vetch or Loco Weed. It was, however, impossible to determine this without flowers, fruits and complete leaves.

6. Potentilla bipinnatifida, Dougl. Like other plants from the lower level, this cinquefoil was much shorter, smaller and less advanced than specimens from the higher areas.

7. Antennaria campestris, Rydb. Rosettes of leaves and portions of stems with roots were collected but no flowers were obtained. The plant seems, however, to be the everlasting called "Cat's-foot."

8. Artemisia fridida, Willd.

9. Artemisia gnaphaloides, Nutt.

10. Ratibida columniferae, (Nutt). Woot & Standl. The northern golden-rod ranges from Labrador to British Columbia and south to Colorado. It has spatulate, almost entire lower leaves and narrow sessible upper leaves. The inflorescence in this specimen was more elongated than the type form, approaching a spike in outline.

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SECTION V.

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Dairy Bacteriology and its Earlier Investigators.

By DR. F. C. HARRISON, B.S.A., D.Sc., F.R.S.C.

(Read May Meeting, 1919.)

A. Kircherus in 1671 was the first investigator to observe the presence of living organisms in milk. He did not attribute any importance to their presence, and it is impossible now to state what sort of structures they were. A few other observers in the 17th and 18th centuries made similar observations. Schwann, in attempting to shew that fermentation was a vital phenomenon, made use of a number of organic infusions and demonstrated that after application of heat subsequent exposure to heated air would not start the fermentation, thus proving that the fermentation was not a chemical but a vital process. His experiments with milk were a failure; for after thorough boiling he was unable to prevent milk from undergoing fermentation changes.

During the two decades, 1840 to 1860, the chemical theories of Liebig were generally accepted, and the fermentation of milk sugar to lactic acid was regarded as a simple oxidation. Following such a theory Rowlandson advanced the following marvellous explanation of the souring of milk: "When cows run their respiration is faster, and this causes them to absorb more oxygen and the milk in their udders is therefore oxidised faster, becomes warmer and sours more quickly. Hence, the evil effects of allowing cows to run."

Turpin, about 1840, suggested that the souring of milk was due to something contained in the milk which came from the udder of the cow and was probably lodged in the fat globules. Under the microscope he saw somethings that sprouted from the fat globules and grew into a mould, similar, if not identical, with *Penicillium glaucum.* He found similar growth in various dead bodies exposed to air, and he concluded that it was the oxygen that caused the organisms to develop.

Fuchs in 1841 made a real and permanent contribution to the early history of dairy bacteriology. When examining sour milk he found organisms present in all cases. One was a monas (now called micrococcus) and another an infusoria (a bacillus). These observations are probably the first recorded of the actual presence of bacteria in milk.

Later, some specimens of milk of a blue colour and others of a yellow colour were sent to him, which, on microscopical examination revealed the presence of micro-organisms. He sent some of these to Ehrenberg, who at that time was working on bacteria and this scientist gave to them the names of *Bacterium syncanum* (subsequently called *B. cyanogenus* by Hueppe) and *Bacterium synxanthum.* Fuchs studied these and even cultivated them in a medium made from mallow slime and actually developed the blue colour in fresh milk by inoculating it with some of his culture. He found that a temperature of 50–55°C would destroy the organism but that it might be frozen or dried and remain alive for some time. Its growth could be inhibited by chemicals. Fuchs regarded blue milk as an infection, and the only means of prevention was by keeping the organisms out of the milk which could be done by the exercise of care and cleanliness in the dairy and by heating all utensils which had held any of the infected milk.

Fuchs' directions for washing the hands of the milker, cleaning the udders of the cow and the milk vessels as a means of preventing the trouble seem quite modern and stand out with peculiar distinction at a time when there was general scepticism regarding the agency of living organisms as producers of fermentation. Thus in 1842 Gielen denied Fuchs' conclusions and was supported in this denial by Elten in 1864. Haubner attempted to show that the cause of the trouble was a chemical ferment associated with the casein, and Hoffman also denied the connection of blue milk with bacteria.

In 1868, Mosler found the common blue mould present in blue milk, and whilst suggesting that it might have some connection with blue milk, thought that the chief effect resulted from some condition of the cow.

To return to a somewhat earlier date, we find, Blondeau in 1847 stating that he had discovered two micro-organisms in milk, one was a yeast (Torula) and the other a mould (Penicillium) and he thought that the latter was the cause of the souring of milk through contact with the milk.

Haubner in 1852 concluded that the souring of milk was produced by something outside and was a true infection similar to blue milk.

Schlossberger in 1855 showed that milk did not sour in the udder, even if allowed to remain there a long time.

Schröder and Dusch who gave to bacteriology the cotton wool plug and who made important contributions to the study of fermentation, fell into error regarding milk, owing, as we know now, to the difficulty of sterilizing it. They attempted to preserve milk by boiling it and then filtering all the air that subsequently was brought into contact with it, but as milk so treated soured they concluded that the souring of milk was a spontaneous change.

In the course of his experiments on spontaneous generation, Pasteur, between the years 1850–1860 approached the subject of the fermentation of milk. He showed that organisms were always present in fermented milk and in 1857 described a "yeast" which he found in sour milk. Undoubtedly he was not working with a pure culture, as the milk acted upon by his "yeast" formed products which did not result from the growth of lactic acid organisms. In 1858 he succeeded in separating alcoholic from lactic fermentation and made a more careful examination of the organism producing the latter. Pasteur shewed that the two fermentations were distinct and whenever lactic acid was formed he could always find his lactic yeast.

Here, then, was the first real conception of a number of distinct species of organisms in milk, each producing characteristic changes or a distinct kind of fermentation.

In 1860, Pasteur published his results dealing with the changes occurring in milk which had been boiled and which had subsequently fermented spontaneously. Such milk did not become sour but bitter, and contained butyric and not lactic acid. Microscopic examination revealed the presence of numerous organisms different from those of sour milk. He regarded these organisms as Infusoria because they were motile. As they had withstood the temperature of boiling he though that they were introduced from outside. He named this organism *Vibrio butyricus*. As this organism had withstood the temperature of boiling, Pasteur tried the effect of exposing it to a higher temperature. He heated milk under a pressure of two and a half atmospheres and obtained a temperature of 110 to 112°C. After such heating, milk if kept out of contact with air, would remain sweet indefinitely, but it would undergo fermentation if inoculated with micro-organisms.

Thus, the butyric and lactic fermentations were separated, each fermentation was associated with a particular type of micro-organism, and milk was shown to be a liquid which might undergo a variety of fermentative changes if acted upon by different organisms.

Naturally, these results of Pasteur were challenged.

Tercul in 1872 and later Béchamp insisted that souring was due to minute living bodies (microzoma) in the milk, which were derived from the cow, and were capable of developing into the organisms described by Pasteur. These views, however, were soon discredited.

So far, however, nothing had been found out as to the source of these organisms in the milk. Did they get into milk from the cow or was the normal souring due to some enzyme secreted by the animal? Or was it possible that these organisms came from the air?

Hallier (1866), believed that micrococci and yeasts were simply stages in the life history of the higher fungi; thus, he considered micrococci as the spores of one of the higher plants and believed that these could and did pass into the blood and therefore that the organisms in milk came from the cow. Schröder was of the same opinion that the organisms came from the udder and were the normal constituents of milk. Hoppe-Seyler (1859) held the view that souring was due to some enzyme secreted by the cow and that milk contained a ferment which was destroyed by heat but reactivated by oxygen. Even in 1881 whilst admitting that micro-organisms might hasten the process, he was of the opinion that souring was normally caused by an unorganized ferment produced by the cow.

The proof of the external source of infection was first made by Robert Hall in 1874 but before outlining his results, mention must be made of the work of Lister published in 1873 and 1877. The earlier paper described the microscopical examination of (sour) milk in which he saw many bacteria, some singly and others in chains. A drop of this milk was transferred to sterilized media, such as beef infusion, milk, urine, etc., and was followed by the development of different media. After several subcultures and cross inoculations he reintroduced them into sterile milk and found that the milk soured normally. He concluded that he had only one organism, changed in shape and function by growth in the various media employed. To this organism he gave the name of *Bacterium lactis*. Later, however, Lister noticed the error of having impure cultures to start with and he devised the first method of obtaining a pure culture of a bacterial organism, a method we know now as that of high dilutions and which has in these later days been improved and used with success.

Lister by this means obtained one of the first pure cultures of the lactic acid organism, and was enabled to study it and ascertain its permanent specific characteristics. Another series of his experiments consisted of exposing sterile milk in various places—in his laboratory, in the open air, in a stable, etc., and he found that milk so exposed would ferment but would not necessarily undergo the typical lactic fermentation but would curdle, putrefy, etc. In fact, he ascertained, what subsequent experiments have confirmed, that the lactic acid organism was common in the dairy, but more rare elsewhere.

To return to the work of Robert Hall, already mentioned and which in point of time comes between Lister's two papers, Hall obtained milk direct from the udder by inserting a sterilized tube into the milk duct and thrusting it upward into the milk cistern, then allowing the milk to flow into sterilized vessels, which were immediately closed to avoid air contamination. By this means, he obtained milk that was sterile and which kept sweet and unchanged.

This experiment proved that the lactic ferment was not derived from the cow, but was caused by micro-organism gaining access from some external source. This important observation was confirmed by Lister and later by Meisner and in more modern times by de Feudenreich and others.

Bert in 1878 announced that a pressure of several atmospheres would prevent the souring of milk, although such pressure had no effect upon unorganized ferments. Hagemann (1882) noted that bacteria were the producers of lactic acid in milk and the addition of chloroform stopped the action, whilst this chemical was without effect on chemical enzymes.

Boutroux in 1878 shewed that the growth of the lactic organism was checked by the presence of considerable quantities of acid and that the growth of the organism ceased as soon as there was an accumulation of acid.

Richet in 1879 determined the relation of the organism to various temperatures—finding that the growth of the organism increased up to 40°C and then diminished, ceasing entirely at 52°C.

In the meantime F. Cohn had demonstrated the presence of spores of bacteria in milk and thus furnished the reason for the difficulty of sterilization.

With the methods of research invented and perfected by R. Koch, especially the use of gelatine and agar and the obtaining of pure cultures by the plate method Dairy Bacteriology received a great impetus, and the pioneer work here outlined was subjected to rapid revision by a host of investigators and was followed by the establishment of new principles in modern dairying practice.

Comparative Studies of Purine Metabolism in Various Representative Mammals

By ANDREW HUNTER, M.A., B.Sc., M.B., F.R.S.C., and
F. W. WARD, B.A.Sc.

(Read May Meeting, 1919.)

The urinary constituents representative in the mammalia of successive steps in purine metabolism are purine bases (chiefly xanthine and hypoxanthine), uric acid, and allantoin. While none of these appears ever to be entirely absent, the proportions in which they are excreted vary greatly from species to species. In human urine, for instance, allantoin has been detected in such insignificant traces, that for all practical purposes the catabolism of purines in man may be said to terminate at the stage of uric acid. The other extreme is represented by such an animal as the dog, in which 97 per cent of the urinary nitrogen derived from purines may be present as allantoin, and uric acid assumes a relatively unimportant position. By the systematic comparison, from this point of view, of many different animals several other types of purine metabolism have been distinguished. It becomes of interest therefore to ascertain to what extent these types are definitely characteristic of zoological species or groups, and whether between the extremes represented there is any such gradation, as would correspond to the probable course of evolutionary development.

The list of species already studied, either by ourselves or others, includes the opossum, rabbit, guinea-pig, rat, sheep, goat, cow, horse, pig, raccoon, badger, dog, coyote, cat, guenon monkey, chimpanzee, and man. This list we are now in a position to supplement by the addition of the Australian dingo dog (*Canis dingo*, Blumenbach), the American black bear (*Ursus americanus*, Pallas), the mouse (*Mus musculus*, Linnaeus), and the elephant (*Elephas indicus*, Linnaeus), from which species we secured data presented in summary form in Table I.

TABLE I

		Dingo Dog	Black Bear	Mouse	Elephant
		gms.	gms.	gms.	gms.
Total Urinary Nitrogen		7·79	4·98	5·50	4·05
Nitrogen in form of	Allantoin	0·123	0·134	0·315	0·058
	Uric Acid	0·0076	0·0079	0·0054	0·0217
	Purine Bases	0·0086	0·0042	0·0047	0·0042
Sum of allantoin and purine nitrogen		0·1392	0·1461	0·3251	0·0839
Per cent of purine-allantoin nitrogen as	Allantoin	88·4	91·7	96·8	69·2
	Uric Acid	5·5	5·4	1·7	25·9
	Bases	6·2	2·9	1·4	5·0
Uricolytic Index		96	94	98	72

For the proper elucidation of this table it ought to be stated that the figures for the dingo dog and the black bear represent the average daily output of a single animal as derived, in the case of the first, from observations upon two, and in the case of the second upon four, consecutive days. On the other hand the data for the elephant give merely the amounts of each substance found in one liter of a random specimen, while those for the mouse show the composition of the mixed urine obtained by collecting, as completely as possible, the output of twenty-four mice for twenty-one days. As they stand, therefore, the figures are mutually comparable only in respect of the proportions shown to exist between the different products of purine metabolism. This comparison is effected by reducing all data to a percentage basis as referred to the sum of allantoin, uric acid and purine base nitrogen. It is further facilitated by the calculation of the "uricolytic index." By this we mean the ratio, again as a percentage, of allantoin nitrogen to the sum of uric acid and allantoin nitrogen only; and we take it to indicate specifically the capacity of the animal to effect the final stage of purine catabolism, the conversion of uric acid into allantoin.

In Table II the results obtained with the four species here for the first time reported upon are compared, in classified series, not only with all earlier ones of our own, but also with the few additional, often imperfect, data that can be collected from other sources.[1]

[1] Cf. Hunter, Givens and Guion: *J. Biol. Chem.*, xviii, p. 387, 1914; Hunter and Givens: *ibid.*, xviii, p. 403, 1914; and earlier sources quoted in these papers.

TABLE II

Order and Species	Per cent of Purine-Allantoin Nitrogen			Uricolytic Index
	Allantoin	Uric Acid	Bases	
Marsupialia				
Opossum	76·0	19·0	6·0	79
Rodentia				
Rat	93·7	3·7	2·7	96
Mouse	96·8	1·7	1·4	98
Guinea-Pig	91·0	6·0	3·0	94
Rabbit	....	....	....	95
Carnivora				
Raccoon	92·6	5·4	2·0	95
Black Bear	91·7	5·4	2·9	94
Badger	96·9	1·9	1·2	98
Cat	....	....	....	97
Coyote	95·6	2·6	1·8	97
Dog	97·1	1·9	1·3	98
Dingo Dog	88·4	5·5	6·2	96
Coach Dog	....	....	....	32
Ungulata				
Cow	92·1	7·3	0·7	93
Horse	88·0	12·0	0·5	88
Sheep	64·0	16·0	20·0	80
Goat	81·0	7·0	12·0	92
Pig	92·3	1·8	5·8	98
Proboscidea				
Elephant	69·2	25·9	5·0	72
Primates				
Monkey	66·0	8·0	26·0	89
Chimpanzee	....	....	....	0
Man	2·0	90·0	8·0	2

The data thus assembled illustrate the following types of purine metabolism:

(1) The apparently predominant type, exemplified mainly by carnivora and rodents, in which bases as well as uric acid play a relatively insignificant role among the excretory products, and a uricolytic index of at least 94 implies the almost complete destruction of intermediary uric acid. It is possible that this type may prove to be susceptible of subdivision, for the rodents appear in general to excrete a distinctly higher proportion of uric acid than the carnivores.

(2) One in which the proportion of bases remains low, but that of uric acid increases, so that the uricolytic index, in no case higher

than 93, may sink as low as the neighbourhood of 70. To this type conform the marsupialia and the proboscidea, as exemplified respectively by the opossum and the elephant, and also certain ungulates, such as the cow and the horse.

(3) A type in which, while the power to destroy uric acid is apparently as high as in the first, the bases exceed appreciably that substance in quantity. The only known representative of this type is the pig.

(4) The fourth type resembles the third in the excess of bases over uric acid, but differs from it in having the uricolytic index comparatively low. The guenon monkey among primates, and the sheep and goat among ungulates, are examples.

(5) Man and the chimpanzee (possibly of course the other anthropoids) form a class by themselves, characterized by the practically entire absence of uricolytic power, and the consequent replacement, as end product of purine metabolism, of allantoin by uric acid.

As far as our personal observations go, the individuals of a *species* not only conform to a single type, but vary to a very limited extent within it. It would nevertheless be an error to convert this experience into a generalization. Wiechowski[1] has reported observations upon two horses, from which one may calculate uricolytic indices, 50 and 79 respectively, that are decidedly lower than our estimate of 88; and according to Schittenhelm and Bendix[2] the ratio of bases to uric acid in horses' urine may be as high as 8 to 1, although the horses coming under our observation excreted hardly any purine bases whatever. A still more striking instance of variability within the species has recently been reported by Benedict.[3] The Dalmatian coach dog, as he discovered, differs from other dogs in excreting a decidedly higher proportion of uric acid than of allantoin, so that its purine metabolism actually approaches the human type more than that of any other mammal lower in the scale than the chimpanzee. It appears therefore that, although as a general rule each species maintains a characteristic type of purine metabolism, special circumstances (among which domestication possibly plays an important part) may induce divergences peculiar to a particular race or breed. This possibility has an obvious bearing upon the problem of the evolutionary development of the different types.

On passing from the species to the *order* somewhat similar relations are encountered. No positively significant difference exists

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[1] Wiechowski: *Biochem. Z.*, xix, p. 368, 1909.

[2] Schittenhelm and Bendix: *Z. physiol. Chem.*, xlviii, p. 140, 1906.

[3] Benedict, S. R.: *J. Lab. and Clin. Med.*, ii, p. 1, 1916.

between the various species of rodents, or the various species of carnivora examined; but among primates we find represented two, and among ungulates three, distinct metabolic types. It cannot therefore be said for the order, any more than for the species, that its purine metabolism invariably presents the same, or even similar characteristics. It is again perhaps not without importance that the order presenting in this respect the greatest variety is that which has been, in the examples available, the most subject to the selective operations of the breeder.

Viewing the collected results from the standpoint of phylogeny, we have to admit that they do not as yet reveal any continuous line of development from one type to another. The most that can be said is that, though totally dissimilar groups, such as rodents and carnivora, may present almost identical metabolic habits, widely divergent types arise for the most part in remotely related orders. Even this limited generalization has exceptions, as may be seen by comparing the pig with the horse, or the monkey with the chimpanzee. The second of these exceptions points, as it happens, to the most interesting single fact discovered in this connection, namely, that the primates nearest to man have already acquired his peculiar type of purine catabolism; but between these and the lower primates there still exists a gap as great almost as that which separates man from the dog. Evidently the history of the evolution of purine metabolism among mammals, if it should ever be possible to write it, demands as its basis a much more extensive material than we yet possess.

We take pleasure in acknowledging the courtesy of Mr. R. C. Harris, Acting Commissioner of Parks, City of Toronto, and Mr. F. Goode, formerly Superintendent of the Riverdale Zoo, in facilitating, by the loan of animals and otherwise, the progress of this investigation.

The Naso-Orbito-Alveolar Craniometric Method (*Abstract*)

By JOHN CAMERON, M.D., D.Sc., F.R.S.C.

(Read May Meeting, 1919.)

Hitherto Craniometry has been applied almost exclusively to the cranial portion of the skull. This new method is, on the other hand, a craniometric study of photographs of the *facial aspect* of the skull, and it is applied as follows: Horizontal lines are drawn through the nasion, the lower orbital margins, the akanthion and the prosthion or alveolar point. Vertical lines are then drawn through the lateral margins of the nasal aperture. The result is the production of upper, middle and lower rectangles the relative proportions of which vary in the different races of mankind. It was found that this method divided ancient and modern man into two great groups—EURASIATIC and NEGRO. The crania of Europeans, ancient Egyptians, Hindoos, Chinese, Eskimos, Polynesians, North American Indians, Incas and Patagonians conformed to one type of index and these races were therefore grouped under the term EURASIATIC. Thus one important fact suggested by the study of this index was that the aborigines of the western hemisphere represented an offshoot from the Eurasiatic group. In all these Eurasiatic races the uppermost rectangular figure formed an oblong with its long side placed vertically, while the middle and lowest rectangles were almost equal in surface area, and approximated to the outlines of squares, with of course slight individual racial variations.

In the negro races, on the other hand, the uppermost and middle rectangles were almost equal in surface area, and approximated to the outlines of squares, with of course slight individual racial variations; while the lowest rectangle formed a narrow oblong figure with its longer sides placed horizontally. The great reduction in the height of the lowest rectangle is of course due to the marked prognathism that exists in negro races.

This investigation therefore suggested that the main human evolutionary stem had bifurcated *early* into two main groups each of which exhibited its own specific modelling of the facial skeleton, and therefore its own specific form of nase-orbito-alveolar Index.

A Study of Marine Bacteria, Straits of Georgia, B.C.

By CYRIL BERKELEY, Vancouver, B.C., late Agricultural Bacteriologist to the Government of India

Presented by PROFESSOR E. E. PRINCE, F.R.S.C.

(Read May Meeting 1919.)

It is now well recognised that bacteria play an indispensable part in maintaining the circulation of the elements necessary for the maintenance of life on the land portions of the earth's surface and the study of the individual species participating and their particular activities is the chief concern of agricultural bacteriology. Comparatively little attention seems to have been given to the allied problem under the conditions which exist in the open sea. It is generally conceded that the decay of marine animals and plants is brought about in some measure by bacterial agency, that the complex compounds of which they are composed are broken down to simpler forms and that these simpler compounds are in due course assimilated by the living agencies and so returned to the cycle; but this is largely argued by analogy with the conditions known to exist on land and very little knowledge appears to exist as to the particular bacteria participating in the processes or the nature of the chemical change brought about. Involving as it does an enormous field of study not only in bacteriology and chemistry, but also in plant and animal physiology under conditions which are often themselves little known this is not surprising, but the fascination of investigation on the lines indicated is as obvious as are its difficulties.

In 1914, the late G. H. Drew published[1] a valuable and suggestive paper in which he established the connection between the greater development of the plankton in temperate than in tropical seas with the greater activity of denitrifying bacteria in the latter case. He showed that nitrogenous compounds which have been broken down to the condition of nitrate are very speedily reduced to elementary nitrogen by bacterial agency in tropical seas. The nitrogen is thus eliminated from the cycle of marine life unless there be other organisms present in the open sea, as there are on land, which are capable of

[1] "On the Precipitation of Calcium Carbonate in the Sea by Marine Bacteria, and on the Action of Denitrifying Bacteria in Tropical and Temperate Seas," G. H. Drew—"Papers from the Tortugas Laboratory of the Carnegie Institute of Washington," Vol. V, 1914.

recombining it. No evidence of the existence of such organisms has yet been brought forward. In temperate seas, on the other hand, this reduction of nitrates takes place very little, if at all, and the nitrogen remains in combination dissolved in the water and available for subsequent assimilation. Drew isolated a particular species of denitrifying bacterium to which he attributed the loss of nitrogen in tropical seas (*Bacterium calcis*—Drew; *Pseudomanas calcis*—Kellerman & Smith[1]) and observed incidentally that the reduction of the nitrate by the organism was accompanied by the precipitation of calcium carbonate from the calcium salts dissolved in the water. He suggests that the chalky mud flats forming the great Bahama Banks, and those which are found in places in the neighbourhood of the Florida Keys, are being precipitated by the action of *Bact. calcis* and that the same organism may have been an important factor in the formation of chalk and oolite rocks elsewhere.

A number of references will be found in Drew's paper to previous work on marine bacteria considered both generally and in particular regard to denitrifying, nitrogen fixing, and nitrifying species, but in nearly all the cases quoted here and in the papers to which I have had access, the authors seem either to have been content to isolate and describe types without considering their chemical activities or to have dealt with species collected in inshore waters where the conditions would not be comparable with those existing in the open sea.

The original object of the work to be described was to ascertain whether the water in the open sea in the neighbourhood of Vancouver contained bacteria capable of bringing about denitrification in simple culture media containing nitrates and, if so, if Drew's *Bact. calcis* could be isolated from it, but in its subsequent development its scope was widened to include an examination for ammonifying, nitrifying and nitrogen fixing bacteria.

Sampling

The samples of water on which the work was carried out were taken on August 27th, 1917, at a point about 3 miles due east of Nanaimo, Vancouver Island. It was hoped that this point was sufficiently far from land to provide water in which land or littoral forms of bacteria might be expected to be absent but the conditions were not oceanic owing to the effect of the fresh water from the Fraser and other rivers. The density of the surface water was, for instance, only 1·0171 (corrected for 15°C). It seemed, however, sufficiently

[1] Kellerman & Smith, Journal of the Washington Academy of Science, Vol. IV, No. 14.

near open sea conditions for preliminary experiment and was the farthest point accessible from the Marine Biological Station at Departure Bay in the short time at my disposal. Dr. C. McLean Fraser, the director of the station, very kindly took me out in the station launch to secure the material and placed his apparatus for collecting samples of water at fixed depths (the Peterson-Nansen deep-sea water bottle) at my disposal. Samples were taken at the surface and at depths of 20 and 100 fathoms. The temperature of the water at the surface was 16·6°C, at 20 fathoms 9·45°C and at 100 fathoms 7·42°C.

There is considerable difficulty in taking samples of water below the surface under sterile, and otherwise reliable conditions. Drew (loc. cit.) discusses this fully and describes an apparatus used by him specially designed for the purpose, the chief features of which are that the samples are taken in glass vessels which can be sterilized and sent down full of alcohol which is discharged only when the required depth is reached. The results obtained from my own samples taken at 20 and 100 fathoms are open to the criticism that they were taken in a vessel which could not be sterilized and which was made of metal. The container was washed as thoroughly as possible before use and, for the rest, reliance was placed on the vigorous flow of water through the vessel during its descent to ensure that the sample secured really represented bacteriologically the depth reached. The metallic container is objectionable because of the bactericidal action which practically all metals are known to possess, but no quantitative determinations were attempted and any positive qualitative results obtained from the samples are free from objection from this standpoint. The samples were transferred to glass bottles, which had been washed out with a saturated solution of corrosive sublimate and were thoroughly rinsed with the water being collected, immediately on reaching the surface and were kept as cool as possible during transference to the laboratory. The surface sample was taken in a "Thermos" bottle which had been thoroughly washed out with saturated corrosive sublimate solution and was kept full of the solution for several days before use. The antiseptic was poured out and the bottle thoroughly washed with the water being sampled before use. The neck of the bottle was held a few inches below the surface and the cork replaced under water. The object of using a "Thermos" bottle was to keep the water at as nearly as possible its original temperature until reaching the laboratory.

During the taking of the samples, and subsequently all the way back to Vancouver until the inflow of the Fraser river made the water too muddy for observation, a peculiar flocculent turbidity was noticed in the sea extending from the surface as far down as could be seen. Dr. Fraser told me that, although this appearance was not uncommon in the neighbourhood in late summer and early autumn, he had never been able to collect any of the suspended material or to arrive at any explanation of its formation. It was found impossible to collect anything in the finest net at our disposal by dragging and samples of water when brought up to the deck of the boat seemed to be clear and normal. The material evidently deflocculated during collection and did not reflocculate on standing.

Direct Examination of Samples

The bottles containing the samples were put upon ice immediately on reaching the laboratory and kept there until most of the inoculations of media were completed. A preliminary direct microscopic examination of the water was made to see if any explanation of the flocculent material referred to in the last paragraph could be found. Hanging drops or films made direct from the samples and stained with Carbol Fuchsin or Löfflers Methylene Blue showed nothing definite. Some whole and several fragmentary desmids and diatoms, and a few other organisms, too small or poorly stained to be identifiable, were found in the surface sample; practically nothing in the other two. By centrifugalising the water deposits of the same material were obtained, but there did not seem to be nearly enough solid material collected in this way to account for the flocculation seen in the sea. Addition of a drop of normal solution of caustic soda to 10cc. of water in the centrifuge tube before spinning led to more satisfactory results. A gelatinous precipitate, consisting chiefly of magnesium hydrate, was thus formed in the water which collected all the suspended material and brought about its concentration. Films were made and fixed in the ordinary manner from the centrifuge deposits thus obtained, and, after treatment with a 2 per cent solution of acetic acid to remove the mineral matter, were stained with Aniline Gentian Violet. Large numbers of bacteria were thus found to be present in the water.

Surface Sample. The predominating forms seen in this sample were:—

(i) A round-ended bacillus about $\cdot 3\mu$. long by $\cdot 5\mu$. wide occurring singly and in pairs. Dividing individuals frequent.

(ii) A round-ended bacillus about $1\cdot 5\mu$. long by $\cdot 4\mu$. wide also occurring singly and in pairs and in active division.

(iii) A round-ended bacillus about 2μ. long by $1\cdot 5\mu$. wide occurring singly. Stains more intensely than (i) and (ii).

(iv) A thin square-ended bacillus occurring in short chains, about $4 \cdot 5\mu$. long by $\cdot 2\mu$. wide.

(v) A coccus occurring in small groups, about $\cdot 5\mu$. diam. No. (i) seemed to occur in greatest number. The particles of diatoms, etc., present were covered with bacteria chiefly of this type.

Twenty and 100 fathom samples. These gave comparatively little deposit on making alkaline and centrifuging. In both cases only two types of bacterium seemed to be present and these in far fewer numbers than in the surface sample. They approximated very nearly to types (ii) and (v) of the above series.

Cultural Examination

Since the original intention of this work was to endeavour to isolate denitrifying species of bacteria the only solid sea-water medium available at its start was one designed to that end: Its composition (medium A) was as follows:—

Calcium Acetate	5·0	grams
Peptone (Witte's)	·2	gram
Potassium Nitrate	·5	gram
Sodium Phosphate (Na_2HPO_4)	·25	gram
Agar	·20	grams
Sea-water	1000	cc.

In making up this medium, and all others used in the course of the work, the sea-water used was collected from the shore at a point in the neighbourhood of Vancouver where the density was usually very near to that of the surface sample under examination. The medium was made just alkaline to phenolphthalein after the agar was dissolved, but it developed a slightly acid reaction during sterilization. The precise degree of acidity was not determined.

Two cultures were made on slopes of this medium from each of the samples of water. In each case one was kept in the incubator at 28°C., the other at air temperature (15° to 20°C)[1]. No growth was obtained at the former temperature in the case of the 20 fathom or 100 fathom sample. The surface sample showed a light dotted growth after 43 hours incubation, which appeared to consist of an almost pure culture of a round-ended bacillus about $\cdot 5\mu$. wide by $1 \cdot 5$ to $2 \cdot 5\mu$. long occurring most commonly in pairs and in an active state of division. A few thinner round-ended bacilli were also present.

[1] In all subsequent references to "air temperature," a temperature range within these limits is meant.

After three days this culture had assumed a characteristic appearance. The growth was white, semi-transparent, rather dry, very adherent to the medium and had a peculiar cracked and wrinkled surface (Culture I)[1]. A finely granular deposit had formed in the medium in the neighbourhood of the growth which was found to consist of minute spherular nodules of calcium carbonate. This will be referred to in a later paragraph. A film prepared from the culture at this stage[2] showed a predominance of similar forms to those seen in the young growth but the organisms were frequently thicker and ran up to $4 \cdot 5\mu$. in length. Both their form and the staining were less regular than in the young culture.

All the cultures kept at air temperature showed growth after six days. The character of the culture from the surface sample was similar to that obtained at 28°C after 3 days and similar organisms were present (Culture VI). The 20 fathom sample gave a faint dotted growth which did not develop sufficiently to assume any definite character. There was a slight deposition of calcium carbonate in the medium. A film showed round ended bacilli about $\cdot 5\mu$. thick and ranging from 1 to $2 \cdot 5\mu$. long mixed with a longer and more slender organism (about $\cdot 25\mu$. thick by 3 or $3 \cdot 5$ μ. long) (Culture XXII). The culture from the 100 fathom sample grew more freely. The growth was almost transparent and colourless and in the early stages moist and spreading. After a few weeks it became drier and more adhesive to the medium and a considerable deposition of calcium carbonate occurred in the medium. A film prepared from this culture showed a small coccus or very short bacillus (width about $\cdot 4\mu$., length $\cdot 4$ to $\cdot 5\mu$.) (Culture VII).

Each of the three samples of water was also plated on the same medium using 1cc. of water and 10cc. of medium. The plates were kept at 28°C. No colonies developed in the case of the 20 fathom or the 100 fathom sample. It was subsequently found that this was due to the temperature of incubation being too high, no satisfactory

[1] The numbers of the cultures refer to the summary of cultural characteristics at the end of the paper.

[2] The method used for staining films throughout this work was as follows: The film having been fixed by flaming in the usual manner was treated with 2% acetic acid for two minutes. As much as possible of the acid was then poured off the coverglass and freshly prepared Anilin Gentian Violet applied for about two minutes. This method was found to give much better results than either Carbol Fuchsin, Löfflers Methylene Blue or Aniline Gentian Violet used direct. In many cases these failed to stain the organisms at all. The organisms frequently seemed to be surrounded by a substance which prevented the penetration of the stain and which the acetic acid treatment removed.

growth in any medium being obtained from these samples at 28°C. This is not surprising seeing that the temperature is some 20° above that of the natural habitat of the organisms.[1] Colonies were visible on the plate inoculated with surface water after 2 days. In 3 days six surface colonies had developed which appeared to be of three kinds.

(i) Round, white, flat, denser at centre than at edge, undulating edge, mottled surface (Culture II).

(ii) Round, white, flat uniformly dense throughout, entire edge, finely granular surface. (Culture III).

(iii) A type intermediary between (i) and (ii). (Culture IV).

A granular deposit of calcium carbonate was visible in the medium surrounding all the colonies of these types after 4 days. In ten days the colonies of types (i) and (iii) had acquired a very characteristic appearance. They were now about ¼ in. in diameter, were considerably raised from the medium and were dry and wrinkled. The centre of the colony was thicker and darker than towards the edges and the wrinkles radiated from this dark area nearly to the edge. The colonies of type (ii) had increased in size but had not altered appreciably in character.

Two additional types of colony had now developed:—

(iv) Round, semi-transparent, moist, greyish, entire edge, domed with depression at centre (Culture V).

(v) Round, pale yellow, flat, dry, entire edge (Culture XXVIII).

Several submerged colonies of indeterminate type also developed on this plate: 15 colonies in all were counted.

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[1] In the case of agar plates it must be remembered that the bacteria are called upon to withstand a temperature of at least 40°C. during inoculation, since the agar solidifies a few degrees below this temperature. Probably for this reason no satisfactory results were obtained by plating cultures containing bacteria obtained from 20 to 100 fathoms during the whole course of this work. In cases where growth was very active at air temperature in liquid media or smear cultures no colonies were obtained on plating, even if the plates were kept at the same temperature. Drew draws attention to the sensitiveness of marine bacteria to heat in the paper to which reference has already been made. This may account in some measure for the marked falling off in numbers of bacteria found by him in the waters of "Tongue of the Ocean" at about 350 fathoms (pp. 35 and 36), the temperature of the water at this depth in the Florida seas approximating to that at 20 fathoms in the case dealt with in this paper. Gelatin media would probably be found to give more satisfactory results in dealing with bacteria drawn from environments in which such temperatures prevail.

Denitrification

The term "denitrification" is used by Drew to cover both the partial reduction of nitrates to nitrites and ammonia and their complete reduction to nitrogen gas. The same use of one term with two meanings occurs commonly in discussions of the same processes under the influence of soil bacteria and even in connection with the activities of pathological bacteria in culture fluids. It would simplify matters very considerably if the production of nitrites or ammonia were described as "partial reduction" and the term "denitrification" were reserved for the reaction resulting in the complete elimination of nitrogen. I shall use the terms in these respective senses in what follows.

The two processes are clearly of very different significance in their application to the question of the supply of available nitrogen in the sea, for, if the nitrates present are only partially reduced, the compounds formed are still available for plant assimilation (whether or not they have to be reoxidized before being suitable for that purpose) whereas if denitrification takes place the nitrogen is completely lost to the cycle of marine life.

The power of bringing about partial reduction of nitrates is very generally possessed by bacteria found on land; that of causing denitrification is comparatively uncommon. It is probable that this is also the case in the sea and that sea-water from at, or near, the surface will be generally found to possess the power of inducing partial reduction, whilst that of causing denitrification occurs less commonly. It is unlikely that the temperature at which growth takes place will affect the nature of the end product, other conditions being equal. Bacteria which can only partially reduce at one temperature are not likely to be able to denitrify at another, nor, according to temperature, are denitrifying species likely to sometimes carry the reaction only as far as nitrite or ammonia. The rate of reaction will, of course, be affected by the temperature, but, provided growth can take place and given sufficient time, the end product will probably depend in the first place on the specific nature of the bacteria present and, in the second place, on the composition of the culture medium.

Looking at Drew's results from this point of view it is apparent that he found very little evidence of denitrifying species of bacteria in temperate seas. He records it in fact only in the case of samples drawn from the English Channel in 1909 and here "uniformly consistent results were not obtained, as in some of the cultures complete denitrification was never obtained even after several months." (*loc. cit.* p. 24).

It will be seen from what follows that the same thing has been found to hold in my own experiments.

The following media were used to follow the course of nitrate reduction under the influence of the bacteria in the three samples.

Medium B.

Calcium Acetate....................	5·0 grams
Potassium Nitrate..................	·5 gram
Sodium Phosphate (Na_2HPO_4)	·25 gram
Sea-water..........................	1000 cc.

Medium C.

The same as Medium B with addition of ·2 gram Peptone (Witte's). Both these media were boiled and filtered before sterilizing to remove the precipitate which formed. The media, after sterilizing, were alkaline to litmus and neutral (or very slightly alkaline) to phenolphthalein.

A series of six, 120cc. Erlenmeyer flasks each containing 25cc.[1] of Medium B was inoculated from the three sea-water samples using ·3cc. of each sample and inoculating two flasks with each. One series of three was kept at 28° (Series B1), the other series at air temperature (series B2) and blanks were kept under the same conditions.

A second series of six similar flasks containing the same amount of Medium C was inoculated in the same way and kept under the same conditions (series C1 and C2 respectively) and blanks were kept under the same conditions.

The following reagents were used for detecting the products of the reduction:—

For nitrites. The Griess—Ilosvay reagent.

This is prepared as follows:—

(i) ·5 gram sulphanilic acid is dissolved in 150cc. dilute acetic acid.

(ii) ·2 gram of α naphthylamine is boiled with 20cc. of water, the colourless solution is poured off from the bluish-violet residue and 150cc. dilute acetic acid added.

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[1] The effect of using only a small volume of liquid in a comparatively large flask was to have a thinly spread layer of medium thoroughly exposed to aeration. It is possible that this condition inhibited the development of one class of denitrifying bacteria. Organisms producing denitrification in similar media to those in question here, under conditions of both very free and very limited aeration, can be isolated from soil, but they are of different type to one another and their *modus operandi* is probably also different. It is possible that this also holds of marine bacteria. A second series of tests should be carried out to determine this point.

The two solutions are mixed in equal volumes immediately before use. This is an exceedingly delicate reagent for nitrites and gives no reaction with nitrates. In use 5 drops of the reagent were added to 2cc. of the culture under examination. If nitrites were present a distinct red colour generally developed immediately. If no red tinge appeared after five minutes nitrites were certainly absent.

For ammonia. Nessler's reagent.

5 drops added to 2cc. of culture under examination.

For nitrates. Either Diphenylamine or Brucine. The former reagent is prepared by dissolving ·5 gram of diphenylamine in 100cc. of concentrated sulphuric acid and adding 20cc. of water. The latter by dissolving ·2 gram of Brucine in 100cc. of concentrated sulphuric acid. 5 drops of either of these reagents were added to 1cc. of culture mixed with 2cc. of concentrated sulphuric acid.

The nitrate tests could only be applied when a previous test had shown nitrites absent. There is no satisfactory qualitative test for nitrates in aqueous solution in the presence of nitrites.

The samples were withdrawn from the culture flasks for testing with small sterilized pipettes and all the tests were carried out under like conditions.

In no case was there any direct evidence of denitrification. Nitrogen compounds were still present in quantity in the culture solutions kept at 28°C after three weeks and in the cultures kept at air temperature after three months. No evolution of gas was visible at any time in any of the cultures. It is not possible to state definitely that absolutely no denitrification took place since no quantitative determinations of nitrogen were carried out. Facilities for this were not available and no really reliable method for determining nitrogen compounds in sea-water exists; but, judging by the intensity of the qualitative reactions at the final tests, and the complete absence of any bubbling in the cultures, denitrification, if it had taken place at all, must have been insignificant. The nitrates and nitrites would no doubt have ultimately disappeared from the medium containing no peptone since bacterial growth was still active in the cultures when last examined and the bacteria had in this case no other source of nitrogen to draw upon. The disappearance of nitrogen in this way is, however, of the same significance, from the point of view of the nitrogen cycle in the sea, as the conversion of nitrate to nitrite or ammonia, the nitrogen is still retained in the cycle to become available on the death of the bacteria.

The following table illustrates schematically the results obtained in each series at the periodic tests. Where O is inserted in the table it indicates that there was no evidence of growth in the culture, and it was therefore not tested, + indicates a positive reaction,—a negative one. Whenever the nitrite test gave a negative result the culture was tested for nitrate which was invariably found.

Period of growth	Series B1						Series B2						Series C1						Series C2					
	Surface		20 fms.		100 fms.		Surface		20 fms.		100 fms.		Surface		20 fms.		100 fms.		Surface		20 fms.		100 fms.	
	NO_2	NH_3	NO_2	NH_3	NO_2	NH_2	NO_2	NH_3	NO_2	NH_3	NO_2	NH_3	NO_2	NH_3	NO_2	NH_2	NO_2	NH_2	NO_2	NH_3	NO_2	NH_3	NO_2	NH_3
2 days......	0	0	0	0	0	0	0	0	0	0	0	0	+	+	0	0	0	0	0	0	0	0	0	0
6 days......	+	−	0	0	0	0	+	−	+	−	+	−	+	+	0	0	0	0	+	+	−	+	−	+
14 days......	+	−	0	0	0	0	+	−	+	−	−	−	+	+	0	0	0	0	+	+	+	+	−	+
22 days......	+	−	0	0	0	0	+	−	+	−	−	−	+	+	0	0	0	0	+	+	+	+	−	+
3 months....	cultures not kept						+	+	+	−	−	−	cultures not kept						+	+	+	+	−	+

In addition to the fact that no bacteria capable of bringing about denitrification are demonstrable in the samples under examination the following conclusions can be drawn from these results:—

(i) The surface water contains bacteria capable of reducing nitrate to nitrite and nitrite to ammonia. In the absence of peptone the latter reaction does not set in at 28°C for 22 days and at air temperature only after 3 months. In the presence of peptone ammonia is formed immediately, but this is probably independent of the formation of nitrite and is due to the direct action of other bacteria on the peptone.

(ii) No bacteria contained in the 20 fathom and 100 fathom samples will grow in the media under consideration at 28°C.

(iii) The 20 fathom sample when inoculated into media kept at air temperature behaves in the same way as the surface sample in respect of nitrite and ammonia formation except that nitrite formation does not set in so rapidly in the presence of peptone and ammonia is not formed even after three months in its absence.

(iv) The 100 fathom sample when inoculated into media kept at air temperature grows freely but does not form nitrites (the reaction after 6 days in the absence of peptone seems to be an anomaly). It forms ammonia freely in the presence of peptone. Whenever growth took place these cultures were plated on medium A. Colonies of the following types were obtained in this way and subcultures made from each type on to a slope of the same medium:—

(i) Round, white, flat, dry and adhesive to medium, undulate edge, rough surface (Culture XVII).

(ii) Round, white, flat, moist, entire edge, smooth surface (Culture XVIII).

(iii) Small, round, white, raised, entire edge, granular surface (Culture XIX).

(iv) Smooth, yellowish, flat, round, entire edge, finely granular surface (Culture XXVII).

These were all obtained from the cultures inoculated with surface water. No satisfactory development of colonies was obtained on the plates from the cultures inoculated with the 20 fathom and 100 fathom samples probably for the reason suggested in the footnote on p. 21.

The Precipitation of Calcium Carbonate.

In all the cultures in the denitrification media bacterial growth was accompanied by the formation of a white precipitate clearly distinguishable from the growth itself. Culture of the organisms isolated on Medium A was also accompanied by a granular precipitation in the medium. This has already been referred to in connection with the direct cultural examination of the water samples.

The precipitates in the liquid cultures settled after a few days on the walls of the flasks and gradually increased in thickness as growth progressed, particularly at the surface of the cultures where growth was most active. The deposits were scraped off the flasks and examined microscopically and chemically and were found to consist of spherular crystalline nodules of calcium carbonate containing traces of magnesium carbonate. The deposits in the solid medium were separated by dissolving the latter in boiling water and centrifugalizing the solution whilst still hot. They seemed to consist of the same material.

Specimens of the precipitates obtained by these means were submitted to Dr. Edwin T. Hodge of the Geological Department of the University of British Columbia for mineralogical examination. From a consideration of the optical properties of the precipitates Dr. Hodge considered that they consisted of calcite. He found perfect rhombs scattered throughout all the precipitates from liquid media, but only spherules in the preparation from the agar medium. In the former case the cleavages are related to each other at angles which are a little small for calcite which Dr. Hodge suggests may be due to the presence of the dolomite molecule. The precipitates agree therefore in the main in mineralogical properties with those obtained by Drew by the action of marine denitrifying organisms.

This precipitation of calcium carbonate does not seem to depend entirely on the production of nitrite or of ammonia in the cultures. It occurred quite as strongly in the cases of the cultures inoculated with the 100 fathom sample, in neither of which nitrite was formed and in only one of which ammonia developed, as in the others. In the cases in which ammonia was formed, either by reduction of the nitrite or by the break down of peptone, the calcium carbonate clearly resulted in part from the direct interaction of the CO_2 produced by bacterial action, on the calcium salts in solution. Granted the presence of a base to combine with the acid radicle set free from the calcium salt this reaction is bound to occur in neutral solutions and it is clear that ammonia when present will so function. In cases where denitrification occurs (as in those studied by Drew) the base liberated by the complete elimination of the acidic group from the nitrate will also perform the function,[1] but in cases where neither ammonia forma-

[1] It is interesting to note in this connection that precipitation of calcite takes place in media containing the same constituents as those dealt with here, but made up with distilled water, under the influence of organisms isolated from soil.

tion nor denitrification takes place, as in that of the culture in Medium B inoculated with the 100 fathom sample, another explanation is called for. In such cases the production of calcium carbonate undoubtedly results from the direct oxidation of the calcium acetate.[1] Since there is no other source of carbon for the utilization of the bacteria than that of the calcium acetate it is clear that a proportion of this carbon must be eliminated by their growth. This elimination may perhaps be represented by some such equation as the following:—

$$Ca\,(COOCH_3)_2 + O_2 = Ca\,CO_3 + 3\,H_2O + \text{"3C"}$$

The presence of ammonia or other base is clearly unnecessary in order that such a reaction may result in the formation of the normal carbonate and a reaction of a similar kind must occur in any case where no source of carbon other than that of an organic calcium salt is present in a medium in which bacterial growth takes place.

It seems questionable whether precipitation of calcium carbonate in the manner in which it occurred in the cultures can be a factor under the conditions which obtain in the open sea. Its occurrence depends on the relative concentration of the calcium salts and the carbonic acid present and under normal conditions in the sea this relation is the reverse of that holding in the culture solutions. In the latter case the concentration of calcium salts is high and that of the carbonic acid nil; in normal sea-water the concentration of calcium salts is relatively low and that of carbonic acid high. In these circumstances bacterial production of CO_2 would not lead to the precipitation of calcium carbonate. If the equilibrium is upset by the production of ammonia or by denitrification the case is altered and the

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[1] The writer has been working on the fermentation of the Giant Kelp (macrocystis pyrifera) since this paper was written. This fermentation has recently formed the basis of a process for the production of Acetone conducted by the Hercules Powder Company at San Diego, California. It is of interest in connection with the observation that bacteria capable of oxidizing organic salts to carbonates exist in the sea, because the essential products of the fermentation are acetic acid and other members of the fatty acid series. The fermentation process is a purely spontaneous one and there is every reason to suppose that the kelp undergoes the same changes after death in its natural habitat as it does in the factory. If this is the case, it follows that the carbohydrate substances, of which the organic portion of kelp is almost entirely composed, are constantly being returned to the sea in the form of fatty acids. These would be neutralized by calcium carbonate, or similar basic substances, and the salts formed would in due course be converted into carbonates by bacterial action. It seems not unlikely that such a cycle of reactions between vegetable and mineral material is common in the sea and accounts in great measure for the maintenance of the balance between acids and bases. Similar reactions have been shown to occur in soil under the influence of bacteria by Hall and Miller. (Proc. Roy. Soc. B., Vol. 77, 1905).

separation of calcium carbonate will then depend on the new equilibrium set up between the base produced and the carbonic acid in solution. It is clear that under these conditions calcium carbonate may be precipitated from the bicarbonate already in solution, quite apart from fresh CO_2 introduced into the system by the vital activity of organisms. It is very doubtful, however, whether the production of ammonia would go on sufficiently rapidly in the open sea to neutralize the carbonic acid in solution, except perhaps in the immediate neighbourhood of a mass of decaying organic material, in which case the reaction may also be a factor in the production of calcareous fossil casts. Denitrification, to any significant extent, appears to be a factor in this connection only in special cases and in warm seas. It should be borne in mind, too, in considering the question from the geological standpoint, that in the deep sea, though conditions may conceivably be such as to lead to the bacterial production of calcium carbonate at or near the surface, where, due to both temperature and pressure, the concentration of carbonic acid is relatively low, it would probably be redissolved at depths where the concentration was greater.

The case studied by Drew seems to have been one of a somewhat special nature in which, not only were denitrifying organisms prevalent in the sea, but also the concentration of carbonic acid was low, due to its high temperature and comparatively small depth, and that of calcium salts high, due to the draining into the sea of a heavily wooded country with a calcareous subsoil.

Ammonification

The power of producing ammonia from complex organic nitrogenous substances is one very commonly possessed by bacteria. The usual method of testing for it is to inoculate into a medium containing Peptone in solution and to test the culture with Nessler's Reagent after incubation. This method was employed here, the medium used being a ·2 per cent solution of Peptone in sea-water. This medium was neutral and contained only a trace of ammonia. Flasks containing 25cc. of it were inoculated with ·3cc. of each sample of sea-water; three were kept at 28°C and three at air temperature and a "blank" kept under like conditions in each case. As in the case of the denitrification cultures the flasks inoculated with the 20 fathom and 100 fathom samples and kept at 28°C failed to show any growth. The flask inoculated with the surface sample and kept at this temperature developed a heavy flocculent growth after 2 days. The growth had a peculiar "woolly" appearance exactly like that which had been seen all through the sea when the sample was taken. So remarkably like this was it that reinoculation was repeated several times into larger volumes of the medium and in every case the same peculiar appearance developed. The similarity may have been mere coincidence, but it seems quite probable that the appearance in the sea was due to some large mass of organic material undergoing bacterial decomposition. It is significant in this connection that only a few days previously, at spots not far distant from that at which the sample was taken, the surface tow-net had brought up solid hauls of practically pure cultures of Ctenophora. A test of one of these surface water cultures in the Peptone medium showed copious ammonia production after 2 days. Microscopic examination of the culture showed an apparently pure growth of an actively motile round-ended bacillus about $\cdot 5\mu$. wide and $1 \cdot 5$ to $2 \cdot 5\mu$. long in an active state of division.

The cultures kept at air temperature all showed growth in 3 days. The culture from the surface sample the strongest, the 20 fathom sample rather less and the 100 fathom sample least. The culture from the surface sample had, however, not developed the peculiar flocculent precipitate formed at 28°C; the medium was uniformly turbid and a thick scum had formed on the surface. All showed the presence of ammonia, the surface culture more strongly than the others.

All the cultures showing growth were plated on a medium consisting of the $\cdot 2$ per cent Peptone sea-water with 2 per cent of Agar added. The reaction of this medium was less acid than $+\cdot 5$ (*i.e.* contained less than $\cdot 5$ per cent normal acid) and was therefore not neutralized. As in the previous cases no growth was obtained on the plates from the 20 fathom and 100 fathom samples. From the cultures from the surface sample the following types of colony were obtained and subcultures made from one of each on to slopes of the same medium:—

(i) Small, round, cream-coloured, flat, smooth surface, entire edge (Culture X).

(ii) Like (i), but white and spread (Culture XII).

(iii) White, flat, round, finely granular surface, slightly undulate edge, dry and adherent to medium (Culture XIV).

(iv) Like (iii) but smaller (from different plate) (Culture XV).

Inoculations were also made into a 2 per cent solution of Casein in sea-water from the surface sample in order to test the power of ammonia formation from a more complex nitrogenous compound than Peptone. Ammonia was formed in quantity after 3 days incubation at 28°C.

Nitrification

By nitrification is meant the conversion of ammonia into nitrite and nitrate. These processes are carried out in the soil by very specialized groups of bacteria and it seemed of interest to determine whether organisms of a like kind could be found in the sea-water under examination.

The only reference to work on these lines which I have been able to find is in a paper by Thomsen quoted by Drew; [1] but this author appears to have isolated his organisms from the bottom of inshore waters.

Each of the samples was inoculated into a 2 per cent solution of ammonium sulphate in sea-water containing magnesium carbonate in excess. Cultures were kept both at 28°C and at air temperature as in the previous cases, but no growth appeared to take place and no trace of nitrite or nitrate could be found in any of them after three months. It cannot be taken from a single series of experiments that nitrifying organisms do not occur even in the samples examined, still less that they do not occur at all in the open sea. It is true that any normal soil would have produced nitrate under the same conditions in a much shorter period than three months, but these conditions may not be suitable for the development of marine forms. Cultivation should be tried in solutions of salts of ammonia other than the sulphate and of different concentrations. The presence of organic nutrient material in culture solutions may be necessary for marine nitrifying forms, if such exist, though it is injurious to soil forms.

The question of the occurrence of nitrifying organisms in the sea is of considerable interest in its bearing on that of the form in which marine plants absorb their nitrogen. Recent work has shown that land plants can assimilate nitrogen from ammonium salts direct, though normally they are converted into nitrate by nitrifying bacteria before assimilation. If marine plants require their nitrogen in the form of nitrate, and no agency exists in the sea for oxidizing the ammonia produced by the break down of complex organic compounds, they must depend upon nitrates produced by bacterial agency on land and washed into the sea. This seems to be in the highest degree unlikely for the result would be an accumulation of ammonia in the sea and a gradual depletion of the store of nitrogen on land for the benefit of life in the sea, except in so far as the loss from the land could be made good by nitrogen fixation.

[1] Thomsen, R., 1910. "Ueber das Vorkommen von Nitrobakterien in Meere." Wiss. Meeresunters, Vol. XI. Kiel.

It is probable that floating marine plants absorb their nitrogen from ammonium salts, for, as has already been pointed out, the reaction of sea-water is normally acid from the bicarbonates (and possibly free CO_2) in solution, and, arguing by analogy with soil organisms, it is questionable whether nitrification would take place in these circumstances. Where the water contains chalk, or other carbonate, in suspension the conditions would be suitable for nitrification. At the sea bottom, for instance, where chalk is accumulating, or on calcareous rocks, nitrification might be expected to take place provided sufficient oxygen were available. Marine plants growing in such situations may therefore obtain their nitrogen as nitrate and differ in this respect from floating forms.

Nitrogen Fixation

If denitrification occurs to any considerable extent under normal conditions in the sea the question of the existence there of a capacity for the fixation of free nitrogen becomes a most important one, for, if such capacity does not exist, it means that the stock of fixed nitrogen on the earth's surface is being constantly depleted except in so far as nitrogen fixation on land is making the loss good. Only two agencies capable of fixing free nitrogen in quantity under the conditions existing on land are known with certainty, both bacterial, the nodule-forming bacteria (*Pseudomonas radicicola*) living in association with certain leguminous plants, and the free living soil bacteria of the groups *Clostridium pasteurianus* and *Azotobacter*. Something akin to the former of these two agencies seems to have been described by Keding and Keutner[1] in cases of marine bacteria living in association with algae or plankton organisms, and to the latter agency in free-living forms found on the sea-bottom close inshore. I have not been able to see either of these papers, but gather from the reference made to them by Drew that no free-living nitrogen-fixing organisms are described from the open sea.

Denitrification has not been found to be a factor in the conditions existing in the sea where the samples dealt with in this paper were taken. Nevertheless it seemed of interest to see whether any nitrogen-fixing forms could be isolated from them. Accordingly they were inoculated into media made up in the same way as those usually used for the isolation of Azotobacter in examining soil, substituting, of course, sea water for fresh water. The composition of the media was as follows:—

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[1] Keding, M., 1906. Wiss. Meeresunters, Vol. IX. Kiel. Keutner, J., 1905. Wiss. Meeresunters, Vol. VIII. Kiel.

Medium D

Glucose...............................	2·0 grams
Potassium phosphate (K_2HPO_4)..........	·2 gram
Sea-water.............................	1000 cc.

Medium E.

Same as Medium D with Mannose substituting Glucose.

Medium F

Same as Medium D with Glycerine substituting Glucose. The media were boiled, made just alkaline to phenolphthalein, and filtered before sterilization. As in the previous instances each sample of sea-water was inoculated with each medium and a set of each kept at 28°C and air temperature respectively.

The media were all perfectly clear after 3 months; no bacterial development appeared to have taken place and it is exceedingly unlikely that any nitrogen-fixation had occurred. Facilities were not available for confirmation of this by chemical means, but, in the absence of any sign of growth in the culture, this seemed hardly necessary.

So far as they go then these experiments point to the absence of any free-living aerobic nitrogen-fixing bacteria in the samples examined. It would, however, be interesting to try other carbon compounds in the media, since those used in these experiments may not be sufficiently near in composition to those which result from the break down of marine plants and animals and are used naturally by nitrogen-fixing bacteria in the sea if such exist. It would also be particularly interesting to look for them in waters where denitrification occurs, since here, not only does nitrogen-fixation become a process of considerable significance inasmuch as it may modify the apparent loss of nitrogen occurring, but also, since there would be an abnormally large amount of free nitrogen dissolved in the water, conditions would seem to be good for the development of organisms capable of its assimilation.

Characterization of the Bacteria Isolated

Broth Cultures

In order to more closely characterize the bacteria isolated in the course of this work the cultures obtained were inoculated in the first place into broth made up with:—

(*a*) Tap-water.

(*b*) Tap-water with sufficient sodium chloride added (about 3 per cent) to make it up to the density of the sea-water used during the experiments.

(*c*) The same as (*b*) with addition of the following salts to make it more nearly the same composition as sea-water:—magnesium chloride ·36 per cent, magnesium sulphate ·23 per cent, calcium sulphate ·14 per cent, potassium chloride ·076 per cent.

(*d*) Sea-water.

The other constituents of the media were:—

"Lemco".................................	·3 per cent
Peptone (Witte's)........................	·5 per cent

The media were not neutralized since their reaction after boiling was less acid than + ·5.

The cultures were kept at air temperature for a week to ten days. Those showing no growth after this period were reinoculated and kept at 28°C.

None of the cultures in the (*a*) medium showed any growth at air temperature. Only No. XXVIII grew at 28°C.

In the (*b*) medium Nos. I, VI, XII, XIX, XXVII, XXVIII, showed growth at air temperature. No. X grew only at 28°C. All of these showed only a weak growth as compared with that obtained in sea-water broth and the remainder failed to grow at all.

In the (*c*) medium all the cultures grew at air temperature except Nos. XII and XXVII, which grew at 28°C, and Nos. III, VII, XV and XXII, which failed to grow at all.

In the (*d*) medium, sea-water broth, all the cultures grew at air temperature. The cultures showed considerable variation in vigour of growth some forming a thick scum and heavy precipitate, others little more than a turbidity. This is indicated in the summary of growth characteristics at the end of this paper by the figures 1, 2 and 3 respectively, 1 indicating a very strong growth, 3 a very slight one and 2 an intermediary degree. Hanging drops of the culture were examined as soon as growth was apparent and the degree of motility of the organisms present recorded in the same way, 1 indicating a highly motile form, 2 a slightly motile one and 3 an absence of motility. Films from each culture were also prepared and examined.

Precipitation of Ammonium Magnesium Phosphate.

In all of the cultures (except Nos. XXII and XXVII) in both artificial and natural sea-water broth, a crystalline precipitate, of which the individual crystals were easily visible to the unaided eye, formed after two or three weeks. The crystals were easily separated by centrifugalizing the cultures and were found to consist of ammonium magnesium phosphate. A solution of "Lemco" invariably contains phosphoric acid, presumably the result of the hydrolysis of the nucleo- and phosphorproteins of the meat used in its manufacture. The precipitation of ammonium magnesium phosphate in cultures evidently resulted from a combination of this phosphoric acid with the ammonia produced by bacterial action and the magnesium contained in the sea-water. Dr. Hodge kindly examined some of the precipitates from a mineralogical standpoint and reported their exact agreement in crystalline form with the mineral described by MacIvor under the name "Hannayite."[1] This appears to be the first record of the artificial production of this mineral, but I have found that crystals of the same form can be obtained by adding dilute ammonia gradually to a dilute solution of $MgNH_4PO_4 \cdot 8H_2O$ in acid. The composition of the mineral according to MacIvor is $Mg_2H_2(PO_4)_2 \cdot MgH_2(NH_4)_2\ (PO_4)_2 + 8H_2O$.[1] I am hoping to determine whether this is true of the salt precipitated by bacterial agency and by the chemical method described.[2]

In this connection it is worthy of note that the formation of crystals of ammonium magnesium phosphate, having the crystalline form of the mineral "Struvite," in artificial cultures of micro-organisms, has been previously recorded.[3] This mineral has been found by MacIvor to have the composition $Mg^2(NH_4)_2(PO_4) + 12H_2O$, and it is entirely different in crystalline form to Hannayite. No crystals of the form of Struvite have been found in any of the cultures in the course of this work.

The geological significance of the precipitation of this substance from organic matter in sea-water under the influence of bacteria is probably limited in the same way as that of the bacterial production of calcium carbonate. Its production in the open sea would probably depend on much the same conditions; that is to say it would be expected to occur only where a mass of decomposing organic material was giving rise to a local production of large quantities of ammonia and phosphoric acid. It would seem to be of some interest from the geological standpoint inasmuch as it suggests a means whereby the phosphoric acid combined in the soft parts of plants and animals may be thrown out of solution when they decompose and thereby contribute

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[1] MacIvor. Ch. News. 65. 215. 1887.

[2] Chemical analysis of these salts, carried out since this paper was written, shows them both to possess a composition approximating nearly to the formula $Mg.\ NH_4PO_4 \cdot 7\ H_2O$. It is probable that this compound is the predominating one in Hannayite and determines the crystalline form. MacIvor's analytical figures indicate a mixture of combinations of ammonium, magnesium and phosphoric acid.

[3] Robinson. Camb. Phil. Soc., May 20th, 1889, and Solly. Minn. Mag., 8, 279, 1889 (quoted by Dana in his "System of Mineralogy").

to the formation of phosphatic minerals and fossils. Ammonium magnesium phosphate may easily undergo transformation into calcium phosphate in contact with water charged with calcium bicarbonate and thereby supply an explanation of the deposition of that compound supplementary to that of its derivation from bony material on which attention is usually focussed.

Broth Agar Plates.

Each of the broth cultures was plated on Broth-Agar made by adding 2 per cent of Agar to the Broth (reaction unneutralized = $+\cdot 3$) in order to confirm the purity of the cultures. No. VII failed to grow and on making a subculture into a fresh broth tube (in order to avoid the submission to a high temperature involved in plating) this also failed, showing that the organism had died out. This culture was therefore lost. A typical colony from each plate was subcultured on to a slope of the same medium. In only one case was more than one type of colony obtained, that of Culture I. In this case each type was subcultured (Cultures IA and IB respectively).

Broth Agar Slopes.

The characteristics of the cultures obtained on Broth-Agar slopes could be divided into four classes to one or other of which all the cultures, except two (Nos. XV and XXVIII), conformed very nearly. These classes are designated in the table of characteristics as A B, C, and D respectively. They may be described as follows:—

Class A. Fairly dry, slightly spreading, grayish white, transparent.
Class B Dry, confined, white, opaque.
Class C. Moist, spreading, grayish yellow, transparent.
Class D. Fairly dry, confined, yellow, transparent.

In many of the cultures large crystals, similar to those formed in the broth media, were found imbedded in the Agar after a month or so. They were separated, by dissolving the medium in hot water and centrifugalizing hot, and were found to have the same crystalline form and qualitative chemical composition as those isolated from broth

Films from each of the Agar cultures were made and stained in the routine manner as soon as growth was well established. A second series was made a few days later and stained by Gram's method. Where the organism failed to stain by this method the ordinary staining was repeated in order to note any change that took place in the morphology of the organism with age.

Gelatin Stab Cultures

A gelatin medium was prepared by adding 12 per cent of gelatin to the broth medium. It was made just alkaline to phenolphthalein. Stab cultures were made from each of the agar cultures into this medium and kept at 18°C. Three degrees of liquefying power were noted in the various cultures. These are designated by 1, 2 and 3 in the following table: 1 indicates that the medium was almost entirely liquefied after 2 weeks, 2 indicates a slight liquefaction, and 3 that no liquefaction occurred at all. In the last cases the organisms, though they all grew both at the surface and along the track of the needle, developed no particularly characteristic manner of growth.

Denitrification Media

Each of the agar cultures was subcultured into each of the two denitrification media (Media B and C respectively) and incubated at 25°C. All the cultures in Medium B, except X, XII and XIV, showed growth accompanied by varying degrees of precipitation of calcium carbonate after 4 days. After 17 days this precipitation had increased considerably in some of the cultures, particularly at the surface and particularly in the cases of Cultures 1A, III and XXII. Each of the cultures was tested at this stage for alkalinity to phenolphthalein, for ammonia and for nitrite. None of them gave any reaction for ammonia. All the cultures in Medium C showed growth and precipitation after 2 days; they had developed a strong turbidity and heavy precipitate, accompanied in some cases by a scum and a ring of calcium carbonate on the walls of the tube at the surface of the culture, after 10 days. They were tested at this stage for alkalinity to phenolphthalein, for ammonia and for nitrite. All of them showed the presence of ammonia.

The results of the tests for alkalinity to phenolphthalein and for nitrite are summarized in the following table, + indicating a positive reaction, —a negative one. The uninoculated tubes incubated with the cultures showed no deposition of calcium carbonate and no alkalinity to phenolphthalein. The definitely alkaline reaction which some of the cultures produced in Medium B may be due to a limited denitrification having taken place or to the production of normal calcium carbonate in the solution by oxidation of the calcium acetate. The latter explanation seems most probable since the strongest alkaline reaction was set up in some cases where no trace of nitrite was found and there was not the faintest indication of bubbling in any instance. The precipitation of calcium carbonate to some extent in all these cultures, and in some cases quite heavily, brings out very definitely the independence of this precipitation on nitrite or ammonia production. The absence of alkalinity to phenolphthalein in some of the cultures in Medium C in spite of their showing an ammonia reaction must be due to the ammonia being completely neutralized by the acid displaced from the calcium acetate or by carbonic acid, so that it is present only as acetate or bicarbonate.

Another point of interest in connection with these cultures is that nitrite is produced by many of the organisms in Medium B, but not in Medium C. This seems to indicate that, although these organisms can break down nitrate to obtain their nitrogen, they do so only in the absence of such complex organic nitrogen compounds as peptone.

Similarities Amongst the Organisms Isolated

Each culture whose characteristics are described in the annexed table originated from a single colony from a plate showing colonies of only one kind, and this plate was itself derived from a culture obtained from a single colony on a previous plate. There can therefore be little doubt as to the purity of the cultures. The variation in form seen in many of the cultures both in Broth and on Agar can therefore be attributed to nothing but polymorphism on the part of the organisms so that the miscrocopic form is of little service in establishing identities between the various cultures. For this reason the measurements given were not determined in specially carefully fixed specimens. They should, however, be comparable amongst themselves since all were fixed and stained under like conditions. The forms in cultures having quite different growth characteristics showed in many cases close approximation to one another, there was in fact frequently as close agreement in form and size between the organisms in two different cultures as there was between the individuals in either of them. The age of the culture also made a very considerable difference in the size of the organisms found in it. In many cases, for instance, the agar culture when examined at two or three days old showed an organism nearly twice as long as any found when the same culture was examined a few days later when testing the ability of the organism to stain by Gram's method. The size of the organism has therefore been taken into account only in the most general way in endeavouring to establish identities between the various cultures.

Chiefly therefore from a consideration of the other characteristics it is considered that the following cultures are identical or very nearly allied forms:—

II, III and XV.
V, XXII (and possibly IA).
IB and XIX.
X and XII.
IV and XVIII.

The others seem to differ so widely in some characteristics from those of either of these groups and from one another as to leave little doubt that they are separate species. They are not sufficiently well characterized, nor have I had sufficient literature at my disposal, to determine whether any of them are new.

At least ten different species have therefore been isolated. Probably more were present in the water but were missed owing to the specialized nature of the culture media used. For instance, No. (iv) of the forms seen on direct examination of the surface sample was not obtained in culture and no organism from the 100 fathom sample was fully characterized though bacteria were undoubtedly present.

The complex nature of the bacterial flora thus shown may be due to the presence of fresh-water forms since the low density of the water clearly indicated fresh water dilution. On the other hand the fact that none of the organisms isolated would grow in fresh water media seems to show an adaptation to saline conditions. It is hoped at some future time to repeat the work with samples from such a locality that this doubt cannot arise.

In conclusion I wish to express my thanks to the late Dr. Wesbrook and Dr. Mullin, the past and present professors of bacteriology at the University of British Columbia, for their kindness in allowing me the use of their laboratory in which this work was carried out.

CHARACTERISTICS OF ORGANISMS ISOLATED

Number of Culture	Biological							Morphological*			
	Broth	Agar	Gelatine	Denitrification				Motility in Broth Culture	Form in Broth Culture	Form in Agar Culture	Staining by Gram's Method
				Medium B		Medium C					
	Vigour of Growth	Cultural Charac-teristics	Degree of Lique-faction	Alkalin-ity	NO_2	Alkalin-ity	NO_2				
I A		A	2	+ slight	trace	+	–		Singles and pairs. $W = \cdot 8\mu$; $L = 1$ to 3μ. Some bent forms. Many dividing. Some almost Cocci $\cdot 8$ to 1μ in diameter.	Singles and a few pairs. $W = \cdot 7\mu$; $L = 1$ to 3μ. Some bent individuals. Some showing unstained spots.	+
I B	1	B	3	+	trace	+	–	1		Singles, pairs and chains of 3 or 4. $W = \cdot 7\mu$; $L = \cdot 7$ to 1μ. Mostly short coccus-like forms.	–
II	1	A	2	+ slight	+	+	+	2	Singles and pairs. $W = \cdot 6\mu$; $L = 1$ to 3μ. Many dividing. Some Cocci $\cdot 6\mu$ diam. Beaded staining.	Mostly pairs and dividing organisms. $W = \cdot 5\mu$; $L = \cdot 7$ to $2 \cdot 5\mu$.	–
III	1	A	2	–	+	+	+	1	Singles, pairs and chains of 3 or 4. $W = \cdot 5\mu$; $L = \cdot 7$ to 3μ. Newly divided organism about $\cdot 7\mu$ long.	Singles. Few dividing, some bent. Slight polar staining. $W = \cdot 5\mu$; $L = \cdot 7$ to $2 \cdot 5\mu$.	–
IV	1	C	2	+	–	–	–	2	Singles and pairs. $W = 1\mu$; $L = 1 \cdot 5$ to 3μ. Newly divided organism about $1 \cdot 5\mu$ long.	Singles and a few pairs. $W = \cdot 4\mu$; $L = 1\mu$. Poor and dotted staining.	–
V	1	B	2	+	–	–	–	3	Singles and pairs. $W = 1\mu$; $L = 1$ to 3μ. Some almost Cocci 1μ in diam.	Coccus $\cdot 5$ to $\cdot 7\mu$ diameter. Pairs and short chains.	+
VI	1	A	1	+	–	+	–	1	Singles and pairs. $W = 1\mu$; $L = 1$ to 6μ. Both short and long individuals dividing.	Singles and a few pairs and dividing individuals. $W = \cdot 7\mu$; $L = 1 \cdot 5$ to 3μ.	–
X	2	D	3	–	–	–	–	3	Singles and pairs. $W = 1\mu$; $L = 1 \cdot 5$ to 3μ. Many dividing.	Chiefly singles. Very regular. $W = 1\mu$; $L = 2$ to 3μ.	–
XII	3	D	3	–	trace	–	–	3	Singles, pairs and long chains (3 to 12 individuals of various length). $W = \cdot 8\mu$; $L = 1 \cdot 5$ to 6μ.	Chiefly chains of 3 to 12 individuals of various length. $W = \cdot 8\mu$; $L = 1$ to 8μ. A few singles and pairs.	–
XIV	1	A	2	–	–	–	–	2	Chiefly singles. $W = 7\mu$; $L = \cdot 8$ to 2μ. Some oval forms. Polar staining.	Chiefly singles. $W = \cdot 5\mu$; $L = \cdot 7$ to $2 \cdot 5\mu$.	–

XV	2	Between A & B	2	–	+	+	+	2	Singles and pairs. W = ·5μ; L = ·7 to 3μ. Polar staining.	Singles and pairs. W = ·5μ; L = ·7 to 1·5μ. A few as long as 3μ.	–
XVII	1	B	3	+	–	–	–	1	Coccus or very short bacillus—·4μ diameter. A few ·4μ x ·7μ.	Coccus ·5 to ·7μ diameter. Pairs and short chains.	+
XVIII	1	C	2	+ slight	+	–	+	2	Singles and pairs. W = ·7μ; L = 1 to 1·5μ. Some ovals. Polar staining. Some irregular (involution?) forms ruuning up to 4 or 5μ.	Chiefly singles. W = ·4μ; L = ·5 to 2μ. Tendency to spindle forms and irregular staining.	–
XIX	3	B	3	+	trace	+	–	2	Singles, pairs and short chains W = 1μ; L = 2 to 10μ. Also shorter singles and pairs 1μ x 2 to 3μ.	W = Chiefly singles. W = 4μ; ·L = 2 to 3μ. A few longer individuals (4 to 5μ) in short chains.	–
XXII	1	B	1	+ slight	+	+	trace	1	Singles and pairs. W = 1μ; L = 2 to 3μ.	Coccus ·5 to ·7μ diameter. Pairs and short chains.	+
XXVII	3	B	2	+	+	+	+	3	Very short—almost Cocci. W = ·7μ L = ·7 to 1μ.	Pairs and short chains. W = ·5μ; L = 1μ. Pairs commonest. Looks like diplococcus.	–
XXVIII	3	smooth dry pale yellow	–	+	+	–	–	1	Chiefly singles. Few dividing. W = 1μ; L = 1·5 to 3μ.	Coccus or very short bacillus. W = ·4μ; L = ·4 to ·5μ.	–

*All forms were round-ended Bacilli unless otherwise stated. W = average width of organisms. L = extremes of length of organisms.

Copepods Parasitic on Fish from the Vancouver Island Region

By C. McLEAN FRASER, Ph.D., F.R.S.C.

(Read May Meeting, 1919.)

In "Contributions to Canadian Biology, 1906–1910," a paper by Dr. C. B. Wilson was published, under the title, "Parasitic Copepods from Nanaimo, British Columbia, including eight species new to science." This report was based on a number of specimens sent from the Biological Station by the late Rev. G. W. Taylor. Since this publication appeared, although no systematic attempt has been made to collect copepods, quite a large number has accummulated. The additions to the collection include many specimens of species that appear to be new as well as those already described, and it is well that they should be reported, although it is fully recognized that even the list to date is far from being a complete list of the copepods that are to be found on the fish that inhabit the waters of the strait of Georgia in the vicinity of the station.

Wilson listed 13 species. To those 13 more are added, 11 of them new and 2 already described but not reported from this region. The 11 new species are:—*Bomolochus cuneatus*, *Ergasilus turgidus*, *Lepeophtheirus bifidus*, *L. breviventris*, *L. hospitalis*, *L. parvicruris*, *Chondracanthus deltoideus*, *C. gracilis*, *C. irregularis*, *C. rectangularis* and *Nectobrachia indivisa* (*Nectobrachia*, a new genus). The two not previously reported are:—*Caligus gurnardi* and *Echthrogaleus coleoptratus*. The male of *Lepeophtheirus nanaimoensis* has also been found. In some cases, copepods already reported, have been found on hosts other than those from which they were first reported.

The list here presented includes those in Wilson's list as well as those now reported from the vicinity for the first time.

Family ERGASILIDÆ

BOMOLOCHUS CUNEATUS new species

Pl. I, Figs. 1–11

Female.—General body form cuneate, tapering very regularly from the anterior to the posterior. Cephalothorax slightly narrower and more rounded anteriorly than posteriorly, length two-thirds width. The carapace does not cover the first antennæ but a small lobe projects between the bases. Second, third, fourth and fifth segments decreasing regularly in width, each of them being nearly three-fourths of the one preceding; the fifth is about one-fourth the width of the carapace. The second segment is one-half the length of the cephalothorax, the third slightly longer, the fourth about half the length of this and the fifth about one-third the length of the fourth. Genital segment slightly wider than the fifth segment, nearly the same width throughout; the sixth pair of legs is represented by papillæ, each bearing three setæ. Abdomen not very distinctly separated from the genital segment, and not definitely divided into segments, tapering gradually, with a lateral seta on each side where it joins the laminæ; the anal laminæ are not distinctly separated from the abdomen, rather slender, well separated from each other; one short lateral and three terminal setæ, of which the inner is quite long, as long as the abdomen and anal lamina. Egg strings elliptical, nearly two-thirds of the total length of the body, with 5 or 6 vertical and 24–26 horizontal rows of eggs.

First antennæ showing the joints distinctly, the division of the two basal joints being indicated; heavy setæ appear around the margin of the first three joints, becoming more nearly parallel with the antennæ the farther from the base, the most distal one is longer and stouter than the others; there are two small setæ at the end of the fourth and fifth joints and four at the end of the terminal joint; from the second joint the tactile hairs project forward, the proximal one two and a half times, and the distal one twice the length of the setæ. Second antennæ with the terminal joint roughened; it is provided with three claws of unequal length, and a rough finger-like process. Labrum with length two-thirds width, a process projects at each side in front of the base of the mandible. Mandible small, smooth, projecting backward along the surface of the labrum. First maxilla with one longer seta extending diagonally to the median line and two shorter ones running backward side by side. Second maxilla with large base and broad terminal joint, reaching horizontally almost to the median line, blunt at the end and supplied with several setæ. Maxilliped with basal joint passing directly outward, second joint somewhat larger than the basal, passes outward in continuation of the first joint and then well forward so as to be well away from the remainder of the mouth parts, with a single large plumose seta at the distal end, curved like the joint and reaching backward past the proximal end of this joint; terminal claw S-shaped, passing backward to lie parallel to the second joint and to the seta of this joint, a little more than half of the length of the seta, provided with a long straight seta at the base and a small blunt, claw-like projection about two-thirds the distance from the base to the point.

The first legs have a two-jointed exopod, the basal joint unarmed, the terminal one with six large setæ, the endopod is three-jointed; each of the two basal joints have a large seta on the inner margin and hairs on the outer, the terminal joint has five setæ. The arrangement of the spines, and setæ on the other legs are as follows:—Second exopod, I–0. I–1, II–1, II–4; endopod, O–0, O–2, O–3; third exopod, I–0, I–1, I–1, II–4; endopod, O–1, I–0, III–2; fourth exopod, I–0, I–1, I–1, II–3; endopod, O–1, O–1, O–3. The fifth leg is two-jointed, the first joint is rectangular, the second clavate, with a spine near the centre of its outer margin and three at the tip.

Total length 1·9mm., cephalothorax, length 0·64 mm., width 0·96 mm., length of the four free thoracic segments 0·9 mm., width of genital segment 0·25 mm., length of anal setæ 0·3 mm., length of egg strings 1·2 mm.

(*Cuneatus*, from general shape of the body).

Only females were obtained, these from the gills of the Pacific herring, *Clupea pallasii*, and the gills of the shiner or small viviparous perch, *Cymatogaster aggregatus*.

Ergasilus turgidus new species

Pl. I, Figs. 12–14, Pl. II, Figs. 15–21

Female.—Body long and slender, over two and a half times as long as wide, narrowing gradually posteriorly. Head completely fused with the first thoracic segment without any indication of the junction. Carapace almost two-thirds of the body length, much arched, hence the body is one-third deeper than wide, it makes a slight, blunt projection anteriorly and posteriorly extending to entirely cover the second thoracic segment so that it cannot be seen in dorsal view; a line passes transversely across the carapace just at the base of the second antennæ and another about twice as far back of this as this is from the anterior margin; posterior margin almost straight but slightly rounded laterally. The third thoracic segment nearly as wide as the posterior portion of the carapace, the fourth narrower than this and the fifth still narrower. Genital segment about the same width as the fifth and a little longer than the fourth and fifth together. Abdomen three-jointed, the first one narrower than the genital segment and the other two slightly tapering from this. Anal laminæ same length as the last segment, well separated, each provided with three setæ, the innermost one being more than twice as long as either of the other two.

Egg strings almost cylindrical, but tapering slightly from anterior to posterior, longer than the body and two-thirds the width, eggs in 4 to 6 longitudinal rows with about 20 eggs in each row.

First antennæ short, reaching about half way along the second segment of the second antennæ, six-jointed, well provided with setæ, two on first joint, four on second, two on third, two on fourth, two lateral and a terminal on the fifth and three terminal on the sixth. Second antenna with length equal to width of carapace, distinctly four-jointed; basal joint short, with a large globular swelling, whose diameter is twice as great as the diameter of the main portion of the joint; second joint longer than the first, smooth; third joint with a ridge going partly around the base, and a blunt spine or tubercle on the inner surface of the claw which is not very strongly curved. Mouth parts small. The mandibles are wide and are fringed with long hairs, the palp is slender and the hairs on it are short. The first maxilla is small and the two setæ are short. The second maxilla is enlarged at the end of the terminal joint to be somewhat clavate, this clavate portion is well provided with hairs.

In the four pairs of swimming legs, the endopod is larger than the exopod in each instance except in the case of the third where they are nearly equal in length; all the rami are three-jointed with the exception of the fourth exopod which is one-jointed. The fifth legs are small with a basal portion and a terminal claw or seta. The arrangement of the spines and setæ on the four pairs of legs are as follows: first exopod, I-0, 0-1, II-5; endopod, 0-1, 0-1, 1-3; second exopod, 0-0, 0-1, I-5; endopod, 0-1, 0-1, I-4; third exopod, 0-1, 0-2, 0-5; endopod, 0-1, 0-2, I-4; fourth exopod, I-4; endopod, 0-1, 0-2, I-4. Total length 0·78 mm., length of carpace 0·51, width 0·30, depth 0·39; length of egg strings 0·82, width 0·21.

(*turgidus*—referring to basal joint of antennæ).

Found on gill filaments of the small viviparous perch, *Cymatogaster aggregatus.* No males were obtained.

Family ARGULIDÆ

Argulus Borealis Wilson

Argulus borealis. Wilson, Contr. to Can. Biol., 1912, p. 84.

Specimens of this species have been found on *Lepidopsetta bilineata*, the host from which they were originally described, and also on *Hippoglossoides elassodon.*

ARGULUS PUGETTENSIS Dana

Argulus pugettensis DANA, U.S. Exploring Exped., 1838–1842, vol. XIII. The Crustacea. 1852, p. 1351.
WILSON, Proc. U.S. Nat. Mus., vol. XXV, 1903, p. 711.
WILSON, Proc. U.S. Nat. Mus., vol. XXXV, 1909, p. 432.
WILSON, Contr. to Can. Biol., 1912, p. 87.

The rainbow trout, *Salmo irideus*, and the blue perch, *Taeniotoca lateralis*, served as the hosts for this species in the specimens examined by Wilson. They have also been found on the steelhead trout, *Salmo gairdneri*, and the silver perch, *Phanerodon furcatus*.

Family CALIGIDÆ

CALIGUS GURNARDI Kröyer

Caligus gurnardi KRÖYER, Naturh. Tidsskrift, Ser. 3, vol. II, 1863, p. 150.
WILSON, Proc. U.S. Nat. Mus., vol. XXXV, 1909, p. 439.
SCOTT, T. and SCOTT, A., Br. Parasitic copepods, 1913, p. 52.

Many specimens have been found in different stages and on a great variety of hosts, one in a plankton haul, May 9, 1917, made in Northumberland channel, at the edge of the Dodds narrows tide-rip. The hosts were: the steelhead, *Salmo gairdneri*, the dog salmon, *Oncorhynchus keta*, the rock cod, *Sebastodes* sp., and the Pacific herring, *Clupea pallasii*. The young stages were found on herring less than two inches long, when the scales were just beginning to appear.

Wilson has reported some from other points on the Pacific coast from the spring salmon, *Oncorhynchus tschawytscha*, and the rat fish, *Hydrolagus collei*.

LEPEOPHTHEIRUS BIFIDUS new species

PL. II, FIGS. 22–35

Female: Carapace nearly circular but flattened posteriorly; frontal plates well defined; posterior sinuses broad, widely separated, leaving a median lobe almost half the greatest width of the carapace; lateral lobes broad and well rounded. Free thoracic segment half the width of the genital segment, of medium length. Genital segment nearly half the length of the carapace, considerably wider than long, well rounded anteriorly and posteriorly. Abdomen small, one-third the length of the genital segment, length and width nearly equal. Anal laminæ large, curved outward, each one supplied with three long and one short setæ and a short spine placed just dorsad to the inmost seta.

The two joints of the first antennæ of nearly the same length, well supplied with setæ. The second antennæ quite long, with the terminal hook sharply curved; a short, stout spine is attached to the basal joint. Maxillary hook stout, shorter than the claw of the second antenna. Rami of first maxilla somewhat dissimilar; the outer one is distinctly flanged, with a distinct constriction at the base, the inner slightly longer, without a noticeable flange, with its axis in a slightly different plane; neither branch is as long as the basal portion. The second maxillæ are long and slender, the second joint being half as long again as the first. Maxillipeds stout, with the second joint almost as long as the first, the accessory spine scarcely noticeable. Furca short but very wide, wider at the tip than it is long and nearly this width throughout; the sinus between the rami reached half way to the base of the joint and the base of the sinus is made up of two concave portions meeting in the middle line; each ramus is bifid, each with a secondary sinus shaped like an inverted V; the four points thus formed are rather abruptly pointed but not rounded; the secondary sinuses are not so deeply cut as the primary sinus.

The first swimming legs are of medium length, the second joint being the longest; the first joint has a small spine on its antero-lateral border and a stouter one on its postero-lateral; the four setæ on the terminal joint decrease in length distally, the most distal being as short as the shortest of the three terminal claws. There is a long seta on the basal joint of the second leg; the second joint is longer than broad; the exopod and endopod are much the same length; the inner side of the second joint of the endopod projects beside the terminal joint so that the setæ on the end of it are in line with the setæ on the terminal joint. The spine at the base of the third leg is stout and blunt. The fourth legs are four-jointed; the first joint is stout with a spine at its distal end; the third joint has a short, stout spine distally and the terminal joint has three spines. The fifth legs are well defined but do not show dorsally.

Total length 4·7 mm., length of carapace 2·9, width 2·9, length of genital segment 1·3, length of abdomen 0·3, length of egg strings 3·1.

Male: Carapace much similar in shape to that of the female. Free thoracic segment but slightly narrower than the genital segment. Genital segment with length and breadth nearly equal, well rounded anteriorly and posteriorly, scarcely one-third of the width of the carapace. The fifth and sixth legs show distinctly from the dorsal side. The abdomen is quadrangular, wider than long. The anal laminæ are relatively long, each being provided with three long plumose setæ and two small spines, one placed interiorly and the other exteriorly.

In the appendages the main differences from that of the female are in the second antennæ and the first maxillæ. The second antenna has a stout base, and the terminal claw has a small accessory claw on each side of it. The first maxilla is relatively smaller than that of the female; there is a spine present rising from the shoulder of the inner ramus and running parallel to it.

Total length 3·2 mm., length of carapace 2·1, length of genital segment 0·65, length of abdomen 0·4.

Colour: Uniformly yellowish.

Nauplius: Body oval, nearly twice as long as wide; anterior end truncate, posterior end rounded; balancers of medium size. Pigment present in large amount; a single large shovel-shaped mass reaches almost the whole length of the body, with the tip of the shovel at the posterior end; there is a small oval spot, sometimes two, in the median line in which the pigment is absent. The pigment is a bright purple. Length 0·39 mm., width 0·21.

(*bifidus*, referring to the bifid rami of the furca.)

Found on the outer surface of the flounder, *Lepidopsetta bilineata.*

LEPEOPHTHEIRUS BREVIVENTRIS new species

PL. III, FIGS. 36–46

Female: Body rather small; carapace slightly broader than long, rounded anteriorly and posteriorly; lateral grooves well in from the margin, transverse groove well forward; posterior sinuses deep but not very wide; lateral lobes narrow, median lobe five-ninths the width of the carapace, rounded posteriorly and projecting backward farther than the lateral lobes. Free thoracic segment, one-third the width of the carapace. Genital segment slightly broader than long, well rounded anteriorly and posteriorly with scarcely any sign of posterior lobes in dorsal view; on the ventral surface the two pairs of rudimentary legs are visible but only the setæ of the outer pair are visible dorsally;

each of the outer pair has a seta and of the inner pair three, nearly equal in length. Abdomen very short, only one-fifth as long as broad. Anal laminæ widely separated, small, each supplied with five setæ, of which the three inner are much longer than the two outer Egg-strings two-thirds the length of the body, with about 50 eggs in each string.

First antennæ projecting beyond the carapace, the terminal joint slender, slightly longer than the basal joint. Second antenna with the terminal claw long, slender and abruptly bent near the end; the basal joint is provided with a short spine. Maxillary hook stout, tapering rapidly to a sharp point, strongly curved. First maxilla small, with both rami sharp-pointed, the inner much smaller than the outer. Just posterior to the outer portion of the maxilla there is a papilla provided with two spines, an inner, shorter and an outer, much longer. Furca, with rami rounded at the tip, but little separated at the base, looking like the fangs of a premolar tooth. The two joints of the second maxilla are nearly equal in length, both joints free of spines. Maxillipeds short and stout in both joints, no spines.

In the first swimming leg, the spine on the basal joint is strong; a small spine is present at the antero-dorsal margin of the second joint. Basal joint of the second leg with a strong spine on the posterior border. The rami of the third leg are not widely separated; the spine at the base of the exopod is as long as the breadth of the joint. Fourth leg stout; a short spine at the distal end of the basal joint; second joint with a short claw; third joint larger than the second, with a strong spine; terminal joint the shortest, with four spines, the inner short, the next one long, the fourth short but longer than the first.

Total length 3·68 mm., length of carapace 2·14, width 2·32, length of genital segment 1·2, width 1·4, length of egg strings 2·3.

Male: Body about half the length and half the width of the female. Carapace slightly longer than broad, rounded posteriorly and anteriorly. Posterior sinuses narrow and deep; lateral lobes wide and blunt; median lobe rounded, half the width of the carapace. Free segment broad but narrowed where it joins the other segments, relatively long. Genital segment broader than long, rounded anteriorly and posteriorly; each of the outer pair of legs is provided with four setæ, the innermost one being the longest and the third, second and fourth following in order. There are three setæ on each of the inner pair, of which the innermost is long, the next one much shorter and the third short and weak. The anal laminæ are well separated; each is provided with three strong setæ, the two inner being nearly equal in length, longer than the third, and three very small setæ, one inside and two outside of the other three.

In the appendages the main differences, as compared with the female, are in the second antennæ, the first maxillæ and the maxillipeds. The basal joint of the second antenna is corrugated and the basal portion of the claw has also a ring of striæ and a small curved spine or claw near the bend; the main claw has a smaller, accessory claw on each side. The first maxilla is quite different in appearance to that of the female; the portion that corresponds to the outer ramus is blunted and in place of the inner ramus there are two spine-like projections, the one larger and stronger than the other. The terminal joint of the maxilliped is longer and more slender, relatively to the basal joint than it is in the female.

Total length 1·8 mm., length of carapace 1·23, width 1·16, length of genital segment 0·34, width 0·42.

Colour: Bright flesh colour in living specimens but this colour disappears in preserved specimens.

(*breviventris* is self-explanatory.)

Found attached to the mucous membrane of the roof of the mouth of the ling cod, *Ophiodon elongatus*.

LEPEOPHTHEIRUS HOSPITALIS new species

Pl. IV, Figs. 47–58.

Female: Body short and stout. Carapace ovate, narrower anteriorly, length slightly greater than breadth; lateral grooves well in from the margin; transverse groove well forward, dividing the carapace into nearly equal parts; posterior sinuses of medium depth and width; lateral lobes broad; median lobe a little less than half the width of the carapace. Free thoracic segment not distinctly separated from the genital segment, over half as broad as the median lobe. Genital segment much broader than long, rounded anteriorly and posteriorly; posterior lobes not showing dorsally. Abdominal segment undivided, short, about one-fourth the length of the genital segment, of nearly uniform width. Anal laminæ not large, well separated, six setæ on each lamina but two of them very small; a third one is much shorter than any of the other three. The egg strings are long and slender, a little longer than the carapace, with over 50 eggs in each string.

First antennæ short and stout, not projecting far past the carapace. Second antenna with a small spine at the base, the distal portion slender and abruptly curved. Maxillary hook, short, tapering. First maxilla with a broad base that projects laterally much farther than the outer ramus, but medially is almost in line with the inner ramus; the inner ramus is slightly longer than the outer but rather blunt. The maxilliped is slender; the distal joint is provided with a long seta that reaches almost to the tip of the joint. Furca with stout, flaring rami, the flare being largely on the inside, the sinus somewhat key-hole-shaped, the base broad.

First swimming leg with the basal spine short and blunt and a small spine at the distal end of the intermediate joint. Second swimming leg slender, the joints of both exopod and endopod relatively long; the spine on the basal joint long and slender and a small spine at the distal end of the second joint. Third swimming leg of the usual type. Fourth leg well developed, the basal joint slightly longer than the next two, without spine or seta; the second joint provided with a short claw; the third joint is longer than the second and is provided with a spine distally; the terminal joint is shorter than the third; it has three well-developed setæ and a claw. Fifth and sixth legs are but little developed, only a small portion of the setæ showing in dorsal view.

Total length 7·7 mm., length of carapace 4·45, width 4·3, length of genital segment 2·2, width 2·8, egg strings 4·6.

Male. Male about half the length of the female. Carapace rounded, length and breadth equal; sinuses relatively deeper and lateral lobes larger than in the female. Free segment wide and long, not distinctly separated from the genital segment. Genital segment slightly broader than long, well rounded anteriorly and posteriorly; the fifth and sixth pairs of legs are not large; each is provided with three setæ. Abdominal segment broader than long of similar width throughout. Anal laminæ well separated and distinctly projecting, each with four strong setæ.

In the appendages the main differences, as compared with the female, are in the second antennæ and first maxillæ. The distal joint of the second antenna has a laterally projecting hook on each side, near the distal end, almost as prominent as the main portion of the joint. Besides these there is a long seta attached near the middle of the length, which extends almost as far as the claw. The first maxilla has three rami instead of two, or it seems as though the inner ramus was split in two throughout its length; the outer ramus and the base resemble those of the female.

Length 3·8 mm., length of carapace 2·3, width 2·3, length of genital segment 0·7, width 0·8.

Colour: Uniformly white.

Scores of specimens of this species were obtained and without exception they were so much covered with parasites that it was a difficult matter to be sure of the more minute surface structure.

(*hospitalis*, on account of the species being host to so many parasites.)

Found in large numbers in company with *L. parvicruris* on the flounder, *Platichthys stellatus*. Some specimens were also obtained on *Pleuronichthys cœnosus* and *Gadus macrocephalus*.

Lepeophtheirus nanaimoensis, Wilson

Pl. IV, Figs. 59–61.

Lepeophtheirus nanaimoensis. Wilson, Contr. to Can. Biol., 1912, p. 89.

Male: Body short and broad, about three-fifths of the size of the female. Carapace nearly as wide as long, frontal margin slightly curved, but slightly incised; posterior sinuses deeper than wide; median lobe four-ninths the width of the carapace; lateral lobes reaching nearly as far back as the median lobe. Free segment almost the same width as the genital segment, narrowed anteriorly. Genital segment two-sevenths the width of the carapace; separation into two segments plainly indicated on the ventral surface, each segment with a pair of legs, plainly visible from the dorsal as well as from the ventral surface. The fifth pair forms the postero-lateral angles, each with four setæ nearly equal in length, the exterior the shortest. Each of the sixth pair is provided with two setæ, the inner one being much the longer. Abdominal segment slightly wider than long. Anal laminæ as long as broad, each with four setæ projecting posteriorly and a much smaller placed ventrally and projecting laterally. Of the posterior setæ, the second from the inside is the longest, the third being slightly longer than the first and the fourth the shortest. The appendages, with the exception of the second antennæ, are not very different from those of the female. The second antennæ are strongly developed; the basal joints are corrugated and the basal part of the claw is corrugated also; the claw is divided into two, near the tip and is provided with a spine a short distance proximal to where the division takes place.

Total length 2·4 mm., length of carapace 1·55, width 1·4, length of genital segment 0·45, width 0·4.

The female of this species was described by Wilson but he obtained no females. The only specimens obtained, male and female, were from a flounder of which the species was not determined, caught in Winter harbour, off Quatsino sound.

Lepeophtheirus parvicruris new species

Pl. V, Figs. 62–76

Female: Body long on account of the great length of the abdominal segment. Carapace somewhat quadrate, length and breadth equal; truncated anteriorly and posteriorly; lateral grooves well in from the margin; transverse groove less than one-third the distance from posterior border to anterior; posterior sinuses narrow and deep; lateral lobes broad, extending as far posteriorly as the median lobe; median lobe little rounded, four-ninths the width of the carapace. Free thoracic segment short, little more than half the width of the median lobe. Genital segment as broad as long, narrowing somewhat anteriorly but scarcely at all posteriorly; posterior lobes not showing in dorsal view; ventrally the two pairs of rudimentary legs are visible but they are but slightly developed, not even the setæ of the fifth pair showing dorsally. Abdominal segment undivided, somewhat longer than the genital segment, of uniform width but tapering slightly posteriorly. Anal laminæ small, widely separated, each with three long setæ medially placed and three small ones, two to the outside and one to the inside of the larger. Egg strings long, as long as the whole body, with nearly 100 eggs in each.

First antennæ short and stout, projecting little past the carapace. Second antennæ, each with a blunt spine at the postero-medial angle of the base and a short spine on the distal margin of the basal joint; the terminal joint slender with the curve abrupt. Maxillary hook abruptly narrowed near the base, the remainder tapering but little. The first maxilla is constricted below the rami; these are of the same size, short and rather blunt. Furca with a base long, but narrower than the fork and tapering; the rami, short, blunt, irregular, with the sinus between them rounded. Second maxilla slender, without spines, the terminal joint being much larger than the basal. Maxilliped with stout base and sharply tapering terminal joint.

First swimming leg with posterior basal spine short; a small spine or claw at the distal end of the intermediate joint. In the second leg, the joints of the exopod and endopod are stout as compared with the size of the basal joint. The third leg is of the usual type, with the basal spine of the exopod short. The fourth leg is very small, almost minute when compared with those of other species. There is a small spine near the distal end of the basal joint; there is but one intermediate joint which is provided with a claw distally; the terminal joint is slightly longer than the intermediate; it has four spines, two of them much shorter than the other two, and one of them quite small, like a claw. The three distal segments are together equal in length to the basal segment.

Total length 5·6 mm., length of carapace 2·4, width 2·4, length of genital segment 1·8, width 1·8, length of egg strings 5·5.

Male: Body about half the length and two-thirds the width of the female. Carapace slightly longer than broad, more nearly square than circular; posterior sinuses narrow but deep; lateral lobes narrow; median segment wide but narrowing anteriorly and posteriorly. Genital segment broader than long, rounded more anteriorly than posteriorly; there are three setæ from each of the fifth and sixth pairs of legs. The abdominal segment as long as broad, nearly the same width throughout. The anal laminæ are well separated; each is provided with three strong setæ, with one short one interiorly and two exteriorly to these. In the appendages, the main differences, as compared with the female, are in the second antennæ, first maxillæ and maxillipeds. The second antenna has a stronger hook at the base of the terminal joint and an extra one near the centre of the joint. The first maxilla is similar in shape to that of the female but on the inner side there is a tubercle at the base of the ramus, from which projects a long, claw-like spine, extended almost to the end of the ramus. The maxilliped is similar in shape to that of the female but is provided with a spine on the terminal joint, placed centrally and pointing towards the tip of the joint.

Total length 2·7 mm., length of carapace 1·7, width 1·5, length of genital segment 0·5, width 0·6.

Colour: Very light yellow, almost white, throughout.

Nauplius: Body nearly rectangular but slightly broader at the middle and tapering slightly anteriorly and posteriorly; four-sevenths as broad as long; anterior end slightly rounded, posterior end truncate; balancers short, far apart; No pigment noticeable. Length 0·37 mm., width 0·21.

(*parvicruris*, referring to the small size of the fourth leg.)

Found in large numbers on the light surface of the starry flounder, *Platichthys stellatus.*

LEPEOPHTHEIRUS PARVIVENTRIS, Wilson

Lepeophtheirus parviventris. WILSON, Proc. U.S. Nat. Mus., vol. 28, 1905, p. 635.
WILSON, Proc. U.S. Nat. Mus., vol. 35, 1909, p. 439.
WILSON, Contr. Can. Biol., 1912, p. 93.

This species has been found on a wide variety of hosts, although no others have been found on *Lepidopsetta bilineata*, from which they were previously recorded. They have been found on *Gadus macrocephalus*, however, and also on *Hexagrammus decagrammus*, *Sebastodes pinniger*, *Scorpœnichthys marmorata*, *Enophrys bison*, *Anoplarchus atropurpureus* and *Raja binoculata*.

LEPEOPHTHEIRUS PRAVIPES, Wilson

Lepeophtheirus pravipes. WILSON, Contr. to Can. Biol., 1912, p. 90.

Numerous specimens of this species have been found on the same host as Wilson recorded, *Ophiodon elongatus*. Much of the colour is lost in the preserved specimens. In the living specimens, the body is not uniformly orange yellow, but while this forms the ground colour, it is thickly dotted over with reddish brown spots, each consisting of a central portion from which extends numerous processes, that each spot has the appearance of a nerve cell. These are found over the surface of the carapace, free thoracic segment and genital segment. The depth of the colour varies somewhat but the spots were present in all live specimens examined.

LEPEOPHTHEIRUS SALMONIS (Kröyer)

Caligus salmonis KRÖYER, Naturh. Tidsskrift, vol. I, 1838, p. 13.
Lepeophtheirus salmonis WILSON, Proc. U.S.N.M., vol. 28, 1905, p. 640.
WILSON, Proc. U.S.N.M., vol. 35, 1909, p. 440.
WILSON, Contr. Can. Biol., 1912, p. 93.

Found on all five species of the Pacific salmon, *Oncorhynchus*, and on the steelhead trout, *Salmo gairdneri*. It is possible to get any number of this species but the live specimens in general do not agree in every detail with descriptions that have been made from preserved specimens, although there is a large amount of variation in the relative size of parts. In specimens that may be considered typical for this region, the carapace of the female is about one-eighth longer than wide. The genital segment is only a little more than half as long as the carapace and a little over half as wide. The abdomen is nearly as long as the genital segment. There is no segmentation at the constriction.

In the male the relative size of the parts agrees more nearly. The genital segment is not concave posteriorly but the central portion extends to form a median lobe, where it is attached to the abdomen.

Although the abdomen is constricted at a point about one-third of the length from the base, there is no further evidence of segmentation.

Although they vary much in size, none of them are nearly so large as those described by Wilson. An average size would give the following measurements: Female: Total length 9·6 mm., length of carapace 4·75, width 4·25, length of genital segment 2·5, width 2·25, length of abdomen 2·3. Male: Total length 5·8 mm., length of carapace 3·5, width 3·2, length of genital segment 1·26, width 1·16, length of abdomen 0·97.

The ground colour is yellow but there is a strong and intricate mottling of reddish brown, which varies much in brightness in different specimens. In some cases it is so dark that it gives a dark colour to the whole specimen.

ECHTHROGALEUS COLEOPTRATUS (Guérin)

Dinematura coleoptrata GUÉRIN, Iconographie du Règne animal, 1837, pl. XXXV, Fig. 6.
Echthrogaleus coleoptratus WILSON, Proc. U.S. N.M., vol. 33, 1908, p. 367.
WILSON, Proc. U.S. N.M., vol 35, 1909, p. 452.

Two specimens were obtained from a shark (species undetermined) caught in Northumberland channel, Sept. 21, 1916. The specimens reported from Unalaska by Wilson were also from a shark.

Family CHONDRACANTHIDÆ

CHONDRACANTHUS DELTOIDEUS new species

Pl. V, Figs. 77–80, Pl. VI, Figs. 81–83

Female.—General shape of the body short and stout. Cephalothorax nearly circular but with very slight lobes at the posterior end of the lateral margin, distinctly separated from the remainder of the thorax; about three-fifths as wide as the thorax; there is a definite median line dorsally. Second and third segments of the thorax are distinct; the second narrower than the cephalothorax, the third the same width as this. The remainder of the thorax shows an indication of division ventrally but not dorsally; it becomes wider posteriorly. The posterior lobes together at their bases are practically the whole width of the body; the tapering takes place on the inside only and the length is about equal to the width at the base. There are no definite lateral lobes. The genital segment is small, about one-fifth the width of the body, wider than long. The abdomen is small, very weakly two-lobed. The egg strings are long, much longer than the body, nearly the same size throughout but tapering slightly towards the distal end; the eggs are arranged in five rows.

The first antennæ are large and rounded, with the joints fused except for one indication of a division, which corresponds to the distal one; the terminal joint is tipped with three small spines and another small one appears about half way along. The second antennæ are large and stout, tapering gradually but with no abrupt bend near the tip. Mandible curved and tapering, with the surface supplied with rows of short spines. The first maxilla has a stout base and slender, curved, terminal joint, with three curved teeth near the distal end of the convex side, the most distal being the largest; there is a stout spine on the basal joint projecting parallel to the terminal joint. The maxilliped has a stout basal joint that narrows abruptly just near the distal end; the terminal joint is also quite stout; the spine is stout and straight and the end of the joint projecting beside the base of this forms a rough knob. Each of the free thoracic segments has a pair of bilobed appendages.

Total length 6·2 mm., length of cephalothorax 1·6, width 1·9, greatest width of body 3·7, length of egg strings 7·3, width 0·9.

Male:—Body short and stout. Cephalothorax inflated, three-fourths as deep as wide. Second thoracic segment somewhat distinctly separated from the cephalothorax, much narrower than it is. The other free thoracic segments are shorter and narrower than the second. The genital segment is greater in each measurement than the last thoracic segment. The abdominal segment is about half the width and half the length of the genital segment. The anal laminæ are slender, without setæ.

The first antennæ are stout, almost to compare with those of the female; the joints are more definitely marked and there are more setæ on the terminal joint. The second antennæ are more curved than in the female. The maxilliped has no rough knob on the terminal joint beside the spine. The other mouth parts are much similar to those of the female. The two pair of thoracic legs are very rudimentary, the first pair in particular, being little more than papillæ.

Total length 0·8 mm., length of cephalothorax 0·53, width 0·35.

Colour: Uniformly yellowish.

(*deltoideus*, from the shape of the body of the female).

Two females of this species, each with male attached, were obtained from the gill cavity of *Hexagrammus decagrammus*, taken at Hardy bay, September 1st, 1915.

CHONDRACANTHUS GRACILIS new species

Pl. VI, Figs. 84–93

Female.—Body long and slender. Cephalothorax slightly broader than long, rounded posteriorly and anteriorly, a distinct joint separating it from the rest of the body. The second thoracic segment is free. The remainder of the body is elongated—oval in shape. A pair of lateral processes stand out distinctly from the body about half way back. The posterior processes are long and slender, gradually tapering and slightly curved, their length more than three-fourths the greatest width of the body. There are two dorsal processes along the median line, the anterior one being about one-third of the way back and the posterior not much anterior to the end of the segment; the former is not very strongly developed and in some specimens is scarcely noticeable; the latter is much more distinct, being nearly the same size as one of the lateral processes. The genital segment is small, about one-fourth the width of the body. The abdomen is nearly as wide but is constricted anteriorly and posteriorly. The egg strings are long and slender, not far from being as long as the whole body. The eggs are small and very numerous.

The first antennæ show indication of division into three joints; there is one seta on the intermediate joint and four on the terminal. The second antennæ are not particularly stout and they do not taper to so sharp a point as usual. The mandible is stout, strongly curved, with the teeth on both sides stout. The terminal joint of the maxilla is turned strongly forward, is slightly curved and has eight or nine small but sharp teeth on the convex surface. There is no accessory spine present. The terminal spine of the maxilliped is set well back from the end of the joint that supports it and is not in the same straight line with it. The end of the joint is roughened by very rough spines. The first pair of legs is attached to the free thoracic segment. The second pair is similar and is attached just behind the joint that separates the second segment from the remainder of the body.

Total length to end of posterior processes 8·2 mm., length of cephalothorax 1·2, width 1·4, width of body 2·1, width of genital segment 0·5, length of egg strings 7·4.

Male: Body short and deep. Cephalothorax five-eighths of the total length; breadth three-fourths of length; depth nearly as great as width. Little or no indication of segmentation between head and thorax. The second thoracic segment is free, much narrower than the cephalothorax. The third segment is smaller than the second and the fourth smaller than the third. The genital segment is longer than the preceding thoracic segment but is not quite so broad. The abdominal segment is small. The anal laminæ are quite long and each is armed with a terminal hook.

The first antenna has a short basal joint and a longer terminal joint; the latter has two lateral spines on its proximal half and four terminal spines. The terminal joint of the maxilla is not so much curved or so much turned forward as in the female and has not the spines on the convex border. The other mouth parts and appendages do not differ materially from those of the female.

The swimming legs are feebly developed. The first pair has one joint and a spine or claw and the second pair, an appearance of two joints with two terminal spines or claws.

Total length 0·88 mm., length of cephalothorax 0·55, width 0·40, depth 0·37.

Colour: White.

Nauplius: Body obovate, nearly twice as long as broad; anterior end broadly rounded, posterior end much more pointed. Balancers short and slender. The wine-coloured pigment occurs in a single large oval mass, a little nearer the posterior than the anterior end of the body. Length 0·22 mm., width 0·12.

Found in the gill cavity of *Scorpænichthys marmorata.*

Chondracanthus irregularis new species

Pl. VII, Figs. 94–100

Female: Body stout, and on account of the many large processes, very irregular, looking not unlike a portion of a vertebral column. Cephalothorax broader than long; depth greater than the length but not so great as the breadth; more rounded anteriorly than posteriorly. Second thoracic segment narrower than the head and distinctly separated from it. A large process projects mid-dorsally and two bi-lobed legs are present. The third thoracic segment is larger; it has two small lateral process and a pair of legs similar to those on the second segment. The remainder of the thorax is somewhat distinctly divided into two parts; the anterior portion is provided with a long dorsal process, two dorso-lateral processes and two ventral processes that project laterally with smaller processes from these projecting posteriorly; the posterior portion has a long dorsal process, two small dorso-lateral processes, a ventral process or fold and two large posterior processes. The genital segment is small and rounded. The abdomen is less than half the width of the genital segment. The egg strings are of large size.

The first antennæ are heavy and rounded, with no indication of division into joints. The second antennæ are strong, taper gradually, regularly curved, with no abrupt curve near the tip. Mandible but slightly curved, palp very small. The terminal joint of the maxilla tapers gradually and is but slightly curved; the distal portion of the convex margin is provided with four curved teeth; there is a spine on the distal end of the basal joint. The terminal joint of the maxilliped is relatively stout; the terminal spine is straight; the end of the joint beside it is rough with teeth but does not form a very distinct knob.

Total length 7·3 mm., length of cephalothorax 1·4, width 2·1, greatest width of thorax 3·8, width of genital segment 0·7, length of egg strings 11·0, width 1·3.

Male: Body rather slender. Cephalothorax not inflated, much longer and slightly deeper than broad. A slight indication of separation between head and first thoracic segment; the remaining three segments free; the second and third much larger than the fourth. Genital segment about the same length as the second thoracic but scarcely any broader than the fourth. Abdomen small; anal laminæ conical, without spines or setæ.

The first antenna is two-jointed, the basal joint being the longer; it has two short spines on the anterior surface; the terminal joint has a spine near the base, one half way along, and five spines or stiff bristles at the tip, one projecting forward and the others in the direction of the joint. The remaining appendages of the head are much similar to those of the female.

The two pairs of swimming legs are much similar except that the first one is biramous and the second uniramous, but all the terminal portions are very minute.

Total length 0·74 mm., length of cephalothorax 0·46, width 0·26.

Colour: Uniform yellowish.

(*irregularis*, on account of general shape of female).

Found on the gills of *Enophrys bison.*

CHONDRACANTHUS PALPIFER, Wilson

Chondracanthus palpiper. WILSON, Contr. to Can. Biol., 1912, p. 93.

Wilson did not give the host for this species. Specimens have been obtained in the gill cavity of *Gadus macrocephalus.*

Chondracanthus pinguis, Wilson

Chondracanthus pinguis. Wilson, Contr., to Can. Biol., 1912, p. 94.

Besides the host, *Sebastodes auriculatus*, given by Wilson, this species has been found on *Sebastodes pinniger, Hexagrammus decagrammus, Scorpænichthys marmorata* and *Anoplarchus atropurpureus.*

Chondracanthus rectangularis, new species
Pl. VIII, Figs. 101–109

Female: Body long and slender, with no processes but the posterior. Cephalothorax, short, much broader than long, rounded posteriorly and anteriorly. Second thoracic segment much narrower than the head dorsally but broader ventrally. The third segment is about the same breadth as the head and is marked dorsally by a band running transversely along the anterior border; from this band of much the same width, passes backward along the median line for about three-fourths the distance to the posterior margin of the thorax. The remainder of the thorax tapers very gradually; one slight indentation on each side is present. The posterior processes are long and tapering. Genital segment small, about one-third the width of the body. The abdomen is narrow where it joins the genital segment, suddenly becomes almost as broad as the segment, but soon narrows quickly again and tapers to a rounded end. Egg strings long and slender, the same length as the body; eggs large.

The first antennæ are large, rounded and blunt, without any indication of joints. Second antennæ long, slender and straighter towards the tip than usual. Mandible but slightly curved, with teeth on both sides. The terminal joint of the maxilla has several teeth (9 or 10) on the posterior border, so much so that practically all this border is toothed; a spine from the base passes out parallel to the terminal joint. In the maxilliped, the terminal spine is supported on a papilla-like prominence and is turned backward so that it is not in line with the joint that supports it. The two pairs of legs are similar bilobed structures.

Total length 8·3 mm., length of cephalothorax 1·3, width 2·0, greatest width of body 2·3, egg strings 8·1 long and 0·25 broad.

Male: Body moderately stout. Cephalothorax longer than broad and broader than deep. No indication of separation between the head and first thoracic segment. The free segments gradually get smaller as they go posteriorly. Genital segment longer but not broader than the last thoracic. Abdomen not clearly distinct from the genital segment. Anal laminæ long and tapering.

The first antenna is two-jointed, the terminal joint the longer, with four terminal setæ and one less than half way along. Second antenna and maxillipeds similar to those of the female. Mandible relatively shorter with coarser teeth. Maxilla with teeth lacking. The swimming legs are rudimentary, the second pair being somewhat more defined than the first.

Total length 0·9 mm., length of cephalothorax 0·63, width 0·39.

Colour: White.

(*rectangularis* from general body shape of the female.)

Found on the gills of the flounder, *Platichthys stellatus.*

Family LERNÆOPODIDÆ

CHAROPINUS DENTATUS (Wilson)

Brachiella dentata. WILSON, Contr. to Can. Biol., 1912, p. 97.
Charopinus dentatus. WILSON, Proc. U.S. Nat. Mus., vol. 47, 1915, p. 654.

Found only on the host originally reported, *Raja binoculata.*

CLAVELLA PARVA, (Wilson)

Clavella parva. WILSON, Contr. to Can. Biol., 1912, p. 95.
WILSON, Proc. U.S. Nat. Mus., vol. 47, 1915, p. 676.

Found on *Tæniotoca lateralis* and *Axyrias harringtoni* as well as on the original host, *Sebastodes auriculatus.*

CLAVELLA UNCINATA (Müller)

Lernæa uncinata. MÜLLER, Zoological Danicae, vol. I, 1776, p. 38.
Clavella uncinata WILSON, Contr. to Can. Biol., 1912, p. 97.
WILSON, U.S. Nat. Mus., vol. 47, 1915, p. 688.

Found only on the original host, *Gadus macrocephalus.*

CLAVELLOPSIS ROBUSTA (Wilson)

Clavella robusta WILSON, Contr. to Can. Biol., 1912, p. 96.
Clavellopsis robusta. WILSON, Proc. U.S. Nat. Mus., vol. 47, 1915, p. 688.

Found on *Sebastodes auriculatus* (original host), *S. pinniger* and *S. melanops.* Those found on the gills of *S. melanops* had much larger posterior processes than those found on *S. pinniger* and *S. auriculatus.*

Genus NECTOBRACHIA, new genus

Female: Body short, stout, dorso-ventrally compressed. Cephalothorax small, fused to the body without any indication of separation and without narrowing. No abdomen or anal laminæ. A single small knob present at the posterior end. Eggs large and few in a string. First antennæ two-jointed, tipped with setæ. Second antennæ small, uniramose. First maxillæ strongly divided at the tip, without palp. Second maxillæ placed ventro-laterally, passing upward at an acute angle with the body; fused for a large portion of the length; bulla single. Maxillipeds with short base, a much narrower second joint and a claw. No thoracic appendages.

Male: No specimens.

(*Nectobrachia*, referring to the joined maxillæ.)

Nectobrachia indivisa, new species

Pl. VIII, Figs. 110–112

Female: Body short, stout, dorso-ventrally compressed. Head forming a tapering projection from the anterior end of the body, without any indication of separation or any constriction to form a neck. Body, second maxillæ and egg strings of the same length. No carapace. Body nearly rectangular, but slightly broader near the posterior end. A slight swelling posteriorly with a knob attached to the swelling. No abdomen, no anal laminæ. Eggs strings the same length as the body and over one-third of its width. Eggs large, 25 to 30 in number, in three longitudinal rows.

First antennæ short, two-jointed; the second joint curved, with a spine on the inner surface; terminal with five tubercles, three of which bear claw-like spines. Second antennæ small, one-jointed, terminating in two spines, one of which is much larger than the other. Mouth tube longer than the antennæ and first maxillæ. Mandible with inner surface slightly irregular but not toothed. First maxillæ terminating in two long tail-like rami, the outer one somewhat curved near the tip, the inner more nearly straight. Second maxillæ placed well to the side but still on the ventral surface, passing outward and upward at an acute angle to the body, come together and are fused for two-thirds of their length. Bulla single. Maxillipeds with stout base; second joint much more slender and narrowing suddenly at the distal end; the terminal claw slightly curved; a small accessory claw present. There are no body appendages.

Length of body equals length of second maxillæ equals length of egg strings equals 2·2 mm., width of body 2·2.

Male: No specimens.

Colour: White.

(*indivisa, since head and body are united so closely*).

Numerous specimens found on the gills of the flounder, *Platichthys stellatus.*

Family LERNÆIDÆ

HÆMOBAPHES CYCLOPTERINA, (Müller)

Lernæa cyclopterina. MÜLLER, Zoologiæ Danicæ, 1776, p. 2745.

Hæmobaphes cyclopterina WILSON, Proc. U.S. Nat. Mus., vol. 35, 1909, p. 458.

WILSON, Contr. to Can. Biol., 1912, p. 99.

Found only on the original host for this locality, *Oligocottus borealis.*

Explanation of Plates

Note:—The measured lines placed beside the figures of the complete animals represent the length of 1·0 or 0·1 mm., as indicated.

Plate I

1. *Bomolochus Cuneatus*, female, dorsal view.
2. First antenna.
3. Second antenna.
4. Mouth parts
5. Maxilliped

6–10. First to fifth swimming legs

11. Genital segment and abdomen
12. *Ergasilus turgidus*, female, dorsal view
13. First antenna
14. Second antenna

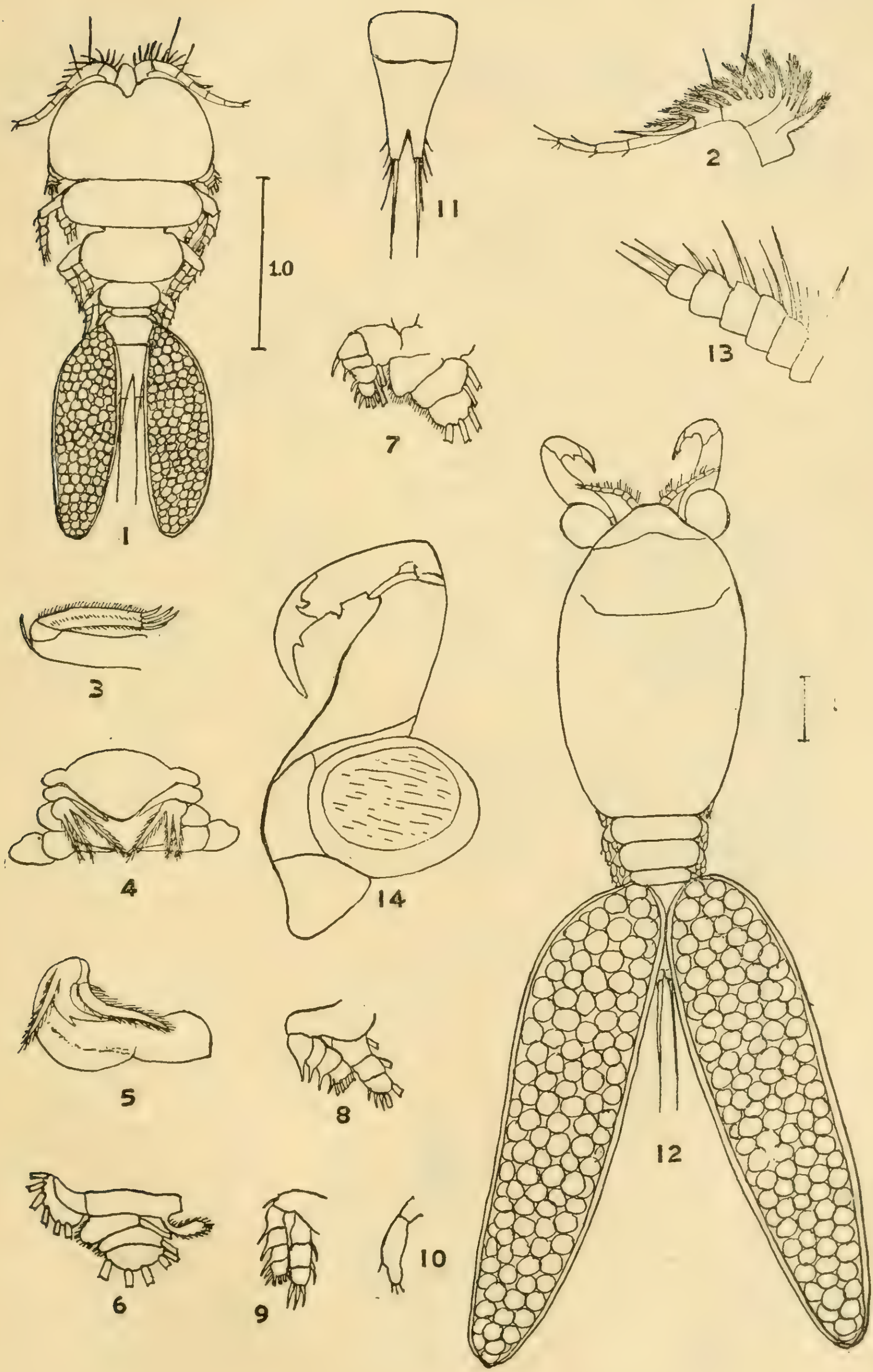
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Plate II

15. *Ergasilus turgidus*, mouth parts
16–20. First to fifth swimming legs
21. Genital segment and abdomen
22. *Lepeophtheirus bifidus*, female, dorsal view
23. Second antenna
24. Maxillary hook
25. First maxilla
26. Furca
27. Maxilliped
28–31. First to fourth swimming legs
32. Male, dorsal view
33. Second antenna
34. First maxilla
35. Nauplius

Plate II

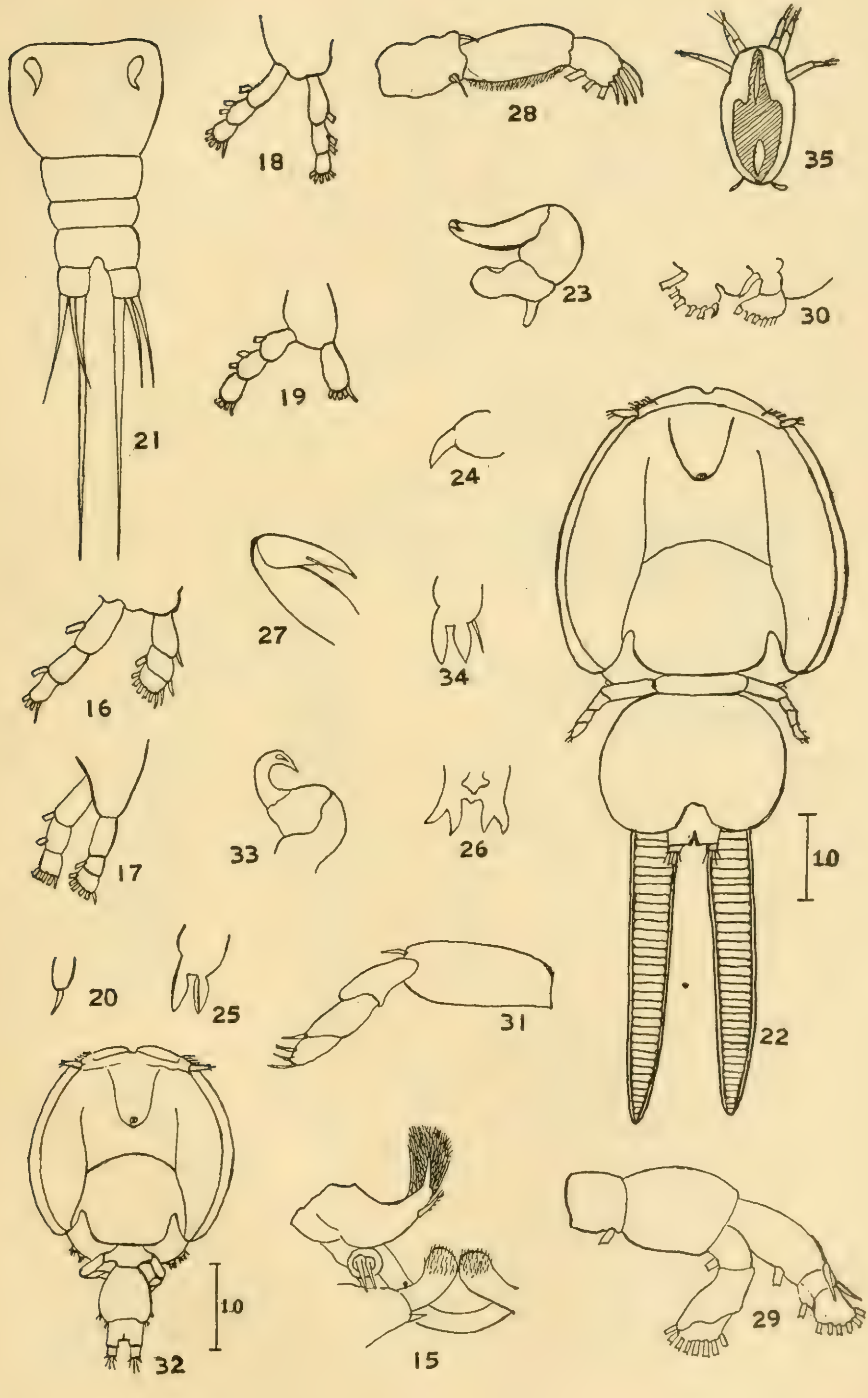

PLATE III

36. *Lepeophtheirus breviventris*, female, dorsal view
37. Second antenna and maxillary hook
38. First maxilla
39. Furca
40. Maxilliped
41–44. First to fourth swimming legs
45. Male, dorsal view
46. Second antenna

PLATE III

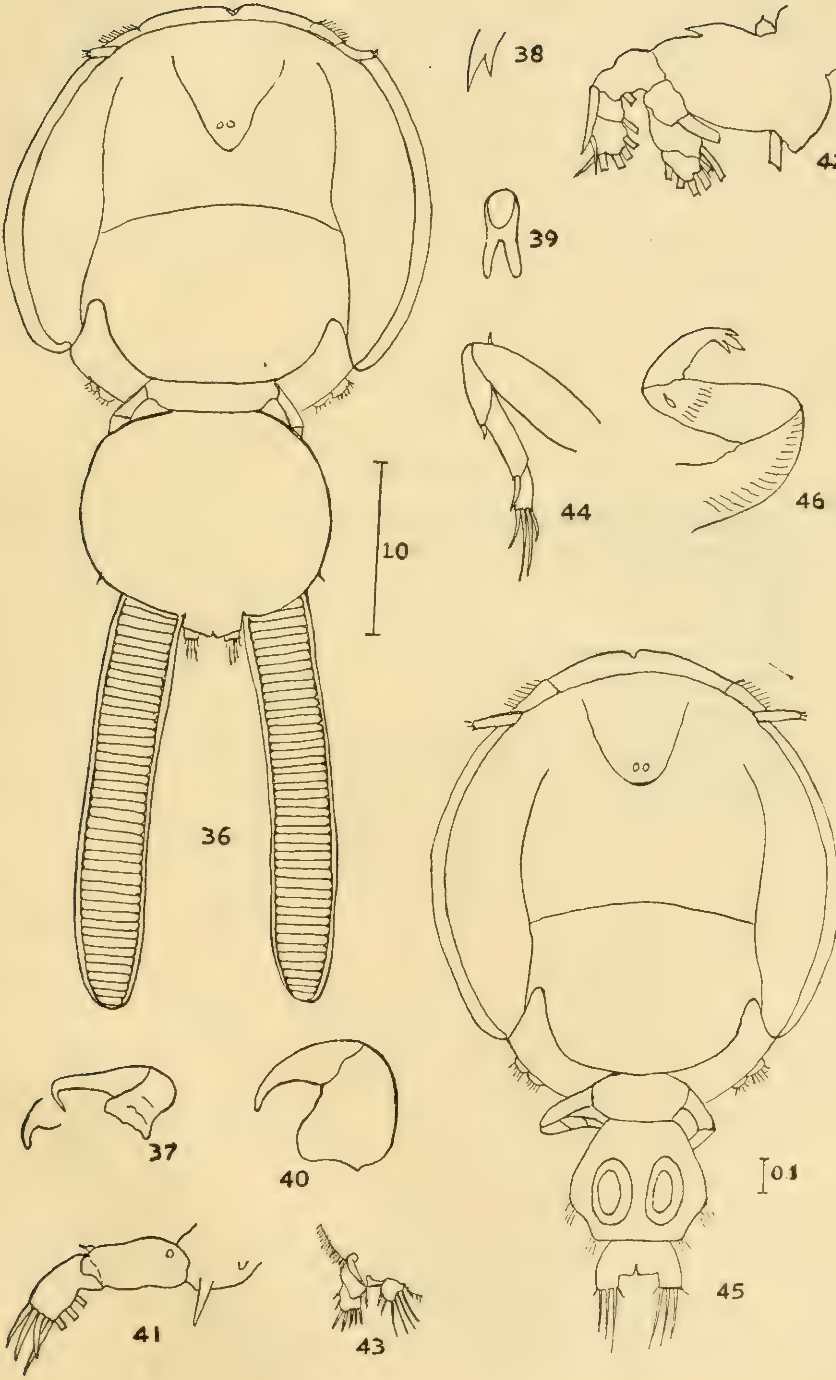

Plate IV

47. *Lepeophtheirus hospitalis*, female, dorsal view
48. Second antenna and maxillary hook
49. First maxilla
50. Furca
51. Maxilliped
52–55. First to fourth swimming legs
56. Male, dorsal view
57. Second antenna
58. First maxilla
59. *Lepeoptheirus nanaimoensis*, male, dorsal view
60. Second antenna
61. Maxillary hook

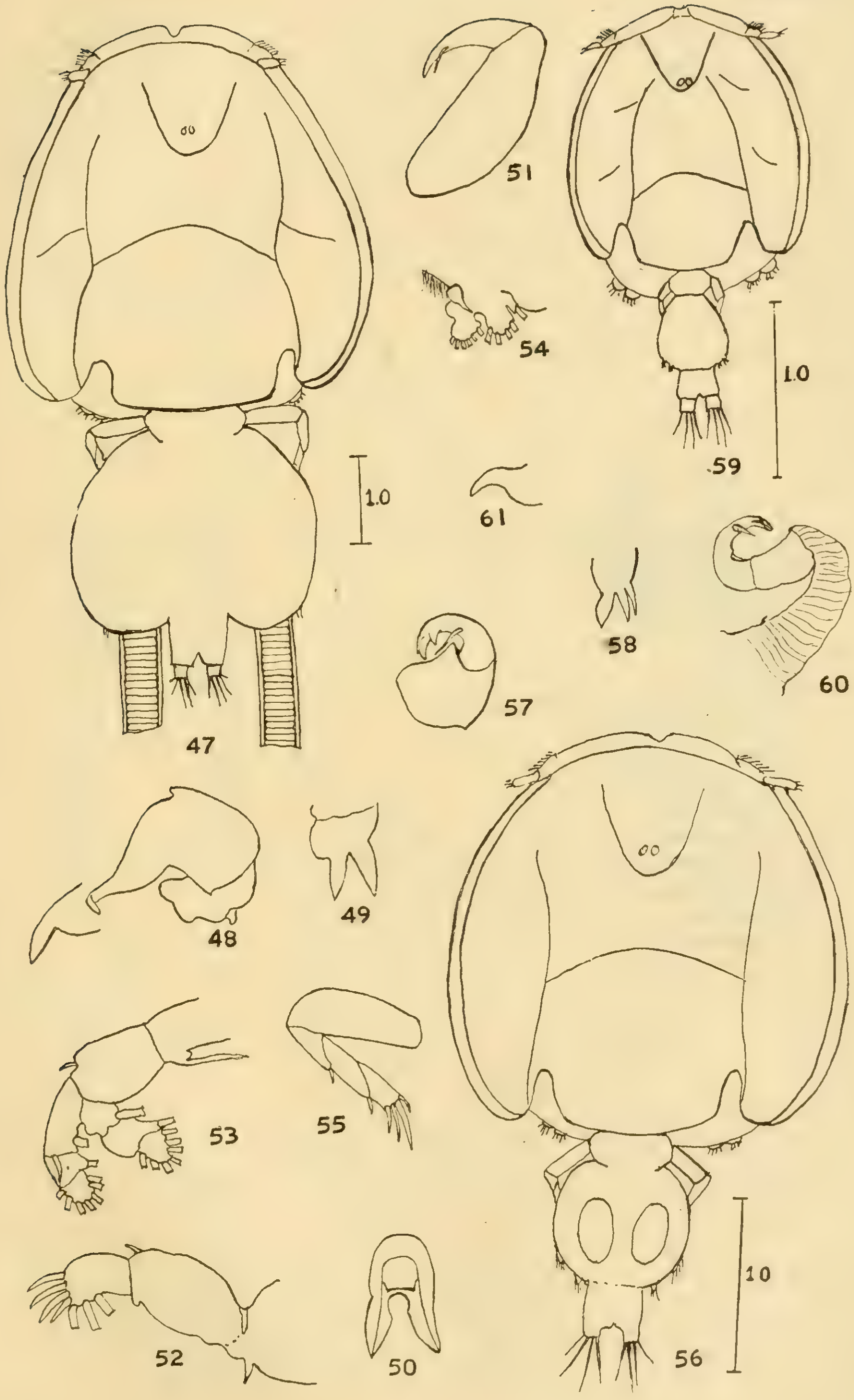
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PLATE V

62. *Lepeophtheirus parvicruris*, female, dorsal view
63. Second antenna
64. Maxillary hook
65. First maxilla
66. Furca
67. Maxilliped
68–71. First to fourth swimming legs
72. Male, dorsal view
73. Second antenna
74. First maxilla
75. Maxilliped
76. Nauplius
77. *Chondracanthus deltoideus*, female, ventral view
78. First and second antennæ
79. Maxilla
80. Maxilliped

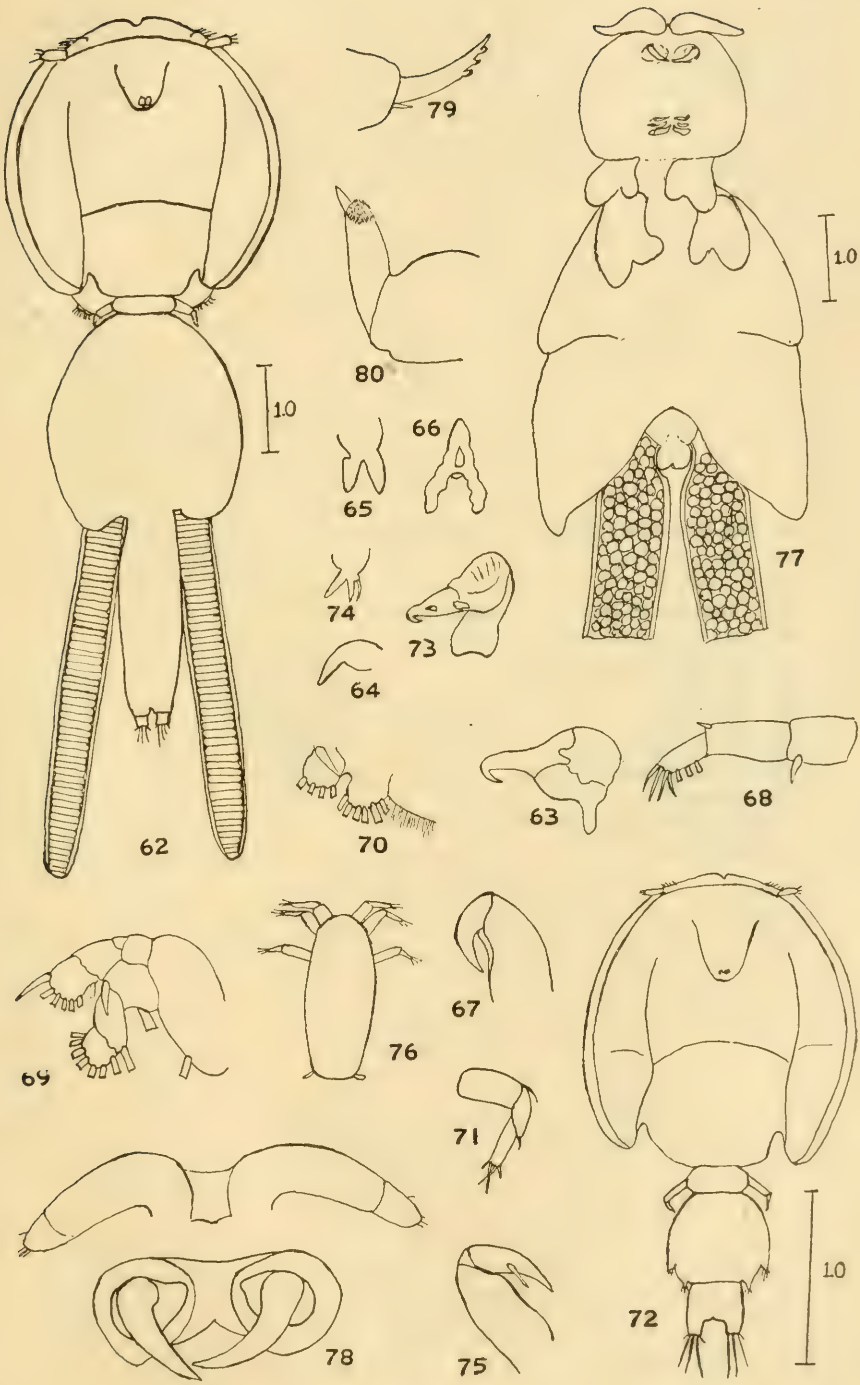
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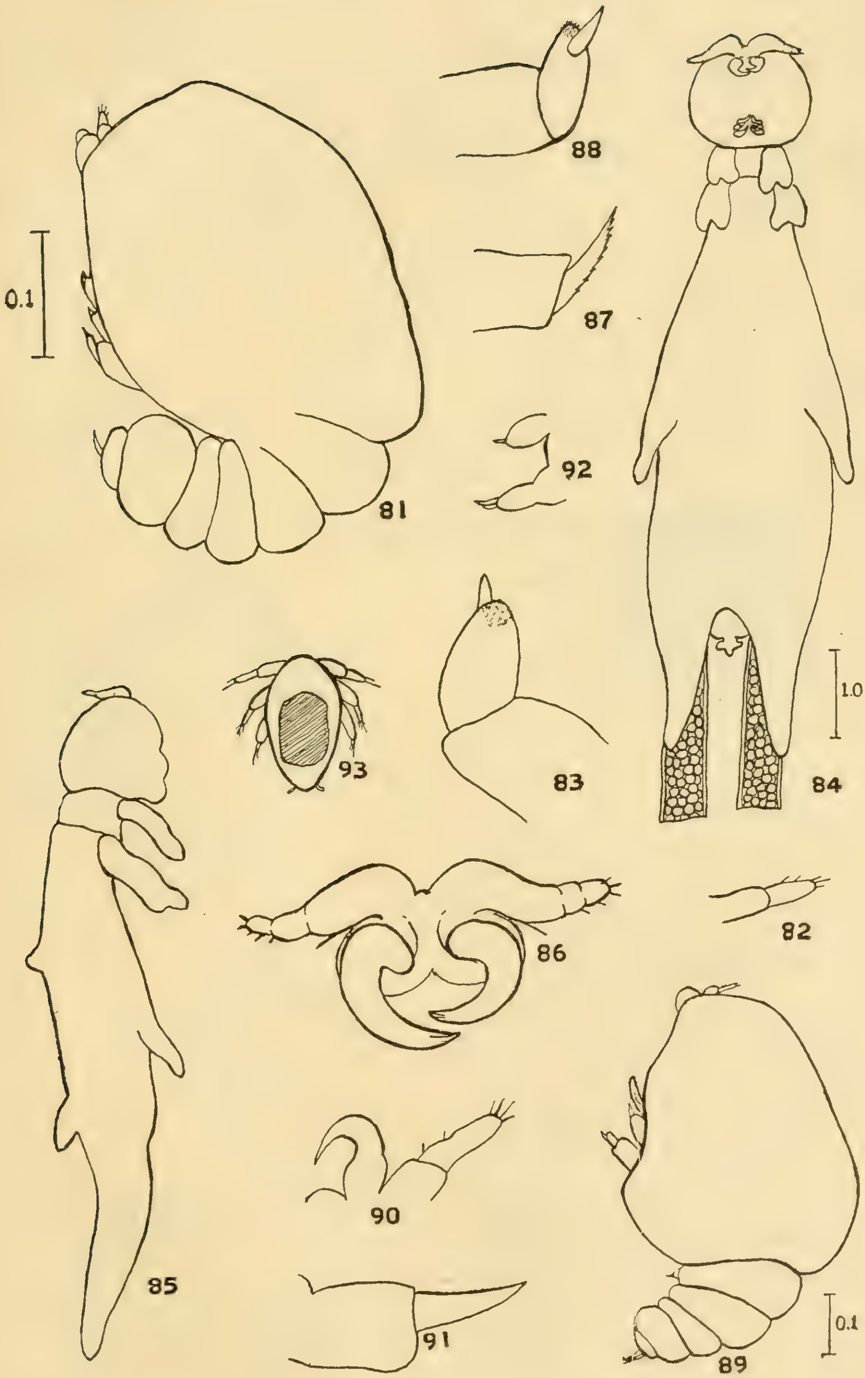
Plate VI

81. *Chondracanthus deltoideus*, male, side view
82. First antenna
83. Maxilliped
84. *Chondracanthus gracilis*, female, ventral view
85. Female, lateral view
86. First and second antennæ
87. Maxilla
88. Maxilliped
89. Male, side view
90. First and second antennæ
91. Maxilla
92. First and second legs
93. Nauplius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89
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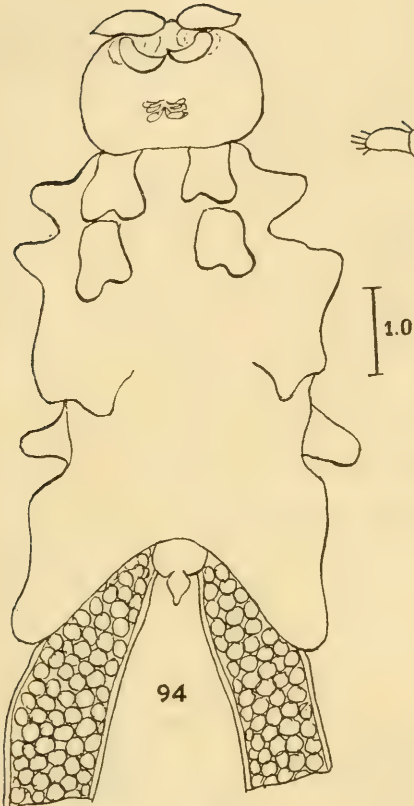
Plate VII

94. *Chondracanthus irregularis*, female, ventral view
95. Female, lateral view
96. First and second antennæ
97. Maxilla and maxilliped
98. Male, side view
99. First and second antennæ
100. First and second legs



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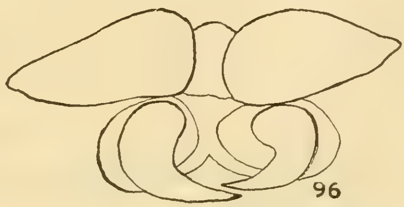

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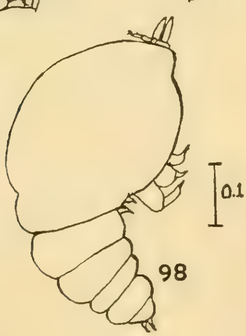

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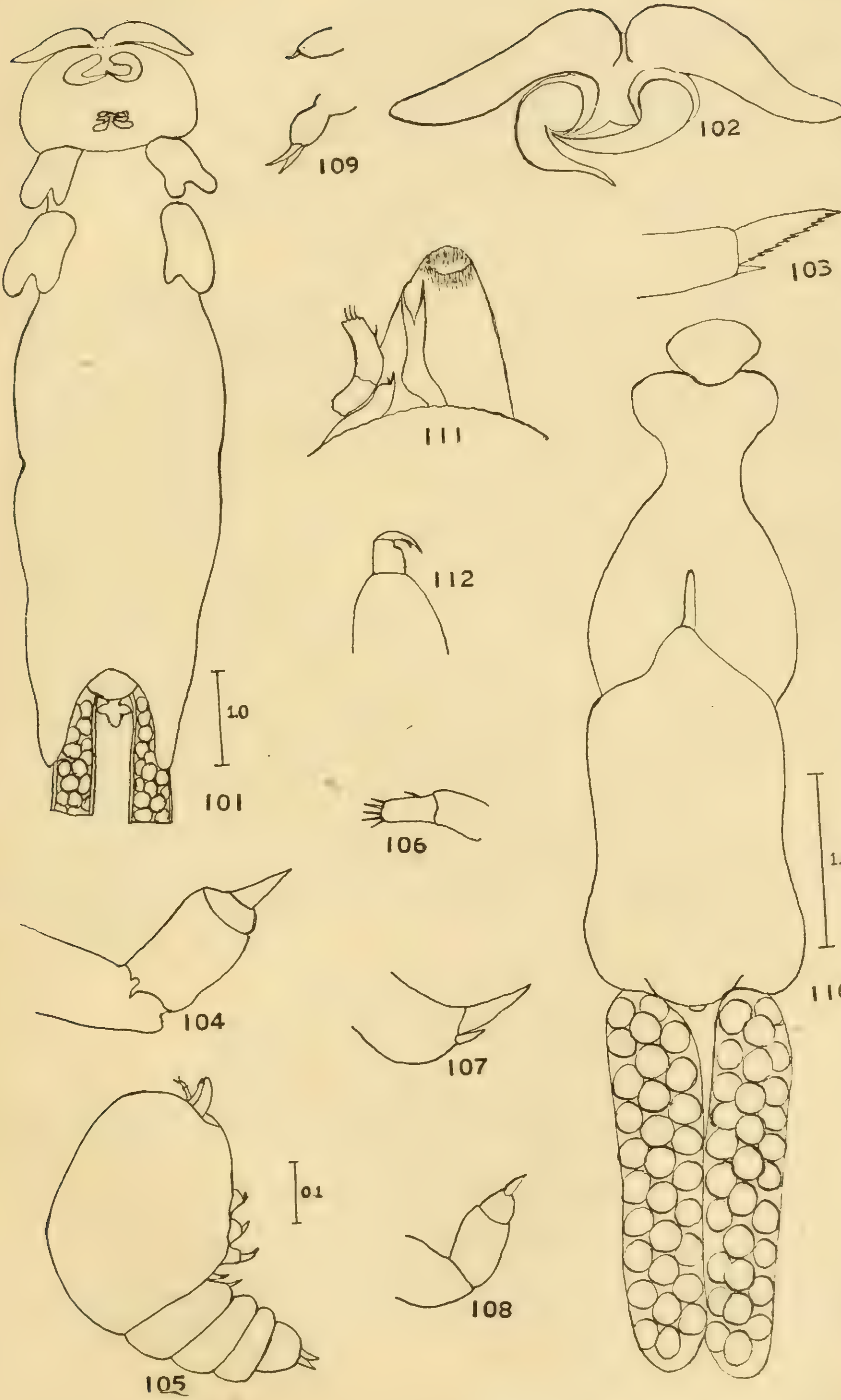
95

97

100

Plate VIII

101. *Chondracanthus rectangularis*, female, ventral view
102. First and second antennæ
103. Maxilla
104. Maxilliped
105. Male, side view
108. First antenna
107. Maxilla
108. Maxilliped
109. First and second legs
110. *Nectobrachia indivisa*, female, dorsal view
111. Mouth parts
112. Maxilliped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105

Notes on a Collection of Fishes from Vancouver Island, British Columbia.

By BARTON A. BEAN and ALFRED C. WEED,
OF THE DIVISION OF FISHES, U. S. NATIONAL MUSEUM

Presented by PROFESSOR E. E. PRINCE, F.R.S.C.

(Read May Meeting, 1919.)

An interesting collection of about two hundred specimens of fishes was obtained by Professor John Macoun, Naturalist of the Canadian Geological Survey, and Messrs. C. H. Young and W. Spreadborough September 8th and 9th, 1908, on the shore of Departure Bay, and from May to August 1909, near Ucluelet, Vancouver Island. The fishes were sent to the United States National Museum for identification and a full set of the duplicates is retained there.

The collection is quite valuable from a scientific point of view in that it adds specimens to those already known of several rare species, extends the known range of some other forms, and furnishes one specimen which is here described as belonging to a new genus and species. This cottid may represent the hitherto unknown male of some well known form, but shows sufficiently well marked differences to separate it from any species of which we find a description in the literature, and the points in doubt can only be settled by a careful biologic study of this and other species living in the tide pools.

Additional specimens, collected in British Columbia by Messrs. J. H. Keen, A. Halkett, G. M. Dawson, Prof. E. E. Prince, and the above-named naturalists, were received at Washington in 1918, and are listed under their proper families in this paper.

Family HEPTATREMIDÆ

POLISTOTREMA STOUTI (Lockington)

One specimen, 18½ inches long, taken by Mr. C. H. Young in Ship Channel, Barclay Sound, July, 1909. Known as "Hagfish."

Family PETROMYZONTIDÆ

ENTOSPHENUS TRIDENTATA (Gairdner). Three-toothed Lamprey.

One specimen, 18·5 cm. long, Comox, British Columbia, June 1893, John Macoun.

Family SQUALIDÆ

Squalus sucklii (Girard). Dog Shark.

Two specimens, with yolk sacs attached. Vancouver Island, 1909. Young and Spreadborough.

Three (Larval) specimens, Departure Bay, B.C., Sept. 4–15, 1908, C. H. Young and W. Spreadborough.

Family RAIIDÆ

Raia binoculata Girard. Skate.

One specimen, 15·7 cm. long, Gulf of Georgia, Vancouver Island, B.C., Feb. 28, 1910, W. Spreadborough.

Raia rhina Jordan and Gilbert

One specimen, 170 mm. long, taken during June or July, 1909, in from 9 to 30 fathoms of water at Ucluelet, by Young and Spreadborough.

Raia stellulata Jordan and Gilbert

Three specimens, 118 and 155 mm. long, and one fetal specimen taken at Ucluelet by Young and Spreadborough, June to July, 1909, in 9 to 30 fathoms of water. In the two younger specimens the yolk sac had not been absorbed.

The largest specimen shows a perfectly distinct anal fin on the lower surface of the tail, extending from near the vent to about opposite the first dorsal fin; in the second specimen this appears as a slight fold.

The species of this genus in the U.S. National Museum are readily separated by the characters given by E. C. Starks.[1]

Family SALMONIDÆ

Oncorhynchus nerka? (Walbaum). Blue-back Salmon.

One specimen, 6 cm. long, Queen Charlotte Island, B.C., May 12, 1893, J. H. Keen.

Salmo clarkii Richardson

Three specimens, collected in creek at Ucluelet, Vancouver Island, summer of 1909, by C. H. Young. "Red-mouth Trout."

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[1] Ann. Carnegie Mus., Vol. No. 2, 1911, pp. 162–213, pls. 29–31.

Family EMBIOTOCIDÆ

Cymatogaster aggregatus Gibbons

One by W. Spreadborough specimen, 65 mm. long, taken in Departure Bay, Sept., 1908.

Damalichthys argyrosomus Girard

Fourteen specimens, about 60 mm. long, taken from "Pirch" at Ucluelet, June, 1909 by Young and Spreadborough ; as shown in the figure (Plate I) there is no pigment developed and the interradial membranes of the vertical fins are extended as large flaps which may have been of use as accessory breathing organs during fetal existence.

Taenitoca lateralis (Agassiz)

One specimen, 95 mm. long, from Departure Bay, June 1908.

Six specimens, 80 mm. long, caught in crab trap at Ucluelet, June, 1909. Young and Spreadborough.

This is evidently the fish called *Embiotoca ornata* by Girard, and placed in the synonymy of *Tæniotoca lateralis*, by Dr. Jordan.

Family SCORPÆNIDÆ

Sebastodes maliger (Jordan and Gilbert)

One young specimen, 54 mm. long, another example about 100 mm. long, caught in crab trap, July, 1909, near Ucluelet. Young and Spreadborough. Labelled "Sea Bass."

Family HEXAGRAMMIDÆ

Hexagrammos decagrammus (Pallas)

One specimen, 8 inches long, labelled "Rock Cod," was obtained by C. H. Young, summer of 1909, at Ucluelet, Vancouver Island.

Family COTTIDÆ

Jordania zonope Starks

One female (?) specimen of this rare species was obtained at Ucluelet, at low tide, June, 1909, by Young and Spreadborough. Length 82 mm.

Chitonotus pugetensis (Steindachner)

One male specimen, 87 mm. long, taken at low tide, at Ucluelet, June, 1909.

One female, 135 mm. long, in 30 fathoms, near Double Island, Ucluelet, June, 1909. Young and Spreadborough.

The dorsal fin of this species is not correctly shown in the figure published in Bulletin No. 47, U. S. Nat. Mus., pl. CCLXXXIII, fig. 687, as the first three dorsal spines are much more distinctly separated from the rest of the fin than there shown. We have examined the specimen from which this figure was made.

The male of our Vancouver Island specimens is very dark and has a large anal papilla. The first dorsal fin is high in front while in the female it is low, reaching only to the base of the fifth spine.

Artedius lateralis (Girard)

Three specimens, 88, 114 and 117 mm., low tide, May and July, 1919, Ucluelet, Young and Spreadborough.

We are not at all sure that *Axyrias*, *Artedius* and *Orthonopias* should be considered separate genera. The specimen numbered 366, U. S. Nat. Mus., from which Girard's figure[1] of *Artedius lateralis* was presumably made is apparently either *Axyrias harringtonii*, *Artedius asperulus* or *Orthonopias triacis*. It has scales on top of the head, the patches of scales meeting behind the dorsal and the preopercular spine with the lower prong very narrowly bifurcate. As Starks has shown[2], the preopercular spine in *Artedius* and *Axyrias* differs fundamentally from that of *Astrolytes* in that when the latter has the spine bifurcate, it is always the lower prong that is lost and there are still two points directed upward, while in the former genera if there are three prongs it is by splitting of the lower one, and we have two points directed downward and backward. This point covers the description of *Orthonopias*. Our specimens from Ucluelet have cirri on the head, and a specimen, No. 24765, U. S. Nat. Mus., collected by Dr. H. C. Yarrow, at Santa Barbara, Cal., differs from *Artedius lateralis* in no way except that it has scales on top of the head.

One specimen, 8 cm. long, Comox, Vancouver Island, 1893, J. Macoun.

Six specimens, 5·8–8·3 cm. long, Skidegate Inlet, B.C., June, 1910, W. Spreadborough.

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[1] Fishes Pac. RR. Surv. p. 70, Plate XXIIa, Figs. 5, 6.

[2] Ann. Carnegie Mus., Vol. VII, No. 2, pp. 188–190, 1911.

ASTROLYTES FENESTRALIS (Jordan and Gilbert)

One specimen, 11·6 cm. long, British Columbia.

One specimen, 8 cm. long, Straits of Georgia, B.C., 1910, W. Spreadborough.

PTERYGIOCOTTUS, new genus, Bean and Weed.

Large cardiform teeth present in jaws, on vomer and on palatines. Top of head as far down as suborbital stay covered with small nonimbricated, ctenoid scales. Scales on back and sides arranged as in *Artedius* and *Axyrias*, meeting behind dorsal fin. Scales on lateral line ctenoid but almost entirely concealed. One or two cirri on nearly every scale. A few scattered cirri on head.

Gill openings very wide, the membranes united and free from the isthmus. Mouth very large. A very large plumose tentacle on the front of each orbit, and a similar smaller one behind each eye. The smaller cirrus is about as in *Archistes*, from which this form differs in the large preorbital cirrus and in the position of the vent.

This genus appears to be most closely allied to *Artedius*, *Axyrias* and *Orthonopias* if these are separable, differing mainly in the immense cirri and in the teeth.

Pterygiocottus from the Greek wood meaning a flap, *Cottus* (the Sculpin).

Type of the genus *Pterygiocottus macouni*.

PTERYGIOCOTTUS MACOUNI, Bean and Weed, new species

A single male specimen taken at Ucluelet, July, 1909, during low tide. Total length 79 mm., standard length 64 mm. Length of head 23 mm. Depth of body 17 mm. Snout 7 mm. long. Eye 6 mm. Interorbital (entire width of fleshy bridge) 3 mm. Interorbital (bony part) 2 mm. Length of preorbital cirrus 12 mm. Postorbital cirrus 5 mm. Length of first dorsal spine 10 mm. Highest dorsal spine 10 mm. Last dorsal spine 5·7 mm. First dorsal ray 11 mm. Highest dorsal ray 11 mm. Last dorsal ray 5·5 mm. First anal ray 8 mm. Highest anal ray (5th) 12 mm. Last anal ray 10 mm. Length of pectoral 21 mm. Length of ventral 11 mm. Maxillary 15 mm. The maxillary reaches more than width of pupil behind eye. Interorbital very concave.

Dorsal IX, 16; Anal 13; Pectoral 14; Ventral I, 3; Caudal III, 11, III. Thirty-eight (38) ctenoid scales in lateral line. About forty (40) diagonal rows of scales on back, four to eleven scales in each row.

A few ctenoid scales in and behind axil of pectorals. The patch of ctenoid scales on sides of back cover about half the space between lateral line and dorsal. It is close to dorsal until about the front of soft dorsal when it begins to bend downward and finally meets lateral line at upper angle of opercle. The two patches of scales meet behind dorsal fin and in front merge in the scaling of top of head.

One row of teeth at sides of jaw, and several rows at centre of jaws enlarged. A few small teeth on the inner side of the jaws. The largest teeth are near the centre of the jaws and are strongly hooked. A few cardiform teeth on vomer and palatines.

Nasal spines short but distinct, with the end of premaxillary coming up between them so as to appear like a third spine. Preopercular spine bifid with apparently two or three weak spines below it. No other spines apparent on head. All the spines are covered with thick skin.

Opercle with a long flap, almost as in *Lepomis*. Gill membranes united and free from the isthmus. Between the nasal spine and the eye on each side is a large plumous tentacle about half as long as head. Behind eye on each side is a similar one about as long as eye.

A row of simple cirri along lateral line, one or two on nearly every scale, and a few scattered ones on head.

Membrane of anal and ventral fins very wide and rounded between the distal ends of the rays so that the ventrals appear spatulate and the anal is much fluted along the margin. This is hardly sufficiently indicated in the figure (Plate II).

The anal papilla is very large.

Colour in alcohol, light brown with four dark blotches along the base of soft dorsal and one at centre of base of spinous dorsal. These blotches extend just below the edge of the band of scales. Below this, the side is vermiculated with darker except on the posterior half of the tail below the lateral line where there are about six irregular cross bands. Fins all dusky, the pectoral showing some indications of mottling. The anal fin is covered with small, evenly spaced white spots, each with a black ring, a row along each fin ray and two or three irregular rows on the interradial membrane.

Type No. 82169, U. S. Nat. Mus. C. H. Young, collector.

Named in honour of John Macoun, who had charge of the collecting.

Pterygiocottus may possibly be a male of some well known species, as a related form has been described by Starks[1] as perhaps the male of *Axyrias harringtonii*.

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[1] Ann. Carnegie Mus., Vol. VII, No. 2, p. 189, 1911.

It is possible that *Archistes plumarius* is also the male of some form described under another generic and specific name.

HEMILEPIDOTUS HEMILEPIDOTUS (Tilesius)

Three specimens, 83, 107 and 116 mm. long, Ucluelet, low tide, June–July, 1909. Young and Spreadborough.

ENOPHRYS BISON (Girard)

Two specimens, 77 and 98 mm. long, Ucluelet, June–July, 1909. Young and Spreadborough.

LEPTOCOTTUS ARMATUS Girard.

Two specimens, 94 and 105 mm. long, Ucluelet, low tide, June–July, 1909. Young and Spreadborough.

OLIGOCOTTUS MACULOSUS (Girard)

Four specimens, taken at Ucluelet, low tide, June and July, 1909, and five specimens, Departure Bay, 1908 Young and Spreadborough. The following table prepared from nine examples, five females and four males, is interesting in showing slight differences in dorsal and anal fin counts as well as those of the lateral line:

UCLUELET SPECIMENS

Total length	Dorsal	Anal	Lateral line	Sex
68 mm.	VIII–17	13	36	female
72 mm.	VIII–17	13	36	male
70 mm.	VIII–18	14	37	male
86 mm.	VIII–17	14	35	female

DEPARTURE BAY SPECIMENS

Total length	Dorsal	Anal	Lateral line	Sex
83 mm.	VIII–18	14	37	male
86 mm.	VIII–17	13	36	female
74 mm.	VIII–17	13	37	female
72 mm.	VIII–17	14	37	male
72 mm.	VIII–17	13	37	female

OLIGOCOTTUS BOREALIS Jordan and Snyder.

Six specimens, 5·8–8 cm. long, Comox, Vancouver Island, B.C., 1893, John Macoun.

Oligocottus maculosus Girard.

Six specimens, 2·5–3·8 cm. long, Discovery Passage, Johnstone Strait, 1885, G. M. Dawson.

Fourteen specimens, 2·5–7·8 cm. long, Vancouver Island, B.C., Active Passage, rock-pool, August 28, 1895, E. E. Prince.

No. 38014, U. S. Nat. Mus., five specimens collected by Rosa Smith Eigenmann at San Diego, Cal., have all the characters assigned by Greeley to *Rusciculus rimensis*, except that the preopercular spine is bifid and that in mostof the specimens the prickles extend on to the lower half of the body in the caudal region; covering the entire space between the soft dorsal and anal fins. Ten specimens, Nos. 6224 and 6225, U. S. Nat. Mus., collected on the California coast by Dr. Kennerly, are in very bad condition but seem to agree with the San Diego specimens in preopercular spine and in the presence of prickles.

Dialarchus snyderi (Greeley)

One specimen, 6·3 cm. long, Skidegate Inlet, B.C., W. Spreadborough.

Three specimens, Ucluelet, June and July 1909, low tide, seem to be referable to this species.

U.	Total length	Dorsal fin	Anal fin	Lateral line	Sex
U.	42 mm.	VIII–19	14	38	male (drawn)
U.	38 mm.	VIII–20	15	39	male
U.	31 mm.	IX–19	15	38	Female

The specimen drawn (Plate IV) has the left preopercular spine trifid as shown. The spine on the right side of this specimen and on both sides of the other two are bicuspid.

Blepsias cirrhosus (Pallas)

One specimen, 19·6 cm. long, British Columbia.

Cottus asper (Richardson). Blob.

Five specimens, 13·5–18·5 cm. long, mouth of Fraser River, B.C., A. Halkett.

Cottus gulosus (Girard). Blob.

Four specimens, 10·8–12·6 cm. long, Victoria, Vancouver Island, B.C., J. Macoun.

Oxycottus embryum (Jordan and Starks)

One specimen, Ucluelet, 68 mm., low tide, June, 1909, Young and Spreadborough.

Blennicottus globiceps (Girard)

Two specimens, Ucluelet, 81 and 125 mm., low tide, May, 1909, Young and Spreadborough.

Myoxocephalus polyacanthocephalus (Pallas). Sculpin.

One specimen, 3·5 cm. long, Skidegate Inlet, B.C., 1910, W. Spreadborough.

Nautichthys oculofasciatus (Girard)

One young specimen, 30 mm. Ucluelet, 1909, Young and Spreadborough.

This fish is very different in many respects from the adult. In the caudal region there is a row of enlarged spines just above the anal fin and a band of three or four very irregular rows below the dorsal. The lateral line is armed with a row of long slender bifurcated spines and the whole abdominal and thoracic region is covered with sharp spines as prominent as those of a *Diodon*. The rest of the body is covered with much smaller prickles.

The drawing (Plate II) is in error in showing the spines too much in rows.

Ascelichthys rhodorus Jordan and Gilbert.

One specimen, 7·6 cm. long, Comox, Vancouver Island, J. Macoun.

Eleven specimens, Ucluelet, low tide, June and July, 1909; 50, 70, 79, 80, 80, 80, 82, 83, 85, 92, 97 mm. Young and Spreadborough.

Psychrolutes paradoxus Günther.

Nineteen specimens, 3·7–5·2 cm. long, Skidegate Inlet, B.C., June, 1910 (low tide), W. Spreadborough.

Family RHAMPHOCOTTIDÆ

Rhamphocottus richardsoni Günther.

One specimen, Ucluelet, June, 1909, 51 mm., June, 9 fathoms. Young and Spreadborough.

One specimen, 3·5 cm., Straits of Georgia, B.C.

Family CYCLOGASTERIDÆ

NEOLIPARIS RUTTERI Gilbert and Snyder.

Twelve specimens, Ucluelet, July, 1909; 43, 48, 58, 58, 61, 74, 74, 84, 88, 89, 100, 104 mm. Young and Spreadborough.

Family AGONIDÆ

AVERRUNCUS EMMELANE Jordan and Starks.

One specimen, 18·5 cm. long, Straits of Georgia, B.C., 1910. W. Spreadborough.

Three specimens were taken at Ucluelet in June and July, 1909, in 30 fathoms of water, measuring 102, 115 and 127 mm. respectively. Young and Spreadborough.

ODONTOPYXIS TRISPINOSUS Lockington.

One specimen, 10 cm. long, Straits of Georgia, B.C.

Two specimens, 6–7·3 cm. long, Vancouver, B.C., John Macoun.

Five specimens taken in 30 fathoms, at Ucluelet, June–July, 1909. These examples are 49, 66, 68, 70 and 73 mm. long. Young and Spreadborough.

BOTHRAGONUS SWANII (Steindachner)

Four specimens of this rare form, measuring 45, 48, 48 and 60 mm. respectively, were taken at Ucluelet (low tide to deepwater), June-August, 1909. Young and Spreadborough.

Family CYCLOPTERIDÆ

EUMICROTREMUS SPINOSUS (Müller)

One specimen, 5 cm. long, Queen Charlotte Island, B.C., May 12, 1893, J. H. Keen.

Family LIPARIDIDÆ

NEOLIPARIS CALLYODON (Pallas). Sea Snail.

Three specimens, 2·8–6·2 cm. long, Discovery Passage, Johnsonet Str. Shore water, 1885, G. M. Dawson.

Three specimens 4·8–7·5 cm. long, Skidegate Inlet, Queen Charlotte Island, B.C., June, 1910, W. Spreadborough.

NEOLIPARIS SP. Sea Snail.

Three specimens, 4–7·5 cm. long, Comox, Vancouver Island, B.C. June, 1893, John Macoun.

LIPARIS CYCLOPUS Günther. Sea Snail

One specimen, 4·5 cm. long, Skidegate Inlet, Queen Charlotte Island, B.C., June, 1910, W. Spreadborough.

Family GOBIIDÆ

GOBIUS NICHOLSI Bean.

Three specimens, 33, 43, and 47 mm. long, taken at Ucluelet during low tide, June-July, 1909. Young and Spreadborough.

GILLICHTHYS MIRABILIS Cooper. Long-jawed Goby.

One specimen, 5 cm. long, Comox, B.C., June, 1893, John Macoun.

LEPIDOGOBIUS LEPIDUS (Girard). Goby.

One specimen, 8·4 cm. long, Comox, B.C., June, 1893, John Macoun.

Family STICHAEIDÆ

LUMPENUS ANGUILLARIS (Pallas). Eel-blenny.

One specimen, 31 cm. long, Comox, B.C., 1893, J. Macoun.

Family BATRACHOIDIDÆ

PORICHTHYS MARGARITATUS (Richardson) Midshipman; Singing Fish

One specimen, 23·4 cm. long, Vancouver Island, B.C., July, 1915, W. Spreadborough.

PORICHTHYS NOTATUS Girard.

Two fine examples, 8 and 9 inches long, were obtained by C. H. Young, at Ucluelet, Vancouver Island, summer of 1909.

Family BLENNIIDÆ

Gibbonsia evides (Jordan and Gilbert)

One specimen 90 mm. long, taken at Ucluelet, July, 1909. Young and Spreadborough.

Of 52 specimens examined, 38 have the anal rays 23, 24 or 25; all these have dorsal rays 7 or 8, and dorsal spines, following the first five, 28 or 29. The other 14 specimens have anal rays 26 or 27, dorsal spines, after the first five, 30 or 31, and all but our Ucluelet specimen have dorsal rays, 9 or 10.

The specimens in the U. S. National Museum thus seem to divide naturally into two groups, which may be only of subspecific value, as follows:

(*a*) Specimens ranging from San Francisco to San Diego, most common northward. These have D. V., XXX or XXXI, 9 or 10; A. II, 26 or 27. The first five dorsal spines are evenly graduated and the sixth is about twice the fifth. There is little trace of a pellucid area in spinous D. between the third and fourth spines. Where there is a pellucid area in soft D. it occupies about the fifth, sixth or seventh interradial space, and this is very little widened. The soft D. is rather evenly rounded, never angled. The last soft ray is not closely bound to back by fin membrane. This group has a slightly greater tendency toward a colour pattern of horizontal stripes instead of the vertical bars that predominate in the other.

(*b*) Specimens ranging from Santa Barbara to San Diego, most common southward. These have D. III, XXIX to XXXI or V, XXVII to XXIX, 7 or 8; A. II, 23 to 25. The first three dorsal spines are evenly graduated, followed by a rather wide pellucid interspace and then by two short spines followed by one about the same height as the ones after it, or two short spines with the third midway in height between them and those following; or all the spines after the interspace about equal in height. A few of these specimens, mostly small ones, have the pellucid area in soft D. very little differentiated and this part of the fin evenly rounded. In the others the rays in front of the pellucid area are distinctly longer and more closely spaced and the rest are evenly graduated. This makes nearly a right angle at about the tip of the third, fourth or fifth soft ray of dorsal. There are three, four or five soft rays closely approximated, followed by three or four rays widely spaced, and with the membrane entirely transparent. The last dorsal ray is nearly horizontal and closely bound to the back by the fin membrane. There is a tendency in this group to a greater development of cross bars than of horizontal stripes.

Our single specimen from Ucluelet agrees with the northern form, except that the pellucid area in spinous dorsal is somewhat larger and that the first five rays of soft dorsal are closely approximated and followed by *two* widely spaced rays with the membrane transparent. The last ray is *not* adnate to the back.

We can not entirely agree with the conclusions of Mr. Greeley[1] and think that a careful plotting of the measurements of his specimens might have shown differences.

In Bull. 47, U S. Nat. Mus., p. 2353, *Clinus evides*, Rosa Smith, is put in the synonymy of *Gibbonsia elegans* with the remark "not of Jordan and Gilbert." An examination of the specimens and of the paper in question shows that both forms were included in the collection.

Apodichthys flavidus Girard.

One specimen, Ucluelet, 33 mm., low tide, June, 1909. The dorsal fin and back of this specimen were somewhat mutilated.

One specimen, 8·2 cm. long, rock-pools, Active Passage, Vancouver Island, B.C., August, 1895, Edward E. Prince.

Xererpes fucorum (Jordan and Gilbert)

One specimen, Ucluelet, 91 mm., June, 1909; low tide.

Pholis ornatus (Girard). Gunnell.

One specimen, Ucluelet, 148 mm., June, 1909. Four specimens, Departure Bay, 112, 121, 124, 143 mm. Three specimens, 7·3, 14·3 cm., Skidegate Channel, Q. C. I., June, 1910, W. Spreadborough.

Two specimens, 12·5–18·5 cm. long, Comox, Vancouver Island, B.C., 1893, J. Macoun.

Three specimens, 7·5, 9 and 9·3 cm. long, Vancouver Island, B.C., J. Macoun.

One specimen, 6·7 cm. long, Houston Stewart Channel, Queen Charlotte Sound, B.C., 1885, G. M. Dawson.

Anoplarchus atropurpureus (Pallas). Kittlitz.

Ten specimens, Departure Bay, 100, 102, 103, 108, 108, 109, 111, 112, 115, 119, 119 mm. Twenty-five specimens, Ucluelet; 48, 54, 54, 55, 61, 61, 62, 64, 65, 68, 76, 77, 78, 80, 86, 91, 95, 97, 99, 100, 102, 113, 116, 125 mm., June and July, 1909.

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[1] Bull. U.S. Fish. Comm., 1899, p. 20.

Seven specimens, 7·6–10 cm. long, Skidegate Channel, Queen Charlotte Island, B.C., low tide, 1910, W. Spreadborough.

One specimen, 8·7 cm. long, Shore-water, Discovery Passage, Johnstone Strait, summer, 1885, G. M. Dawson.

Ten specimens 5·9–10·7 cm. long, Vancouver Island, summer, 1893, John Macoun.

XIPHIDION MUCOSUM Girard.

One specimen, Ucluelet, 134 mm., July, 1909, under stone.

Two specimens, 6·5–17·3 cm. long, Vancouver Island, B.C., summer, 1893, John Macoun.

One specimen, 11 cm. long, Shore of Queen Charlotte Island, B.C.

XIPHIDION RUPESTRE (Jordan and Gilbert)

Two specimens, Departure Bay, 157 and 159 mm. Ten specimens, Ucluelet, 129, 131, 145, 151, 158, 158, 170, 177, 181 and 186 mm., June and July, 1909.

XIPHISTES ULVAE Jordan and Starks.

One specimen, 14 cm. long, Skidegate Channel, B.C., June, 1910, W. Spreadborough.

LUMPENUS ANGUILLARIS (Pallas)

One specimen, Ucluelet, 200 mm., June, 1909.

Family AMMODYTIDÆ

AMMODYTES PERSONATUS Girard. Sand Launce.

One specimen, 12·6 cm. long, Comax, B.C., 1892, John Macoun.

Forty-eight specimens, 9·7–11·2 cm. long, Queen Charlotte Island, Skidegate Inlet, B.C., June, 1910, W. Spreadborough.

One specimen, 72 mm., Ucluelet, July, 1909; low tide.

Family GOBIESOCIDÆ

CAULARCHUS MAEANDRICUS (Girard)

Fourteen specimens, 5·2–8·6 cm. long, Comox, Vancouver Island, B.C., June, 1893, John Macoun.

Six specimens, 7·1–13·2 cm. long, Skidegate Inlet, Queen Charlotte Island, B.C., low tide, June, 1910, W. Spreadborough.

Ten specimens, Departure Bay, 53, 54, 59, 62, 64, 73, 85, 88, 91, 99 mm. Fourteen specimens, Ucluelet, 35, 39, 50, 67, 68, 69, 73, 77, 94, 96, 99, 104, 106, 126 mm., May, June and July, 1909, under stones at low tide.

Family PLEURONECTIDÆ

LIMANDA ASPERA, (Pallas). Rough Dab.

One specimen, 15 cm. long, Queen Charlotte Island, Skidegate Inlet, B.C., June, 1910, W. Spreadborough.

PLEURONICHTHYS CŒNOSUS Girard. Flounder.

One specimen, 12·5 cm. long, Departure Bay, B.C., September, 1908, C. H. Young and W. Spreadborough.

Three specimens, Departure Bay, No. 1, 127 mm., No. 2, 115 and 137 mm., low tide.

PAROPHRYS VETULUS Girard.

Two specimens, Ucluelet, 122 and 124 mm., June and July, 1909, low tide to deep water.

CITHARICHTHYS STIGMÆUS, Jordan and Gilbert.

Five specimens, Ucluelet, 79, 89, 98, 118 and 123 mm., June and July, 1909, low tide to deep water.

Family SYNGNATHIDÆ

SIPHOSTOMA GRISEOLINEATUM (Ayres). Pipe Fish

Two specimens, Ucluelet, 148 and 240 mm., June and July, 1909. The larger specimen has lost the entire caudal fin.

Two specimens, 17·5 and 18·8 cm. long, British Columbia. W. Spreadborough.

One vial containing larval specimens obtained in Discovery Passage, Johnstone Strait, 1885, by G. M. Dawson.

Family GASTEROSTEIDÆ

GASTEROSTEUS CATAPHRACTUS (Pallas). Stickleback.

Five specimens, 7–7·2 cm. long, Comax, Vancouver Island, B.C., 1893, John Macoun.

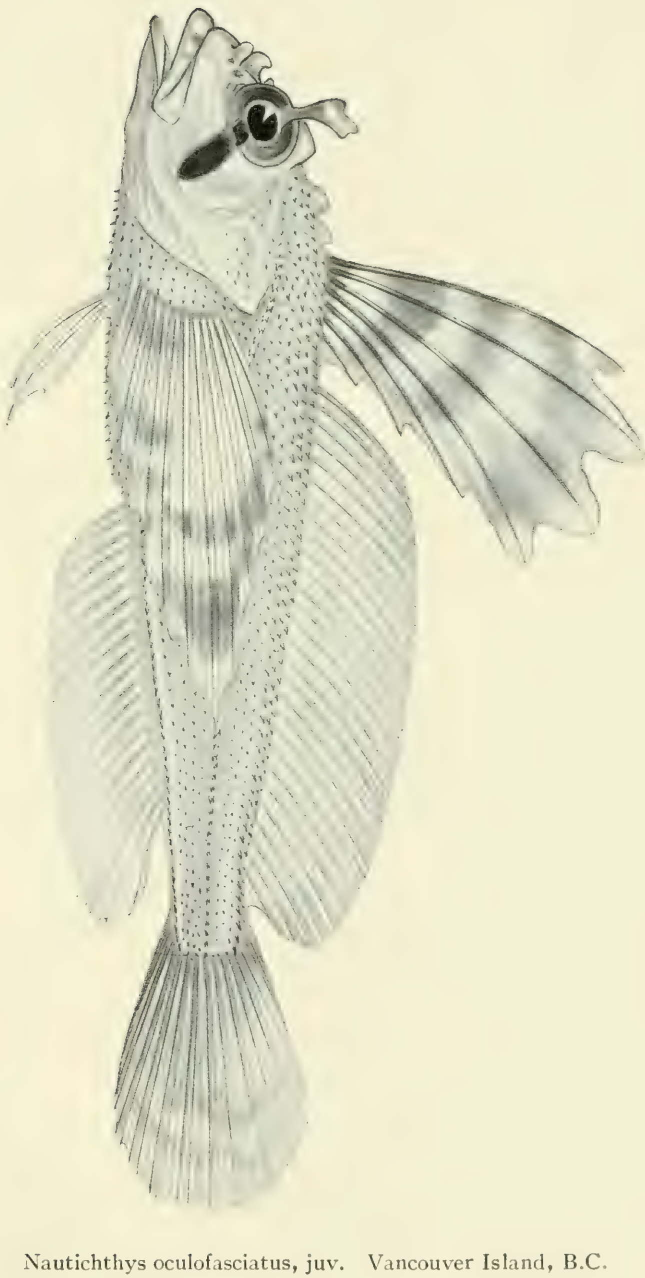
Family AULORHYNCHIDÆ

AULORHYNCHUS FLAVIDUS Gill.

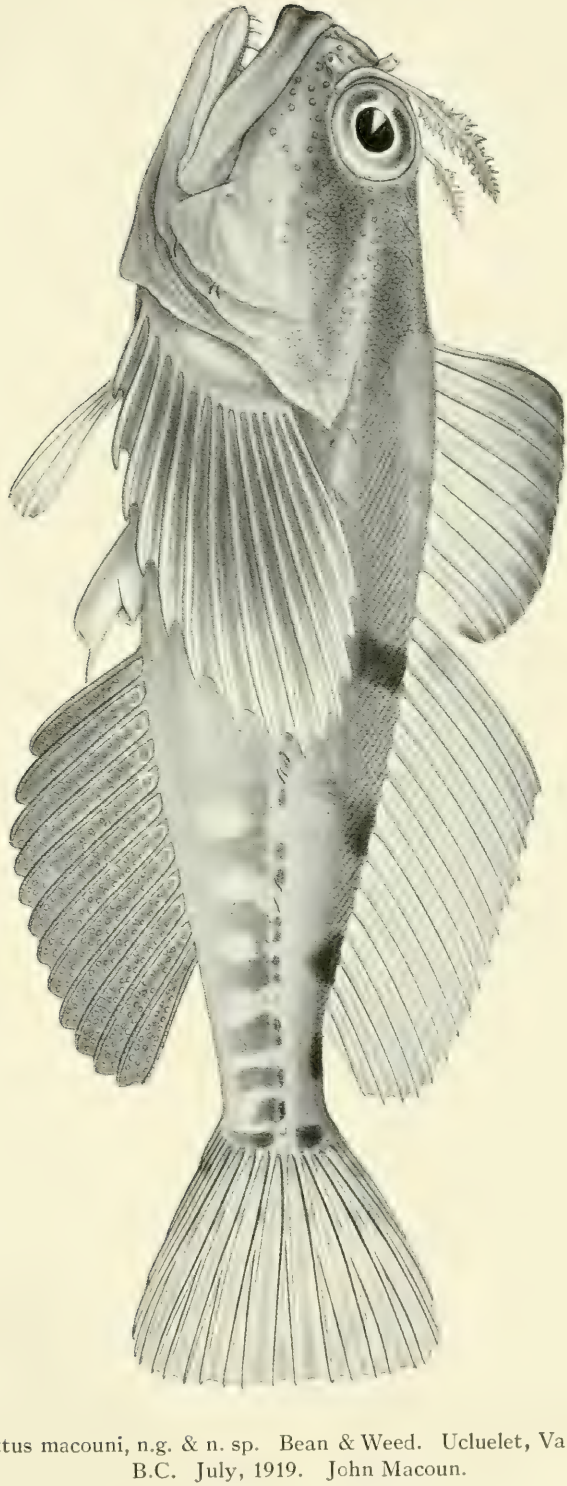
One specimen, 13 cm. long, Mossett, Queen Charlotte Island, B.C., May 12, 1893, J. H. Keen.

Damalichthys argyrosonnus (fetal). June, 1909, Ucluelet, B.C.

PLATE II.

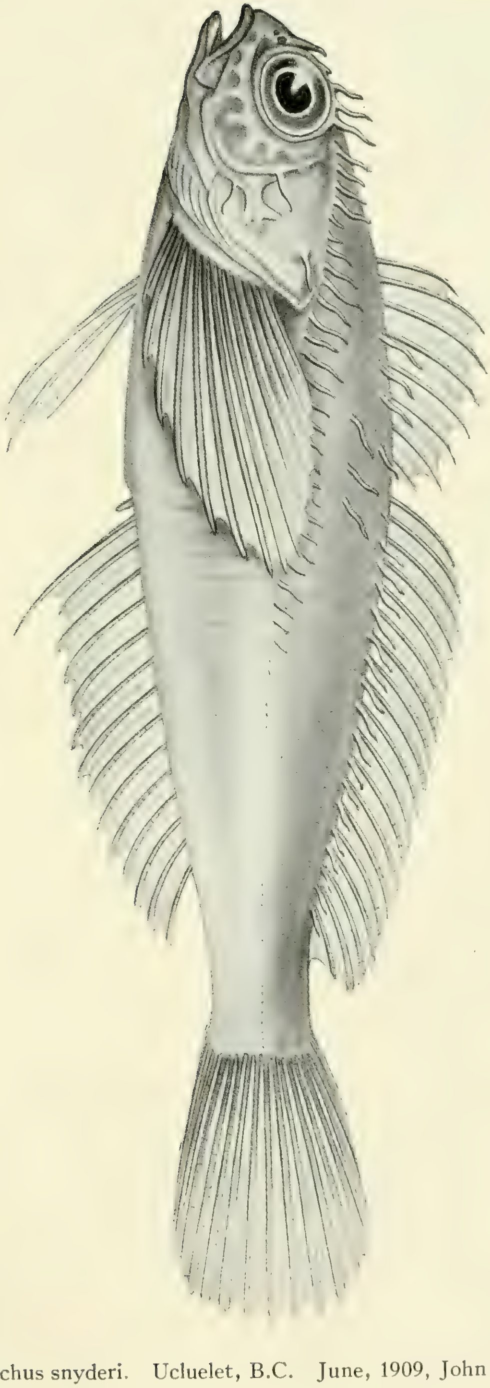


Nautichthys oculofasciatus, juv. Vancouver Island, B.C.



Pterygiocottus macouni, n.g. & n. sp. Bean & Weed. Ucluelet, Vancouver Island, B.C. July, 1919. John Macoun.

Plate IV.



Dialarchus snyderi. Ucluelet, B.C. June, 1909, John Macoun.

Studies on the Respiratory Centre

I. THE BEHAVIOUR OF THE RESPIRATIONS AFTER DECEREBRATION IN THE CAT

By J. J. R. MACLEOD, M.B., F.R.S.C.

(Read May Meeting, 1919.)

Our knowledge of the functions of the respiratory centre depends on observations which have been made either on anæsthetised laboratory animals or on man in the normal state. To both groups of researches serious objections can be raised; to the former because of the use of anæsthesia, which is well known greatly to depress the excitability of the respiratory centre, and to the latter because of the limited variety of observations which it is practicable to make. As a first step to a further investigation of the respiratory function, therefore, it became necessary to seek for some method applicable to laboratory animals, in which the activities of the centre would not be dulled by the use of anæsthetics. It has been found that this requirement can be satisfactorily met by using the decerebrate preparation which was originally described by C. S. Sherrington,[1] and subsequently more closely studied by Theile,[2] Sherrington,[3] Forbes and Sherrington,[4] Miller and Sherrington[5], Weed[6] and Cobb, Bailey and Holtz[7].

The section of the brain stem is usually made about the level of the anterior corpora quadrigemina. After the effects of the initial anæsthesia have passed off a state of rigidity (plastic tonus) of the postural musculature supervenes and the breathing usually remains more or less normal.

In using the decerebrate preparation for investigation of the respiratory function one must not lose sight of the fact that important controlling influences have been removed from the centre, namely those derived from the higher cerebral centres, and that the respiratory function under these conditions may be as far removed from the

[1] Sherrington, C. S. Journ. Physiol., 1897, XXII, 319.

[2] Theile, F. H. Journ. Physiol., 1904, XXXII, 358.

[3] Sherrington, C. S. Quart. Journ. Physiol., 1908, II, 109.

[4] Forbes, A, and Sherrington, C. S. Am. Journ. Physiol., 1915, XXXV, 327.

[5] Miller, F. R., and Sherrington, C. S. Quart. Journ. Physiol., 1915, IX, 147.

[6] Weed, L. H. Journ. Physiol., 1914, XLVIII, 205 and Am. Journ. Physiol., 1917, XLIII, 131.

[7] Cobb, S., Bailey, A. A., and Holtz, P. R. Am. Journ. Physiol., 1917, XLIV, 239.

normal as in an anæsthetised animal with brain intact. It is clear, however, that important facts are likely to be revealed by observing the behaviour of the decerebrated animal in relationship to changes in the chemical condition of the arterial blood, an investigation which is very difficult in man, and which can be carried out in anæsthetised animals only to a limited degree because of the presence of anæsthetics in the blood.

It has been noted by several of the above-mentioned workers, particularly by Theile (loc. cit.) and Weed (Weed, L. H., Am. Journ. Physiol., 1917, XLIII, 131.) that the character of the respirations does not remain the same throughout the period during which the animal survives the decerebration. Weed recognizes three periods of somewhat different behaviour of the decerebrated animals; in the third of these, which supervenes in from two and one-half to three hours following the decerebration, increasing respiratory difficulties with rapid decline are often observed.

In a series of investigations, conducted in the author's laboratory by R. W. Scott, in which the particular problem was to study the influence of rapidly increasing percentages of carbon dioxide in the inspired air and of intravenous injections of alkali on the respiration of decerebrate cats (Scott, R. W., Am. Journ. Physiol., 1917, Vol. 44, 196), it was noted that there were three more or less distinct groups of animals. In one of these, adequate spontaneous respiration did not return, or if it did so it was irregular and incapable to maintain life. In a second group the breathing was fairly satisfactory for the first hour or so but then became dyspnoeic and gasping, and the animal soon succumbed. In the third group the animal breathed with perfect regularity for many hours, and even at the end did not develop the dyspnœa characteristic of the second group.

Since these variations might lead to serious confusion in the further researches which were contemplated, it was decided to make a closer study of the breathing and particularly to see whether variations in it are correlated with changes in the acid-base equilibrium of the blood. It is with this phase of the problem that the present paper is concerned.

Methods

Decerebration was performed with the apparatus and by the method described by Miller and Sherrington (Quart. Journ. Physiol., 1915, IX, 107). It is of interest to note that frequently the respirations became regular almost immediately after the decerebration and remained so, particularly in young animals, even during compression of the vertebral arteries; whilst in other animals apnœa gradually supervened, but could be immediately terminated by allowing some arterial blood to reach the medulla by momentarily releasing the vertebrals. The reflex activities of the decerebrate animal varied considerably according to the exact position of the cut. When this was well forward of the anterior corpora quadrigemina the animals, after the effects of the anæsthetic had passed off, were highly excitable and behaved as if they felt some pain. Section by a scalpel a little further back immediately removed these mimetic reactions, but the resulting preparation was not as a rule so satisfactory as when the first cut had been in the correct position (*i.e.* through the anterior corpora quadrigemina). When the cut involved the posterior corpora quadrigemina spontaneous breathing rarely returned except in very young animals, and even in them it was usually irregular and unsatisfactory. In a succeeding paper we shall show that an abundant oxygen supply to the centre could usually be counted on to restore the breathing to normal in those cases in which it was irregular and spasmodic.

The alveolar air was collected by inserting into the trachea (through a side tube in the tracheal cannula) a narrow tube (gum-elastic catheter), the outer end of which was connected with an all-glass graduated syringe (10 cc., but capable of holding about 16 cc.) with the piston well smeared with vaseline. Towards the end of normal respiration the piston was withdrawn taking in from one half to one cubic centimetre. This process was repeated for several succeeding expirations after which the air was expelled again into the trachea so as to wash out the dead space of the tubing. By a repetition of the above procedure a sample of about 10 cc. of alveolar air was then collected for analysis. The analysis was carried out in a 10 cc. Haldane gas burette, the accuracy of which had been carefully checked against Brodie's apparatus.

There can be no doubt that the fractions of air collected towards the end of normal expirations is alveolar air in the usually accepted sense. The average tidal air of a cat is generally about 35 cc. and the dead space from the point of insertion of the catheter to the alveoli cannot be more than 10–12 cc. so that the last few cubic centimetres of air of a normal expiration, from which the fractions of 0·5–1 cc. are collected, must be undiluted alveolar air, even after allowing for the possibility that some of the peripheral layers of air in the trachea do not move so quickly as the axial currents (cf. Henderson, Chillingworth and Whitney, Am. Journ. Physiol., XXXVIII, p. 1).

Short of making actual comparisons of the tension of carbon dioxide in arterial blood and alveolar air, the most satisfactory evidence that the percentage composition of the alveolar samples collected by the present method really corresponds to the tension of the gas in arterial blood is supplied by the constancy of the results in successive samples of air. This constancy can be seen in the figures given in the tables accompanying this paper.

The percentage of carbon dioxide in the arterial blood was determined by the method of Barcroft and Haldane, using $0 \cdot 5$ cc. of blood and an excess of weak ammonia water, so that the precipitate which is formed when acid is added to dislodge the CO_2 does not make the solution so thick as to interfere with the evolution of the CO_2. The P_h of the arterial flow was measured by the method of Levy, Rowntree and Marriott (Archiv. of Int. Med., 1915, XVI, 389), the exact P_h of the phosphate solutions used for comparison being determined by the electro-metric method.

The total acidity of the urine was computed by adding (1) the titratable acidity (in cc. $n/_{10}$ acid per 100 cc. urine), after shaking with excess of neutral potassium oxalate, using phenolphthalein as indicator, and (2) the ammonia, using the permutit method of Folin and Bell (J. Biol. Chem. N.Y., 1917, XXIX, 329).

The quantity of lactic acid in the blood was determined by the modified von Fürth method described elsewhere by the author (Macleod and Hoover, Am. Journ. Physiol., 1916–17, XLII, 460).

Consideration of Results

The present communication concerns the results obtained on cats which continued to breathe more or less normally for at least two hours following the decerebration. According to the behaviour of the breathing, as judged from the minute-volume of respired air, these animals could be divided into two main groups; in the one, the breathing either remained about constant or it slightly decreased, whilst in the other it progressively increased. In several animals of the first group the observation was terminated by bleeding to death, but in those of the second group it was usually continued until the animal died.

The results of a typical experiment of the first group of animals are given in Table I:

TABLE I

No. Expt.	Time after decere-bration (min.)	Respirations per min. Vol. c.c.	rate	Alveolar CO_2 %	Blood CO_2 %	Acid of Urine c.c.n/10 %	Rectal temper-ature	Remarks
XVIII	15	..	..	..	..	168	..	
	45	770	..	3·6	..	..	37·5	
	60	..	38	3·75	..	..	38	Rigidity
	67	..	..	..	33	..	..	moderate acoustic reflex and hyperexcit-able.
	75	..	..	3·70	..	..	..	
	92	..	..	..	39·6	..	..	
	95	645	..	..	..	..	38·4	
	113	..	..	3·2	..	..	..	
	125	..	..	..	40·9	..	..	
	127	600	..	..	..	..	..	
	142	..	30	..	..	..	..	
	160	..	..	3·1	..	..	..	
	175	570	..	..	..	86	..	Glycosuria.
	200	..	..	3·0–3·5	..	..	37·3	After warm-
	225	616	..	..	38·2	..	..	ing tank.
	238	..	33	..	..	..	38·5	
	257	..	..	3·2	..	..	..	Rigidity less.
	275	..	30	..	..	..	..	
	285	..	..	(3·6)	..	..	..	Rigidity almost gone.
	316	..	..	3·2	..	..	..	
	330	..	..	..	42·8	..	..	
	333	662	39	..	..	..		
	338	..	..	..	..	..	..	B.P. 70 mm. Hg.
						90		Glycosuria.
						bled to	death	P_h of blood at end 7·6

In more condensed form the results of the other observations of this group are given in Table II:

TABLE II

No. Expt.	Time after decere-bration (min.)	Respirations per min. Vol. c.c.	rate	Alveolar CO_2 %	Blood CO_2 %	Urine Acid c.c. N/10 %	NH_2 c.c.N/10 %	Remarks
VI	50-72	..	60	3·3	44·2	120	..	P_h of blood 7·4
	157-165	..	32	2·75	41	..	..	Decerebrate rigidity distinct.
	190-195	..	40	2·25	41	..	..	Temp. 39°C. P_h of blood 7·4. Bled to death
XIV	60-100	1100	..	3·5	52·8	..	..	Marked rigidity
♀	135-165	980	..	2·8	38·5	..	..	Rect. temp. 40°C.
	190-225	855	..	2·7	37	..	..	Rigidity pronounced.
	270-285	875	..	2·9	38·2	..	..	Rect. temp. 39°C.
	290-310	760	..	2·9	40·2	..	..	Lactic Acid 0·175%
XXVI	65-125	1000 -1040	40	4·5	..	..	..	Rect. temp. 39°C.
	155-215	825	32	4·1	..	28	..	Moderate rigidity
	230-240	845	34	4·4	..	..	..	Lactic acid 0·081%
	260-275	..	..	4·4	..	16	..	No glycosuria
XXIII	135-140	1080	27	3·3	..	106	0·107 0·076	
♀	195-215	1120 -1170	28	3·3	..	..	..	Rigidity slight
	230	1150	30	..	..	20	0·033	
	250-255	1120	28	3·0	..	..	..	
	290-295	940	25	2·9	..	..	..	P_h of blood 7·6–7·7
	302-305	960	22	..	45	6·5		Lactic acid 0·098% 0·101%
XII	45-60	..	64	3·6	40·2	..	..	Rigidity moderate
♀	110-115	..	42	3·9	39·6	..	38·5	

TABLE II—*continued*

No. Expt.	Time aster decere-bration (min.)	Respirations per min. Vol. c.c.	rate	Alveolar CO_2 %	Blood CO_2%	Urine Acid c.c.N/10 %	NH_2 c.c.N/10 %	Remarks
	135-147	..	36	3·9	..	..	..	Rigidity moderate
	217-247	..	..	3·1	41·0	..	..	
	265-285	..	..	2·4	37·0	..	..	
	305	412	42	2·0	38·0	..	39·5	B.P. very low
IX	60-79	217	..	4·3	40·8	..	..	Respiratory Quotient 0·68
	98-126	294	14	4·8	..	..	..	Rigidity marked
	131-146	394	16	4·5	44	..	..	Respiratory Quotient 0·74. Rigidity slight. Lactic acid 0·01 %

The following are considered the most noteworthy characteristics of these observations:

1. Both the respiratory volume and the respiratory rate decline gradually, although occasionally after four or five hours a slight increase may occur (cf. IX and XVIII). This increase is doubtless explained by the fact that the respiratory centre is hyperexcitable in decerebrate animals, so that the manipulation involved in withdrawing blood from the femoral artery for analysis, or in cleaning the femoral cannula of clots brings on a marked hyperpnœa which may last for some minutes after the irritation is removed.

2. The percentage of carbon dioxide in the alveolar air collected in from one to two hours after decerebration (when all ether has disappeared from the blood) varies between 3·3 and 3·9 in five of the six cats of this group, and in numerous observations which we have subsequently made this value has usually been found. Occasionally, and for no evident reason, the percentage may be somewhat higher as in experiments IX and XXVI. During the remainder of the period of observation the percentage of alveolar CO_2 either remains practically unchanged (XXVI) or it very gradually decreases.

In a series of decerebrate cats used in a research by Lois Fraser, R. S. Lang and the author, the alveolar air was analysed for both carbon dioxide and oxygen, and it is of importance in the present connection to place on record the respiratory quotients obtained in samples of air removed at varying periods over a time in which the animal was breathing normally. Table III gives these results.

TABLE III

No. of Cat. (new series)	Time after decerebration (minutes)	Respiratory Quotient
X	100	0·71
	175	0·72
	210	0·71
XX	80	0·92
	115	0·90
	131	1·04
XXIII	70	0·72
	90	0·70
XXIV	60	0·89
	86	0·77
	172	0·81
	183	0·82
XXV	68	0·72
	83	0·71
	100	0·68
XXVI	126	0·81
	140	0·72
	161	0·85

It will be observed that, with two exceptions, the respiratory quotient varies in different animals from 0·7 to 0·9, indicating that a normal type of metabolism is in progress. The relative steadiness of the quotient in each animal further shows that the alveoli are being ventilated at a uniform rate.

3. The percentage of carbon dioxide in the arterial blood varies between 37 and 45 volumes per cent, with the exception of the first observations made on cats XVIII and XIV, in the former of which it is abnormally low and in the latter abnormally high. Both of these

exceptional results were obtained in blood removed in about one hour after decerebration, and subsequent experience has taught us that a longer period than this should have been allowed for the ether to have been expelled from the body. Throughout the remainder of the observations the carbonate of the arterial blood remains practically steady. It is impossible to say from the few results on hand and the small degree of fluctuation in the blood-carbonate values whether any parallelism exists between them and those of the aveolar CO_2.

4. Determination of the total acidity and ammonia content of the urine has not supplied results that can be satisfactory interpreted. In practically all cases, of this group as well as of others, in which sufficient urine was obtainable to estimate both the acidity and the ammonia content, a direct proportionality has been observed between the two, so that to follow changes in the acid excretion in a given cat either the titration or the ammonia values may be used. In the three experiments of this group in which there are adequate data a very decided decline in the acid concentration is observed, in fact in two of the animals, XXVI and XXIII, the urine became nearly neutral. Whether this result depends upon a failure of the kidney to remove acid radicles from the blood or upon a relative increase in fixed alkali in the organism cannot be said.

5. The hydrogen-ion concentration of the arterial blood remained normal, at P_h 7·4, in one of the animals, but it became less, *i.e.* P_h became greater (7·6–7·7) in two of them (XVIII and XXIII). On account of technical difficulties it was impossible to secure sufficient data to make certain that these changes are real, but further observations will be published shortly. If a real increase in P_h does occur it would indicate that the decreasing acidity of the urine, above referred to, is dependent upon alkali retention.

6. Lactic acid was determined in the arterial blood of three of the experiments. In two of them (XXVI and XXIII) it varied between 0·081 and 0·101 per cent. In the third (XIV) it was much higher, namely, 0·175 per cent. It is important to note that the last estimation is possibly too high because the extraction with ether had to be performed in two portions of the unevaporated protein-free filtrate. This would relatively increase the error due to any impurities in the reagents.

It is of interest in this connection to place on record results obtained for lactic acid in the blood of two cats which were bled solely for this purpose immediately after anæsthetising with ether. These are as follows: 0·052 per cent (Cat No. XXVIII) and 0·113 per cent (Cat No. XXIX). It is clear that considerable variation exists in the lactic acid content of cat's blood even under approximately normal conditions. Partial asphyxiation, due to the ether, may explain the variability.

7. Other occasional observations included testing the urine for sugar, the extent of muscular rigidity, and the arterial blood pressure. Glycosuria, when tested for, did not appear so frequently in the cats of this group as in those of the second group. On account of difficulties with clotting, to which the blood of many decerebrate animals appears to be very prone, and because of lack of assistance, it was impracticable to secure many records of arterial blood pressure. In about five hours after decerebration in Cat No. XVIII, however, it was 70 mm. Hg., and from the ease with which the blood flowed from the femoral artery for the lactic acid estimation, it must have been at this height, at least, in the case of the other experiments.

The degree of decerebrate rigidity varied considerably in the different preparations.

A typical observation of the group of animals in which hyperpnœa developed is given in Table IV:

In all of the animals of this group the decerebration was performed well forward of the anterior corpora quadrigemina and the decerebrated animal was very excitable, hyperpnœa being induced by the slightest disturbance. As a rule this hyperpnœa was transient (cf. Exp. XXII) and in all the animals the respirations progressively increased in volume and rate without any evident afferent stimulation. In the most extreme cases (Nos. X, XXX and XXXI) death occurred in about two hours after decerebration, being usually preceded by vomiting movements and convulsions. The rapid development of these conditions made it impossible to analyse many samples of alveolar air or blood for CO_2, so that attention was rather given to securing samples of blood and urine of adequate size so that lactic acid, H-ion concentration and the acid excretion might be ascertained. The following observations are noteworthy:

1. If we take the average minute volume of respired air of a normal decerebrate cat as 1000 cc. (cf. R. W. Scott, Am. Journ. Physiol., 1917, XLIII, p. 169), it is seen that in about one hour after decerebration all the animals of this group were respiring normally, although usually somewhat rapidly, the average for normal animals being 20–25 per minute. The hyperpnœa which subsequently developed either did so gradually (Nos. XVII and XXII) or, after doing so for a time, suddenly became much more pronounced (XXX and XXXI), this type being especially prominent in hyperexcitable preparations.

TABLE IV

No.	Time after decere-bration. min.	Res-pira-tions. cc. per min.	Alveolar CO_2 %	Blood CO_2%	Urine n/10 acid %	n/10 NH_3 %	Rectal Temp.	Remarks
XVII	..	..	..	..	82	..	..	Cut far forward. Perhaps slight asphyxia
	25	..	..	..	..	..	..	
	45	..	5·0	..	..	..	..	B.P. 120 mm. Hg.
	55	..	4·9	..	..	..	39	
	60	..	..	41·6	..	..	..	Rigidity slight
	75	916	..	..	..	..	39·8	B.P. 110 mm. Hg.
	80	..	4·5	43·6	..	..	..	
	95	1020	..	..	88	0·16	..	Glycosuria
	105	..	..	..	..	..	..	Occasional sighs
	115	..	3·4	..	..	..	39·8	
	121	1130	3·1	..	..	..	..	
	134	1180	..	..	..	..	..	
	150	..	2·8	..	..	..	..	
	155	..	1·8	..	..	..	..	
	160	..	1·8	..	..	..	..	B.P. 55–60 mm. Hg.
	166	1430	..	31	..	..	..	Rigidity slight
	173	..	2·0	..	..	..	..	
	176	1430	1·9	..	..	..	..	
	191	1720	..	29	..	..	..	
	205	..	1·6	..	..	..	..	
	209	1500	..	27·7	..	..	..	
	215	1560	..	..	..	..	..	Very rigid.
	235	..	..	..	28	0·04	..	Glycosuria. Lactic acid 0·121 % P_h not done

The abridged results on other animals that showed the same behaviour are given in Table V:

TABLE V

No.	Time after decere-bration min.	Respirations per minute		Aveolar air CO_2 %	Blood CO_2 %	Blood Ph	Urine		Rect. Temp.	Remarks
		cc.	rate				n/10 %	n/10 %		
X	71	..	..	3·6	..	..	..	..	..	Cut far forward
	93	850	30	..	20·4	..	..	..	..	Animal hyper-excitable and dysnoeic from start, rigidity marked.
	108	..	..	..	..	7·1	..	..	..	Moribund when Ph measured.
XXII	53	1125	..	3·5	..	..	..	..	39	Cut well forward.
	70									
♀	73–93	1085	28	3·6	..	..	30	..	39	
	108–118	1225	..	3·3	..	..	..	..	40	Animal became suddenly hyperpnoeic.
	133 –148	..	38	2·9	..	7·4	..	..	..	Rigidity marked.
	178	..	44	1·9	..	..	..	..	40	Vomited.
	203–208	..	..	1·7	24·4	7·1	30	..	..	Lactic Acid 0·296 %. Very slight glycosuria.
XXX	74	1290	26	..	..	..	56·6	0·168	39·5	Cut well forward.
♀	100	1660	28	..	..	..	..	..	..	Rigidity marked.
										Hyperexcitable.
	125	2750	40	..	..	7·0–7·1	93·0	..	..	
								0·142	40·5	B.P. 70 mm. Hg. at end.
XXXI	62	1120	36	..	..	..	..	..	38	Cut well forward.
♀	113	2100	48	..	..	..	..	..	..	Rigidity marked.
	142	3200	64	..	..	..	..	..	38·5	Hyperexcitable.
	146	3930	69	..	..	7·0–7·1	..	..	38·5	Lactic acid 0·232 %. B.P. below 40 mm. at end.

2. The alveolar air was analysed for CO_2 in two of the cats and it shows a progressive decrease which was more or less in proportion to the increase in ventilation. There is only one experiment in which sufficiently numerous data were secured to determine the precise relationship between rate of increase in ventilation and alveolar CO_2. In this experiment an increase in volume from 916 to 1130 cc. per minute corresponds to a fall in percentage of alveolar CO_2 from 4·5 to 3·1, giving 1·4 per cent increase in CO_2 for 214 cc. increase in air breathed. Later, an increase in ventilation from 1180 to 1720 cc. per minute corresponds to a decrease in CO_2 percentage from 2·8 to 1·6 giving 1·2 per cent decrease in CO_2 for 540 cc. increase in air breathed. These results indicate that the ventilation increases out of proportion to the decrease in alveolar CO_2.

3. The carbonate content of the blood decreases markedly in all the three cases (X, XVII and XXII) in which it was measured, but there are not sufficient data to say whether this is dependent upon a "blowing off" of CO_2 through the lungs, an "acapnia" in Mosso's sense, or is due to the appearance of fixed acids in the blood. It has been observed by Cannon and others[1] working on the problem of surgical shock that the CO_2 absorbing power of the venous blood invariably becomes lowered when there is a decided fall in the arterial blood pressure. In a general way a similar relationship appears to exist in our observations, but it is impossible to conclude from the data available whether the two values bear any necessary relationship to each other.

4. The H-ion concentration of the arterial blood, measured in four of the observations, before *exitus* becomes decidedly raised (P_h 7·0–7·1). In two of the experiments (Nos. X and XXXI) the animal was practically dead when the blood was collected, so that the low P_h may not be of much significance. In the case of the other two experiments (Nos. XXX and XXII), however, the specimens were collected while the animal was still breathing and they indicate a very decisive degree of acidosis.

5. Lactic acid was measured in three of the animals and is found to be markedly increased in two (XXII and XXXI) and about the upper limit of the normal value in the third (XVII). This observation corresponds with those made on P_h and would indicate that the primary cause for the lowering of the blood carbonates and for the hypernœa is the development of unoxidised acid in the organism.

6. The acid excretion by the urine is depressed in the least acute of the experiments (XVII) in which also there is no decided increase

[1] Cannon, W.B., Journ. of the Amer. Med. Assn., 1918.

in the lactic acid content of the blood, but it remains constant or increases in two experiments in which the hyperpnœa developed acutely (Nos. XXII and XXX) and an excess of lactic acid and a marked lowering in P_h of the arterial blood is evident. Inasmuch as the acid excretion in all of the normal decerebrate animals becomes markedly depressed, it is significant that in those animals of the hyperpnœa group the acid excretion should have continued high.

7. Decerebrate rigidity was very marked in the four animals of this series in which there was excessive hyperpnœa and was slight in that (XVII) in which this was of lesser degree. This observation is possibly of interest, since it suggests that the accumulation of lactic acid, which was very high in two of these cases, may depend on the abnormally contracted musculature. According to such a view, in the state of permanent (plastic) tonus the blood supply to the muscles may be inadequate to supply sufficient oxygen to effect the oxidative removal of the lactic acid which therefore accumulates and overflows into the blood. With regard to the rectal temperature it will be noted that this usually rose somewhat, but not sufficiently to account for the dyspnœa.

Glycosuria of slight degree was observed in two of the experiments; sugar was not examined for in the urine of the other animals.

It may appear that the division of the animals into two groups, according to whether or not decided hyperpnœa became established, is arbitrary and that certain of the observations should have been classified as belonging to an intermediate group. Although this is true, it is nevertheless, we believe, more correct to adopt the present classification since it corresponds to the general impression, which is conveyed by actual experience with decerebrate animals. As a matter of fact, the above records include, out of a total of twenty animals, all those save one in which satisfactory spontaneous regular breathing existed one hour after the decerebration. In the one exception, the breathing was excessively rapid and deep, the aveolar CO_2 well below two per cent and the blood carbonate below twenty per cent. Although the rigidity was of slight degree this animal was extremely hyperexcitable, the section being well forward of the anterior corpora quadrigemina, and the hyperpnœa was definitely dependent upon afferent stimulation induced by faulty technique in catheterization.

In seven of the twenty animals satisfactory breathing did not spontaneously return within one hour after the decerebration, and the animals were discarded. It was usually the case that the section in their cases was well back, but its exact position has not been recorded.

We have preserved the anterior portions of the heads of numerous animals in subsequent experiments of a similar type, and we hope in the near future to be able to furnish data which will enable us to state precisely where the cut should be situated for satisfactory breathing. As far as we can say at present when the posterior corpora quadrigemina are even slightly wounded spontaneous respiration is seldom, if ever, observed.

In collaboration with Lois Fraser and R. S. Lang, I have found, however, that perfectly regular respirations may reappear in animals of the above type by greatly raising the partial pressure of oxygen in the alveolar air. This is done by passing a catheter into the trachea so that its open end lies above the bifurcation, and then discharging washed oxygen at a rapid rate from a cylinder of the gas. In a few minutes, during which artificial respiration may be necessary in order to carry the oxygen to the alveoli, the animal usually begins to breathe in perfectly normal fashion and continues doing so for hours. We are at present engaged in studying the very interesting and far-reaching problems which this observation presents; for the present we may point to the interesting evidence it affords that oxygen deficiency, *per se*, far from acting as a stimulus for the respiratory centre, renders it incapable of rhythmic function, at least in conditions where it is imperfectly supplied with blood, as after decerebration. In this connection attention should again be called to the fact that if the breathing of the decerebrate animal becomes feeble during compression of the vertebral arteries, it can be restored to normal by releasing the blood flow.

Conclusions

After removal of the cerebral hemispheres a certain number of cats continue to breathe in perfectly normal fashion for several hours; others fail to respire adequately and still others breathe normally for some time, but subsequently become hyperpnœic, and finally are usually seized by convulsions to which they succumb. These differences in behaviour seem to be dependent upon the age of the animal and the level at which the section of the mesencephalon is made. Spontaneous breathing is decidedly more likely to return in the younger animals and when the cut is not further back than the anterior edge of the anterior corpora quadrigemina. When the cut is further forward the decerebrate animal is hyperexcitable, decerebrate rigidity is marked, and the animal usually becomes hyperpnœic. When the cut is farther back, adequate spontaneous breathing is unusual.

Particular attention is given in the present research to the possible cause of the hyperpnœa. With this object in view the behaviour of the percentage of carbon dioxide in the alveolar air and arterial blood as well as the hydrogen-ion concentration and the percentage of lactic acid in the latter have been compared with the respiratory behaviour of the animal. The acid excretion by way of the urine has also been observed.

It has been found that the above-mentioned values remain tolerably constant in the animals which do not become hyperpnœic, but that in those which do so the alveolar-CO_2 steadily declines, accompanied or followed by a decline in blood carbonates and by a decided increase in the hydrogen-ion concentration and lactic acid content of the arterial blood. These blood changes indicate that unoxidised acid, lactic, has accumulated in the blood and the main question to be considered is whether the hyperpnœa is the result of the accumulation of acid or whether the acid accumulates because of hyperpnœa. Concerning the first hypothesis the close attention which has been given in recent years to the condition known as acidosis has shown that there are three characteristic signs of the condition: first, a decrease in the percentage of carbon dioxide in the alveolar air; secondly, a decrease in the ability of the blood to combine with this gas, and thirdly, an increased excretion of free acid by the kidney. Now it will be noted that the first two of these characteristics are very prominently affected in those decerebrate cats which became hyperpnœic, and that the third—acid excretion in the urine—in the cases in which it could be measured, remained decidedly higher in the hyperpnœic animals than in those that breathed normally. If we add to these indirect evidences of an acidosis condition the further evidence afforded by a determination of the hydrogen-ion concentration of the arterial blood there seems little doubt that an intoxication by acid must have been the cause of the hyperpnœa. As to the nature and source of this acid there is evidence that it was lactic acid—large percentages being found in the arterial blood—which may have been derived from the plastic tonus of the muscles of the decerebrate animals, for this condition, though present in all the animals, was especially prominent in those that became hyperpnœic. It has been shown by Roaf (Quart. Journ. Exp. Physiol., 912, V, 31–53) that the gaseous metabolism of decerebrate cats is no greater than that of animals whose muscles are paralysed by curare, which indicates that very little energy can be expended notwithstanding the permanently contracted state of the muscles.

If we accept the modern view which is the outcome of the work of F. Gowland Hopkins and Fletcher (Proc. Roy. Soc. Lond., 1917, Ser.

B, LXXXIX, 444) that the lactic acid which is produced by a muscular contraction is removed by an oxidative process before the next contraction takes place, then it is conceivable that in the permanent contraction, to which plastic tonus corresponds, the acid fails to disappear from the muscle so that it overflows into the blood, in which it accumulates, since it can no longer be removed by oxidation, and from which it is only gradually excreted.

In brief, then, the simplest interpretation for the hyperpnœa and final collapse of many decerebrate animals is that it is caused by acute acidosis brought about by an accumulation of lactic acid derived from the permanently contracted extensor musculature which is characteristic of this condition. But we do not intend to imply that this hypothesis is proven by the observations of the present research. In so far as the results themselves are concerned there can be no doubt as to the reliability and tolerable accuracy of the values given for the carbon dioxide of the alveolar air and blood, but there is a possibility of error in connection with those for the P_h and lactic acid content of blood. The greatest care has been taken in the analyses and they have always been carried out under strictly standardized conditions, but nevertheless it is possible that the samples of blood on which they were carried out were removed when the animal was already in a moribund condition, in which because of failing circulation such changes as were observed are to be expected. To circumvent this possible source of error blood was taken from one of the hyperpnœic animals (Table IV, No. XXX) while the arterial blood pressure was still above 70 mm. Hg., with the same results. Further observations of a similar type are, however, necessary.

With regard to the second hypothesis, namely that the organic acid of the blood rises to take the place of the carbonic acid which is blown off because of hyperpnœa induced by afferent stumuli acting on a hyperexcitable respiratory centre, little that is definite can be said. In support of this view, however, stands the fact that the animals exhibiting the hyperpnœa were invariably those in which, because of the forward position of the section, there was decided hyperexcitability of the nerve centres.

Recherches Phytométriques sur le Bartonia virginica L.

Par FRÈRE MARIE-VICTORIN, des E. C.

Présenté par le DR. C. GORDON HEWITT, M.S.R.C.

(Lu à la réunion du mai 1919)

I

On doit à Adolphe-Jacques Quételet d'avoir érigé la statistique en une véritable science, d'avoir établi pour l'espèce humaine l'existence d'un type idéal dont tout écart, dans un sens ou dans l'autre, doit être regardé comme une irrégularité, et d'avoir enfin formulé la loi plus générale, dite des grands nombres ou de Quételet.[1]

Cette loi, dérivée de l'assimilation faite[2] entre la loi de fréquence des variations et la loi de Gauss relative à la probabilité des erreurs d'observation, peut s'énoncer ainsi:

Lorsqu'on mesure la valeur d'un caractère variable chez un grand nombre d'individus comparables, on trouve, en général, qu'une certaine valeur de ce caractère est présentée par le plus grand nombre d'individus, et peut être par conséquent considérée comme la *valeur normale moyenne* du caractère chez le type considéré. Les autres valeurs observées sont d'autant moins fréquentes qu'elles s'éloignent plus de cette valeur normale et décroissent à partir de cette valeur proportionnellement aux coefficients du développement du binôme de Newton.[3]

Malgré l'interférence de causes perturbatrices plus ou moins profondes, l'on admet aujourd'hui que la loi de Gauss reste la loi fondamentale et la plus générale de la variation. L'application de cette loi a peu à peu envahi le domaine de toutes les sciences. En botanique particulièrement, elle a ouvert un champ d'études particulièrement vaste et attrayant, tant au chapitre de la physiologie végétale qu'à celui de la taxonomie. La loi de Quételet est venue offrir une nouvelle façon d'attaquer l'épineux et fondamental problème de l'espèce; elle promet d'affranchir petit à petit la botanique systématique du large tribut qu'elle a toujours payé à l'artificialité et à la convention. Car, il faut avoir la logique de l'avouer, nos délimitations d'espèces sont entachées de vices fondamentaux: elles reposent

[1] Quételet, A. J., *Physique sociale* et *Recherches statistiques*, Bruxelles, 1844.

[2] Ludwig, *Die pflanzlichen Variationscurven und die Gauss'sche Wahrscheinlichkeitscurve*, Bot. Centralblatt, Bnd LXXIII, 1898, No. 8, p. 241.

[3] Amann, J., *Application de la loi des grands nombres à l'étude d'un type végétal*, Journ. de Bot., XIII, p. 176, 1899.

sur des jugements personnels et faillibles; elles font une large part aux considérations historiques; elles sont basées sur des prototypes arbitrairement choisis.

Les botanistes qui, pour établir les règles de la nomenclature ont fait prévaloir le principe de la priorité et décrété que le spécimen d'herbier qu'il plaira à la fantaisie d'un taxonomiste de désigner sera le type éternel auquel on rapportera toutes les formes d'une espèce, ont sans doute eu pour but—et ont peut-être atteint le résultat—de mettre un peu d'ordre dans le chaos de la botanique systématique, mais il n'en est pas moins évident qu'ils ont dressé ainsi des cadres artificiels où les formes de la nature ne s'ajustent que difficilement ou pas du tout, et que, s'il est vrai que toute science qui progresse tend vers la simplification, les beaux jours de la botanique systématique n'ont pas encore lui.

Il semble que, outre leur but principal qui est de déterminer les *valeurs moyennes normales* et de mesurer la variabilité des caractères chez les espèces végétales, les études phytométriques offrent une façon naturelle d'aborder le problème du prototype spécifique. Des mesurages, des dénombrements effectués sur un grand nombre d'individus et coordonnés de manière à former des courbes dites de Quételet permettraient de découvrir pour chacune des espèces vivantes, ce type spécifique moyen autour duquel oscillent les formes individuelles. La diagnose du type ainsi compris sera l'indication des valeurs moyennes normales des caractères importants avec celle de leur *poids*. L'on gagnerait ainsi une meilleure idée des sous-espèces, des variétés et des races et l'on arriverait par des méthodes proprement mathématiques à des ségrégations d'espèces d'où l'arbitraire et l'équation personnelle seraient complètement éliminés. Acheter ainsi chaque pas en avant au prix d'un immense labeur ne serait pas payer trop cher l'avantage de faire de la taxonomie végétale une science exacte.

Les recherches ci-dessous, inspirées de cette idée, ont pour but de déterminer quelques-unes des caractéristiques numériques du type spécifique moyen d'une espèce végétale, le *Bartonia virginica* L. Les mêmes données fournissent aussi incidemment des constatations intéressantes particulièrement sur les phénomènes d'avortement et sur les rapports réciproques des forces végétatives et reproductrices.

Nos résultats ne prétendent pas établir définitivement le type moyen du *Bartonia virginica;* ils ont besoin, en effet, d'être coordonnés avec d'autres obtenus sur divers points de l'aire géographique de l'espèce, et à ce titre, ils ne sont qu'une contribution à l'étude complète de ce type végétal.

II

Le *Bartonia virginica* L. est une petite plante de la famille des Gentianacées, peu connue en Canada et dont on n'a encore trouvé qu'une station dans le Québec: sur la tourbe sèche de Saint-Hubert, près de Montréal. La plante croît en compagnie de *Polytrichum commune* L., *Polytrichum ohioense* R & C., *Cladonia* sp.; elle se tient sous l'ombre relativement dense de divers arbrisseaux éricacés: *Kalmia angustifolia* L., *Ledum groenlandica* Oeder, *Rhodora canadensis* L., *Vaccinium pennsylvanicum* Lam., etc.

La tige est dressée, anguleuse, rougeâtre dans le premier tiers, souvent tordue, filiforme, rigide, garnie de petites feuilles subulées rudimentaires, opposées ou presque et longuement décurrentes de façon à former une aile étroite de chaque côté de la tige, plus nombreuses vers la base.

Les fleurs sont rarement paniculées, le plus souvent disposées en une grappe terminale. Elles sont, comme les feuilles, presque opposées sur des pédicelles relativement longs, arqués à la base et redressés de façon à courir ensuite presque parallèlement à l'axe principal. La fleur comprend un calice verdâtre quadripartit et une corolle jaunâtre de 3-4 mm. de longueur, généralement un peu plus longue. Les étamines sont incluses. La capsule est oblongue-conique.

Nous avons signalé ailleurs[1] l'extrême lenteur de la croissance qui s'explique par l'exiguité de système radiculaire et le peu de surface chlorophyllienne. La remarquable simplicité de la plante dans toutes ses parties en fait un bon sujet pour les recherches phytométriques, et, dans ce but, le 9 août 1918, nous récoltâmes à la station précitée, environ 1000 échantillons du *Bartonia virginica*, pris au hasard sur une superficie d'environ 100 mètres carrés.

Les mesurages et dénombrements suivants ont été effectués sur chacun des 1000 échantillons:

(*a*) longueur totale, à 5 mm. près.

(*b*) nombre de fruits.

Des graphiques ont été ensuite construits permettant le tracé et l'étude des polygones de variation suivants:

(*a*) polygone de variation de la longueur des tiges.

(*b*) polygone de variation de la fréquence du nombre de fleurs par individu.

(*c*) polygone de variation du rapport $\frac{Sm}{Sf}$, Sm représentant la somme totale des mesures de longueur de tige de même chiffre, et Sf, le nombre total des fleurs qu'elles portent.

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[1] Marie-Victorin, Fr., *Contribution à l'étude de la Flore de la Province de Québec*, Nat. Can. XXXVI, pp. 68–70, 1909.

III

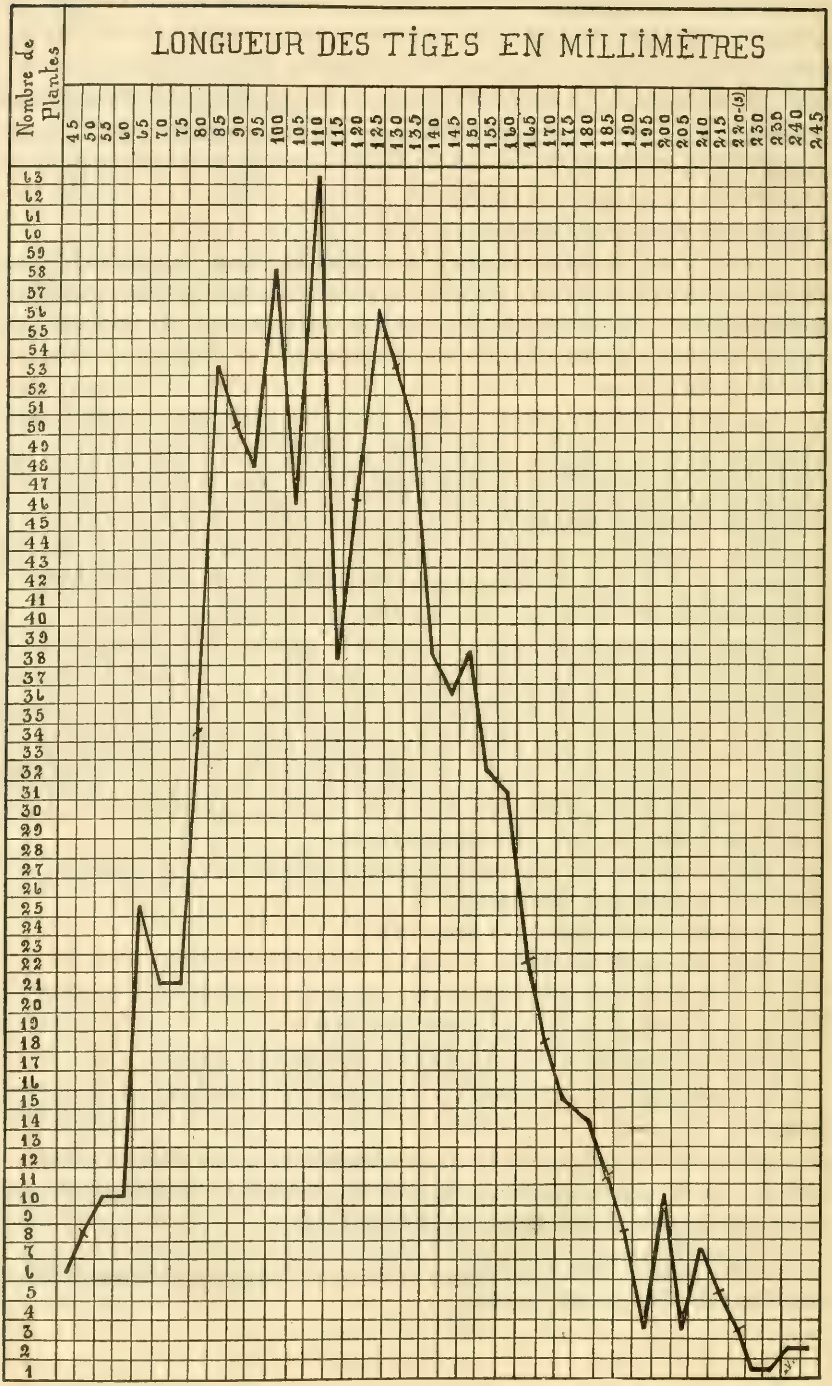

FIG. 1. Polygone de variation de la longueur des tiges.

Tous les échantillons observés ou récoltés portaient des fruits; les échantillons récoltés se répartissent entre les longueurs de 45 mm. et de 245 mm.

La ligne polygonale s'élève d'abord rapidement et assez régulièrement vers le sommet où elle semble affolée et forme des angles rentrants prononcés. Le maximum de la variation, ce que nous appelons la *valeur moyenne normale*, a lieu pour les tiges de 110 mm., avec un optimum bien tranché pour la région située entre les abcisses de 85 mm. et de 130 mm. La ligne redescend ensuite régulièrement et après une nouvelle période d'oscillation dans la région 190–210 mm. se termine à 245 mm.

La *valeur moyenne normale* (110 mm.) coïncide d'une manière assez satisfaisante avec la moyenne arithmétique (120 mm.), que donne le tableau suivant:

CALCUL DE LA MOYENNE ARITHMÉTIQUE = Ma

Longueur *m*	Fréquence *n*	Produit *mn*
45	6	270
50	8	400
55	10	550
60	10	600
65	25	1625
70	21	1470
75	21	1575
80	34	2720
85	53	4505
90	50	4500
95	48	4660
100	58	5600
105	46	4830
110	63	6930
115	38	4370
120	46	5520
125	56	7000
130	53	6890
135	50	6750
140	38	5320
145	36	5220
150	38	5700
155	32	4960
160	31	4960
165	22	3630
170	18	3060
175	15	2625
180	14	2520
185	11	2035
190	8	1520
195	3	585
200	10	2000
205	3	615
210	7	1470
215	5	1075
220	3	660
225	..	....
230	1	230
235	1	235
240	2	480
245	2	490
	Sn = N = 1000	Smn = 120055
	Ma = 120·055 mm.	

Si l'on compare les mesurages ci-dessus avec les chiffres donnés par les principaux manuels floristiques:

Gray's Manual (7th Ed.), 50–300 mm.
Illustrated Flora (Britton & Brown), 100–450 mm.

il paraît probable que le *Bartonia* subit ici une réduction de taille attribuable à l'habitat xérophytique et à la situation excentrique de la localité, en fait, sur la limite de l'aire géographique de l'espèce. Vu l'état avancé de la fructification et la lenteur de croissance, il n'est pas probable que la taille eût pu sensiblement augmenter après la date de la récolte (9 août).

Nous connaissons déjà les caractéristiques *M* (*valeur* normale moyenne) et *Ma* (moyenne arithmétique). Proposons-nous de rechercher, au moyen du tableau ci-dessous, les autres quantités suivantes:

1°—La *déviation moyenne* Q.

2°—Le *module de variabilité* μ qui est donné par la relation:

$$\mu = 2Q^2.$$

3°—Le *poids* de la *valeur moyenne normale* qui est l'inverse de μ, soit $\frac{1}{\mu}$.

4°—La *déviation probable* P, qui est donnée par la relation: $P = 0{\cdot}674486\ Q$. (Cette quantité P est identique à la *valeur quartile* de Galton.)

5°—Le coefficient de variabilité de Davenport $= \frac{P}{Ma}$.

6°—On sait[1] qu'il existe entre les valeurs $\frac{\text{Snd}^2}{N}$ et $\frac{\text{Snd}}{N}$ lorsque N est suffisamment grand et que la variation se fait conformément à la loi de fréquence des déviations, la relation très remarquable:

$$\frac{\text{Snd}^2}{N} = \frac{\pi}{2}\left(\frac{\text{Snd}}{N}\right)^2, \text{ d'où : } \frac{\frac{\text{Snd}^2}{N}}{\left(\frac{\text{Snd}}{N}\right)^2} = \frac{\pi}{2}$$

Il est donc théoriquement possible de calculer le nombre qui exprime le rapport de la circonférence au diamètre au moyen d'un grand nombre de mesures d'un caractère qui varie tout à fait au hasard chez les différents individus d'un type organisé. Nous verrons ci-dessous quelle aproximations nous pourrons obtenir dans le cas du *Bartonia*.

Pour dresser le tableau, nous appelons *d* la différence ou *déviation* entre la longueur observée et la moyenne arithmétique *Ma*.

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[1] Bertrand, *Calcul des probabilités, p. 242.*

Calcul du module de variabilité $=\mu$
et des quantités derivées

Fréquence n	Déviation d	Produit nd	d^2	nd^2
63	10	630	100	6300
58	20	1160	400	23200
56	5	280	25	1400
53	35	1855	1225	64925
53	10	530	100	5300
50	30	1500	900	45000
50	15	750	225	11250
48	25	1200	625	30000
47	0	0	0	0
46	15	690	225	10350
38	5	190	25	950
38	25	950	625	23750
38	30	1140	900	34200
36	25	900	625	22500
34	40	1360	1600	54400
32	35	1120	1225	39200
31	40	1240	1600	49600
25	55	1375	3025	75625
22	45	990	2025	44550
21	50	1050	2500	52500
21	45	945	2025	42525
18	50	900	2500	45000
15	55	825	3025	45375
14	60	840	3600	50400
11	65	715	4225	46475
10	65	650	4225	42250
10	60	600	3600	36000
10	80	800	6400	64000
8	70	560	4900	39200
8	70	560	4900	39200
7	90	630	8100	56700
6	75	450	5625	33750
5	95	475	9025	45125
3	75	225	5625	16875
3	85	255	7225	21675
3	100	300	10000	30000
1	110	110	12100	12100
1	115	115	13225	13225
2	120	240	14400	28800
2	125	250	15625	31250
$N=1000$	..	$Snd=29355$	..	$Snd^2=1334925$

On obtient successivement:

$$Q^2 = \frac{Snd^2}{N} = 1334 \cdot 925$$

$$Q = 36 \cdot 56 \qquad (1)$$

$$\mu = 2\,Q^2 = 2669 \cdot 85 \qquad (2)$$

$$\frac{1}{\mu} = 0 \cdot 0003745 \qquad (3)$$

$$P = 0 \cdot 674486\,Q = 24 \cdot 64302 \qquad (4)$$

$$\frac{Ma}{P} = \frac{24 \cdot 64302}{120 \cdot 05} = 0 \cdot 20527 \qquad (5)$$

$$\frac{\frac{Snd^2}{N}}{\left(\frac{Snd}{N}\right)^2} = \frac{1334 \cdot 925}{(29 \cdot 355)^2} = 1 \cdot 54913 = \left(\frac{\pi}{2}\right) \qquad (6)$$

L'approximation obtenue pour le nombre π, soit $\pi = 3 \cdot 09826$ au lieu de $3 \cdot 1416$ est très remarquable étant donné le petit nombre de cas envisagés (1000). Ludwig [1] a obtenu pour le nombre de feuilles chez le *Fraxinus excelsior* $\pi = 3 \cdot 3074$; Amann[2] pour la longueur du pédicelle chez le *Bryum cirratum* $\pi = 3 \cdot 6370$.

Les différences dans les trois cas cités sont donc ainsi:

Amann	$+ \cdot 4954$
Ludwig	$+ \cdot 1658$
Victorin	$- \cdot 04334$

[1] loc. cit.
[2] loc. cit. p. 191.

IV

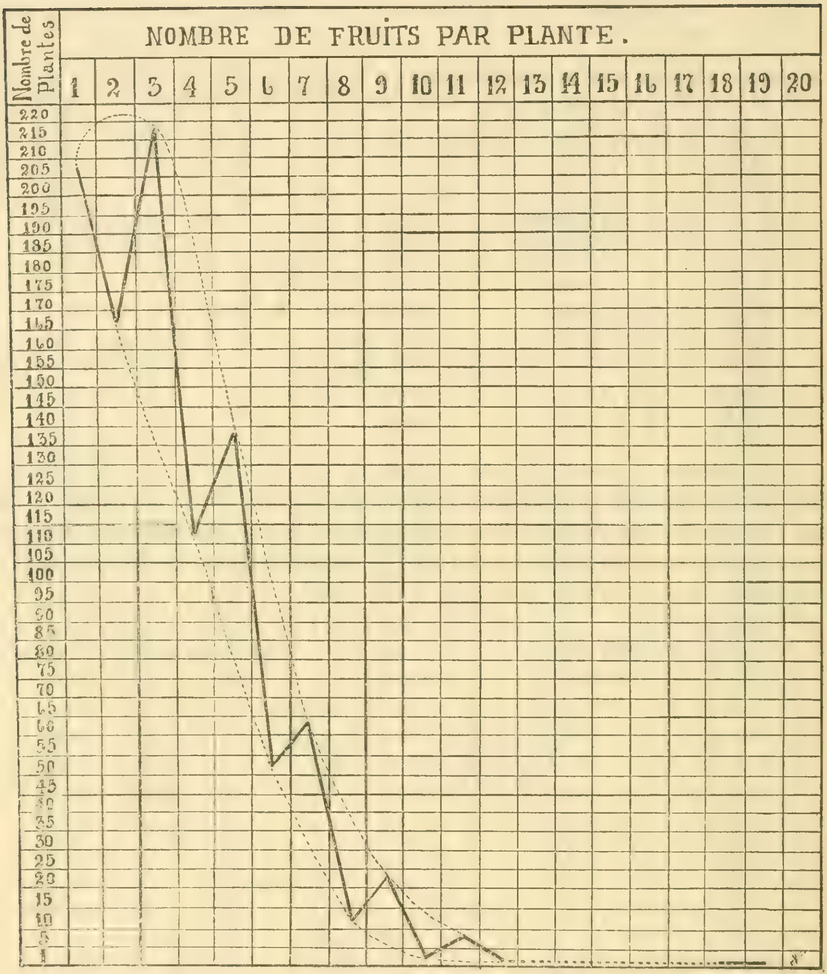


FIG. 2. Polygone de variation de la fréquence du nombre de fruits relativement au nombre de plantes sur 1000.

La ligne polygonale s'amorce avec 205 individus porteurs d'un seul fruit et atteint rapidement son maximum avec 215 individus porteurs de trois fruits; elle subit ensuite une décroissance continue et s'annulle presque pour 10 fruits.

La ligne générale subit une alternance de saillies et de dépressions qui lui donnent une apparence grossièrement sinusoïdale. Il est remarquable que toutes les saillies correspondent aux nombres impairs de fruits, et que toutes les dépressions marquent les nombres pairs de fruits. Cette particularité curieuse a son explication dans la disposition des fruits sur l'axe floral.

En effet ces fruits sont opposés ou presque opposés et naissent de l'aisselle de bractées scalariformes indistinguables des feuilles caulinaires; l'axe est lui-même terminé, dans tous les cas observés, par un fruit. Or l'examen attentif d'un certain nombre d'échantillons montre de suite que l'un des fruits de la paire inférieure avorte fréquemment, et cet avortement, qui accuse une fréquence oscillant entre 16% et 45% avec une moyenne de 33%, se reproduit d'une manière sensiblement uniforme dans la série, de sorte qu'il y a en réalité deux lignes polygonales ou courbes, grossièrement parallèles: l'une, la normale, marquant les nombres impairs de fruits; l'autre, marquant les nombres pairs de fruits.

Il ressort clairement de ce diagramme qu'ici, l'avortement d'un fruit—presque toujours de la paire inférieure—n'est pas un fait accidentel, mais l'effet d'une cause héréditaire que nous ignorons, agissant uniformément sur tous les groupes de la population végétale et qui est fonction de l'action vitale déterminant la multiplicité des appareils de reproduction.

Les polygonales ou courbes du genre de celles de la fig. 2 sont l'indice de la co-existence de plusieurs types dans les cas considérés. Pour attirer l'attention sur cette variation intéressante, il nous paraît utile de distinguer du type spécifique moyen à nombre de fruits impairs, le type secondaire à nombre de fruits pairs. Cette plante pourrait s'appeler BARTONIA VIRGINICA forma ABORTIVA f. nov. —Diffère de la forme typique par l'avortement constant de l'un des fruits, ordinairement de la paire inférieure. QUÉBEC, Saint-Hubert, sur la tourbe sèche, 9 août, 1918, Fr. Marie-Victorin, N° 19570. (Type dans l'herbier Victorin)

V

Étudions maintenant les variations de rapport $\frac{Sm}{Sf}$. Soient Sm, la somme totale des longueurs de tige de même chiffre et Sf le nombre total des fleurs qu'elles portent. Le tableau ci-dessous donne pour chaque longueur de tige, la valeur du rapport.

Longueur en mm.	Nombre d'échantillons	Nombre total de fruits	Rapport moyen
45	6	7	38·6
50	8	9	44·4
55	10	11	50·0
60	10	13	46·1
65	25	31	52·4
70	21	31	47·4
75	21	32	49·2
80	34	53	51·3
85	53	107	42·1
90	50	106	42·4
95	48	98	46·5
100	58	142	40·8
105	46	120	40·2
110	63	175	39·6
115	38	129	33·8
120	47	159	35·4
125	56	202	34·6
130	53	193	35·6
135	50	194	34·7
140	38	162	32·7
145	36	157	39·6
150	38	175	32·6
155	32	161	30·8
160	31	179	27·7
165	22	125	28·8
170	18	93	32·9
175	15	96	27·3
180	14	95	26·5
185	11	71	28·6
190	8	63	24·1
195	3	44	13·2
200	10	68	29·4
205	3	26	23·6
210	7	50	29·4
215	6	70	18·4
220	3	29	22·7
225	0	0	0·0
230	1	9	25·5
235	1	7	33·5
240	2	22	21·8
245	2	15	32·6
250	0	0	0·0

Le nombre entier exprimant le rapport $\frac{Sm}{Sf}$ pour toutes les tiges d'une même longueur, coordonné avec celui qui exprime cette longueur fournit une ligne polygonale (Fig. 3) qui offre les particularités suivante:

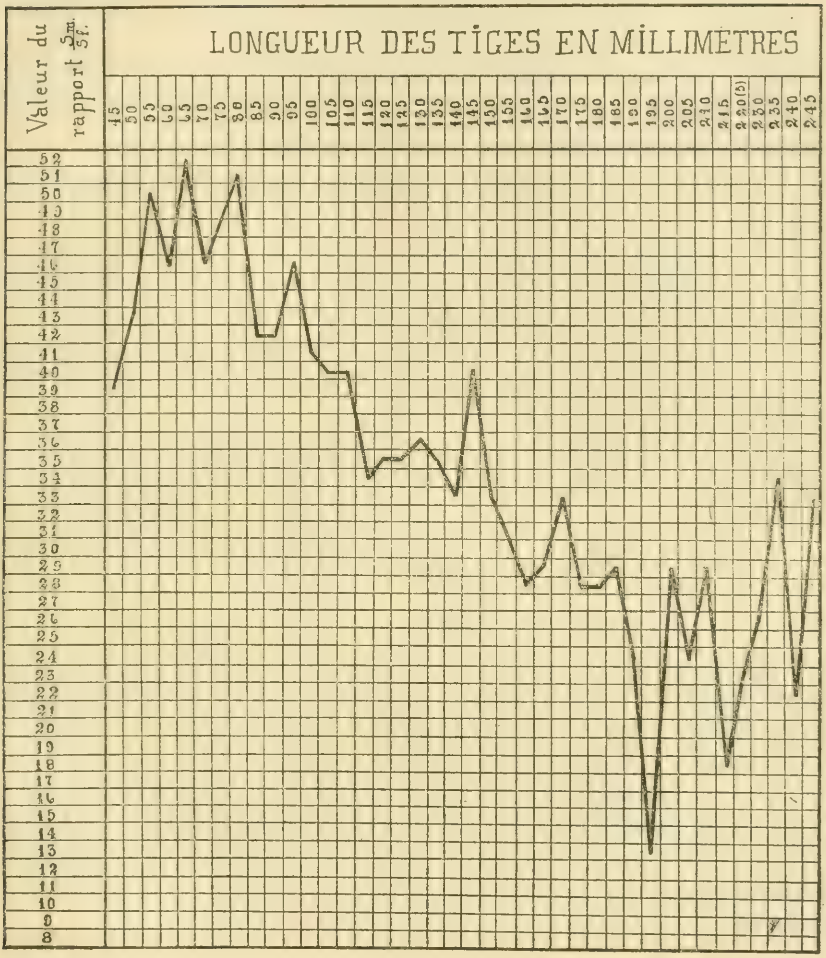


FIG. 3—Polygone de variation du rapport $\frac{Sm}{Sf}$

D'abord ascendante, la ligne atteint son sommet avec $\frac{Sm}{St} =$ 52 et pour une longueur de tige de 65 mm. Ce maximum indique qu'à cet état de développement la fonction reproductrice est à son minimum d'intensité.

La ligne polygonale affecte ensuite une allure générale descendante, avec des irrégularités marquées qui ne présentent pas d'ailleurs de périodicité remarquable.

La ligne polygonale atteint son minimum pour $\frac{Sm}{Sf}=13$; c'est-à-dire que la fonction reproductrice rencontre ses conditions optimum pour une longueur de tige de 195 mm. Au-delà de ce point, la ligne se relève et suit une marche très irrégulière jusqu'à l'extrémité marquée par une longueur de tige de 245 mm.

L'étude de ce polygone de variation suggère les remarques suivantes:

(*a*) Pour les spécimens qui sont dans la norme de l'espèce, la vigueur végétative favorise la fonction reproductrice, ce qui est, semble-t-il, d'expérience vulgaire.

(*b*) Les plantes chétives, anormales, se hâtent de fructifier avant de disparaître et consomment dans cette fonction (relativement exagérée) toutes leurs réserves vitales.

(*c*) Chez les plantes caractérisées par un développement végétatif exagéré, la fonction reproductrice au lieu de bénéficier d'une recrudescence proportionnelle, subit une décroissance marquée.

(*e*) Les irrégularités du polygone de variation sont attribuables aux conditions du milieu immédiat, nécessairement variées à l'infini: nature du sol, humidité, exposition.

(*f*) L'activité reproductrice se superpose à l'activité végétative, mais sans coïncider exactement avec elle; sans être évidemment susceptible de dissociation et d'existence indépendante, elle manifeste cependant une certaine individualité.

En terminant ces quelques notes, je dois offrir mes remerciements à MM. J. Brunel, V. Echave et W. Dufour qui ont bién voulu me prêter leur concours pour la préparation des tableaux et des diagrammes.

Les Réactions Humorales de L'Organisme contre les Infections et les Intoxications

Par M. ALBERT LESAGE

Présenté par DR. C. GORDON HEWITT, M.S.R.S.

(Lu à la réunion de Mai 1919)

1° DÉFINITION

L'étude de l'immunité nous fait comprendre comment, par des réactions humorales et cellulaires variées et constantes, un organisme résiste à l'influence des agents morbigènes qui l'ont envahi.

Si un individu est naturellement réfractaire, nous disons qu'il y a immunité *naturelle ou innée.* Si, après une première atteinte, il devient réfractaire à cette même maladie, nous disons qu'il y a *immunité acquise.*

I. Immunité Naturelle ou Innée

2° LES FAITS

(*a*) *Pathologie Comparée.*—L'immunité naturelle existe chez certains organismes qui résistent à l'action des poisons minéraux ou végétaux. La pathologie comparée nous en fournit de nombreux exemples. Ainsi, l'homme est empoisonné par des doses relativement faibles d'arsenic, d'antimoine, de belladone, de jusquiame, de digitale, de tabac, tandis que le cheval, le porc, l'escargot, les rongeurs résistent à l'action de ces poisons.

On observe pareille immunité à l'égard des venins animaux; c'est ainsi que le hérisson résiste au venin de la vipère, même s'il est piqué au museau.

Dans l'espèce humaine, l'activité des poisons varie suivant les races. Le nègre supporte des doses relativement énormes d'alcool, de mercure ou de tartre stibié.

Mais l'immunité naturelle acquiert une importance capitale lorsqu'il s'agit des maladies infectieuses.

Certaines espèces animales, le mouton, le bœuf, le cheval, le chevreuil, le porc, le cobaye sont sensibles à la bactéridie charbonneuse, tandis que l'homme y est déjà plus résistant comme le prouve la rareté de la pustule maligne comparée au nombre d'ouvriers journellement exposés à la contracter.

D'autres animaux, les chiens, les chats, les renards, les batraciens, les reptiles jouissent, à cet égard, d'une véritable immunité. On peut, néanmoins, chez quelques-uns d'entre eux—moutons d'Algérie, chiens, chats—leur inoculer la maladie charbonneuse en augmentant la quantité du virus ou en choisissant la voie intra-veineuse. Ils succombent le plus souvent, tandis qu'ils avaient résisté à l'inoculation par la voie sous-cutanée.

L'immunité est mieux accusée chez les gallinacés et l'on a tenté de l'expliquer par la température normalement élevée de ces animaux, en se basant sur une expérience célèbre de Pasteur qui rend une poule sensible à la bactéridie charbonneuse en lui plongeant les pattes dans l'eau froide pendant un temps suffisamment long pour abaisser sa température.

Dans une autre expérience, on prive des grenouilles de leur immunité en les plongeant dans une eau à 35 degrés centigrades, afin d'élever leur température.

Cependant, ces expériences ne sont pas concluantes, car le moineau, dont la température est très élevée, prend le charbon; et le crapaud, dont la température est égale à celle de la grenouille, succombe facilement à la maladie charbonneuse.

Les *modifications thermogènes influencent l'immunité en provoquant des perturbations importantes dans le mécanisme de la défense organique.*

D'autres facteurs jouent aussi un rôle important.

Si on soumet des poules et des pigeons à un *jeûne sévère* et prolongé on les rend sensibles au charbon (Canalis et Morpugo).

D'autre part, si, par un dispositif ingénieux on provoque *une fatigue excessive* chez des rats blancs réfractaires au charbon, on les prive de leur immunité. Sur 13 rats ainsi surmenés, 2 seulement résistèrent à l'inoculation (Charrin et Roger).

Si nous étudions *la morve,* nous voyons des exemples très nets d'immunité naturelle, tandis que l'âne, le mulet, le cheval, le chien, le chat prennent facilement la maladie, les bovidés, le porc, les oiseaux sont presqu'absolument réfractaires.

Pour la *tuberculose,* la résistance des animaux à sang froid est non moins remarquable.

Le choléra ne se développe spontanément chez aucune espèce animale.

Il en est ainsi de la fièvre jaune.

L'avariose (syphilis) n'existe spontanément chez aucune espèce animale. On a tenté quelques inoculations heureuses chez le singe, mais ailleurs, elle a donné lieu à bien des mécomptes, et on ne peut la communiquer à l'animal qu'avec difficulté.

La pathologie comparée nous fournit des preuves nombreuses et péremptoires d'une immunité naturelle. Celle-ci s'atténue ou disparaît sous l'influence du froid, du jeûne et de la fatigue.

(*b*) *Pathologie Humaine.*—La *pathologie humaine* nous fournit des exemples non moins frappants d'immunité naturelle.

La race joue un rôle important. Le nègre est réfractaire à la *fièvre jaune.* Sur un effectif de 453 noirs qui prirent part à l'expédition du Mexique, il n'y eut pas un seul décès, alors que l'armée française était décimée par cette maladie.

Pour l'impaludisme, l'immunité du nègre est très appréciable et les statistiques des colonies anglaises sont très concordantes sur ce point.

L'âge.—Il y a une immunité inhérente à l'âge. Tous les auteurs sont unanimes à reconnaître que, dans la première année, les fièvres éruptives les plus contagieuses, comme la rougeole, sont exceptionnelles. Il en est ainsi de la vaccine, dans les premiers jours qui suivent la naissance. De même, la fièvre typhoïde ne frappe jamais le nouveau-né, ni même le jeune enfant.

Chez l'adulte, certaines immunités échappent à toute classification. Dans les épidémies de variole, de scarlatine, de rougeole, de choléra, de grippe, on rencontre toujours des organismes, qui, malgré des chances multiples et variées de contagion, et en dehors de toute atteinte antérieure de ces maladies, restent cependant indemnes.

Nous connaissons la fréquence du pneumocoque, du bacille de la tuberculose, du bacille de la diphtérie quelquefois, de certains tétragènes, du streptocoque et du staphylocoque, dans le nez et la gorge d'un grand nombre de personnes qui ne souffrent nullement.

Tous ces faits sont acquis de nos jours.

3° Les Théories

Quelle est la genèse de cette immunité naturelle?

S'agit-il d'une immunité par atavisme, par transmission héréditaire ?

S'agit-il d'une auto-vaccination lente de l'organisme par les microbes qui y pénètrent et y vivent presqu'à l'état de saprophytes après avoir provoqué des réactions défensives, inappréciables par les porteurs de ces germes ?

Des arguments de divers ordres plaident en faveur de cette interprétation.

L'immunité naturelle est connue et observée dès l'antiquité, mais la pathogénie de l'état réfractaire est de date récente.

Au point de vue historique, elle varie avec les siècles et avec les nations. Elle augmente ou elle diminue chez un peuple suivant que la maladie est récente ou ancienne. On sait qu'une maladie, lorsqu'elle sévit pour la première fois sur un pays, s'y fait remarquer par une diffusibilité et une gravité extrêmes; c'est ainsi que la variole importée en Amérique par les premiers conquérants, s'y montra plus meurtrière qu'en Europe. Il en fut ainsi au Mexique après l'arrivée des Espagnols au 16ième siècle.

Quand la coqueluche est apparue en France en 1414, tous ceux qui en étaient atteints succombaient.

Au 15ième siècle, la Suette miliaire est apparue pour la première fois en Occident; elle fit des ravages terribles en Angleterre où elle tua la moitié de la population, ainsi qu'en France où elle existe encore tout en étant devenue plus bénigne.

La rougeole lors de sa première apparition décima les Îles Féroé en 1781, et les Îles Fidji en 1875.

Nous savons aussi que les premières épidémies de choléra, en Europe, atteignirent les proportions d'un véritable fléau.

Les maladies qui se répandent parmi une population vierge exercent donc de grands ravages.

Quand, au contraire, une maladie régne dans un pays depuis assez longtemps pour que les ancêtres de la population actuelle en aient été tous plus ou moins atteints, alors, on la voit diminuer de gravité en même temps qu'augmente le nombre des réfractaires. Et ce qui montre bien qu'il s'agit là d'assuétude héréditaire, c'est que la maladie peut récupérer sur des sujets neufs sa gravité initiale.

Est-il besoin de rappeler la marche des épidémies de grippe qui reviennent à des intervalles de 20 à 25 ans et qui emportent les *générations nouvelles*, de préférence, parce qu'elles ne sont pas immunisées, comme les anciennes, contre ce germe morbide?

Cet état réfractaire ne provient pas de l'atténuation du virus par suite des transmissions d'homme à homme; c'est à l'augmentation de l'immunité des organismes qu'il convient d'attribuer la décroissance des maladies infectieuses et c'est l'hérédité de cette immunité qui se transmet d'une génération à une autre. On peut en recueillir des preuves tirées de l'expérimentation. Ainsi, une brebis inoculée avec le virus charbonneux atténué, quelques mois avant de devenir grosse, peut mettre bas des agneaux réfractaires au charbon; on a obtenu des résultats équivalents dans la maladie pyocyanique, la clavelée et la vaccine.

On a observé des faits d'immunité congénitale. Des parents syphilitiques ont pu transmettre l'immunité à leurs enfants sans les doter de la maladie; mais il n'en est pas toujours ainsi.

La variole donne lieu à des observations intéressantes. Une femme atteinte de variole grave au neuvième mois de sa grossesse, accoucha à terme d'un enfant sain, lequel se montra réfractaire à la fois à la variole et à la vaccine; mais cette immunité n'est pas constante.

On cite même des cas où l'immunité peut être conférée par la mère alors qu'elle l'aurait acquise avant la fécondation.

L'homme, qui, par une atteinte du mal, a acquis l'état réfractaire presque absolu, confère à sa descendance une résistance plus ou moins nette; mais le passage de l'état réfractaire des générateurs aux engendrés se réaliserait surtout lorsque ces générateurs étaient l'un et l'autre vaccinés. Il devient plus rare si un seul possède ces attributs, surtout s'il s'agit du père.

Ne peut-on pas admettre que du moment où, chez le rejeton, des éléments anatomiques fabriquent de la salive, de la bile, etc., parce que ces éléments procèdent de ceux qui, chez les ascendants, donnaient naissance à ces produits, il pourra se faire que d'autres éléments se montrent capables d'ingérer des parasites, de faire apparaître des composés nuisibles à ces parasites et à leurs poisons, si ce rejeton a pour parents des êtres dont certains organites jouissaient de ces attributs?

Cette hypothèse nous séduit parce qu'elle découle de la physiologie même. D'ailleurs, nous savons que certains sujets n'ayant jamais été atteints de fièvre typhoïde peuvent, avec le sérum de leur sang, agglutiner le bacille typhique à 1 pour 10, c'est-à-dire 1 goutte de culture de ce bacille dans 10 gouttes de sérum frais. Le bacille, animé de mouvements rapides à cause de ses nombreux cils vibratiles, est immobilisé au bout de quelques heures et s'agglutine en petites masses inertes.

Il y a donc une immunité innée, héréditaire, chez certains sujets.

Quels sont donc ces produits qui circulent dans le sang de ces réfractaires et qui paralysent et tuent ces germes? Ce sont des produits intermédiaires appelés opsonines par Wright, en 1903, qui adhèrent au microbe circulant, le sensibilisent et le préparent à être dissous par les phagocytes.

4° Conclusion

Bref, sans violenter les faits, on peut dire que tous les êtres possèdent un certain degré d'immunité naturelle assurée par le jeu régulier de leurs organes. Quand les humeurs et les sécrétions sont normales, quand les téguments internes et externes sont intacts, quand les épithéliums et les éléments phagocytaires remplissent bien le rôle protecteur qui leur est dévolu, alors l'organisme présente à l'infection le maximum de résistance. C'est ce qui explique comment, malgré le nombre et la variété des causes de contagion, la proportion des sujets atteints est relativement si faible. On sait, en effet, que les microbes les plus virulents peuvent vivre dans les cavités naturelles sans infecter l'organisme lorsque celui-ci n'est pas en état de réceptivité; car on ne doit pas oublier que chez l'homme comme chez les animaux, le jeûne, le froid, la fatigue, le surmenage affaiblissent ses réactions défensives naturelles et favorisent l'éclosion d'une maladie aiguë dont le germe existait quelque part à l'état latent.

Or, la coopération de tant d'atténuations légères, la sommation de toutes les résistances acquises, aboutissent à une immunité naturelle dont l'existence est démontrée par la pathologie comparée, l'observation, l'hérédité et l'expérimentation. Elle s'accompagne de réactions humorales qui neutralisent l'action de l'agent morbigène, pourvu que tous les organes fonctionnent dans un juste équilibre et s'adaptent rapidement aux variations des milieux ambiants.

II. Immunité Acquise

1° Les Faits

L'immunité acquise relève: 1° de l'action réciproque de l'organisme et des agents pathogènes: l'assuétude, l'influence des maladies antérieures et l'antagonisme; 2° de procédés artificiels imaginés par l'homme; les vaccinations et la sérothérapie.

(*a*) *Assuétude.*—L'assuétude désigne les modifications que subit l'organisme soumis à l'action graduelle et prolongée des agents toxiques et infectieux. On peut ainsi résister à des attaques, qui, primitivement, nous auraient été fatales.

Les poisons minéraux et végétaux fournissent des exemples frappants d'assuétude. On sait que quelques centigrammes d'arsenic ou de morphine suffisent, dans les conditions ordinaires, pour empoisonner l'homme, mais si l'on commence à administrer le poison à doses minimes et qu'on élève ensuite ces doses d'une façon lente, graduelle et prolongée, on arrive à faire supporter à l'organisme des quantités relativement énormes et qui eussent été mortelles au début. C'est là ce qu'on a appelé mithridatisme, en faisant allusion à la légende du roi de Pont qui, dit-on, s'étant accoutumé de longue date à différents poisons, les trouva sans effet quand il leur demanda la mort.

Pareille assuétude peut se manifester à l'égard de certains venins.

Dans les pays chauds infestés de moustiques, les étrangers sont en butte, dès leur arrivée, à des piqûres très douloureuses, puis peu à peu ils s'y habituent et cessent bientôt d'en ressentir toute fâcheuse influence.

L'accoutumance peut aussi, à l'égard de quelques maladies infectieuses, procurer une certaine immunité. Il est d'observation vulgaire que l'influence nuisible d'un foyer d'infection se fait surtout sentir sur les sujets qui y sont exposés depuis peu, tandis que ceux qui y sont acclimatés demeurent plus ou moins réfractaires.

On sait aussi que les médecins, les infirmiers, les garde-malades, tous ceux, en un mot, qui sont en contact perpétuel avec les contagieux, finissent, au bout d'un certain temps, par acquérir une réelle immunité.

Des auteurs dignes de foi rapportent des faits positifs d'immunité conférée par l'accoutumance.

Durant l'épidémie de choléra en Égypte, en 1865, on plaçait dans des lazarets tous les individus fuyant les foyers cholériques. Malgré l'encombrement et une hygiène défectueuse, il n'y eut que très peu de cas et la mortalité fut très faible, parce que la plupart d'entre eux avaient déjà subi l'influence du milieu; ils étaient acclimatés. On fit les mêmes constatations pendant la même épidémie sur des bateaux venus d'Alexandrie aux Dardanelles. Il y eut 16 cas de choléra sur 5326 hommes.

On peut encore citer comme type d'immunité par assuétude, la fièvre typhoïde, qui sévit à l'état endémique dans certains endroits; et on observe fréquemment que les personnes qui y séjournent depuis peu de temps contractent la maladie, tandis que les adultes autochtones ou plus anciens restent relativement indemnes.

Cette immunité par assuétude provient probablement d'une infection à doses trop faibles pour produire la maladie, mais suffisantes pour amener l'état réfractaire; car l'adulte qui vit dans un milieu où règne la fièvre typhoïde peut arriver à se vacciner d'une façon inconsciente par une absorption graduelle et insensible de poison typhique. Mais cette immunité, souvent, tiendrait plutôt à une atteinte antérieure de la maladie, assez légère pour que le sujet en ait perdu le souvenir, mais capable, cependant, de l'avoir rendu réfractaire. Combien de prétendus embarras gastriques, de fièvres éphémères, ne sont que des formes abortives de la fièvre typhoïde et susceptibles, comme telles, de conférer l'immunité.

L'assuétude ne serait donc qu'une immunité inconsciente, secondaire à un véritable mithridatisme bactérien.

(*b*) *Influence d'une maladie antérieure.*—Nous savons qu'un grand nombre de maladies infectieuses ne récidivent pas. Une première atteinte confère une immunité évidente. Ce fait a une portée si générale, qu'avant d'admettre les cas de récidive, il convient de les soumettre à une analyse rigoureuse pour rechercher l'erreur de diagnostic, s'il y a lieu.

Mais on doit reconnaître qu'il existe des récidives parfaitement démontrées. Cela prouve seulement que l'immunité n'est ni absolue, ni d'une durée illimitée; ces variations sont absolument individuelles et échappent à toute régle générale, car elles ne semblent nullement dépendre de l'intensité de la première atteinte. Une varioloïde réduite à quelques pustules, une scarlatine frustre, une atteinte légère de typhoïde créent, le plus souvent, l'état réfractaire au même titre qu'une variole confluente, une scarlatine grave ou une fièvre sévère.

Une première atteinte, quand elle n'empêche pas la récidive, peut-elle au moins l'atténuer ?

Pas toujours, mais pour certaines infections dans lesquelles les récidives sont fréquentes, les atteintes s'atténuent à mesure qu'elles se multiplient v.g. l'érysipèle, la variole, etc.

(*c*) *Antagonisme.*—L'antagonisme est un principe en vertu duquel une diathèse ou un état morbide confère à l'organisme une immunité plus ou moins prononcée contre certaines maladies infectieuses. Ainsi, Baudin, en 1845, publia, le premier, une série de travaux sur ce sujet. Il avait cru établir que là où existe la malaria, la tuberculose est exceptionnelle, et que plus une race est réfractaire à l'impaludisme, plus elle est prédisposée à la tuberculose.

Voici un fait qui vient à l'appui de cette thèse: à Whitehall (É.U.) un marais ayant été converti en étang, les fièvres intermittentes y furent remplacées par la phtisie. Sur les plaintes de la population, le marais fut rétabli et la phtisie disparut en même temps que revinrent les fièvres intermittentes.

Un autre auteur, Brun, de Beyrouth, a rapporté, en 1888, le fait suivant: Sur la côte et dans l'intérieur des terres à Beyrouth, la tuberculose était, il y a 20 ans, à peu près inconnue alors que l'impaludisme y revêtait les formes les plus variées. Peu à peu, à mesure que le sol était défriché, l'impaludisme disparaissait, mais en même temps se multipliaient les cas de tuberculose. Sur un total de 3207 malades pauvres, il n'y avait eu que 24 tuberculeux, soit 1/174, et 827 paludéens, soit 1/5, tandis que dans la population aisée, où les conditions d'hygiène étaient plus favorables, le chiffre des paludéens atteignait 1/32 et le chiffre des tuberculeux 1/18. L'opposition de ces chiffres est remarquable.

On rapporte d'autres faits d'antagonisme entre l'impaludisme et la fièvre typhoïde; entre la fièvre intermittente et la fièvre typhoïde; entre le cancer et la tuberculose.

Il semble bien établi que le saturnisme, l'asthme, l'emphysème, la syphilis, l'artério-sclérose sont un mauvais terrain pour le développement de la phtisie, parce qu'elles ont pour caractère commun la sclérose, et que le bacille tuberculeux s'implante mal dans les tissus sclérosés.

L'antagonisme microbien a été démontré par les recherches expérimentales. On sait que, quand on ensemence divers microbes dans un même milieu, il en est qui succombent et d'autres qui résistent, la culture arrive à se purifier par une véritable sélection naturelle.

Ainsi, on a pu rendre des cobayes réfractaires au charbon en leur inoculant le microbe de l'érysipèle; on a pu sauver de l'infection charbonneuse un certain nombre d'animaux à qui on avait inoculé à quelques heures de distance, la bactéridie et le bacille pyocyanique.

On ne peut s'empêcher de rapprocher ces faits expérimentaux des faits observés en clinique.

Peut-on par une médication préventive conférer l'immunité ?

Parmi tous les médicaments qui ont une action spécifique contre certaines maladies, il n'y a que la *quinine* contre le paludisme qui semble exercer une action préventive, si on s'en rapporte aux auteurs bien documentés sur cette question. Il en serait ainsi du néosalvarsan. Injecté dans les veines, à la dose de 0·30 à 0·60 centigrammes, il empêcherait l'évolution de la syphilis en tuant le tréponème au point d'inoculation. Mais la plupart des médicaments sont impuissants à procurer l'immunité.

2° Les Théories

Une doctrine nouvelle devait naître, le jour où il fut établi que la virulence des maladies dépendait, en grande partie, des sécrétions des microbes: la *vaccination* et la *sérothérapie*. Ces deux opérations immunisent l'organisme en procédant d'une façon différente.

Dans le premier cas, vaccination, il y a *immunité active*, c'est-à-dire que l'organisme fabrique lui-même les substances immunisantes contre le germe qu'on y a introduit.

Dans le second cas, *sérothérapie*, il y a *immunité passive*, c'est-à-dire qu'on introduit dans l'organisme des substances immunisantes fabriquées par un autre organisme. Il y a enfin *immunité mixte*, si elle résulte de l'inoculation du vaccin et du sérum.

Un vaccin contient les microbes virulents, atténués ou morts, d'une maladie infectieuse spécifique, v.g. vaccin contre la fièvre typhoïde; vaccin contre la variole.

Un sérum en est totalement dépourvu, il provient du sang d'animaux immunisés contre telle maladie reconnue v.g. sérum antidiphtérique provenant du sang d'un cheval immunisé contre la diphtérie.

Essayons de pénétrer le mécanisme et la nature intime de l'immunité.

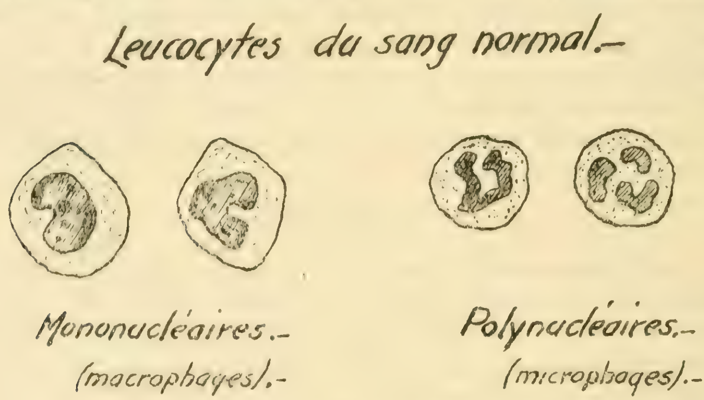
Deux théories jouissent d'une très grande faveur en ce moment:

1° La théorie cellulaire ou phagocytaire.

2° La théorie humorale.

1°.—*Théorie Cellulaire ou Phagocytaire.*—En 1883, Metchnikoff, de l'Institut Pasteur, démontra que certaines cellules du sang étaient en activité pendant la lutte de l'organisme contre l'infection microbienne: ce sont les *leucocytes* ou globules blancs.

Cet auteur avait montré autrefois que chez les spongiaires, les substances alimentaires, après avoir pénétré par les ouvertures si nombreuses à la surface des éponges, étaient saisies par les cellules vibratiles ou amiboïdes qui englobaient ces substances et leur faisaient subir une digestion intra-cellulaire. Ces cellules, il les avait nommées *phagocytes*, à cause de leur faculté de s'emparer et de digérer des substances étrangères ou nuisibles à l'organisme. Il y en a plusieurs variétés:



1° Les leucocytes polynucléaires (plusieurs noyaux) ou microphages, qui sont très actifs dans les infections aiguës.

2° Les leucocytes mononucléaires (un seul noyau) ou macrophages, qui agissent surtout dans les infections chroniques.

Mode d'action.

1ière expérience: résorption des éléments figurés.

Si on injecte dans le péritoine d'un cobaye du sang défibriné d'oie, au bout de 2 à 3 heures, il se produit dans la cavité péritonéale une inflammation aseptique (sans suppuration) révélée par l'exode de leucocytes, surtout des mononucléaires ou macrophages. Ceux-ci poussent des prolongements sur la paroi des hématies, la saisissent et l'emprisonnent à l'intérieur où elle subit des modifications importantes; l'hémoglobine de cette hématie diffuse, le corps protoplasmique se digère, le noyau se divise bientôt en fragments qui disparaissent au bout de quelques jours. Puis ces leucocytes macrophages quittent le péritoine pour aller dans l'intestin, les ganglions, le foie ou la rate, achever leur digestion.

Quel est ce ferment ou cette diastase intracellulaire qui digère l'hématie ?

Metchnikoff l'a désignée sous le nom de *cytase;* d'autres auteurs lui ont donné le nom d'*alexine* ou de *complément.*

Cette opération d'absorption et de digestion représente l'effort naturel d'un organisme neuf pour résister à la cellule étrangère et l'éliminer.

Si on répète cette expérience plusieurs fois chez le même animal, on constate que son sérum acquiert des propriétés nouvelles; il détruit les globules rouges ou hématies de l'oie, il les hémolyse.

Pourquoi ?

Parce que des injections répétées de sang d'oie ont provoqué l'apparition d'une substance nouvelle appelée *sensibilisatrice.* Celle-ci rend les hématies de l'oie plus sensibles à l'action de la cytase ou *alexine*, et favorise ainsi leur dissolution.

2ième expérience: résorption des bactéries.

Dans les maladies infectieuses, la résorption des microbes se ferait de la même manière.

On avait déjà mis en évidence la résorption phagocytaire chez les Daphnies. Celles-ci sont sujettes au parasitisme d'une levure (monospora) dont les spores pénètrent dans le tube digestif. Elles traversent les parois intestinales pour se rendre dans l'intérieur du corps. Immédiatement après, les leucocytes entourent les spores et les englobent. La surface de la spore, lisse et régulière, devient échancrée et onduleuse; la spore se détruit, et il n'en reste plus que des débris informes. Cette levure a donc subi une digestion qui a abouti à sa destruction. La Daphnie qui a été ainsi infestée, reste indemne et bien portante.

En d'autres circonstances, si les leucocytes n'ont pas englobé la spore dès son invasion, celle-ci germe et secrète un poison qui éloigne les phagocytes; les parasites se mettent à pulluler et l'animal succombe.

3ième expérience: Chez un animal réceptif au charbon, comme le lapin, on fait une injection sous-cutanée de culture charbonneuse; après quelques heures, l'examen de l'exsudat qui s'est formé au point d'inoculation révèle une pullulation intense de bactéridies et la *rareté des leucocytes.* Ces bactéridies sont libres, elles passent dans la circulation et entraînent la mort. La phagocytose a été négative.

4ième expérience: Chez un animal réfractaire au charbon, comme la poule ou le chien, la même opération donne un résultat différent. L'examen de l'exsudat montre qu'après un certain temps, toutes *les bactéridies sont englobées* dans *les* cellules phagocytaires (leucocytes microphages), qui sont très nombreuses. La phagocytose est positive.

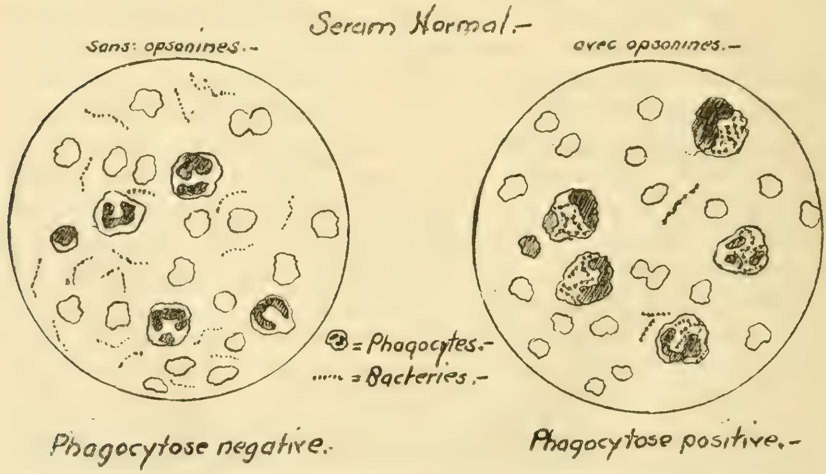
Si, par contre, on diminue artificiellement la résistance de l'animal (immersion des pattes de la poule dans l'eau froide, etc.), l'englobement de la bactéridie charbonneuse par le leucocyte ne se produit plus, elle pullule et l'animal succombe au charbon.

Toutes ces expériences concordent.

Le leucocyte apparaît comme le véritable défenseur de l'organisme.

Si la diapédèse s'opère dans les conditions normales, il résorbe la bactérie comme il a résorbé l'élément figuré (hématie) et il la détruit ou en paralyse l'action. La digestion intra-cellulaire s'opère par un ferment issu des leucocytes microphages (microcytase) et des leucocytes macrophages (macrocytase).

Les mêmes considérations s'appliquent *aux toxines,* c'est-à-dire aux poisons solubles. Si on introduit dans l'organisme de certains animaux des doses croissantes de toxine tétanique ou diphtérique, on constate qu'au bout d'un certain temps, leur sérum a acquis un pouvoir antitoxique considérable. Or, Metchnikoff a montré que cette immunité acquise relève aussi des leucocytes qui absorbent et transforment ces poisons.



(Théorie Metchnikoff).

Cette dernière proposition est bien démontrée par les deux faits expérimentaux suivants:

On injecte dans les veines de lapins 0 gr. 2 d'atropine, on les saigne et on recueille séparément, par centrifugation, le plasma et les globules blancs. On injecte le plasma (sérum sanguin) dans le cerveau de lapins neufs: réaction insignifiante; si on injecte les leucocytes, on provoque des phénomènes graves pouvant entraîner la mort. Donc l'atropine est arrêtée par les leucocytes. (Calmette, Directeur de l'Institut Pasteur.)

Dans une autre expérience, on injecte du trisulfure d'arsénic dans le péritoine de lapins habitués à ce poison. Au bout d'un certain temps, il se produit une hyperleucocytose abondante où les leucocytes macrophages mononucléaires (un seul noyau) sont bourrés de grains de ce sel insoluble qui finissent par être digérés totalement.

Si on diminue la réaction phagocytaire par l'injection de grains de carmin, que les leucocytes sont occupés à englober, l'animal présente des troubles graves auxquels il succombe.

D'autre part, l'injection de ces sels dans le cerveau provoque la mort avec une dose cent fois moindre.

Enfin, des animaux qui ont reçu à plusieurs reprises des doses croissantes de toxine tétanique, diphtérique, sont vaccinés au bout d'un certain temps contre ces toxines. Leur sérum acquiert en général un pouvoir antitoxique considérable; et c'est aux leucocytes mononucléaires ou macrophages qu'on attribue le rôle de défense contre les toxines.

Les leucocytes digèrent non-seulement les éléments figurés et les bactéries, mais ils neutralisent aussi les toxines.

Les conditions qui facilitent la phagocytose sont de celles qui favorisent la diapédèse, c'est-à-dire l'arrivée en grand nombre des leucocytes vers le point infecté ou intoxiqué; car pas de phagocytose active sans leucocytes, pas de leucocytes abondants sans diapédèse, c'est-à-dire l'appel des leucocytes contre le poison.

On a tenté d'expliquer la diapédèse par la chimiotaxie, à savoir; la chimiotaxie positive, qui exerce une action attractive, et la chimiotaxie négative, qui exerce une action répulsive sur les leucocytes. Or, les composés microbiens, d'après leur nature et leur titre de concentration, exercent une action tantôt positive, tantôt négative sur la diapédèse.

Une concentration faible est négative; une concentration forte est positive; une concentration excessive est négative.

Au surplus, le surmenage en faisant osciller l'acidité, l'alimentation, les intoxications, les maladies, l'infection, les réactions nerveuses, la faim, la soif, l'inanition, les anesthésiques, les lésions des nerfs et des vaisseaux, font osciller ces attributs d'attraction ou de répulsion en agissant sur la composition du terrain, en modifiant l'activité des parasites. Tout repose donc dans la vitalité des cellules.

Bref, dans la théorie cellulaire, tous les *phénomènes d'immunité naturelle* ou *acquise contre les microbes et les toxines se résument dans la phagocytose;* les leucocytes les englobent et les détruisent, grâce à la présence dans les sérums normaux d'opsonines et de bactériotropine, qui sensibilisent les germes morbigènes et les préparent à la digestion leucocytaire.

2° La Théorie Humorale

La théorie humorale soutient que l'immunité est due à la présence dans le sang de substances immunisantes appelées *anticorps*.

Les anticorps sont des substances spécifiques agissant contre un microbe ou sa toxine, et qui se produisent dans l'organisme à la suite de la pénétration de certaines substances *étrangères* appelées *antigènes*, v.g. des microbes, des toxines, des globules rouges, des albumines, des venins et des colloïdes.

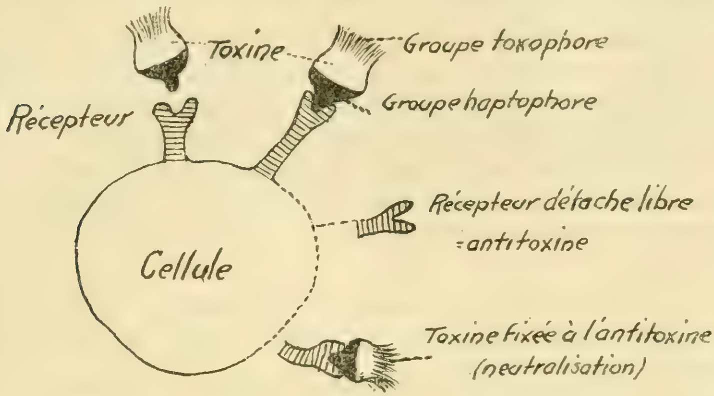
Cette théorie, imaginée par Erlich, repose entièrement sur la vitalité cellulaire et sa résistance contre une infection.

La molécule protoplasmique (cellule) offre certaines analogies avec les groupements de la chimie des corps aromatiques. Comme ces derniers, cette molécule possède un groupement central (noyau) nécessaire à la vie et caractéristique du fonctionnement spécifique de la cellule et des *chaînes latérales*, véritables *récepteurs* vis-à-vis des divers principes en état de dissolution dans les humeurs.

En vertu de leurs affinités chimiques et spécifiques, elles attirent certains de ces principes, surtout les principes nutritifs, elles les fixent et permettent à la cellule de se les assimiler. Une substance alimentaire serait ainsi fixée par les chaînes latérales, et après avoir subi les modifications indispensables à son assimilation, serait rejetée par la cellule sans que cette dernière soit altérée.

Il se passerait, pour les toxines, un phémomène analogue.

La molécule de toxine serait constituée par deux groupes; un premier, toxique (toxophore); un second, non toxique (haptophore), dont une partie serait soudée au groupe toxophore, l'autre serait libre, mais pourrait se fixer sur les récepteurs de la molécule vivante pour permettre l'action de la toxine.



Récepteur de premier ordre
"Théorie d'Ehrlich."

Si la cellule est saturée par les groupes toxophores, elle est mise hors d'activité; quand cette saturation s'opère sur un grand nombre d'éléments cellulaires de l'organisme, la mort s'ensuit. Par contre, si la saturation est incomplète, la cellule, pour regénérer les récepteurs devenus inactifs, en forme d'autres, mais elle les regénère en excès et les déverse dans le sang et les humeurs de l'organisme. Ces récepteurs libres constituraient les *antitoxines*, qui fixeront au fur et à mesure les doses successives de toxine.

Ces récepteurs ou anticorps sont des antitoxines.

Il y en a de trois ordres:

1° (*a*) *Les antitoxines*, qui neutralisent les toxines d'origine animale, végétale ou bactérienne. On les trouve dans le sérum d'animaux immunisés v.g. sérum antidiphtérique; ou bien dans le sang et les humeurs d'individus qui ont été atteints par une maladie infectieuse.

(*b*) *Les antiferments*, qui neutralisent l'action de certains ferments. On les compare à des diastases ou enzymes.

2° (*a*) *Les agglutinines :* substances spécifiques qui prennent naissance dans le sérum de sujets infectés et qui agissent sur la bactérie infectante en la paralysant et l'agglutinant en petits amas.

(*b*) *Les précipitines*, qui existent dans tout sérum anti-infectieux et qui précipitent l'albumine contenue dans un filtrat de bouillon de culture d'un microbe spécifique.

3° (*a*) *Les lysines*, qui dissolvent les hématies étrangères (hémolysines), les bactéries (bactériolysines), les cellules des organes et des tissus (cytolysines).

Cette théorie humorale, en des termes différents, se rapproche de la théorie précédente, car les propriétés antitoxiques que nous venons d'énumérer, et qui apparaissent successivement dans le sang des organismes infectés, proviennent des globules blancs ou leucocytes, auxquels nous devons adjoindre les cellules lymphatiques, les éléments fixes du tissu conjonctif, les cellules de la moëlle osseuse, de la rate, de l'amydgale, des follicules clos, des plaques de Payer, des ganglions.

La neutralisation des toxines s'opère selon le principe d'une chimiotaxie positive ou négative et selon leur degré de concentration.

Elle renforce la théorie cellulaire malgré une interprétation qui ne diffère que dans les termes.

La clinique démontre aujourd'hui l'importance de ces théories. Des travaux récents prouvent que la leucocytose peut nous guider dans la marche de la maladie. En effet, la leucocytose utile varie suivant la nature du tissu infecté. Lorsqu'il s'agit d'un organe riche en éléments lymphoïdes (intestins, amygdales) c'est le *mononucléaire* qui est le pivot de la défense, c'est sur lui que devra porter l'attention dans l'interprétation des résultats.

Lorsqu'il s'agit, au contraire, d'un organe ou tissu dépourvu d'éléments lymphoïdes ou peu riche en ces éléments (tissu cellulaire, poumon, sang, etc.), c'est le *polynucléaire* qui joue le rôle primordial dans la défense et c'est de cet élément qu'il faudra tenir compte pour le pronostic.

La *résultante* dans chaque cas nous indiquera la marche de la maladie, nous aidera à fixer le pronostic.

Conclusions générales

L'immunité résulte des réactions humorales de l'organisme contre les infections et les intoxications.

L'immunité naturelle peut être transmise par hérédité ou apparaître à la suite d'une auto-vaccination lente et silencieuse de l'organisme.

Elle nous protège contre les infections légères et les intoxications fréquentes, auxquelles nous sommes sans cesse exposés, grâce aux propriétés antitoxiques du plasma et des globules blancs qui en neutralisent les mauvais effets.

L'immunité acquise apparaît à la suite de la vaccination, d'une maladie infectieuse, d'une intoxication ou de la sérothérapie. Elle marque un degré de plus dans la réaction défensive. Elle est spécifique, c'est-à-dire qu'elle exerce son action sur le germe qui a provoqué la maladie et sur nul autre.

Elle est cumulative, c'est-à-dire qu'elle peut engendrer en même temps des contre-poisons variés dont l'action antitoxique s'additionne pour lutter avec succès, souvent, contre des germes qui circulent simultanément dans l'organisme.

Quelle que soit la théorie que l'on adopte, l'immunité paraît se réduire à une propriété que les cellules ont reçue de leurs ascendants ou acquise par voie d'éducation.

Les plasmas sont en partie ce que les cellules les font. Il en résulte que le pouvoir bactéricide, aussi bien que le phagocytisme, se trouve être une dépendance de la vie des organites.

Dès lors, les diverses conditions visant l'état réfractaire se ramènent à un seul point; l'activité cellulaire modifiée par la vaccination chimique ou figurée, modifiée par une infection.

Comme le leucocyte est le pivot de la défense de l'organisme, nous pourrons, à l'aide d'analyses répétées du sang, durant l'évolution de la maladie, apprécier à sa juste valeur l'issue de la lutte en suivant la marche de la leucocytose, et fixer plus sûrement le pronostic dans chaque cas.

La vie n'est pas seulement l'ensemble des fonctions qui résistent à la mort, elle est aussi l'ensemble des fonctions qui résistent à la maladie.

Further Work on the Bacteriology of Swelled Canned Sardines

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Presented by ARTHUR WILLEY, F.R.S., D.SC., F.R.S.C.

(Read May Meeting, 1919.)

The investigation into the "Bacteriology of Swelled Canned Sardines" was begun by one of us in the summer of 1916, under the auspices of the Biological Board of Canada. The work was done at the Biological Station, St. Andrews, N.B., and in the laboratories of Macdonald College (McGill). An Interim Report was published by the Board in 1918;[1] and in March of the same year, a short paper was presented to the Food and Drugs Section of the American Public Health Association.[2]

The publications thus far have recorded the isolation and detailed studies of eight strains of gas-producing bacteria. Of these, two strains have been classified as *B. vulgaris* (Hauser, 1885), (Migula, 1900)[3]. The remaining six strains are typical and a-typical types of the *colon-aerogenes* group (Escherich)[4].

Experimental swellings of normal cans of sardines were accomplished by inoculation with three of the cultures respectively which had been isolated from the original cans; and the "Postulates of Koch" were satisfied.

PRESENT PAPER

The present paper is concerned with that phase of the investigation which deals with the enquiry into the possible sources of the causative bacteria. The investigation has been conducted partly on the Atlantic coast from the Biological Station, St. Andrews as the centre; and partly in the laboratories at Macdonald College, and the University of British Columbia, respectively.

METHODS

The methods used in the collection of material for examination, and in the subsequent cultural work, are, with some minor adaptations, in conformity with those previously adopted and already noted in the Interim Report.[1]

Material Examined

Some two hundred herrings were secured, usually first hand from weirs, from fishing smacks, and from the canneries. The weirs included in the enquiry extended from Oak Bay in the St. Croix river, to the harbour of St. John, N.B. Inoculations were made from the intestines and from the gills of these herrings. Samples were also taken of (*a*) water from the inside of various weirs; (*b*) mud from weirs at low tide; (*c*) water at low tide as used for pickle in the canneries; (*d*) sea water as run into cannery just before entering pickle tank; and (*e*) sea water dipped out of pickle tank one half hour after the herrings had been put in.

Cultural Studies

The presence of gas-producing bacteria has been demonstrated in some or all of the material from each of the sources enumerated above. Ten strains of these bacteria have been studied in detail, and herein we present the results up-to-date.

Based on their reactions in laboratory media the ten strains divide themselves into three main groups:

1. Those which liquefy gelatine, but fail to ferment lactose to gas.
2. Those which do not liquefy gelatine, but which ferment lactose to acid and gas.
3. Those which do not liquefy gelatine, do not ferment lactose to acid and gas, but which produce acid and gas in glucose.

Group I

Cultures 1, 5 and 22 are members of this group. They have been isolated from the intestines of herrings, water in a weir, and the pickle tank in factory respectively. Microscopically they are short rods, gram negative, and motile.

Each culture liquefies gelatine and fails to ferment lactose to gas. In certain other reactions some differences are exhibited.

Culture 1.—No action on litmus milk in seven days; faintly acid to Methyl Red; negative to the Voges-Proskauer reaction. Glucose, saccharose, maltose and xylose are fermented to acid and gas. Lactose, mannite, dulcite, salicin and aesculin are not fermented.

Culture 5.—Litmus milk is coagulated, bleached and digested; digestion almost complete within six days; indol is produced; alkaline to Methyl Red; faintly positive to the Voges-Proskauer reaction. Glucose, saccharose, maltose, mannite, xylose and salicin are fermented to acid and gas. Lactose, dulcite and aesculin are not fermented.

Culture 22.—Litmus milk is bleached and digested; digestion is almost complete in six days; acid to Methyl Red; negative to the Voges-Proskauer reaction. Glucose, saccharose, maltose, xylose, salicin and aesculin are fermented to acid and gas. Lactose, mannite and dulcite are not fermented.

Classification

In spite of the differences exhibited by the three strains of this group in certain of the reactions, we consider each to be a variety of the type *B. vulgaris* (Hauser, 1885), (Migula, 1900).[3]

Group II

Cultures 2, 9, 15, 17 and 18 are members of this group. They have been isolated from the intestines of herrings, gills of herrings, sea water used for pickle, and water from weirs respectively.

Microscopically they are all short thick rods, gram negative, and with the exception of culture 2, motile. Gelatine is not liquefied; litmus milk is coagulated and bleached with formation of gas; indol is not produced; lactose is fermented by each to acid and gas. In certain other reactions some differences are to be noted.

Culture 2.—Acid to Methyl Red; negative to the Voges-Proskauer reaction. Glucose, lactose, maltose, mannite, xylose, salicin and aesculin are fermented to acid and gas. Saccharose and dulcite are not fermented.

Culture 9.—Alkaline to Methyl Red; faintly positive to the Voges-Proskauer reaction. Glucose, lactose, saccharose, maltose, mannite, xylose and salicin are fermented to acid and gas. Dulcite and aesculin are not fermented.

Note: The fermentation of lactose is delayed, usually from two to three days being required for the production of gas.

Culture 15.—Alkaline to Methyl Red; positive to the Voges-Proskauer reaction. Glucose, lactose, saccharose, maltose, mannite, xylose, salicin and aesculin are fermented to acid and gas. Dulcite is not fermented.

Note: The fermentation of lactose is delayed, usually from two to three days being required for the production of gas.

Culture 17.—Acid to Methyl Red; negative to the Voges-Proskauer reaction. Glucose, lactose, maltose, mannite, dulcite, xylose, salicin and aesculin are fermented to acid and gas. Saccharose is not fermented to gas.

Culture 18.—Alkaline to Methyl Red; positive to the Voges-Proskauer reaction. Glucose, lactose, saccharose, maltose, dulcite, xylose, salicin and aesculin are fermented to acid and gas.

NOTE: The fermentation of lactose is delayed, usually from two to three days being required for the production of gas.

Classification

The organisms of this group are all to be considered as varieties of the *colon-aerogenes* group (Escherich)[4]. Using the classification of Jackson,[5] which has since been adopted by the American Public Health Association,[6] we are justified in sub-dividing this group and classifying as follows:

Culture 2 as of the type *B. acidi-lactici* (Hueppe).
Cultures 9 and 15 as of the type *B. aerogenes* (Escherich).
Culture 17 as of the type *B. coli* (Escherich).
Culture 18 as of the type *B. communior* (Durham).

Group III

Cultures 8 and 24 are members of this group. They were isolated from the gills, and intestines of herrings respectively.

Microscopically they are short rods, gram negative and motile.

Gelatine is not liquefied; litmus milk is not changed; indol is not produced; each strain is faintly acid to Methyl Red, and negative to the Voges-Proskauer reaction. Both cultures ferment glucose and maltose to acid and gas, the action of culture 24 being feeble and slow. Gas is not produced from lactose, saccharose, mannite, dulcite, salicin or aesculin. The action on xylose is variable.

Classification

These strains are of very considerable interest. They are ruled out of the *colon-aerogenes* group on account of their inability to attack lactose. They more nearly approach the type *B. paratyphosus*, or the type *B. enteritidis*—(Gaertner group)—the organisms of the *Gaertner* group being those most commonly associated with cases of food poisoning; these types, however, are both able to ferment dulcite. Besson[7] considers the organisms of the *Gaertner* group always ferment dulcite. Savage,[8] in his numerous and valuable reports on cases of food poisoning, is very definite as regards the ability of the true *Gaertner* group to ferment dulcite to acid and gas. Jordan[9] reports that all the *Gaertner* strains with which he worked are dulcite positive. Our cultures, 8 and 24, are unable to ferment dulcite to gas. Savage[10] reports a strain of the hog cholera bacillus (*B. suispestifer*) obtained from McFadyean, which failed to ferment dulcite; this organism also failed to ferment maltose, while our cultures are positive to maltose. Jordan[9] reports that several stock cultures of *B. suispestifer* have failed to ferment dulcite. Savage,[8] in his classification of the *Gaertner* group, describes a number of strains which are in many respects similar to the true *Gaertner*, but which do not ferment dulcite, as *Para-Gaertner* bacilli. Whether our cultures 8 and 24 would have fermented dulcite when freshly isolated, is a matter upon which we have no evidence. As at the present time we have no sera specific for the several variations and are therefore unable to confirm with the agglutination test; and as our strains do not produce acid and gas from dulcite, we classify cultures 8 and 24 as varieties of the *Para-Gaertner* group after Savage[8].

NOTE:—On reference to the data accumulated at the time the material was collected, we find that *Cultures 8 and 24* were isolated from herrings caught in a weir which was reported to be subject to sewage contamination.

An Observation on the Methyl Red Reaction

We consider it important to make special mention of the reaction of our cultures to Methyl Red. During the last few years, evidence has accumulated to show that faecal strains—from bovine sources—of *B. coli*, give an acid reaction to Methyl Red; and that non-faecal strains of *B. coli*—from grains—give an alkaline reaction to Methyl Red. The former are recorded as the organisms of the low-ratio group; the latter as the organisms of the high-ratio group. The philosophy of the reaction is that Methyl Red differentiates according to the H^+ion concentration. The work is reported by Harden and Walpole;[11] Rogers; Rogers, Clark and Davis;[12] Rogers, Clark and Evans;[13] Clarke and Lubs;[14] Levine[15], and others.

A reference to the data recorded by us in this paper, reveals the fact that without exception the cultures isolated from the intestines of herrings have given an acid reaction to Methyl Red. Some of these cultures are types of *B. vulgaris*, some are typical strains of *B. coli*, while some are organisms of the *Para-Gaertner* group. Culture 17 is from the pickle tank, but isolated from the pickle immediately after the tank had received its quota of fresh herrings.

On the other hand, the cultures we have isolated from water in the weirs have all proved to the alkaline to Methyl Red. We have repeatedly confirmed these reactions. This is not the place to enter upon any discussion.

But, that several strains of organisms, varying sharply as regards many of their main characteristics, yet having a common source—the intestines of the herrings—should each be acid to Methyl Red, would appear to be a point of sufficient interest to warrant this special note.

Experimental Swelled Cans

Up to the present, cultures 5, 17 and 18 respectively have been used for the purpose of inoculating normal cans of sardines. Typical swellings have been produced, the organisms have been recovered, and the "Postulates of Koch" have been satisfied.

Comparisons

The Strains of this Series, and Those Obtained from the Original Swelled Canned Sardines

As the present studies have proceeded, it has become evident that certain of the strains of the series with which this paper is concerned, are very closely allied to some of the strains of which descriptions have been detailed in the Interim Report;[1] and as a matter of interest, we draw attention to these similarities at this time.

Culture 5 of this series differs from *Culture 24* of the former series as regards the production of indol, and the reaction in aesculin. In all other main features and reactions the two strains are identical.

Apart from the action on inulin *Cultures 9 and 15* of this series are culturally and biochemically identical with *Culture 32* of the former series according to the description given in the Interim Report;[1] *particularly with respect to the delayed action in lactose.* We have in this later work been unable to secure a satisfactory supply of inulin, and consequently have been obliged to disregard our results with this substance in all cases.

Summary

1. Certain possible sources of the bacteria responsible for the swelling of canned sardines have been investigated.

2. From the various sources enumerated herein, gas-producing bacteria have been isolated.

3. Ten strains of these bacteria have been studied, are divided into groups, and are classified as follows:

Group I

Cultures 1, 5 and 22, as types of *B. vulgaris* (Hauser, 1885), (Migula, 1900).

Group II

Culture 2, as of the type *B. acidi-lactici* (Hueppe).
Cultures 9 and 15, as of the type *B. aerogenes* (Escherich).
Culture 17, as of the type *B. coli* (Escherich).
Culture 18, as of the type *B. communior*.

Group III

Cultures 8 and 24, as of the *Para-Gaertner* group (Savage).

4. Experimental swelled cans of sardines have been produced by inoculation with cultures 5, 17 and 18 respectively, and the "Postulates of Koch" have been satisfied.

Acknowledgements

We desire to express our thanks to the Biological Board of Canada for permission to publish this paper. To Dr. F. C. Harrison, of Macdonald College (McGill); and to The University of British Columbia, respectively, we record our appreciation of the laboratory facilities which have been placed at our disposal.

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The Inheritance of Earliness and Lateness in Wheat[1]

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(Read May Meeting, 1919.)

Last year the writer communicated to the Royal Society of Canada some results of experiments planned to determine the inheritance of the length of the growth period in wheat. At that time the experiments had been carried as far as the second generation of hybrids. During the past summer many families of third generation of hybrids were grown in order to determine the exact constitution of the second generation plants and to test the theoretical conclusions reached. Some of the data on these families are given and explained in the following pages.

In the previous report it was explained that crosses were made in various combinations between several varieties of wheat which showed different degrees of earliness. If A, B, C, D and E represent the varieties in the order in which they ripened, crosses were made between A and B, A and C, A and D, B and D, B and E, D and E, etc. In all cases a blending type of inheritance was found and the range of F_2 variation extended at least from the mean of the early parent to that of the later. In many cases it extended from the lower extreme of the lower parent to the higher extreme of the higher parent. Some of the data given in last year's report are shown in condensed form in Table I. The variation curves for F_2 were uniform, revealing no indication of dominance or simple segregation. It was pointed out that the special value of the work from the theoretical standpoint lay in the special test which it made possible of hypotheses of blending inheritance. An hypothesis put forward to explain the results of crossing A and E can be tested in a way not done hitherto, when we also have the results of crossing A with B, A with D, D with E, etc., where B, C and D are intermediate between A and E. On the multiple-factor hypotheses of blending each successive pair of varieties must differ by a certain minimum number of factors, which can be determined by crossing and the conclusion was reached that when the sum of these differences is calculated it is apparently found to exceed the

[1] Results of an investigation carried on with the aid of a grant from the Honorary Council of Scientific and Industrial Research, and published with the permission of the Council.

TABLE I

LENGTH OF GROWTH PERIODS IN 1917.

Variety	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121
A	....	....	....	....	....	....	....	....																						
B							....	....	....	....	....	....	....	....																
C													....	....	....	....	....	....	....	....										
D																	....	....	....	....	....	....	....	....						
E																							....	....	....	....	....	....	....	....
F																						....	....	....	....	....	....	....	....	
F_2 A x B		....	....	....	....	....	....	....	....	....	....	....	....	....	....	....														
F_2 A x C		....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....											
F_2 A x D		....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....									
F_2 A x F				....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	
F_2 B x E									....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....		

TABLE II

LENGTH OF GROWTH PERIODS IN 1918

Variety	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149
A	....	....	....	....	....	....	....														
B						....	....	....	....	....	....										
C										....	....	....	....	....	....						
D														....	....	....	....	....			
E																....	....	....	....	....	

maximum number possible as determined by direct crosses between the earliest and the latest.

As in previous years the greatest care was taken to eliminate environmental errors as much as possible. All seeds were sown on two successive days. The plot of ground on which the plants were grown was chosen with particular reference to its flatness and uniformity. The plants were spaced in regular rows six inches apart and three inches apart in the row. At harvest time two plants at both ends of each row were discarded as were those on either side of a blank resulting from the failure of a seed to germinate or from the death of a plant. The latter fact accounts for the differences in the numbers recorded for the different families.

The season was unfavourable for the investigation for two reasons. In the first place, a cold spring in which almost no growth was made was followed by a very hot dry summer, with the result that the varieties ripened much more nearly at the same time than is usually the case. In the second place a severe epidemic of rust broke out in spite of the dryness and the seed of the later varieties and hybrids became shrunken and hardened much sooner than the normal ripening time. Both these influences tended to lessen the real hereditary differences between the different races, and to make interpretation of the results more difficult.

On account of the very large number of plants to be grown and recorded in order to secure a reasonably large number of each family, it was found to be impossible to continue the work with all the crosses of the previous year. Record taking was therefore either abandoned entirely, or of a very general nature with some of the least important crosses. One very important cross, the ene involving the widest difference, could not be investigated completely because of the partial sterility of many of the F_2 plants, resulting from the remoteness of the relationship of the parents (*Triticum vulgare* and *T. durum*). In most cases of wide crosses in wheat the F_1 plants are very vigorous and productive, but the F_2 plants show various degrees of sterility. Consequently, in this case, not enough viable seed could be obtained from many F_2 plants to raise sufficiently large F_3 families.

The only contribution to the literature of the subject since the previous article (2) was written, has been made by Caporn, (1) who worked with oats. He crossed a single pair of parental varieties whose ripening times did not overlap. Unfortunately, the F_2 data are not available, but the F_3 families were for the most part intermediate and showed greater variation than either parent. Many families were distinctly earlier than others. The parental types were not recovered.

TABLE III

LENGTH OF GROWING PERIOD IN F_3 A x B

Family	Parent Plant F_2 in 1917	Number of Days from Planting to Ripening, 1918												
		127	128	129	130	131	132	133	134	135	136	137	138	139
A				....	....	....	....	....	....	....				
B									....	....	....	....	....	....
1	95	4	4	4	3	10	8	3	1					
2	95		1		2	10	9	6	8	2				
3	99		1	1	2	1	7	4	9	1				
4	98		1	1		1	2	3	14	2	2			
5	96		1	2	1	1		2	4	18	3			
6	96			2	4	1	10	1	2	1	2			
7	97			3	5	2	3	2	1	3	3			
8	96			3			2	1	11	1	1			
9	98			2	5	3	4	1	2	4	3	1		
10	99			2	1	1	4	2	3		2	2	1	
11	96				3	2		5	5	9	2			
12	96				4	1	1	11	6	11	1			
13	97				1		5	2	3			6	2	1
14	102				2		1	2	4	3	4	2	3	3
15	100				4	9	3	5	5	1	2			
16	99				1	1	4		3	18	1			
17	94					4	2	16	6	5	1			
18	93					2	3	17	9	4				
19	95					1	2	1	7	8	5			

20	100					2	2	7	9	1	1	3		
21	99						3	2	10	5	3			
22	100						2	3	2	12	1			
23	101						1		6	3	11	1		
24	102						1	3	4	7	6	1		
25	103						4	3	2	8	15	8	2	3
26	101							3	1	2	6	7	4	1
27	101							5	3	20	9	3		
28	104							2	2	21	4	2		
29	106							1	2	16	3	1		
30	102								4	1	10	8	3	
31	103								1	23	9	1	2	
32	104								3	12	12	6	1	
33	105								2	2	18	8	2	1
34	106								3	4	15	4	2	2
35	108								.	5	9	4	5	2
36	108									2	10	7	6	1
37	102										1	10	7	4

Caporn suggests that the results indicate a three-factor difference between the parents. But this interpretation is admittedly incapable of proof from the available data.

Table II shows the length of the period from planting to ripening of those varieties for whose crosses in various combinations the F_3 records are somewhat detailed. It will be observed that the length of this period is much greater than in 1917 (compare with Table I). This is largely due to the fact that on account of the cold spring the seeds did not germinate until nearly a month after planting. It will also be observed that the ripening times overlap to a greater extent than in 1917. This is particularly true of the later varieties for the reasons already mentioned.

Table III gives the data obtained on the F_3 plants of the cross between the two earliest parents, together with the range of the pure parental varieties for comparison. The second column gives the length of the growth period of the F_2 parent plant of each family in 1917. The F_2 plants, whose offspring were to be grown, were selected in such a way that there would be a few representatives of each day of the F_2 variation. This column should be compared with Table I. For convenience in comparison, the families are arbitrarily arranged in the order in which their earliest plants ripened. As will be explained more fully below, this does not mean that the order is a genetic one.

In connection with this table, the following points should be noted. Some of them are much better illustrated in later tables, but it is desirable to note the uniformity in all crosses.

1. One family (No. 1) began to ripen before the earlier parent, and all its members were ripe before the later individuals of this parent. The difference is not very great and may not be due to hereditary causes, but as a very large number of individuals of the parental variety were recorded in order to determine the extremes of variation, it seems probable that there is a true hereditary basis for the difference. In the same way a few families began to ripen after the later parent. In these late families the range of variation was less than that of the parent, partly because not nearly so many individuals were grown, and partly because the rust attack pushed forward some individuals.

2. In several families the range of variation in the ripening time nearly coincides with that of the earlier parent, and in several other families it nearly coincides with that of the late parent.

3. Many families are intermediate between the parents. Apparently, all possible degrees of earliness are shown in different families. To what extent this appearance is produced by environ-

ment will be discussed later. It must be remembered, moreover, that the proportion of families given in the table for any particular range of variation does not represent the real facts because only a small fraction of the total possible number of families were actually grown. In F_2 the great majority of individuals were intermediate, but those chosen to be carried on to F_3 were selected in nearly equal numbers from each day of the ripening time of F_2. Consequently, the great mass of intermediate F_2 individuals were not chosen. The immense amount of work precluded the study of more families and it was considered desirable to study representatives from the whole range of variation. The small proportion of F_3 families grown and the disproportionate representation of the extreme families precludes the drawing of theoretical inferences from the proportions of early, late and intermediate families.

4. The degree of earliness of a family corresponds in general with that of its F_2 parent. Of course, environmental influences made some F_2 plants earlier or later than they should have been with the result that the order of the families is not exactly the same as that of the F_2 parents. For example though No. 15 was slightly earlier than No. 17, the F_2 parent of No. 15 was recorded as later than that of No. 17. Moreover, as pointed out more fully in (5) below, the arbitrary method of arranging the families in the order of their earliest plants, does violence to a true genetic order. Nevertheless, the general agreement is apparent.

5. There is a considerable difference in the variability of different families. For example, in No. 14 the range of variation extends almost from the earliest date of the early parent to the latest date of the later parent, while in other cases the range is no greater than in either parent. In some cases, particularly among the later families, the variability is less than in the parents, but this is probably due to the smaller number of individuals recorded or to the rust attack. This difference in variability in different families is evidently due to differences in the genetic constitution of the F_2 parents. Following the usual interpretation the great variability of certain families would be due to Mendelian segregation. If only a small number of factors are concerned, all the intermediate families should show the segregation. Therefore, the occurrence of several intermediate families with a small variability demands the assumption of several factor differences. The small proportion of families to the total F_2 population precludes theoretical deductions from the relative numbers of families showing great and small variability.

TABLE IV

LENGTH OF GROWING SEASON IN F_3 A x D

	Parent Plant F_2 in 1917	Number of days from planting to ripening																						
		128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150
A			.....	.....	.....	.....	.....	.....	.....															
D																.....	.....	.....	.....	.....				
1	93	1			1	2	3	3		2	3	3												
2	96	1	6	1	6	8	4			2														
3	96	1		2	2	3		7	15	14		2												
4	97	3		5	3	3	8		2															
5	97	2	5	5	4	14	2		5	2			1		3	1								
6	98	3			1	1		7	1	2														
7	99	2		8	1	2	4		14	5		2	4											
8	98	1	3	5		1		5	15	2	1	5	1											
9	98		2		2		1	5	4	7	7	11			3	3								
10	99		5		9		8	2		2	2	1	1			1	3	2						
11	95			1	1		4	1	2	4	3	5												
12	97			5		4	1		6	14		3	1			1								
13	97			1		1	2	3	24	7		1												
14	97			2		4		1	25	9		3	1			1								
15	98			1	1	3	2	4	20	4		2				3								
16	98			1		1	2	4	11	7		1	1		4	3								
17	98			2	3		5	2		1	3	3												
18	99			7	1	5	3	1	8	3		3			1									
19	99			2	7	5	4	9	9	5		2												

20	99			1	2	2		2	13	4														
21	99			1		6	1	3	13	10		3												
22	100			4	1	1	4	5	10	3		4				4								
23	100			1		1	2	6 6	7	4														
24	101			2	4	1	6	2	18	2		1			1	1								
25	101			5	7	5	7	13	8	7	2	2												
26	102			3		3	2	1	10	9		1	1			2	1							
27	103			6	2		1	2	10	4	1	6				2	3							
28	103			3	1	3	3	2	12	6		6	2			5	1							
29	102				1	5	1	5	6	4		14	1		2									
30	98				4		1	3	14	8		2	1		1	3								
31	98				1	18		24	2	5	7	10	6		2		1	1						
32	100				1		1		17	5		6												
33	96					2		9	4	5	2	1												
34	100					3		4	26	6		2	2											
35	101					1	9		5	2	2	2	1			2								
37	102					1		2	12	7		4	4			3								
38	102					1	5	5	9	8		4	1		6									
39	103					2	12	4	12	1		2	2											
40	106					3	2	3	16	2		11			3	3	1							
41	99						2	4	32	22		8			3	5								
42	101						1		4		5	16				6	9	2	2					
43	105						1	2	12			15			7	3	1							
44	107						2	7	3	2	7	4				6	3							
45	103							6	5	8		2	1		4	5								
46	103							1	10	6	4	13			2	6								

TABLE IV—*continued*

	Parent Plant F_2 in 1917	Number of days from planting to ripening																						
		128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150
47	105							2	3			14	1		12	6								
48	109							2	2	1	2	8	1			2	2	2	1					
49	99								1	0	7	12	2											
50	104								5	5		5	4		9	6								
51	107								2	7		8	4		5	7	1							
52	107								1	5	7	5			14	12	1							
53	102									1	2	3	2		2	2	1							
54	104									4		14			7		1	1						
55	104									3	10	13				14	2	4						
56	105									1		17			5	1	1	1						
57	105									2		16			14	12	26	8						
58	106									1		19			10	9								
59	106									3		19			2	3								
60	108										4	10	8		16	3								
61	107											1			6	2	2	1	1					
62	110											7			3	2	18	7	1					
63	108															1	15	14	4	1				
64	109															6	12	5	2					
65	111															2	25	6	4	1				

*Many of the irregularities and blank spaces in this table mean that it was found to be impossible to take records every day.

It should be pointed out that this difference in variability would make the order of the families arranged according to the date on which their first members ripened, differ from the order of the F_2 parent, quite apart from the environmental influences mentioned in 4, above.

6. In certain families there is a heaping up of individuals at a particular point in the range of variation (e.g. Nos. 4, 5, 16). Following the usual interpretation this would be taken to indicate dominance along with segregation. In view of the fact, however, that there was no indication of dominance in F_2 and in many families of F_3, this interpretation is open to question.

Table IV presents in a similar way the data on the F_3 of the cross A x D (first and fourth families with respect to earliness). Many of the blanks in this table are due to the physical impossibility of taking records on all the families every day. On the 140th day, for example, no records at all were taken on this cross. In certain cases when a day was missed, an attempt was made the next day to date the over-ripe plants back, but this proved unsatisfactory and was abandoned after a time.

The points to which special attention was directed in connection with the previous table are all well illustrated here, and this constitutes a special point to be emphasized, namely, that though the difference between the two parents is so much greater the results are very similar. Certain of the points are more clearly evident in this table.

The chief difference is that which is to be expected—the greater variability of the individual families. Compare Nos. 4, 10, 31, 34, 39. The disturbance to the natural genetic order of the families through disregarding this variability and using only the date of the first ripening plant is seen well by comparing Nos. 48 and 49. The F_2 plants which ripen on a given day particularly the intermediate ones, therefore have considerable genetic differences. In part, this is due to the pushing of plants out of their proper class by environmental influences, and in part represents the production of phenotypically similar results by genotypically different constitutions. The differences in the constitutions reveal themselves in the next generation by differences in variability.

Though the gap between the means of the parents is much greater, all possible intermediate conditions are represented and only a small proportion of the F_2 intermediates furnished seed for F_3.

It is unfortunate that no reliable data were obtained for the third generation of a cross involving greater parental difference. Such a cross was carried to the second generation with results similar to those in the other cases, but so large a proportion of the F_2 plants

TABLE V

LENGTH OF GROWING SEASON in F_3 B x E

Number	Parental Plant: F_2 in 1917	Number of days from planting to ripening																		
		130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148
B						.....	.....	.....	.....	.....	.....									
E																.....	.....	.....	.....	.....
1	101	3	3	6	8	5	8	5	1											
2	103	1		1	2	4	12	8	5	1										
3	103		1	4	12	3	2	4	3	1										
4	102		1	6			17	8	4											
5	102				1	9	9	9	8	2										
6	102				3	3	15	13	4											
7	103				3	7	13	10	5	3										
8	104				1	7	9	6	5	1										
9	105				1	4	7	5	9	5										
10	104				1	2	7	7	10			1	1							
11	102					5	7	11	5			2	1	4						
12	104					1	3	4	5	1		4	2	3	2	1				
13	105					1	9	7	9	4										
14	106					2	17	4	9	4										
15	106					2	4	6	10	3	22	11								
16	108					3	5	5	9	4	6	5	3							
17	109					2	6	6	5	2		7		3	2					
18	113					1	2	6	5			11		5	3	1	1			
19	105						3	6	7	3		3								

20	106						2	4	4		4	2			2					
21	108								4			5		4	8	10	1			
22	108								4	1	1	3	1	4	3					
23	111								2	1			1	13	11	7	2	1		
24	110									2	1	2			20	5				
25	110									1		5			20	6	3			
26	115									1		9	3	3	8	3	1			
27	116									1	3	9	2	4	11	7				
28	113										1	2	1	16	27	1				
29	115											3			25	2				
30	115											1			19	4	2			
31	116											1	1		23					
32	117													1	25	2	1			
33	112														2	20	3	1		

proved partially sterile that the records would not have been sufficiently comprehensive to justify the labour. Many small families were raised, however, and general observations made on them. The results appeared to be very similar to those already described. Some families appeared to be as early as the early parent, and some as late as the late parent, but most were quite obviously intermediate with various degrees of earliness. For theoretical purposes, therefore, it seems safe to extend the conclusions to this cross.

The results of another cross involving very different parents (B and E) are given in Table V. The difference between the parents this year was not nearly so great as is usually the case. The similarity to Tables III and IV is obvious. In this case there seems to be little doubt that some of the earlier families of the third generation are genetically earlier than the early parent. It may be mentioned that from a cross between this same variety E and another variety which ripens at about the same time, families were raised which ripened much earlier than either parent. Detailed records, however, are not available. It appears that the variety E, even though very late itself, makes a contribution for earliness which is lacking in the other varieties. In the cross B x E, no families later than the late parent were found, but whether this is due to the small number of late F_2 plants chosen cannot be definitely stated.

For economic reasons a larger number of families of the cross A x C than of any other were grown and studied. But as the results are very similar to those already described and as the cross involves neither very small nor very wide parental difference, the data are not given in extended form but are condensed in table VI. The position of most of the families on the left of the table is due partly to environmental influences, partly to the method of recording them by their earliest plants, and partly to the fact that the great majority of the plants chosen are, for economic reasons, within the range of the early parent or intermediate (see columns 2 and 3). It is possible that some of the families are genetically earlier than the early parent but this cannot be stated positively from the results of one year's work.

I also have records on several other crosses between parents at different places on the whole scale of variation. In one case the difference between the parental means is as small as three days. But as the results are very similar to those just described, it has not been thought necessary to include them. The results for all the crosses are remarkably uniform, including families whose ranges of variation occupies various portions of the whole range of parental variation and occasional families extending a little beyond one extreme or the other.

Last year the cross A x E had not been carried to the second generation. It was hoped that on account of the very wide difference between the parents, this cross would furnish important evidence in regard to the theoretical interpretation of the results as a whole. During the past summer, the F_2 plants were raised, and the results are given in Table VII. On account of the influences mentioned the difference between the parents this year is much reduced. Consequently, the results are not as valuable as had been hoped. Nevertheless, they are exactly the same as were found in all the crosses involving smaller differences. In all probability if the difference had been as great as in 1917, the results would still have been the same—a variability extending nearly from the lower extreme of A to the higher extreme of E.

The second hybrid generation of several other crosses were also raised. We now have the results of crosses involving differences as small as three days and as big as 22 days, and various sizes between. Furthermore, the crosses involving small differences were made between parents at various places in the whole range of variability.

In regard to the length of the period from planting to flowering (heading) records were taken on all the crosses mentioned. In a few cases the records were assembled in tables similar to those which accompany this paper, but as no marked differences from the results in connection with ripening were found, this work was not carried further.

In discussing (2) the results of the investigation up to and including the F_2, it was pointed out that, assuming the multiple-factor hypothesis of blending inheritance to be correct, each successive pair of parental varieties must differ by a certain minimum number of factors. Summing up the factor differences between the individual pairs we get the number of factors by which the latest differs from the earliest. The number of these factors will determine the relative amount of F_2 variation in a direct cross between the earliest and latest. The greater the number of factors, the less the probability of recovering the parental types in F_2. For example, where the differences between the parents involve 6 factors, the smallest number of F_2 plants which must be raised in order to secure the parent type will be 4096 (Mendel's 4^n where N equals 6); for 7 factors, 16,384; for 8 factors, 65,536. It was concluded that the actual recovery of what appeared to be parental types among a small number of F_2 plants from direct crosses of earliest and latest, limited the factors to a number less than the sum obtained by adding up intermediate differences.

TABLE VI.

F_3 A x C

Growing Period of F_2 parent in 1917	Variety A in 1917	C in 1917	Total No. F_3 families reared 1918	Number of Families with First Plant Ripe on given date in 1918.																	
				126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143
92	—																				
93	—		1		1																
94	—		4				1	3													
95	—		9		1	2	1	5													
96	—		7		1	2	3	1													
97	—		7			1		5		1											
98	—		9		1		1	3	1	2		1									
99	—		9						4	2	2	1									
100			8					1		1	3	2	1								
101			7						1	1	3	1		1							
102			5								1	3	1								
103			7								1	1	2	2	1						
104		—	7								1	4		1	1						
105		—	6								1		2	3							
106		—	2									1	1								
107		—	1												1						
108		—																			
109		—																			
110		—																			
A, 1918							.....	.....	.....	.....	.....	.....	.....								
C, 1918																.....	.....	.....	.....	.....	.....

TABLE VII

A x E

Variety	Number of Days from Planting to Ripening																			
	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148
A	.....	.....	.....	.....	.....	.....	.....													
E																	.....	.....	.....	.....
F_2 A × E			.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....		

The F_3 results reported in the present paper have revealed the genetic constitution with respect to earliness of many of the F_2 plants. They have shown that in every case, no matter how wide the parental difference hybrids have been obtained which are apparently at all grades between the parents. That the spread of the families in this way is not entirely due to environmental influences even in the crosses involving only a small difference is indicated by the general agreement between the F_2 plants and their F_3 families in the order of their arrangement according to earliness. As one looks over a plot containing a large number of third generation families, one cannot fail to notice the marked differences between the different families and the fact that the means of the different families apparently occupy all possible positions between the parental means. There appears to be no grouping of the families at any particular centres as in cases of simple segregation. Of course it may be that there are several centres separated by slight distances about which the families group themselves, and that these centres are obscured by environmental influences. But the general agreement, already referred to, between the order of the F_2 plants and F_3 families would argue to the contrary.

If we assume that the multiple-factor hypothesis of blending inheritance is correct, it is obviously extremely difficult to state what are the exact factorial conditions involved. The uniform distribution of the families—the lack of grouping—supplies no basis for interpretation. Only a small proportion of the F_2 plants could possibly be carried on; therefore the proportion of the total possible families which fall at any particular point (for example, along with one parent) or which show great variability (indicating heterozygosity in the F_2) cannot be determined. Apparently, the only conclusion possible on the multiple-factor basis is that even slightly different parental varieties differ by several factors. Segregation will then produce races whose genetic differences are so slight as to be obscured by environmental influences.

If this interpretation is put upon the results, then the sum of the differences between the successive pairs of varieties must be great. The number of factors by which the members of each successive pair differ must be considerable because if only one or two, then the parental types should be recovered among four or sixteen F_2 plants respectively, whereas really, the great majority of F_2 plants are intermediate. Moreover, all the F_2 intermediates should give a very variable F_3, including the parental types, though it must be admitted that the numbers are rather small to reveal the whole range of variation.

If the sum of the number of factors which distinguish the successive pairs of parents is great, then the parental types in a cross involving wide difference, should be recovered only among an extremely large number of plants in F_2. And yet the F_3 results show that the parental types were recovered among very few. The mathematical considerations have been dealt with in the previous paper and need not be repeated here.

From the practical point of view the chief conclusion is that by crossing an early with a later type races can be established from a reasonable number of F_2 plants, whose means will occupy any position from that of the early parent to that of the later. The great majority of races will occupy some intermediate position. Consequently, if it is desired to combine earliness in as great a degree as it is shown in the early parent with several desirable qualities of the later parent, it will be necessary to grow a very large number of F_2 plants. But if it is sufficient to combine an intermediate degree of earliness with characteristics of the late parent, the task is comparatively easy. When certain varieties are used in crossing it is apparently possible to secure races earlier than either parent.

Summary

1. Records are given in this paper of the length of time from planting to ripening in many families of the third generation of several crosses between wheat varieties which differed by various degrees in regard to the character in question. The second generation results had been reported previously.

2. In all cases families were obtained which correspond with the parental types. In some cases families were obtained earlier than the early parent. But most of the families were intermediate and all possible intermediate positions were occupied. To what extent this fact is due to environment is discussed. There was no evidence of special groupings of families around certain centres.

3. There was considerable difference in the variability of different families and in the distribution of individuals within a family. Many intermediate families showed no greater variability than the parental types.

4. It is impossible from the data to draw conclusions based on the proportion of very variable families or the proportion of families which occupy a given position (e.g. with one parent).

5. The difficulty in applying the multiple-factor hypothesis of blending to the results as a whole is brought out.

6. It is possible to establish races which combine the earliness of certain inferior varieties of wheat with the good qualities of standard varieties.

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Growth Rate in the Pacific Salmon

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(Read May Meeting, 1919.)

It is becoming more evident each year that the salmon question on the Pacific coast, instead of being a single, comparatively simple question, is a large series of problems more or less closely related, since not only is it not safe to infer that what is true of one species is true of any other species, but further it is not safe to infer that what is true of one species, spawning in one river-system, is true of the same species spawning in a different river-system. It follows, therefore, that there is a separate problem for each species in each spawning area along the coast. Fortunately, many of these problems are closely related so that, when certain facts are brought to light in one case, inferences may be verified in other instances with comparative ease if suitable material can be obtained.

Since it has been definitely established that scale and otolith reading, within certain limits, can be depended upon in age determination and rate of growth calculation, it is now possible to fill in many of the gaps in life-history that of necessity were left, in all accounts where direct observation was the only basis on which conclusions could be drawn, not that direct observation is now any the less important, because it is even more useful when the information obtained by scale and otolith study is available to connect up the scattered data thus obtained to make a complete life-history of the species in question.

In previous papers the two methods have been combined in the study of the spring salmon and the coho. During the season of 1916 advantage was taken of the opportunity to get material and data of the whole five species of Pacific salmon, and this paper embodies some of the results obtained by the examination of this material. In the case of three species, the sockeye, the humpback and dog, material was obtained from different location and hence a comparison was possible. In the case of the spring and the coho this was not so, but here it was possible to compare with material of these species from the same locality in the preceding year. The sockeye were obtained from the Fraser river and from Rivers inlet, the spring and coho from the strait of Georgia, the humpbacks from Rivers inlet, and from the strait of Georgia near Comox, and the dog from the mouth of the Little Qualicum river and from near Nanaimo. For the opportunity to obtain this material I am much indebted to the managers of Wadham's cannery, on Rivers inlet, and of the Nanaimo cannery, as well as to the various employees who so willingly gave all the necessary assistance.

To avoid falling into the error of drawing general conclusions from too few specimens, a large number of each species was examined, about 9,000 in all, and in each case the age was determined and the growth rate calculated. This gave a good basis for taking averages.

The scales of the Pacific salmon are much more satisfactory for examination than the otoliths. The otoliths are dense and do not show up the growth areas readily without considerable clearing up. The scales are much more easily obtained and possibly in no species are the growth areas more distinct or more easily read after one becomes familiar with the commoner types. Since the ridge lines, like the growth of the scale, are concentric, the winter check does not cross them, as it does in the herring for instance, and there are no radii present. As few specimens in any of the species reach a greater age than five years, the outer winter checks are not close enough together to cause any special bother as they often do when the fish gets to a greater age. The scales are relatively thin, and hence sufficiently transparent to be examined readily with transmitted light or to be photographed. The winter checks are quite definite so that calculation of growth-rate can easily be made. Since in this genus, therefore, the scales are so much more suitable than the otoliths, it is not desirable to use the latter except as a corroboration of what the scales indicate. Little use has been made of them in the work for this paper.

In collecting scales, several are scraped from the fish and placed in a pence envelope, where they can be kept indefinitely without danger of confusion. On the envelope is recorded the species, locality, sex, weight, length and the date. As the scales in each envelope are examined, the envelope is numbered in order that it may be easily picked out if necessary for future reference. When the scales are required for microscopic examination, they can be softened almost immediately in fresh water and left there in a watch glass for examination, after which they may be returned to the envelope. If the scales are to be photographed they can be permanently mounted as follows: When the scales are in the water, the skin can readily be taken off by rubbing between the thumb and finger. When perfectly cleaned a scale is placed on a clean glass slide, and a cover glass is placed over, no mounting medium being used. The cover should be clamped tightly over the scale by a clamp (a spring clothes peg suits the purpose very well) so that the scale will be pressed flat and let stand for 24 hours, so that the scale becomes set thus, after which the cover may be fastened permanently with a small strip of lantern slide binding on each side. This keeps the slide flat and keeps out the dust.

As the method of age determination was the same as that commonly used when the ridges on the scale are more or less concentric, as they are in the salmon, and as it has been considered in other papers and described in many instances, it is not necessary to treat it further here, but as the method of growth calculation used differs in some respects from those that have been described, it may be worth while to give a description of the method.

As in the case of scales previously reported upon, the increase in length of the fish after the nucleus of the scale was formed until the fish was caught has been divided in the same proportion as the radius of the scale is divided by the points where the winter checks give way to the more rapid growth of spring. To get this increase, the total length of the fish (the length as here considered does not include the caudal fin rays) is diminished by the length of the fry when the first ring appeared around the nucleus. The latter length varies slightly in different fish of the same species but as it is evidently impossible to get that length for each individual, an average of several were taken and no individual varies greatly from the average.

The method of measuring and calculating growth rate described by Lea[1] has been extensively used, but I have not found it possible to work it rapidly with any reasonable degree of accuracy, hence, another method, which has given better satisfaction, has been adopted.

Using a pad of paper, a straight line is drawn near and parallel to the left hand margin, from top to bottom. By means of the camera lucida, a portion of this line is made to coincide in position with the long radius of the image of the scale. The points where the innermost ring, the outer limit of each of the winter checks and the margin of the scale, meet the radius, are marked on the line. From the first of these points as a point of origin, a straight line is drawn, making any acute angle with the line on the paper. From the same point, using any scale desired (half a millimeter to the inch has generally been used), a length corresponding to the growth in length of the fish during the life of the scale, is measured. Using a parallel rule, the measured part of the oblique line is divided in the same proportions as the portion of the vertical line that corresponds to the radius of the scale. The growth in each year is then read off according to scale. A diagram will show how the parallel rule is used.

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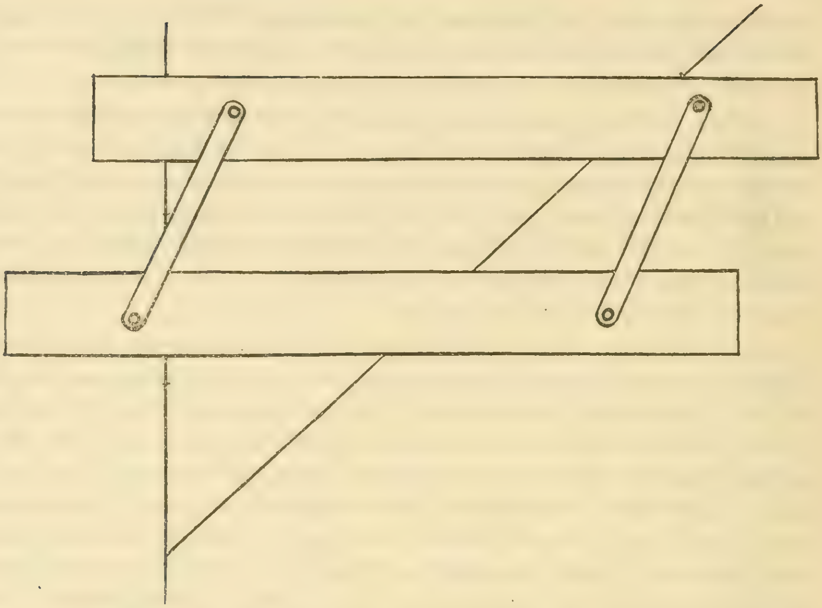
[1] Publications de Circonstance, No. 53, 1910, p. 37.



By this method the calculation can be made as accurate as it is possible to divide the scale radius, and it should be possible to use it with at least as great dispatch as Lea's method. As the same line, not the same portion of it, may be used for several scales in succession, the amount of preparation is practically nil.

Little attention has been paid to the number of rings in any year's growth as it has been observed in these species of salmon, as Miss Esdaile, Dahl and others have shown to be true in the Atlantic salmon and others have shown for other species, that the number of rings in any year's growth may vary greatly, even in different scales of the same fish, so much so that one scale may have more than twice as many rings as another from the same fish, in the same year's growth.

Occasionally expression is still given to a doubt that the Pacific salmon of the genus *Oncorhynchus* die soon after the first spawning, although no direct evidence, with the exception of the appearance of an alleged spawning-mark in some instances, that any of them ever spawn a second time. Milne claims to have found a spawning mark in a spring salmon scale[1]. Yet in his paper he gives (fig. 107) a figure of a sockeye scale, concerning which he says (p. 593): "its interest is in showing, from the worn condition of its edge, that if a sockeye ever

[1] Milne, J. A., History of the Pacific Salmon, Proc. Zool. Soc., London, 1913, pp. 572–610.

returned to the sea and was caught again, a clear spawning mark should be apparent on the scales." In scales of over 9,000 salmon, 1500 of them sockeye, I have seen no such lack of conformity as would be shown by new growth appearing around the margin of the scale that he figures, and yet as far as disintegration goes, this scale is good as compared with many others that could readily be obtained. The very absence of such strongly indicated spawning mark is one of the most convincing pieces of evidence that these fish do not spawn a second time. It is quite true that because no such spawning mark has ever been found, it does not follow that none has ever existed and consequently, all that can be said is that while it has not been proved that all Pacific salmon die soon after spawning once, neither has it been proved that any have long survived under ordinary conditions. Certainly the great majority die, and the evidence so far obtained all points to the conclusion that all of them do.

On the other hand, there is the case of the sockeye reared in fresh water, recently reported,[1] in which specimens became perfectly mended after spawning.

There is not so much difference between the habits and life-history of the Atlantic and the Pacific salmon as we have been led to believe, since the work of later investigators, such as Hutton, Calderwood and others, has shown that but a small percentage of the Atlantic salmon return a second time to spawn. The work done on the Atlantic salmon helps a great deal to solve some of the Pacific salmon riddles.

Is annual spawning the primitive characteristic, from which condition the Atlantic salmon has reached a situation where normally the great majority die after the first spawning, and the Pacific salmon, a situation where they all normally do, but where under certain conditions, such as continuous life in fresh water, they may revert more or less to the primitive type?

The five species of the genus *Oncorhynchus* are:

O. tschawytscha.—Spring, king, quinnat, chinook, tyee, Columbia river salmon, Sacramento salmon, with spring-jack, grilse and sea-trout, used as names for the immature forms.

O. nerka.—Sockeye, red salmon, redfish, blueback, Quinault.

O. kisutch.—Coho, silver salmon, silverside, medium red, with blueback and grilse for immature forms.

O. gorbuscha.—Humpback, pink salmon.

O. keta.—Dog, keta, chum.

[1]Rearing Sockeye salmon in fresh water. Cont. Can. Biol for 1917, 1918, pp. 105-109.

In this paper the names, spring, sockeye, coho, humpback and dog will be used throughout.

Before going on to the consideration of the individual species, it might be well to give a rapid review of some of the literature bearing on the work.

Review of Literature

Ever since Steller, in 1791, and Walbaum, in 1792, distinguished the five species of Pacific salmon, much interest has been taken in the genus and many articles have been written about one or all of the species. In 1894, T. H. Bean published a bibliography in Bulletin XII of the United States Fish Commission, in which reference is made to all of the papers available that were published before the end of 1892. Apart from the diagnostic features, the run to the spawning ground and some observations on spawning, these papers contain little concerning the life-history of any of the species. Bean includes practically all this information, at least in so far as it affects the Alaska fisheries in his salmon papers of 1891 and 1894.

A more detailed study of life-history, with more definite and more extended observation began with the work of Evermann and his associates in Idaho, and later at other points in the Columbia river system, from 1894 to 1896. The work was largely confined to the chinook, the sockeye or redfish and the little redfish or Kennerly's salmon. Here for the first time convincing evidence was obtained as to the death of these salmon soon after spawning. It was shown that most of the fish obtained almost all of their wounds on the spawning ground. In 1897, Stone added some data on the time and nature of the spawning of the quinnat. In 1899 and 1902, Moser gave extensive reports on the nature of salmon runs in Alaska. In 1900, Rathbun, after acting on the International Commission, gave a lengthy review of the fisheries in the contiguous waters of the State of Washington and British Columbia, in which he dealt at length on the habits of the five species of salmon. He gave more information as to the supposed salt-water life of these fish than had been given previously, but as all the information was hearsay, it had not the same value as if it had been from personal observation. Rutter's contribution to the natural history of the quinnat salmon in 1904, based on observations made on the Sacramento river, added much to the information available for this species. The work on migration was especially valuable. The spawning habits and the habits, food, etc., of the fry were carefully observed.

In 1911, Cobb, in his paper on "Salmon Industries of the Pacific Coast," gave a comprehensive statement of the life-history of the five species as far as it had been worked out and supplied a great fund of statistical and commercial information. A new edition, brought up to date in 1917, is invaluable for reference on almost every matter in connection with the salmon industries.

Greene, in several papers from 1911 to 1914, gives much information on the anatomy and physiology of the chinook salmon, but possibly his most important single contribution, as far as life-history work is concerned, was that showing that the chinook may stay near the meeting place of the salt and fresh water for as much as 30 or 40 days, going backward and forward in the meantime.

In 1907, Evermann and Goldsborough gave further information as to salmon runs in Alaska, with which was coupled a good bibliography. In the same year Chamberlain published "Some Observations on Salmon and Trout in Alaska," a paper of much importance, since in it he went into a detailed description of the five species of salmon, traced migratory movements and took into account the size and appearance of these fish at various times in fresh and in salt water. He concluded that there was a greater tendency for the young fish to remain over in fresh water for a year or more in large streams than in small. A large number of spring, sockeye and coho remain over for at least a year, but humpbacks and dogs pass out to the sea shortly after hatching. Sockeye do not show the same rate of growth in different river systems nor the same amount of growth in different years.

McMurrich, in 1909, gave an account of the life-history of the five species, making the first mention of making use of otoliths in age determination of these species. This was followed by another paper in 1912, in which the first attempt at age determination by means of the scales in these salmon was attempted. In the next year Milne did some work along this same line and found what he supposed to be a spawning mark on the scale of a spring salmon. In the same year Gilbert published a paper on age determination, in which, as he examined a great number of specimens, he went much more fully into the different types. He demonstrated the difference in the nature of the scale of a fish that migrated as fry (sea-run) and of that of one that remained in fresh water for a year or more (stream-run). In his later papers he has dealt with sockeye and in them has done much to show that each river system has its own characteristic fish, and hence, that all Pacific salmon tend to return to the spawning grounds from which they began to migrate.

In 1915 and 1917, the writer showed that the record obtained by age determination and growth calculation from the scales in the case of the spring and coho was corroborated from direct observation of the habits and life-history and gave evidence to show that the periodical check in the growth of the scale takes place during the winter season. Another paper gives an account of some sockeye reared in fresh water, that apparently mended perfectly after spawning.

The Annual Reports from the Departments of Fisheries in Canada, the United States, British Columbia and the Pacific coast states, contain much useful information on life-history as well as that on the statistical, commercial or industrial side.

Although much use has been made of the work that has been done on the Atlantic salmon, no attempt will be made to review the literature, although it is not out of place to mention the work of Calderwood, Menzies and Johnston, in connection with the work of the Fisheries Board for Scotland, Masterman in connection with the English Board of Agriculture and Fisheries, Hutton for his work on the Wye salmon and Dahl for his work on the salmon of Norway.

As Taylor has so recently reviewed the literature on scale reading in his paper on "The Structure and Growth of the Scales of the Squeteague and the Pigfish as Indicative of Life-History," there is no necessity of doing so here.

Graph 1.—Spring—sea type. 1st year growth.

SPRING SALMON

In 1916, scales were taken from 1412 spring salmon, but as in the previous year a large proportion of these salmon were immature, since spring salmon of all ages are caught in the waters of the strait of Georgia, hence from this lot no estimate can be made of the relative proportion of those spawning at different ages. The ripe and the unripe fish come into the cannery and no attempt has been made to procure a record of the number of each. Several of the two-year males were mature, but no mature females at that age were noticed. Both males and females were found mature at three years, but the proportion was small. The majority of the four and five year fish were mature. There were no six year fish among the number.

The term "grilse" which in a previous paper was applied to salmon maturing at an early age is in common use for young Pacific salmon whether they are mature or not. Since European ichthyologists now restrict the use of this term to Atlantic salmon that spend two years in fresh water and come back in the fourth year to spawn, it would save confusion if in connection with the Pacific salmon it were discarded entirely as there is no exact parallel in any of the species.

Graph 2.—Spring—sea type. 2nd year growth.

All the fish from which these scales were taken were caught in the strait of Georgia, not far from Nanaimo or in the lower portion of the Fraser river, and probably many of them had never been farther away from the mouths of the rivers down which they migrated than the confines of the strait. Of the 1412 examined, 924 or 65.4% were of the sea type and 488 or 34.6% of the stream type.

Of the 924 sea run fish, 11 (1·2%) were in the 5th year, 257 (27·8%) in the 4th year, 396 (42·9%) in the 3rd year and 260 (28·1%) in the 2nd year. The average length of the 5-year-olds was 34·3 inches, of the 4-year-olds, 29·0, of the 3-year-olds, 24·7, and the 2-year-olds, 18·3. Since these were collected at various times from July 8 to October 19, the earlier fish at least would not have nearly completed the growth for the year. The figures may be put in tabular form thus:

Sea Type

	Total	5 yr.	4 yr.	3 yr.	2 yr.
Number...............	924	11	257	396	260
Percentage............		1·2	27·8	42·9	28·1
Average total length....		34·3	29·0	24·7	18·3

In calculating the growth for each year, the same method was used as in former calculations, 1·5 inches being taken as the average length of the fry when the first ring around the nucleus is formed. From these calculations the following averages were obtained:

Table of Growth

Sea Type

Year Class	No.	Growth During			
		1st yr.	2nd yr.	3rd yr.	4th yr.
2nd	260	11·2			
3rd	396	10·6	9·3		
4th	257	9·8	8·8	6·7	
5th	11	10·0	9·0	7·3	5·5
Average.....		10·5	9·1	6·8	5·5

Year Class	No.	Length at end of			
		1st yr.	2nd yr.	3rd yr.	4th yr.
2nd	260	11·2			
3rd	396	10·6	19·9		
4th	257	9·8	18·6	25·3	
5th	11	10·0	19·0	26·3	31·8
Average.....		10·5	19·4	25·4	31·8

In this table the uncompleted year is not included in any case, as the average could not be compared with the full year's growth in the other year classes. They may be given here to show the difference. The average growth in the incomplete year of the 2nd year class was 7·1, of the 3rd year, 4·8, of the 4th year, 3·7 and of the 5th year 2·5. At the same time they show that the great portion of the growth of the year takes place before July, as was shown in a previous paper.

The growth for any year of life differs but slightly in the different year classes although the fourth year class is rather low throughout. The average taken for a year of life applies to a different number in each year, e.g., in the 1st year the average is taken for the whole 924, for the 2nd year for only 664, the number of the 2nd year class not being included, reductions taking place similarly in the other cases.

Looking at the frequency curves, it will be seen that with the exception of a few of abnormal growth, the range of growth of the first year extends from 8·2 inches to 13·0. The second year growth varies from 7·3 to 11·2, and the length at the end of the second year, from 16·7 to 22·7. The growth in the third year ranges from 5·3 to

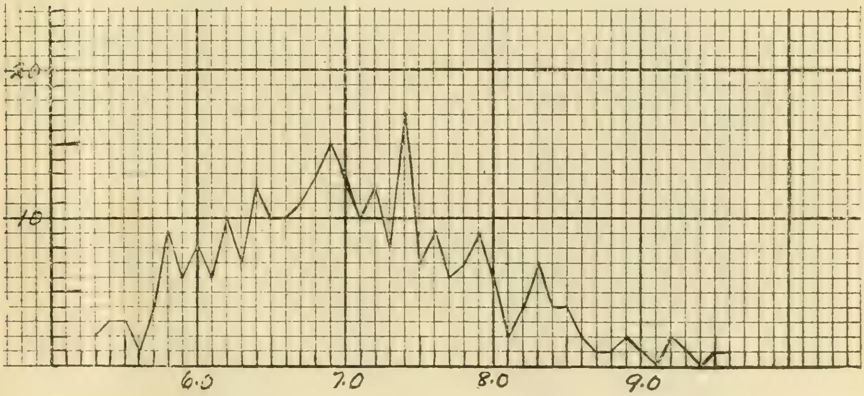


Fig. 3.—Spring—sea type. 3rd year growth.

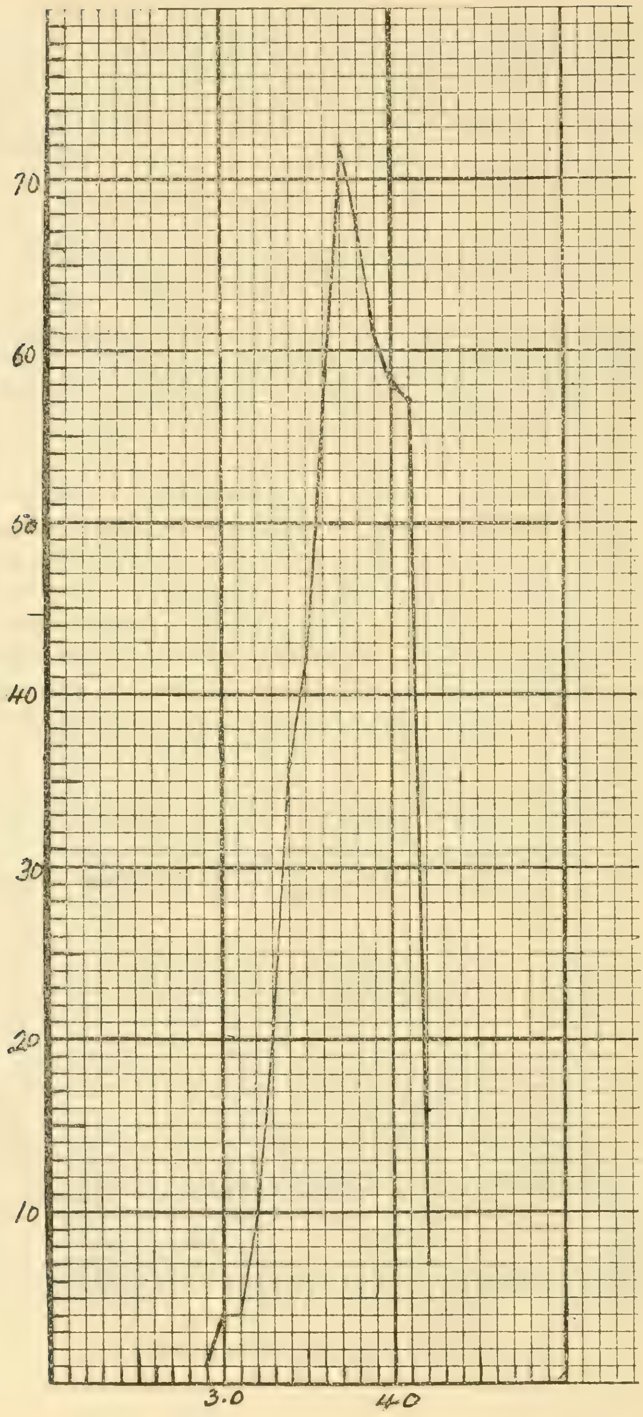


Fig. 4.—Spring—stream type. 1st year growth.

9·3, and the length at the end of the third year from 23·5 to 28·6. The numbers in the fourth year were too small to make a satisfactory curve, and in the fifth year there were only the uncompleted years of 11 fish.

Turning now to the salmon of the stream type, of the 488 examined, 22 were in the 5th year, 83 in the 4th year, 382 in the 3rd year and 1 in the 2nd year. The length of the 2nd year fish was 12·5 inches, the average of the 3rd year, 20·9; that of the 4th year, 27·6 and of the 5th year, 31·5. In tabular form:

STREAM TYPE

	Total	5 yr.	4 yr.	3 yr.	2 yr.
Number...............	488	22	83	382	1
Percentage............		4·5	17·0	78·3	0·2
Average total length....		31·5	27·6	20·9	12·5

From the calculated growth in each year of each fish, the following averages were obtained:

TABLE OF GROWTH

		Growth During			
Year Class	No.	1st yr.	2nd yr.	3rd yr.	4th yr.
2nd	1	3·8			
3rd	382	3·7	11·0		
4th	83	3·8	10·8	8·7	
5th	22	3·9	10·5	8·0	5·9
Averages....		3·7	10·9	8·5	5·9

		Growth at end of			
Year Class	No.	1st yr.	2nd yr.	3rd yr.	4th yr.
2nd	1	3·8			
3rd	382	3·7	14·7		
4th	83	3·8	14·6	23·3	
5th	22	3·9	14·4	22·4	28·3
Average.....		3·7	14·7	23·1	28·3

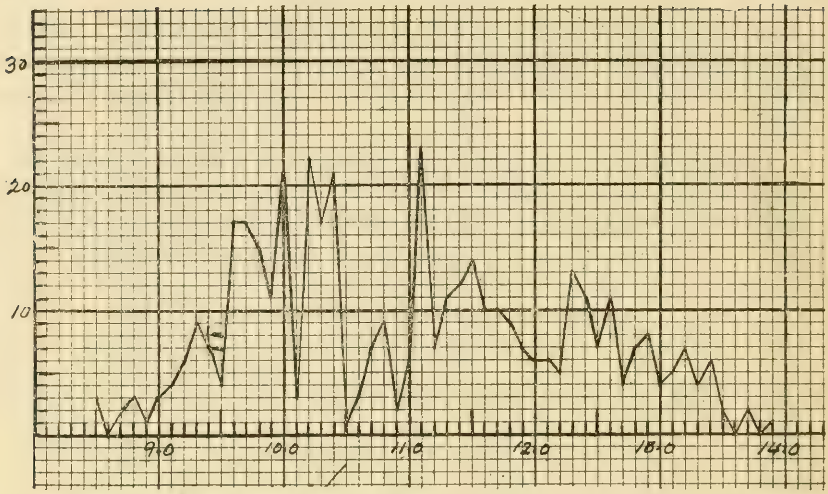


Fig. 5.—Spring—stream type. 2nd year growth.

The average growth in the uncompleted year of the 2-year class was 8·7, of the 3-year class, 6·2, of the 4-year class, 4·3 and of the 5-year class, 3·2. The growth in length for any year of life differs less in the stream run forms than the sea run forms, largely because since the growth in the fresh water is slow there is but little difference in length of those when the growth of the second spring starts, no matter what time of the year they were hatched, and thus having a similar start there is more likely to be more sameness throughout. In the sea run fish, however, since there is a great variation in the time the eggs are hatched there is great variation in length when the first winter begins and hence when the rapid growth starts the second year. Thus, variation is likely to be continued throughout life, although there may be individual cases where a fish, small in the second spring, if it is in good health, may get a better chance to feed well and may become a large specimen of the class by the time it is four or five years old. Similarly, a fish, large when young, may not keep up with the growth rate of its class but may be a small fish when it becomes mature.

The frequency curve shows a range in the first year of the stream type fish from 3·0 to 4·2 inches. The second year growth varies from 8·5 to 13·7 and the length at the end of the second year from 12·3 to 17·2. The numbers for the other years are not sufficiently numerous to give satisfactory graphs.

In both sea-run and stream-run fish the males are slightly in the majority and almost to the same extent, but this is maintained by the much greater number of males among the younger fish caught.

Among 4 and 5-year fish, most of which were mature, the females very distinctly predominate. A table will show the ratios:

SEA TYPE

Year Class	Total	Female	%	Male	%
5th	11	8	72·7	3	27·3
4th	257	161	62·4	96	37·6
3rd	396	197	49·7	199	50·3
2nd	260	87	33·5	173	66·5
All years....	924	453	49·0	471	51·0

STREAM TYPE

Year Class	Total	Female	%	Male	%
5th	22	13	59·1	9	40·9
4th	83	45	54·2	38	45·8
3rd	382	177	46·3	205	53·7
2nd	1	1	100·0	....	....
All years....	488	236	48·4	252	51·6

The data are not suitable for determining the relative growth of male and female fish.

It is interesting to attempt a comparison between these spring salmon and the smaller number examined the previous year, although, as in that number there were several from localities other than the strait of Georgia, differences might reasonably be expected.

In the first point to consider, viz.: the percentages of sea-run and stream-run fish, the parallel is striking. In the 1916 collection there were 924 out of 1412 or 65·4% of the sea type; in the 1915 collection there were 199 out of 306 or 65·0%. This would be worthy of remark even if they were all from the same locality, in the succeeding years. As it is, the conclusion seems justified that the outside localities have much the same proportion of each type as the strait of Georgia unless it be that there are different proportions in the different localities and these balance each other to get a resultant proportion similar to that in the strait, but while that would be possible it would be scarcely probable.

In the fish of the sea type, the first year growth of the 2-year class is higher than in the preceding year and in consequence, since there was quite a large number of these, the whole average is slightly higher, although the growth in the other year classes is slightly lower. The growth in all the other year classes is lower in the 1916 fish. The higher averages in 1915 were at least partly due to the fish from Barkley sound and other outside points as the fish from the open sea, or the approaches from the open sea, are larger than those in the strait of Georgia. An illustration of this will be given later.

The range of length at the end of the first year is much the same in each year and so with the second year, but as the age increases the higher range for the 1915 fish is noticeable as well as the greater range, the lower part of the range being made up of those from the same locality and the higher part from the outside points. In the fish of the stream type, much the same thing holds true. There is similarity of growth in the first and second year growth of the different year classes in the two cases, but in the third and fourth years the averages as well as the range are higher in the 1915 fish.

There is nothing in the present collection to indicate that the four-year fish that spawn are any larger than those belonging to the same year class that remain in the sea for another year, although that seemed to be indicated by the results obtained in the preceding year.

Besides the 1412 spring salmon from the strait of Georgia, a small number was obtained from other sources, and as they agree in showing a more rapid growth than the average of those from the strait of Georgia they may be considered together as the number from any one locality was not great enough to make it worth while considering separately. Of the 20 thus obtained, 7 were from Campbell river, 2 from Rivers inlet and 11 from Claxton on the Skeena river. 11 of these were of the sea type and 9 of the stream type. Of the sea type, 7 were in the 5th year, 3 in the 4th and 1 in the 3rd. Of the stream type, 7 were in the 5th year and 2 in the 3rd. The average length of the sea type 5-year fish was 38·6 inches, of the 4-year fish, 29·2 and the 3-year fish, 25·5. Of the stream type, the 5-year average was 35·9 and the 3-year, 20·8. In the sea type fish the average growth was: first year, 11·0; second year, 10·2; third year, 7·8, fourth year, 5·9 and fifth year, when caught, 2·3. In the stream type: first year, 3·5; second year, 11·7; third year, 9·4; fourth year, 7·9 and the portion of the fifth year, 3·5. In comparing these figures with those from the strait of Georgia it is easy to see that it would not take very many of them to make a noticeably higher average for each year's growth.

Among the scales of some large salmon caught off Prince Rupert, early in 1916, by Mr. E. Webber, were some from a male 41·5 inches long, weighing 42·5 pounds, caught on February 24, that had completed its fifth year. It was of the stream type. The growth was 4·1 inches the first year, 11·1 for the second year, 11·5 for the third year, 9·0 for the fourth year and 5·8 for the fifth year. Except that this was a somewhat larger fish than the Skeena river fish examined, the rate of growth is in much the same proportion except that the third year growth is greater than the second.

SOCKEYE

Of 1916 sockeye, 1502 in which the scales were suitable for examination were obtained. Of these, 613 were procured at Wadham's cannery, Rivers inlet, July 18 to 21, and the remainder from the Fraser river on different days during August.

Dr. Gilbert, in his extensive investigations into the life-history of the sockeye in British Columbia, has discovered characteristic differences between the Fraser river sockeye and those from Rivers inlet. The scales under consideration give evidence of a similar nature, and, since the rate of growth has been calculated for all of these fish, some points of difference are more strongly emphasized. It is not necessary to compare in detail the results here obtained with those recorded in Gilbert's reports. It will be sufficient to make an occasional reference in the statement of these results as they have been deduced.

As the salmon, both in the Fraser river and in Rivers inlet, were caught with drift nets, the samples taken did not necessarily represent the whole run in either case, as there may have been, and probably were, smaller fish that passed through the meshes of the net, and it is not known what percentage of the whole number these were in either case, but as the conditions were similar it seems quite permissible to make a comparison on such a basis.

The first conspicuous difference to be considered is that in the degree of uniformity of the fish from the two systems. The Rivers inlet fish are essentially uniform in type, while the Fraser river fish are much less so. All of those obtained in Rivers inlet were of the stream type that passed to the sea in the second year, and all were in the 4th or 5th year, with the exception of one in the 3rd year, that was brought in by the captain of one of the cannery tenders. Apart from this one, out of the total of 612, 423 were in the 5th year and 189 in the 4th year. In the Fraser river specimens, besides those, the majority, that passed to the sea in the second year, there were others

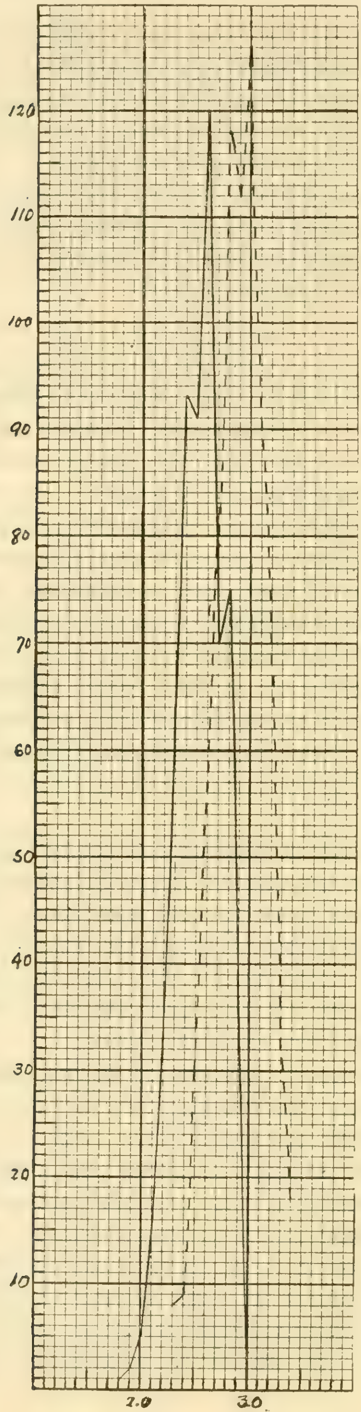


Fig. 6.—Sockeye. 1st year growth.

that passed down in the third year, having spent over two years in fresh water, as well as some of the sea type. Of the total of 889, 59 were of the stream type over two year old when migrating, 741 of the stream type over one year old and 89 of the sea type. Of the 59 belonging to the first of these classes, 3 were in the 6th year and 56 in the 5th year; of the 741 of the second class, 127 were in the 5th year and 614 in the 4th year, and of the 89 of the sea type, 5 were in the 5th year, 77 in the 4th year and 7 in the 3rd year. The comparison may be made more readily when this is put in tabular form.

RIVERS INLET

	Total	5 yr.	4 yr.	3 yr.
Number.........	613	423	189	1
Percentage.......		69·0	30·8	0·2

FRASER RIVER

	Total	Stream Type		Sea Type
		(2 yr.)	(1 yr.)	
Number.........	889	59	741	89
Percentage.......		6·6	83·4	10·0

STREAM TYPE (2 yr.)

	Total	6 yr.	5 yr.	
Number.........	59	3	56	
Percentage.......		5·1	94·9	

STREAM TYPE (1 yr.)

	Total	5 yr.	4 yr.	
Number.........	741	127	614	
Percentage.......		17·1	82·9	

SEA TYPE

	Total	5 yr.	4 yr.	3 yr.
Number.........	89	5	77	7
Percentage.......		5·6	86·5	7·9

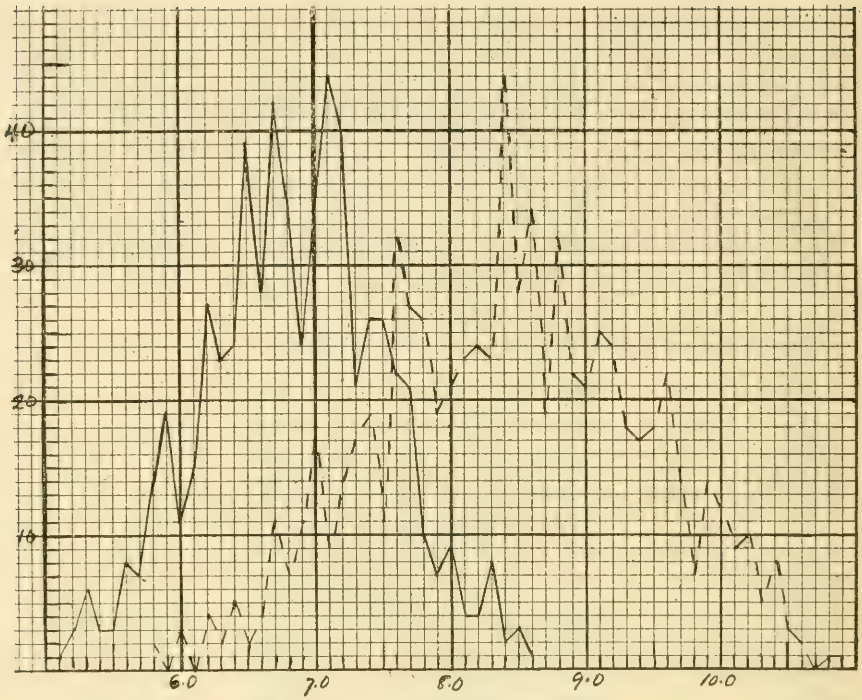


Fig. 7.—Sockeye. 2nd year growth.

The Rivers inlet collection does not call for much comment in this regard. Gilbert has come across specimens of other types besides the one year stream type, but they have been so scarce that they have not materially affected the results. The percentage of 5-year and 4-year fish apparently vary from year to year, but only in 1913, which must have been an unusual year, were the 4-year fish in the majority. The percentages given above are therefore not unusual.

The different types in the Fraser river collection are those that have been found in other years. There is a higher percentage of those of the sea type, but as the percentage is still low and the number is small it does not represent a much greater number of individuals.

The stream type that has spent over one year in fresh water predominates largely but not so exclusively as in Rivers inlet, but in this type the 4-year fish are much in the majority, not the 5-year fish as in Rivers inlet. Of those that spent over two years in fresh water almost all are 5-year fish. These, like the 4-year fish of the one year stream type, have spent two winters and three summers in the sea. Of the fish of the sea type the majority were in the fourth year, but a greater variation is shown than in the other two types, as there were some in the third year as well as in the fifth year. This difference may only be a seeming one as if there were 3-year fish in the stream type they would likely be too small to be caught in the nets.

Of the fish that have been called "grilse," as above indicated, no specimens were obtained. Here, as in the case of the spring salmon, it would avoid confusion if the term were not used.

In the relative number of males and females in the different years Rivers inlet is very distinct from the Fraser river. In the Fraser river fish they were approximately equal in all years where the numbers were large enough for comparison, and the total number of each was similar, but in the Rivers inlet fish the males predominated in the 4-year fish and the females in the 5-year fish, and as the 5-year fish were much in the majority the total number of females was noticeably greater than that of the males.

RIVERS INLET

Year Class	Total No.	Males	%	Females	%
5th	423	157	37·1	266	62·9
4th	189	123	65·1	66	34·9
3rd	1	1	100·0	....	....
All years....	613	281	45·8	332	54·2

FRASER RIVER

Year Class	Total No.	Males	%	Females	%
2 yr. stream					
6th	3	2	66·7	1	33·3
5th	56	27	48·2	29	51·8
1 yr. stream					
5th	127	63	49·6	64	50·4
4th	614	300	48·9	314	51·1
Sea type					
5th	5	3	60·0	2	40·0
4th	77	42	54·5	35	45·5
3rd	7	6	85·7	1	14·3
All years....	889	443	49·8	446	50·2

The percentage of males and females in the 5-year fish at Rivers inlet are exactly the same as Gilbert obtained in 1913 and 1914, but the percentages for the 4-year fish are more nearly the exact reverse of these for the 5-year fish than he has found in any of the years, hence, it is more definitely indicated that the lack of females in the 4-year fish is nearly equalled by the excess in females in the 5th year.

These percentage differences in type and in sex serve to distinguish the Rivers inlet run from the Fraser river run, but they do not help in distinguishing the individual fish, and here the differences are more marked than in the whole run. Gilbert has pointed out that the fresh water growth in the Rivers inlet fish as well as the first year growth in the sea is much less than that of the Fraser river fish, but this is compensated by the growth in the second year at sea. A comparison of the annual growth calculated from the scales makes this distinction much more vivid. Tables of growth during each year and of the length at the end of each year form the best basis for such comparison. In the calculation 1·2 inches is taken as the average length of the fry when the first ring is formed around the nucleus of the scale.

RIVERS INLET—1 YEAR STREAM

Year Class	No.	Growth During					
		1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr.	6th yr.
3rd	1	2·1	5·3	5·6	..	..	..
4th	189	2·5	6·8	9·6	3·3		
5th	423	2·5	6·9	9·5	4·4	1·3	
Average........	613	2·5	6·9	9·5	4·1	1·3	

FRASER RIVER, 2 YR. STREAM

5th	56	2·6	3·2	8·2	6·1	2·4	
6th	3	2·6	3·5	8·2	6·0	3·3	1·1
Average........	59	2·6	3·2	8·2	6·1	2·4	1·1

1 YEAR STREAM

4th	614	2·9	8·6	7·7	3·1		
5th	127	2·9	8·3	7·3	4·1	1·4	
Average........	741	2·9	8·5	7·6	3·2	1·4	

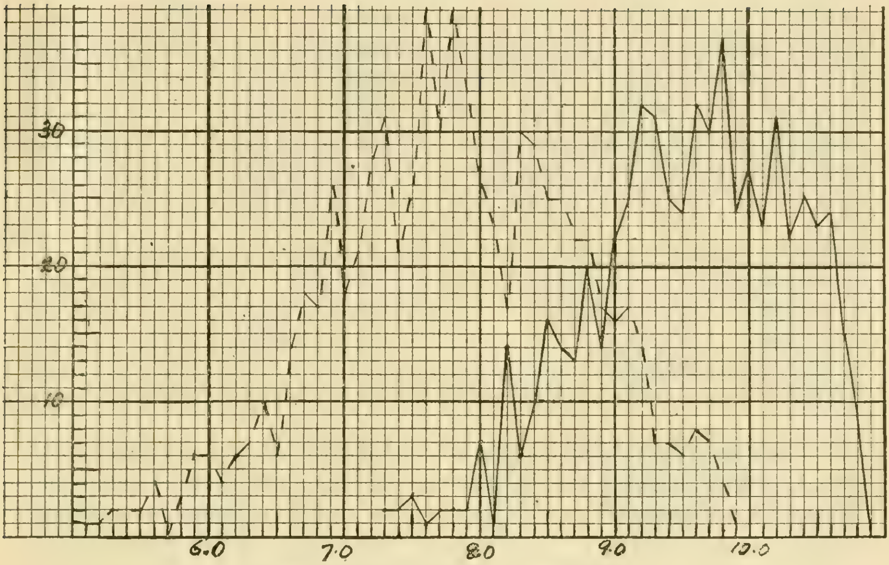


Fig. 8.—Sockeye. 3rd year growth.

SEA

3rd	7	5·8	8·5	5·4			
4th	77	6·5	8·3	6·6	1·8		
5th	5	5·6	7·9	6·3	4·0	1·3	
Average........	89	6·4	8·3	6·5	1·9	1·3	

RIVERS INLET, 1 YEAR STREAM

Year Class	No.	Length at end of					
		1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr.	6th yr.
3rd	1	2·1	7·4	13·0			
4th	189	2·5	9·3	18·9	22·2		
5th	423	2·5	9·4	18·9	23·3	24·6	
Average........	613	2·5	9·4	18·9	23·0	24·6	

FRASER RIVER, 2 YEAR STREAM

5th	56	2·6	5·8	14·0	20·1	22·5	
6th	3	2·6	6·1	14·3	20·3	23·6	24·7
Average........	59	2·6	5·8	14·0	20·1	22·6	24·7

1 Year Stream

4th	614	2·9	11·5	19·2	22·3		
5th	127	2·9	11·2	18·5	22·6	24·0	
Average........	741	2·9	11·4	19·0	22·3	24·0	

Sea

3rd	7	5·8	14·3	19·7			
4th	77	6·5	14·8	21·4	23·2		
5th	5	5·6	13·5	19·8	23·8	25·1	
Average........	89	6·4	14·7	21·2	23·2	25·1	

Taking first the Rivers inlet fish all of which were of the 1-year stream type, the first year's growth varies mainly from 2·0 to 2·9. This range corresponds to the range of the yearlings recorded by Gilbert from this area. The average, 2·5 inches, is the same for the 4-year and the 5-year fish. The second year's growth varies from 5·1 to 8·6, and the third year's from 7·9 to 10·9. The fourth year growth in the 5-year class varies from 2·8 to 6·4, with an average of 4·4. Although the fourth year growth of the 4-year class is complete when it comes into the inlet, the year is not a complete one and hence the growth is not so great on the average as that of the fourth year of the 5-year class, the individuals of which complete their fourth year. The

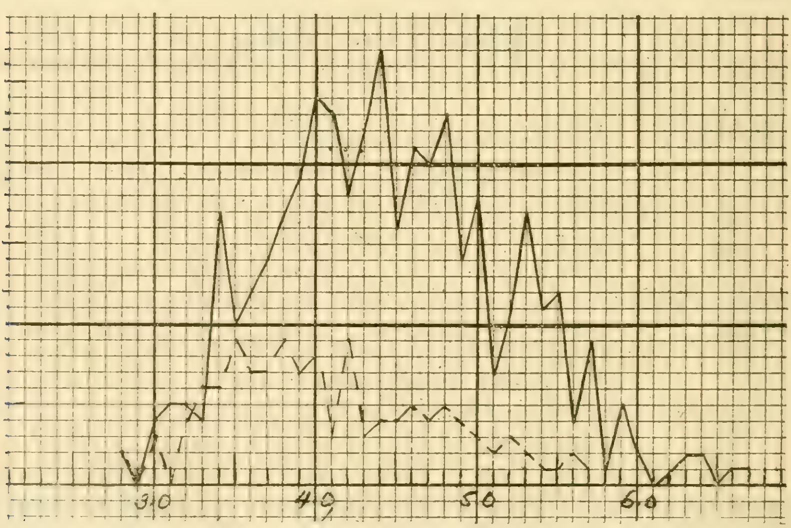


Fig. 9.—Sockeye. 4th year growth.

average growth for the last summer of the 4-year class was 3·3 inches. The growth of the last summer of the 5-year class was small, only 1·3 inches on the average. There is no material difference in the growth of the 4-year and the 5-year fish to the end of the third year. It must be remembered that 5-year fish taken on 1916 were from eggs liberated in 1911, and the 4-year fish in the following year, hence size cannot be a determining factor in the date of maturity.

The length at the end of the second year varies from 7·8 to 10·8 and at the end of the third year from 16·3 to 21·0. At the end of the fourth year the range is from 21·7 to 25·6, with an average of 23·3 in the 5-year class and of 22·2 in the 4-year class. The total length of the 5-year class varies from 22·0 to 27·0 with an average of 24·6.

The average length of the males in both the 4-year and the 5-year classes is slightly in excess of the average for the females as the following table shows, although the largest fish obtained was a female.

Length in inches	Number of Individuals			
	4 years old		5 years old	
	Male	Female	Male	Female
19·5	1	1		
20·	2	1		
20·5	6	..		
21·	13	9		
21·5	18	9		
22·	15	20	2	2
22·5	20	13	5	3
23·	20	9	5	25
23·5	12	2	8	27
24·	15	2	30	74
24·5			13	25
25·	1		25	54
25·5			19	28
26·			29	21
26·5			12	4
27·			9	2
27·5				
28·				1
Totals.......	123	66	157	266
Average length...	22·4	22·1	25·0	24·5

The measurements here are lower than Gilbert's, as the median caudal fin rays are included in his measurements, but are not in these.

Turning now to the Fraser river sockeye, since the great majority were of the stream type that remained over one year in fresh water, they may well be considered first as with them the comparison direct may be made with the Rivers inlet fish. The first year growth ranges from 2·3 to 3·4 inches and is the same average for the 4-year and the 5-year fish. The second year's growth varies from 6·2 inches to 10·6, with an average of 8·6 for the 4-year fish and 8·3 for the 5-year fish, or 8·5 for all. The range of the third year's growth extends from 5·6 to 9·8, with an average of 7·7 for the 4-year fish and 7·3 for the 5-year or 7·6 for all. For the fourth year growth in the 5-year class the variation runs from 2·8 to 5·7, with an average of 4·1, while the growth for the portion of the fourth year of the 4-year fish is 3·1. The average growth of the 5-year fish in the last spring and summer is 1·4 inches.

The length at the end of the second year ranges from 8·4 to 13·6; at the end of the third year from 15·9 to 21·6, but mainly from 17·2 to 21·4; at the end of the fourth year of the 5-year fish from 21·0 to 24·9, with the average length 22·6, while the total length of the 4-year fish was 22·3. The average total length of the 5-year fish was

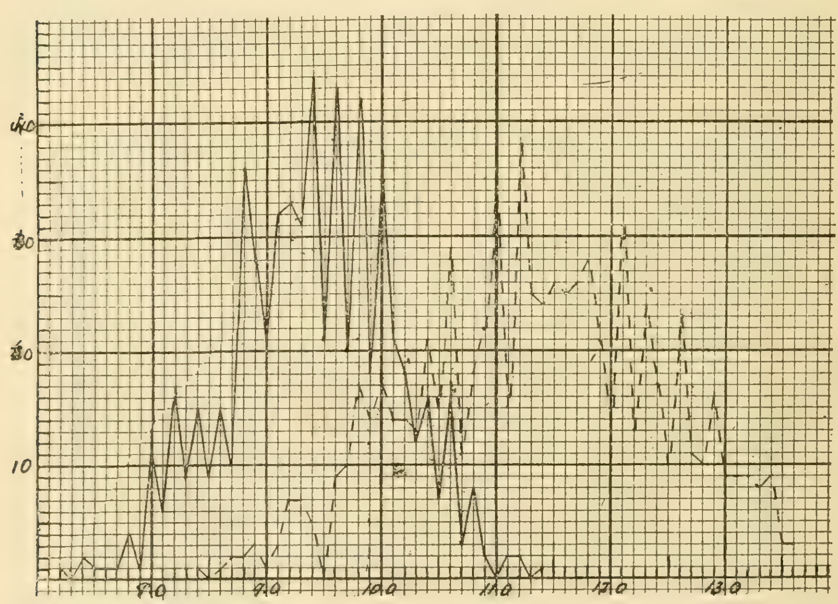


Fig. 10.—Sockeye. Length at 2 years.

24·0. In this case the 4-year fish were somewhat larger throughout than the 5-year fish of the previous year when measured at the same period of growth.

The average length of the males in both 4 and 5-year classes is in excess of that of the females.

FRASER RIVER SOCKEYE, 1 YEAR STREAM

Length in inches	Number of Individuals			
	4 yr. Male	4 yr. Female	5 yr. Male	5 yr. Female
19·5		1		
20·	1	4		
20·5	2	6		
21·	9	35		
21·5	15	43		
22·	56	117		2
22·5	70	66	3	3
23·	80	32	5	10
23·5	37	7	7	16
34·	26	3	13	21
24·5	2		18	8
25·	2		10	3
25·5			3	
26·			3	1
26·5			1	
Totals.......	300	314	63	64
Average length...	22·7	22·0	24·3	23·7

Before going on with the other types of Fraser river sockeye, it will be well to compare the growth of the 1-year stream type with the Rivers inlet sockeye, since all of these examined were of this type. It must be remembered that this comparison applies only to the sample specimens of this species caught in 1916. Some of the points may apply quite definitely in other years, but it must not be taken for granted that they do so without further analysis of data necessary for making comparison in the year in question.

The difference is marked even in the first year. The average length of the Rivers inlet fish at the beginning of rapid growth in the second spring was but 2·5 inches, while that of the Fraser river fish was 2·9, *i.e.*, the Fraser river fish average 16 per cent greater length than the Rivers inlet fish. The difference in size of the scale cor-

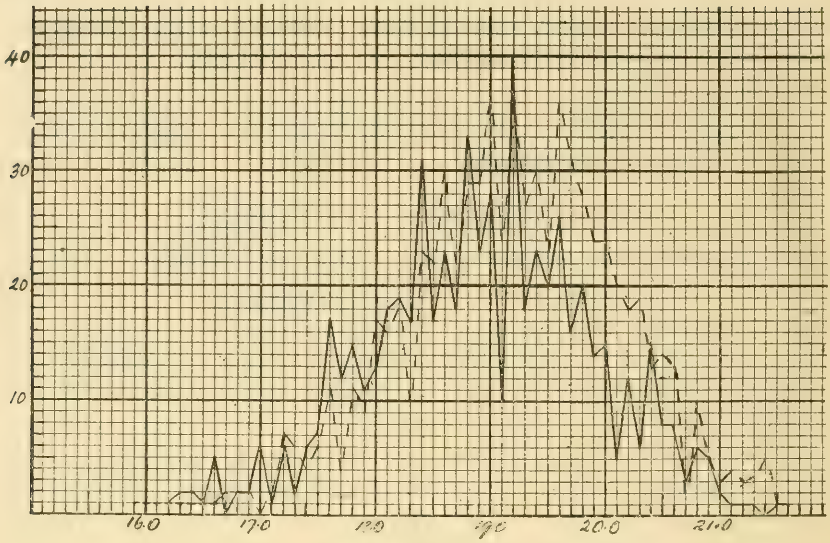


Fig. 11.—Sockeye. Length at 3 years.

responding to this difference in length gives a characteristic difference in the appearance of the central portion of the scale of the mature fish, which usually is sufficient in itself to indicate to which river system the fish belongs.

The difference in growth in the second year is more marked. While the Rivers inlet growth is but 6·9 inches, the Fraser river growth is 8·5 inches, 23 per cent greater. Thus, while the second year growth of a 4-year Rivers inlet fish is only 31 per cent of the total length that of a Fraser river fish is 39.

In the third year growth, the difference is still more marked but the situation is reversed. The third year growth of the Rivers inlet fish is much greater than that of any other year, and also much greater than any year of the Fraser river fish. With an average growth of 9·5 inches, there is an excess over the 7·6 inches of the Fraser river fish of 25 per cent and an excess over its own second year growth of 38 per cent. The third year growth of a 4 year Rivers inlet fish is 43 per cent of the total growth, while that of a Fraser river fish is only 34 per cent.

In the fourth and fifth years there is little difference in the amount of growth although that of the Rivers inlet fish is slightly greater in both instances.

It follows from this comparison that there is more difference in the fish at the end of the second year than at any other time in the

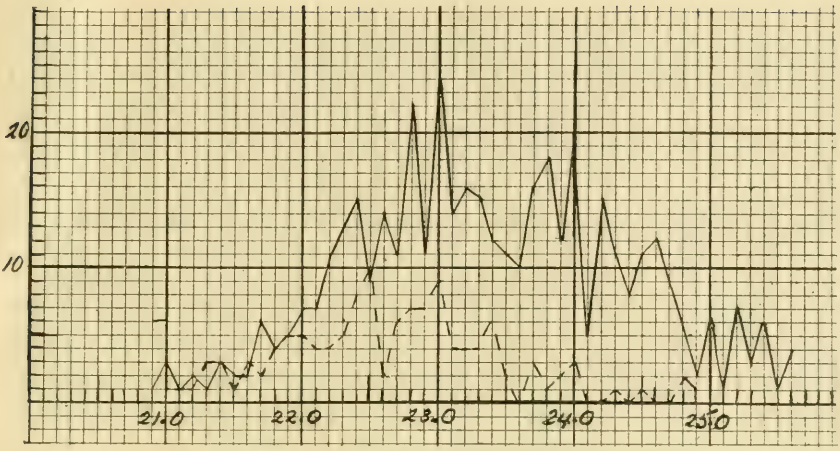


Fig. 12.—Sockeye. Length at 4 years.

life-history, since here is the accumulated difference of the first and second years. During the third year the balance is well restored, so that at the end of the third year, although in the 4-year fish the Fraser river is still in the lead, in the 5-year fish Rivers inlet has surpassed it. The same is true of the fourth year growth and in the fifth year of the 5-year fish, the lead is retained by Rivers inlet. In the Rivers inlet sockeye there is no appreciable difference in the annual growth of the 4-year and the 5-year fish, but in the Fraser river fish the growth of the 4-year fish is slightly greater each year.

The relative amount of growth in the second and third years is the most striking point of difference as it is seen in the scales. The relation existing in the Fraser river fish is the usual as when the conditions are similar, such as continued existence in the sea, the extent of the increment in the length of a fish decreases ordinarily with each succeeding year. This is not true of the Rivers inlet sockeye, as the growth in length in the third year, which is the second year in the sea, is greater than that of the second year which is the first year in the sea. It cannot be that the ultimate feeding ground of the Rivers inlet fish is poorer than that of the Fraser river fish, as in the third year the Rivers inlet fish grows more than the Fraser river fish does in any year of its life. Why it should be longer getting to a suitable food supply is not apparent.

The frequency curves emphasize the differences here mentioned.

Turning now to the other types of sockeye that were found in the Fraser river collection, those that were of the stream type but had spent over two years in fresh water may next be considered. There

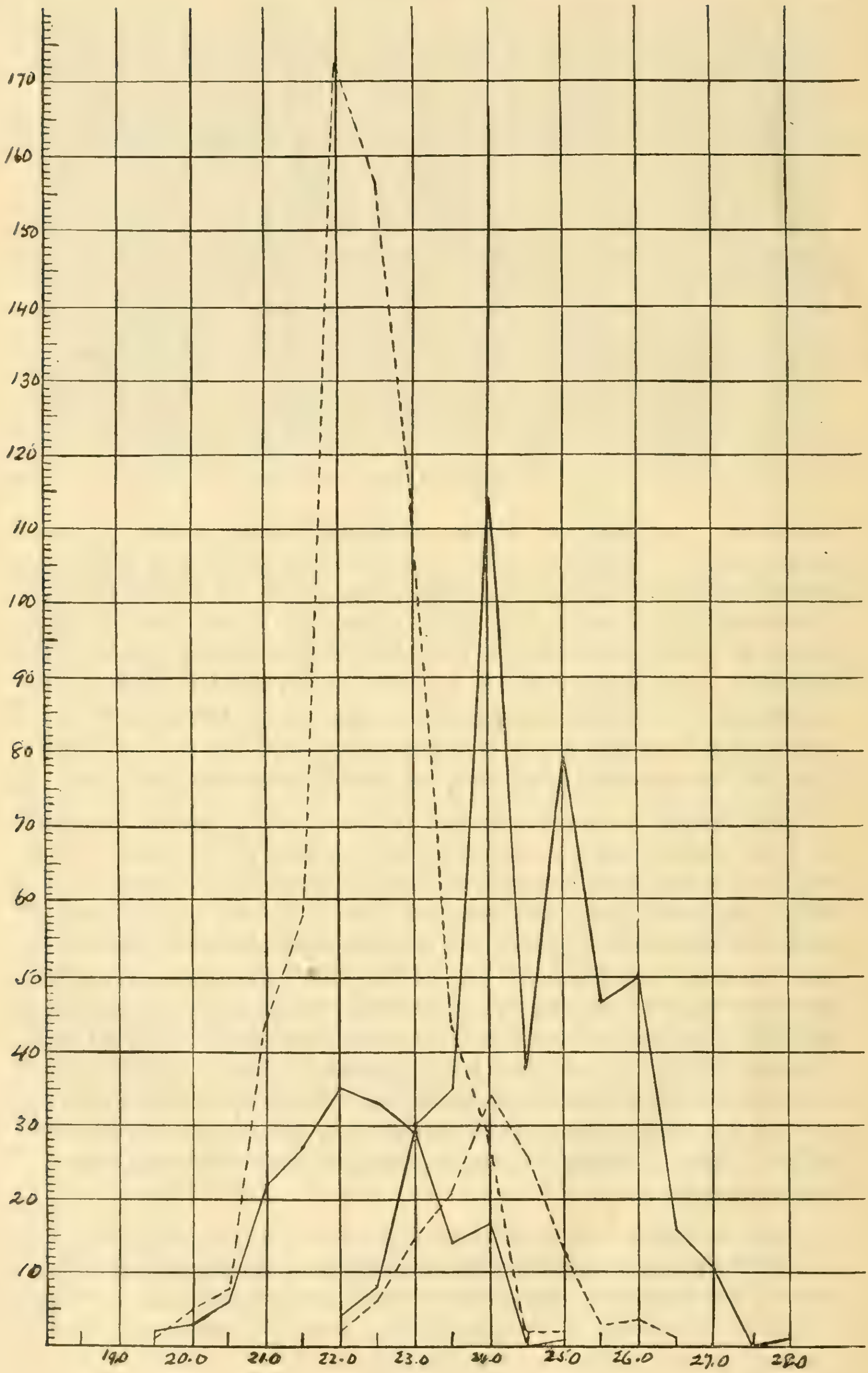


Fig. 13.—Sockeye. Total length.

were not enough of them to make satisfactory bases for conclusions and they may or may not be representative, hence, too much weight must not be put on the conclusions that appear to be warranted. It is interesting to examine them nevertheless.

It will be noticed, in the first place, that there were no 4-year fish of this type. There may have been some of them in the run, but like the 3-year fish of the previous type, they may have been small enough to pass through the net. There were 5-year fish and 6-year fish, but the latter were very few in number (only 3). The disparity agrees very well with that between the 5-year and 4-year fish in the 1-year stream type. There were not enough specimens to make it worth while attempting an extended analysis of the growth or to make a frequency curve, but it may be noted that taking the average, the first year growth was 2·6 inches, the second 3·2, the third 8·2, the fourth 6·1, the fifth in the 5 year class 2·4, in the 6-year class 3·3 and the sixth year in the 6-year class 1·4.

It is profitable to compare this growth with that of the 1-year stream type in the same river. The first year growth is much less, almost as low as in the Rivers inlet fish. The second year growth is much similar to that of the first year and in the different years in the sea the two types correspond, but that of the 2-year stream is slightly less in each case, so that by the time the third year in the sea is reached, the 2-year stream fish has lost the excess length that it obtained by remaining a year longer in fresh water, and the two are now practically the same length. The 5-year fish of the 2-year stream type, having spent three summers and two winters in the sea, has a length of 22·5 inches as compared with 22·3 inches, the length of the 4-year fish of the 1-year stream type that has spent the same length of time in the sea. The 6-year fish, having spent four summers and three winters in the sea is 24·7 inches long, while the 5-year fish, the same length of time in the sea, is 24 inches. It would seem, therefore, that those sockeye that remain in the fresh water for the extra year, practically lose that year as far as growth in length is concerned.

The sockeye of the sea type remain to be considered. Here again the numbers are not sufficiently great to provide satisfactory bases for conclusions. Here the 3-year fish were big enough to be caught in the net, but there were not many of them. The majority were 4-year fish and there were some in the 5th year. If there were any 2-year fish they were probably too small to be caught in the nets.

The first year growth averages 6·4 inches, the second 8·3, the third 6·5, with the portion of the third year in the 3-year class not much short, 5·4 inches, the fourth year of the 5-year class 4·0, of the 4-year class 1·8, the fifth year of the 5-year class 1·3.

Here again, there is the anomaly of the second year at sea exceeding the first year, similar to that found in the sockeye of the 1-year stream type in Rivers inlet, but there it is even more remarkable. Although 6·4 inches is given as the first year's growth, it is really the length of a year from the time the yolk was absorbed, or shortly after, at which time the fry would be nearly 1½ inches long, hence, the actual growth during the year would be only about 5 inches, while in the second year, it is 8·3 inches, about 60 per cent higher. This second year growth corresponds very well with the first year growth at sea of the 1-year stream type. Whether the same influence is at work here as in the case of the Rivers inlet fish or what it is in either case, it is impossible to say at present.

After the second year the growth is not quite so rapid as in the case of the 1-year stream type of the same age, and in consequence the 4 and 5-year fish are not much greater in length than those of the same age of the 1-year stream type. It is little advantage to the fish apparently to migrate to the salt water as fry. In this respect it is very different to the spring salmon, where the sea type salmon are almost a year ahead of the 1-year stream type, throughout.

Coho

All the 1916 coho examined, with exception of a small number of males in their second year, which were taken from a trap belonging to the Fisheries Department, in the Salmon river, near Harmsworth, on November 10, were obtained at the Nanaimo cannery from July 7 to October 6. They were caught at various places in the strait of Georgia between Comox to the northwest and Cowichan gap (Porlier pass) to the southeast, and a few were brought over from the Fraser river. They were therefore suitable for comparison with those examined from the previous year. 2,000 in all were examined, and all of them, with the exception of 28, were in their third year. These 28 were 2-year-old males, largely made up of the lot from the Salmon river above referred to. Scarcely any 2-year fish came into the cannery. When the fish were caught with nets, the mesh suitable for the 3-year fish would let the 2-year fish pass through, but as many of the fish were caught with handlines, one should suppose that they would be as liable to be caught as the larger fish if there were many of them in the same area. They were said to be plentiful in the Fraser river at times, but there the nets are used exclusively. The Salmon river trap was so built across the river that all fish passing up had to pass

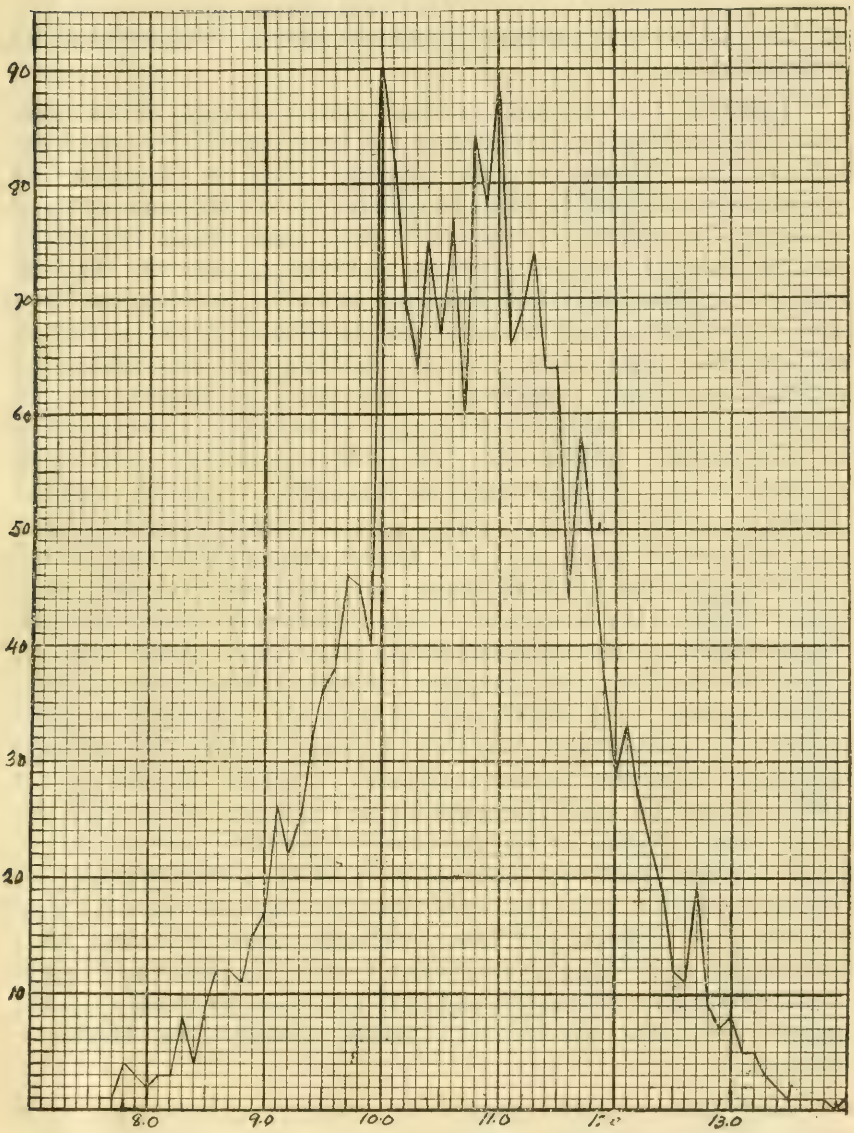


Fig. 14.—Coho. 2nd year growth.

in. Among the coho that were in the trap the day it was visited, quite a large proportion was of the 2-year males. These 2-year males may be characteristic of the Fraser river run or of a part of that run that proceeds to certain streams, tributary to the Fraser. That would not necessarily indicate that they would appear in the rivers and streams on the eastern slope of Vancouver island. No 2-year females were found.

Reference has been made to the "blueback" stage of the coho. Since the Nanaimo cannery took in fish from early in July until the coho run was entirely over, the transition from the "blueback" to the mature coho could be followed readily. At the beginning of rapid growth in the third year, the coho, which then weighs 1½ to 2½ pounds, although some of them are much larger than this, has the characteristic blue which it retains until well on in the summer. The skin is very soft so that the scales are shed very readily, the flesh is soft and dry. Particularly when the fish is gorged with schizopods or other crustaceans, it spoils very soon after being caught. By the end of June or the middle of July many of them have nearly reached the limit of their growth and are now first grade fish. Hence, by catching the fish in April there is destruction of capital, without getting a good product that in three or four months would bring in a profit of from 100 to 300 per cent. During July and sometimes to the end of August, the blueness remains and the scales are still readily shed. The flesh is firm and as a canned product is in great demand. The change from this condition takes place rather rapidly when it starts. As spawning time approaches, the milt or roe develops rapidly at the expense of the other tissues of the body. The flesh becomes poorer in quality, coarser in texture, lacking in color. The blueness disappears, the scales become firmly set as the flesh thickens around them and they become disintegrated at the margin. By the time the hook becomes pronounced in the snout of the male, and the skin is more or less blotched with dark red, the flesh is no longer suitable for consumption. Of those that came into the Nanaimo cannery, very few coho, as distinguished from bluebacks, came in during July; towards the end of August they made quite a significant proportion of the whole catch; through September the percentage rapidly became greater and after the 1st of October scarcely any bluebacks appeared.

All the coho examined were of the stream type, having stayed in the fresh water until some time early in the second year. In this they agree with those caught in the strait of Georgia in the previous year. The three exceptions reported from Neah bay were dog salmon, not cohos. Of the 1972 3-year fish examined, 999 or 50·7 per cent were males and 973 or 49·3 per cent were females. The numbers therefore are practically equal. In fact in the first 1,000 examined, the males and females were exactly equal in number.

Taking the average length of the fry when the first ring appeared on the scale as 1·3 inches, the growth, as calculated from the scales, gave an average of 3·6 inches for the first year, 11·1 for the second year and 7·4 for the third year, the average length of the fish when caught being 22·1 inches. There was no change in the average length during July and August, when it was 21·7. In the latter half of September and in October, while the majority of the fish would give a similar average, in every day's catch there would be a number that were much larger than those, so that from them it would have been possible to pick out a number that would give an average of 25 inches or more. Thus while those caught earlier in the year and the majority of those caught later run chiefly from 21 to 23 inches in length, with only 60 examined of those caught before the middle of September, 24 inches or over, the later addition referred to run from 24 to 27 inches, and some of them up to 29·5. Since a number of these were taken as well, the average for September and the first week of October was raised to 23·0 inches.

These large fish agree in size with those obtained at Neah bay, in October, 1915, and there is a possibility that these have been out in the open sea to feed, while the others have been in the strait throughout their salt water existence. Such an explanation is not necessary, however, as fishermen fishing deep at certain places in the strait find just as large fish as these during the summer and large bluebacks corresponding to these earlier in the year. Even early in the season, the fish brought in from one locality may invariably differ in average size from those brought in from another locality, so much so, that when the lots were not mixed it was possible to distinguish, for instance, those from Gabriola pass or Cowichan gap from those caught in the vicinity of Lasqueti island, although it might not be so easily possible to distinguish the individual fish. A sufficiently careful study of the scales might show a constant difference.

The frequency curve for the length of the coho at the end of the first year is so much out of proportion to the other graphs that it has not been included. A table will serve to give the number for each length.

Length	No.	Length	No.	Length	No.
2·9	1	3·4	194	3·9	187
3·0	17	3·5	211	4·0	168
3·1	23	3·6	282	4·1	149
3·2	81	3·7	262	4·2	3
3·3	112	3·8	319		

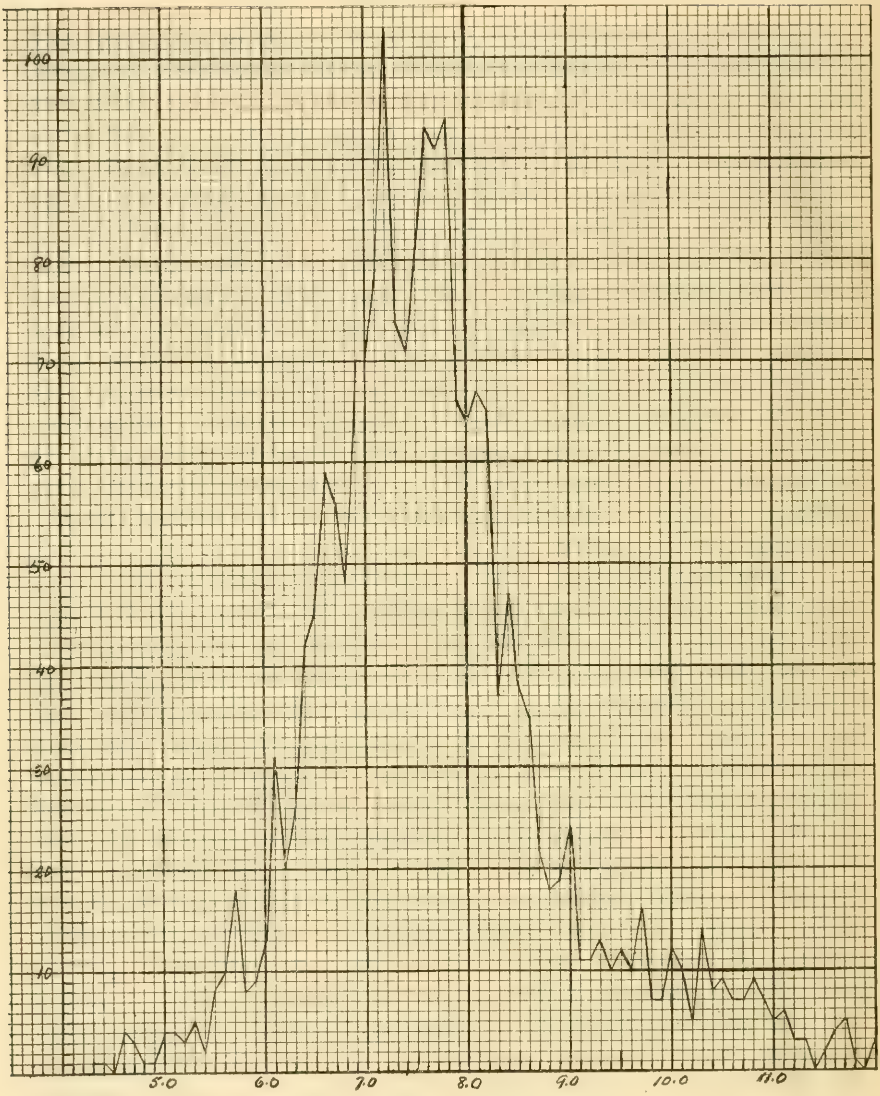


Fig. 15.—Coho. 3rd year growth.

A comparison of the 1916 coho with those obtained in 1915, brings out some points of interest. The average growth for the first year is slightly higher for 1916, 3·6 as compared with 3·3. The second year growth, 11·0 inches, is exactly the same as the average for the whole lot in 1915, but slightly greater than the average when those from Neah bay are excluded (10·8). It is in the third year only that there is a very noticeable difference. The average third year growth of the 1916 fish was 7·4 inches, and even when those caught before the first of September are excluded, the average is only 8·5 inches whereas in 1915, when all are included, the average is 9·7, and when only those from the strait of Georgia are included, it was 9·6. Hence, although the 1916 fish were larger at the end of their second year, the smaller amount of growth in the third year made the average total length noticeable less than in 1915, 22·1 for the whole season, or 23·0 after September 1, as compared with 24·0 for 1915, or 23·7 for the strait of Georgia.

In speaking at the 1916 meeting of the Pacific Fisheries Society on the effects of the severe weather in the early months of 1916, the following statement was made: "The year's growth in all the older fish would be off to a bad start this year and this should be shown on the scales." The above comparison shows how well the statement was borne out. The early months of 1915 were particularly favorable for life in the sea as well as life on land, while the corresponding months in 1916 were decidedly unfavourable. These two lots of coho show distinctly the effects of such different conditions.

In the first year the range of growth, 2·9 to 4·2 was not so great as in 1915, 2·4 to 4·1. As will be seen by the above table, the great majority were between 3·3 and 3·9. The range for the second year, 7·1 to 14·4 is practically the same as that for 1915, 7·5 to 14·4, with the average the same in each case. The length at the end of the second year varies from 10·7 to 18·2, with an average of 14·7 as compared with a range from 11·1 to 18·1, with an average of 14·3 in 1915. The third year growth ranges from 4·1 to 13·0, with an average of 7·4, while in 1915 the range was from 4·0 to 14·2 with an average of 9·7. The total length varied from 16·5 to 29·5, with an average of 22·1, as compared with 18·0 to 31·0 with average of 24·0 in 1915.

It will be noticed that there is a greater variation in the growth of the coho in the third year in proportion to the size of the fish at the beginning of the year than is the case in any other species in any year.

Of the 28 male coho that matured in the second year, the total lengths were 11·0, 11·5 (2), 12·0, 12·5 (4), 13·0, 13·5 (4), 14·0 (4), 14·5 (3), 15·5 (7), 16·0, with an average of 13·8. The average growth in the first year was 3·6, the same as that of the 3 year fish and in the second year 10·2. As the most of these were caught on November 10, there would be little more growth in the year, even if they had not matured, hence, from these at least, there is no evidence that those that matured early were any larger than those that did not.

The average total length of the males and the females in the third year is very similar, much more nearly the same than in any of the other species. The following table shows the similarity:

	No. of Individuals			No. of Individuals	
Length in ins.	Male	Female	Length in ins.	Male	Female
16·	1		23·5	53	43
16·5	1	1	24·	37	26
17·	8	2	24·5	24	20
17·50	4	3	25·	18	18
18·	9	3	2·55	12	21
18·5	14	8	26·	16	13
19·	32	16	26·5	14	4
19·5	40	25	27·	13	11
20·	59	35	27·5	8	3
20·5	65	68	28·	6	3
21·	102	139	28·5	3	
21·5	94	134	29·	5	
22·	118	145	29·5	1	
22·5	120	123			
23·	122	109	Total........	999	973
			Average.....	22·2	22·1

Humpback

When the humpback salmon is in good condition the flesh is very acceptable. It has sufficient colour to go by the commercial name of pink salmon. Even at its best, however, the flesh is less firm that that of any of the other species, and hence it will spoil in shorter time. As spawning time approaches deterioration takes place rapidly so that even before the mouths of the rivers are approached, the quality in many cases has become much poorer and but little later it is no longer fit for human consumption. Circumstances were favourable in 1916 for making a comparison between fish caught early in the season and later. About the middle of July a large number of humpbacks were being caught in Rivers inlet, and several of them that were brought into Wadham's were examined and the scales obtained. In the latter half of August, several catches were brought into the Nanaimo cannery from the vicinity of Cape Lazo and from that to Comox, in the strait of Georgia. These later fish at their best, could not have been anything like as large fish as those caught in Rivers inlet, as will be shown later by giving measurements, but apart from that the condition of the flesh was very much poorer. When cooked in the can there was no colour, and in every way it was a poorer canned product than the Rivers inlet material that had the usual pink colour.

The scales showed distinctly the difference in condition. In the case of the Rivers inlet fish the scales were removed readily and were perfect at the margin, so that there was no trouble in calculating growth, while the scales of the Comox fish could be removed only with difficulty and when they were removed many of them were so disintegrated at the margin that little of the last year's growth remained. It was with much difficulty that enough of them sufficiently perfect could be found to make calculation of growth rate worth while, so much so, that out of 1500 from which scales were taken, only 500 were used for calculation, and even among these there were many for which accurate calculation could not be vouched. They were the most unsatisfactory lot of all the scales examined. On that account, instead of having 2,000 to report upon as was intended, there were only 1,000, 500 of which were from Rivers inlet and 500 from the vicinity of Comox in the strait of Georgia.

All humpbacks examined were of the sea type. In Departure bay, the fry appear somewhat later than the dog salmon, but as the district is not specially partial to humpbacks, it may be different where they are more abundant. They are much the same size as the dogs and feed on anything that may be swallowed, as the dogs do. They disappear from the shallow water about the same time as the dog salmon fry do and as far as I am aware, nothing is seen of them until they come back again the next year on the way to spawn. Since, like the sockeye and the dog salmon, they do not take spoon or bait while they are in the inside waters, they probably spend the greater part of their feeding period in the open sea. Those coming in to spawn were all in their second year, hence they come to normal maturity earlier than any other species, and to prepare for it they grow more rapidly than any other species. Although they are the smallest of the species at normal maturity, they are larger than any other fish at that age.

In those examined, the sexes in both localities are almost of the same number, with the males very slightly predominating. The following table will show the ratio:

—		Male		Female	
	No.	No.	%	No.	%
Wadham's.....	500	252	50·4	248	49·6
Comox........	500	256	51·2	244	48·8
Total.......	1000	508	50·8	492	49·2

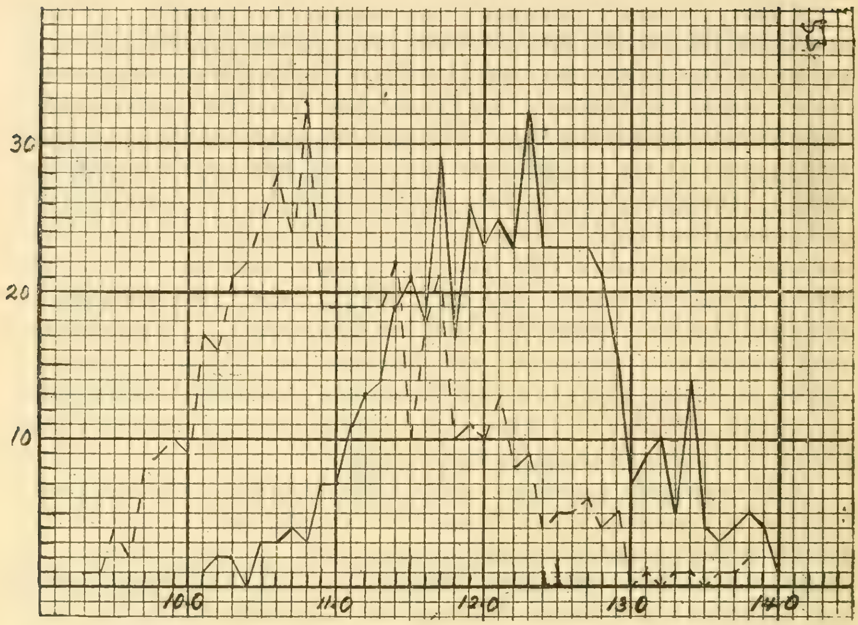


Fig. 16.—Humpback. 1st year growth.

As all the fish were of the same type and all of the same age, there is not the same basis for comparison as there is in the other species, but the differences in the Rivers inlet and Comox fish provide material for comparison.

In calculating growth rate, 1·6 inches is taken as the length of the fry when the nucleus of the scale is formed. The calculations give the following averages:

—	Rivers Inlet	Off Comox
Number	500	500
First year growth	12·1	11·0
Second	9·6	8·7
Total length	21·7	19·7

The Rivers inlet fish are a full two inches longer than the Comox fish, the excess being made up almost equally in the two years. The scales of the Comox fish in general indicate a slower growth in the early part of the first year, as though as fry they remained longer

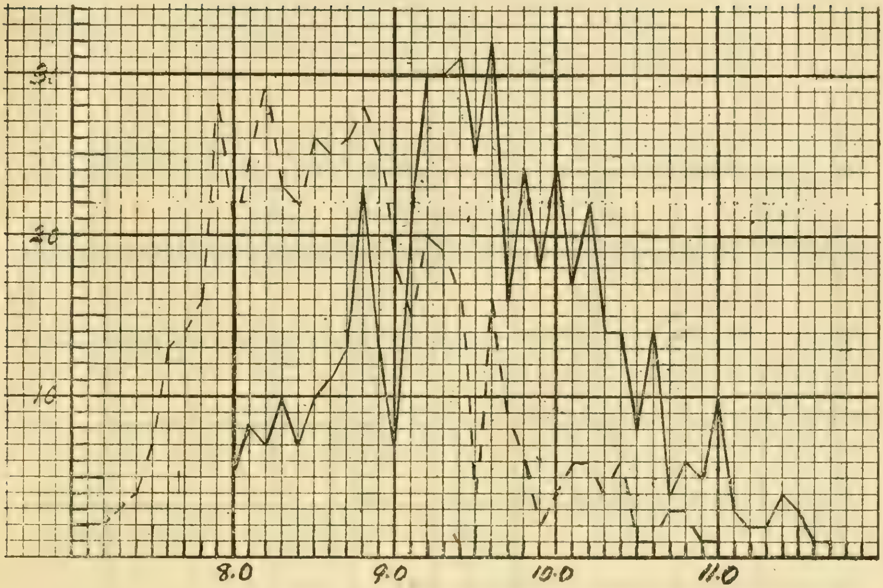


Fig. 17.—Humpback. 2nd year growth.

where feeding was not so good, but that would be the reverse of conditions in the sockeye where the Rivers inlet fish do not grow as much in the first year at sea as they do the second, differing in that respect from the Fraser river fish. Neither would that give any explanation for the smaller growth in the second year, although they were later in coming in than the Rivers inlet fish. They must have reached poorer feeding grounds in the open sea, so that the growth in each year was affected or else they must be constitutionally smaller fish.

The first year growth in the Rivers inlet fish varied from 10·0 to 14·0 inches, with an average of 12·1 and the second year growth from 8·0 to 12·2, with an average of 9·6, while the total length ranged from 19·0 to 25·5, with an average of 21·7. The first year growth in the Comox fish ranged from 9·2 to 13·7, but there are very few over 12·9, with an average of 11·0, the second year from 7·1 to 10·9, with an average of 8·7, while the total length varied from 17·0 to 24·0, with an average of 19·7.

The frequency curves show the difference between the Rivers inlet and the Comox fish very distinctly.

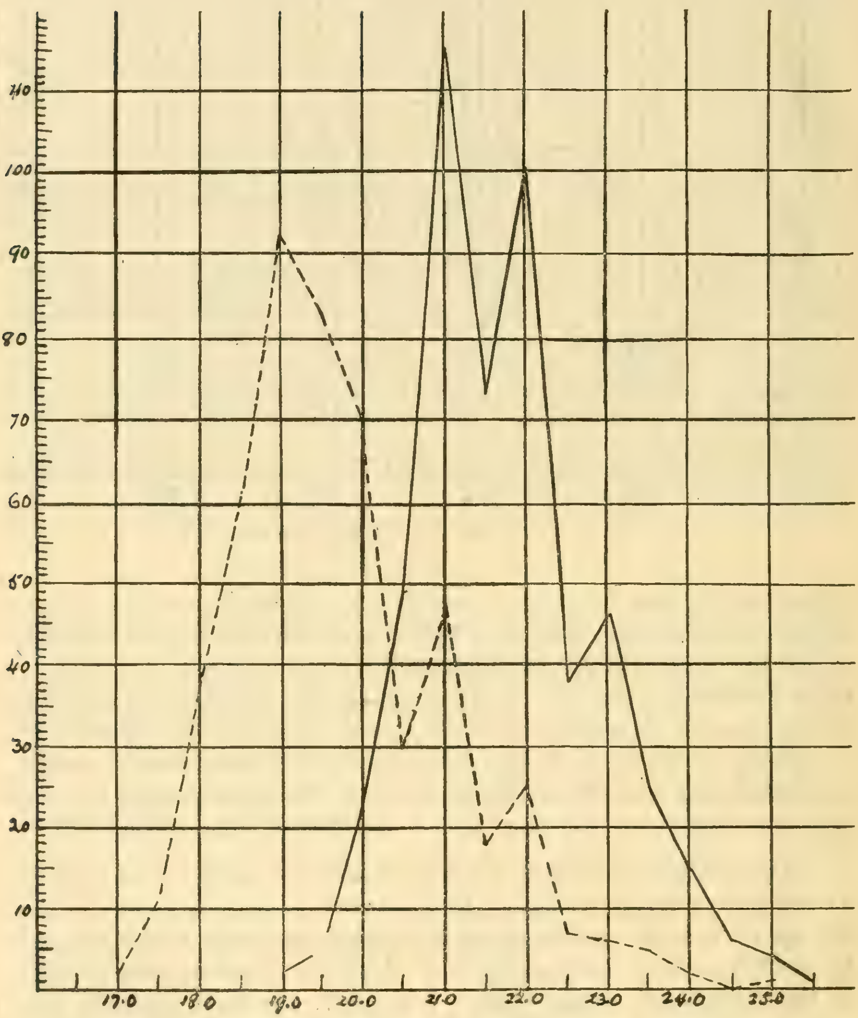


Fig. 18.—Humpback. Total length.

The males have the greater average length both in the Rivers inlet and Comox fish, as shown by the following table:

Length in ins.	Number of Individuals			
	Rivers Inlet		Off Comox	
	Male	Female	Male	Female
16·	1			1
16·5				
17·			2	
17·5			6	5
18·			12	26
18·5			20	41
19·	1	1	25	67
19·5	3	2	40	43
20·	6	16	32	38
20·5	14	35	18	12
21·	34	80	39	8
21·5	27	45	17	2
22·	55	44	24	1
22·5	30	8	7	
23·	33	13	6	
23·5	22	3	5	
24·	15		2	
24·5	5	1		
25·	5		1	
25·5	1			
Totals.........	252	248	256	244
Average length.	22·2	21·3	20·3	19·1

Dog Salmon

The dog salmon or chum has received very scant attention from investigators, and until quite recently very little more from commercial men. The little canned goods that were put up were taken when no other salmon could be got, and hence at a time when the dogs were far from being at their best. In this condition they could not be put on the same markets as the other species. Now that there has been a falling off in the catch of other species, more particularly in the Fraser river sockeye, the dog salmon is beginning to receive a little more of its due.

Prejudices, once they are firmly established, are hard to eradicate, and there is a two-fold prejudice against the dog salmon. The lack of colour has become associated with poor grades of fish, in many cases without reason, and the dog salmon, even in its prime, is not very rich in colour. The fact that badly deteriorated fish have been canned and sold has given a basis for a real prejudice, which has been kept alive by certain canners, who still put up fish unfit for human consumption. On that account there is little chance for even prime dog salmon to take its proper place in general favour, except in certain cases where reliable dealers have been able to get it introduced.

Dog salmon do not go far from the salt water to spawn, and consequently, by the time they enter the mouth of the river or stream, the roe or milt is well developed, with a corresponding deterioration of the other tissues of the body. At this time, however, the flesh is too poor to be suitable for consumption. Before they start up stream these salmon collect in large numbers in the salt water near the mouth of the river, up which they expect to ascend, so that they provide an easy mark for the seine fishermen. On that account there is strong temptation for the canners to unduly prolong the season, especially in a year when there is a big demand for salmon. The immediate gain so obtained is far more than offset by the harm that is done to the trade in general, and to the locality where the fish are caught, while at the same time the chances for the future are imperilled because the excessive drain on the stock of fish will tend to bring about a reduced supply, as it has done in different localities in the case of other species.

Little is known concerning the history of the dog salmon, except what may be learned from the scales. The spawn is deposited in small streams and rivers not far from the sea and all the young fry (as far as our examination has gone) pass down very soon to the sea, where they remain near the mouths of streams for some time. They have been seen in the sea before the yolk was all absorbed. In 1914, the first fry were seen near the station on March 4, in 1915, March 7, in 1916, April 8 and in 1917, April 11. Only in 1914 were any seen with the yolk partly unabsorbed. In 1916 and 1917, the water of the streams was much colder than in the two preceding years and remained cold for a longer period, hence the delay in hatching out and in the appearance in the sea. A note has been published on the fry at this stage.[1] The schools of fry remain in shallow water until the end of June or early in July, after which they are not seen in such numbers, but some of them remain in comparatively shallow water throughout the summer and fall. By the end of August they are

[1] Oncorhynchus keta Walbaum, in Ichthyological notes, Trans. Roy. Can. Inst., 1916, p. 111–113.

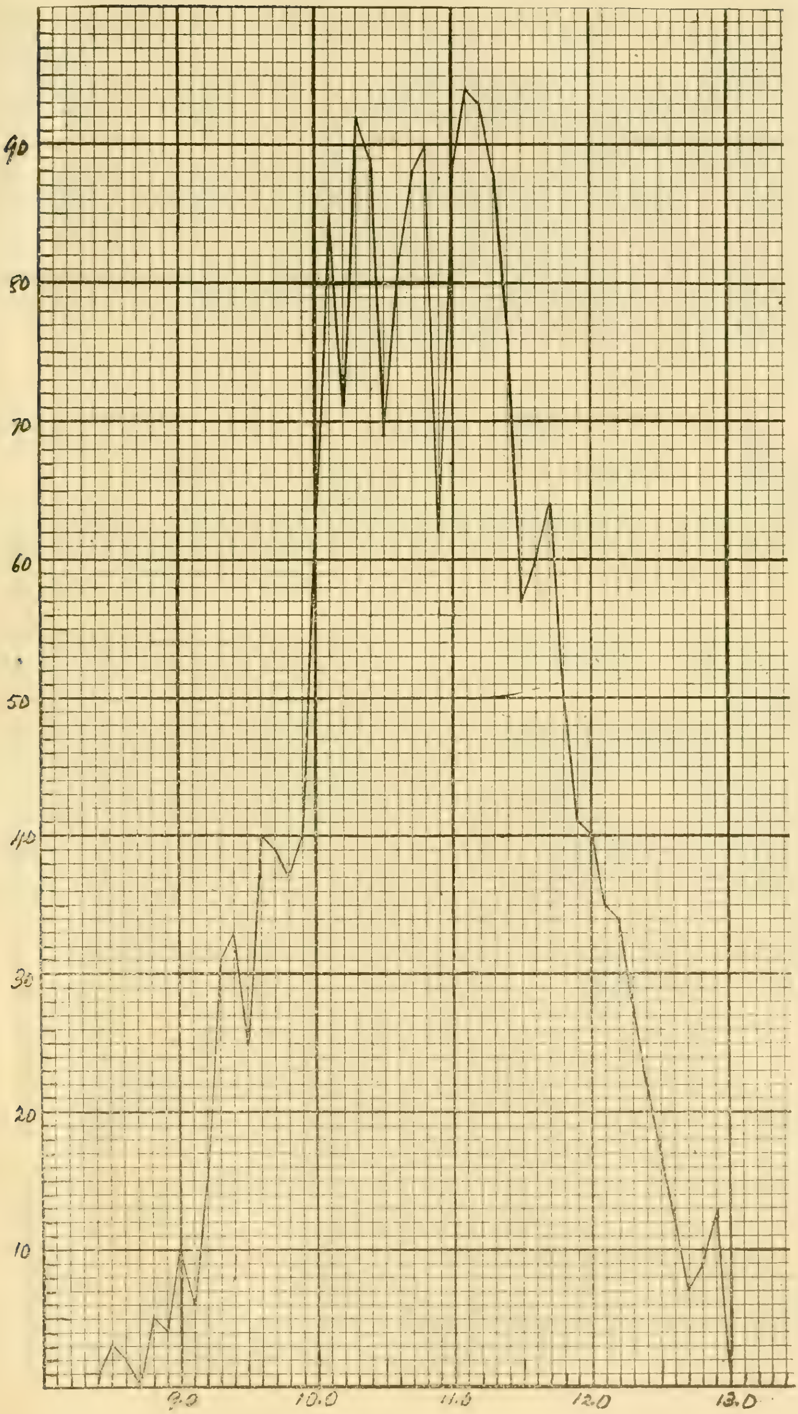


Fig. 19.—Dog. 1st year growth.

from 6 to 8 inches long, and by November, 8 to 11 inches. After that they disappear, and I know of no instance of their appearance later until they are on their way to spawn. As they will not take spoon or bait, it would seem that, like the sockeye, they spend the intervening time in the open sea.

Of the 2,000 dog salmon examined, 1,300 were from near the mouth of the little Qualicum river and the remainder were mostly from the strait near Nanaimo, although at times fish from near Chemainus were mixed with the Nanaimo fish, and it is possible some of these were included. All the fish examined were of the sea type.

The year classes were distributed as follows:

	Total	5 yr.	%	4 yr.	%	3 yr.	%	2 yr.	%
Qualicum.......	1300	16	1·2	836	64·3	448	34·5		
Nanaimo.......	700	6	0·9	367	52·4	326	46·6	1	0·1
Both.........	2000	22	1·1	1203	60·05	774	38·7	1	0·05

This shows that dog salmon from these localities nearly all mature in the third or fourth year, with the fourth year decidedly in the majority.

The proportion of males to females in the Nanaimo and Qualicum lots is somewhat dissimilar. In the Qualicum dogs, the males are in the majority in all the year classes, although not nearly so much in the 3-year class as in the others, hence taking all together, the majority is large. In the Nanaimo fish the females are in the majority in the 3-year class, but not in a large enough majority to balance the excess of males in the 4-year class. The majority of males in the total, however, is not very large. Strange to say, the only 2-year fish obtained was a female.

QUALICUM

Year Class	Total	Male		Female	
		No.	%	No.	%
5th	16	13	81·2	3	18·8
4th	836	539	64·5	297	35·5
3rd	448	256	57·1	192	42·9
All Classes..	1300	808	62·2	492	37·8

NANAIMO

5th	6	6	100·0		
4th	367	228	62·1	139	37·9
3rd	326	139	42·6	187	57·4
2nd	1			1	100·0
All Classes..	700	373	53·3	327	46·7

QUALICUM AND NANAIMO

5th	22	19	86·4	3	13·6
4th	1203	767	63·8	436	36·2
3rd	774	395	51·0	379	49·0
2nd	1			1	100·0
All Classes..	2000	1181	59·0	819	41·0

Taking the average length of the fry when the nucleus is formed in the scales as 1·6 inches and calculating the growth rate, the following averages were obtained:

QUALICUM

Year Class	No.	Growth During				
		1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr.
3rd	448	11·2	8·3	6·5		
4th	836	10·4	7·4	5·8	4·5	
5th	16	10·3	7·0	5·2	4·3	3·4
Average....		10·7	7·7	6·0	4·5	3·4

NANAIMO

2nd	1	11·6	7·9			
3rd	326	11·4	8·2	5·8		
4th	367	10·8	7·5	5·6	4·0	
5th	6	10·3	7·5	5·0	4·0	3·4
Average....		11·1	7·8	5·7	4·0	3·4

QUALICUM AND NANAIMO

2nd	1	11·6	7·9			
3rd	774	11·3	8·3	6·1		
4th	1203	10·5	7·5	5·7	4·3	
5th	22	10·3	7·1	5·2	4·2	3·4
Average....		10·8	7·8	5·8	4·3	3·4

QUALICUM

Year Class	No.	Length at the end of				
		1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr.
3rd	448	11·2	19·5	26·0		
4th	836	10·4	17·8	23·6	28·0	
5th	16	10·3	17·3	22·5	26·8	30·2
Average....		10·7	18·4	24·4	28·0	30·2

NANAIMO

2nd	1	11·6	19·5			
3rd	326	11·4	19·6	25·4		
4th	367	10·8	18·3	23·9	28·0	
5th	6	10·3	17·8	22·8	26·8	30·2
Average....		11·1	18·9	24·6	28·0	30·2

QUALICUM AND NANAIMO

2nd	1	11·6	19·5			
3rd	774	11·3	19·6	25·7		
4th	1203	10·5	18·0	23·7	28·0	
5th	22	10·3	17·4	22·6	26·8	30·2
Average....		10·8	18·6	24·4	28·0	30·2

The regularity in the growth of these fish is quite striking. Taking the averages, the growth in length for each year is almost exactly three-fourths that of the preceding year. Thus the growth in the second year is 72·2 per cent that of the first year; that of the third year, 74·4 per cent of the second year; that of the fourth year, 74·1 per cent of the third year and that of the fifth year, 79·1 per cent of that of the fourth year. In this species, if not in any of the others, there seems to be a very definite relation between size and time of maturity. In any and every year's growth, the average early maturing fish is larger than the later maturing. This cannot be due to a difference in food supply unless the supply is getting greater or more easily obtained each year.

In comparing the Qualicum and Nanaimo salmon, it will be observed that the early growth of those from Qualicum is slightly less than those from Nanaimo, particularly in the first two years. Later, the Qualicum fish regain the lost ground, more especially in the spawning year, and become as large as the Nanaimo fish. The Qualicum fish arrive in the inner waters later than the Nanaimo fish, which in turn are later than the Chemainus fish, hence while the Nanaimo fish and more particularly the Chemainus fish have greatly deteriorated, the Qualicum fish are still in good condition. It would appear, therefore, that they are also later in leaving the feeding grounds, and if they are this would account for the greater growth in the spawning year. The average length of the 4-year and the 5-year classes is the same in each but the average of the 3-year Nanaimo fish is somewhat less than that of the 3-year Qualicum, possibly because of the presence of some smaller Chemainus fish, mostly in their third year, being included.

The first year growth ranges from 8·3 to 13·0 inches with an average of 10·8; the second year 5·8 to 9·8 with an average of 7·8, the third year, 3·9 to 8·0 with an average of 5·8, if the 3-year class is included and 5·7 if it is not, the fourth year 2·5 to 6·7, with an average of 4·3, with the 4-year class included, the fifth year, 2·8 to 4·4, with an average of 3·4, with necessarily only the 5-year included. The growth of the incompleted third year of the 3-year class is greater than that of the completed third year of the 4 or 5-year classes and that of the uncompleted fourth year of the 4-year class is greater than that of the completed year of the 5-year class. This arises from the fact that late in the year when the dog salmon are caught, the growth for the year is practically complete and because of the tendency in these fish for the largest individuals of any year class to mature in the shortest period.

The length at the end of the second year ranges from 14·4 to 22·6 inches, with an average of 18·6, at the end of the third year, 20·6 to 28·5, with an average of 24·4, if the 3-year class is included and 23·7 if it is not, at the end of the fourth year, 24·0 to 32·5 with an average of 28·0, and at the end of the fifth year, 28·0 to 33·5, with an average of 30·2.

Separate frequency curves for the Qualicum and the Nanaimo fish have not been made. The whole lot is taken together.

The following table shows the length frequency for male and females in the 3 and 4-year classes. The 2 and the 5-year classes are not well enough represented to make it worth while giving these.

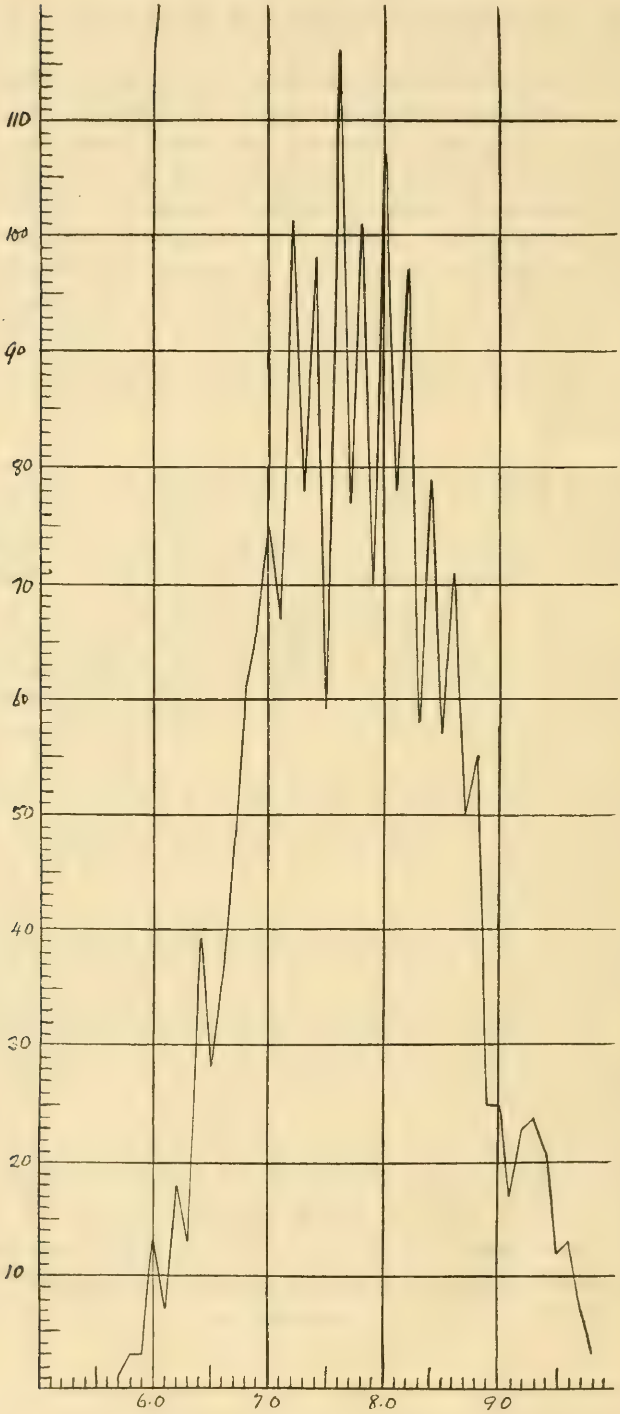


Fig. 20.—Dog. 2nd year growth.

	No. of Individuals			
Length in ins.	Male, 3 yr.	Female, 3 yr.	Male 4 yr.	Female, 4 yr.
21·	1			
21·5				
22·	1			
22·5	2	3		
23·	6	6		
23·5	3	13		
24·	19	33	1	2
24·5	23	44		7
25·	35	81		19
25·5	45	63	7	25
26·	85	78	25	51
26·5	66	36	30	57
27·	75	18	64	107
27·5	25	3	69	64
28·	8		136	48
28·5	1	1	105	21
29·			125	23
29·5			75	4
30·			63	4
30·5			28	1
31·			24	3
31·5			10	
32·			4	
32·5			1	
33·				
33·5			1	
Total............	395	379	767	436
Average length...	26·0	25·2	28·6	27·0

The lengthening snout of the mature male may have had a little to do with the greater length of the male, but at the times the scales were taken, there was little indication of such lengthening. All the dog salmon examined were caught between September 5 and October 7. The first fish that came in were bright and the scales were easily removed. It was not long until an occasional discoloured one appeared and the scales in these were firmly set. The Qualicum dogs remained bright longer than those from other localities brought into the cannery, but even among these, quite a large proportion were getting darker in the skin before the taking of scales was completed. These dark ones were avoided, and consequently, very few of the scales taken even on October 7 showed any sign of disintegration at

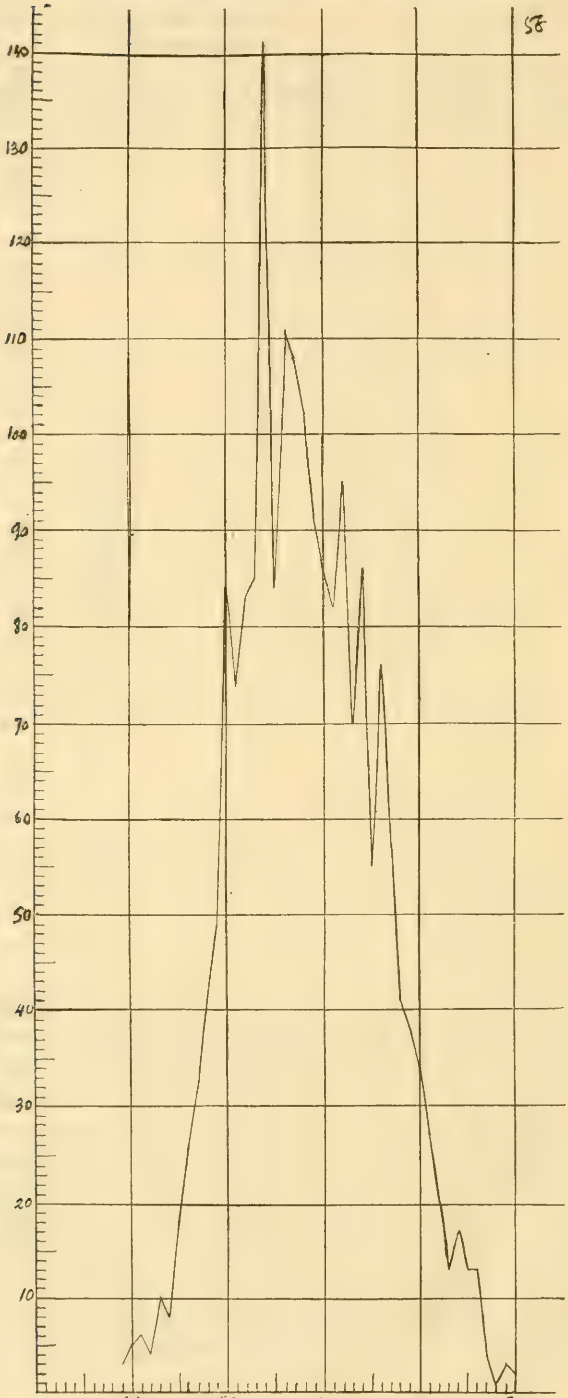


Fig. 21.—Dog. 3rd year growth.

the margin. A month later the scales on the majority of the fish were too much worn to be used for growth calculation. Here again the nature of the scales serves a good indication of the amount of deterioration in the flesh, and their story corroborates the statement that when the dog salmon get to the mouth of the river they are no longer suitable for food, or at any rate are of very low grade.

Summary and Conclusions

Of the 1916 salmon examined, three types, according to the time of migration to the sea, were in evidence. Included in the first of these, those that had migrated during the first spring after being hatched, about the time when the yolk was absorbed or shortly after, were a small number of Fraser river sockeye, approximately two-thirds of the springs, and all the humpbacks and dogs. Of these, the sockeye seemed to gain little by the early descent to the sea, as they did not grow very rapidly in the first year and in the later years lost all the little excess they had over those of the stream type hatched at the same time, so that in the fourth year they are little, if any, larger than the stream type fish. The springs and the dogs started off almost alike, but after the first year the spring had the greater growth and became the bigger fish. In the case of the springs, the great advantage gained over the stream type fish of the same year class, in the first year, is kept throughout life so that the sea type spring is practically one year ahead of the stream type hatched at the same time. The humpbacks made the greatest growth of all in each of the two years of life but the Rivers inlet fish grew more in each year than the Comox fish.

Included in the second type, those that migrated during the second spring after being hatched, were all of the Rivers inlet sockeye, the large majority of the Fraser river sockeye, about one-third of the springs and all of the cohos. The springs and the cohos grew more during the stay in fresh water than the sockeye do, and the Fraser river sockeye grow more than the Rivers inlet sockeye. In all these cases with the exception of the Rivers inlet sockeye, the increase in length for each year in the sea decreased in each succeeding year. In the Rivers inlet sockeye, the growth in the first year at sea was scarcely three-fourths that of the second year.

Included in the third type, those that remained in the fresh water over two years before migration, there were but a few among the Fraser river sockeye. As these grew little in either years in the fresh water, they were much the same size when mature as the one year stream type hatched one year later.

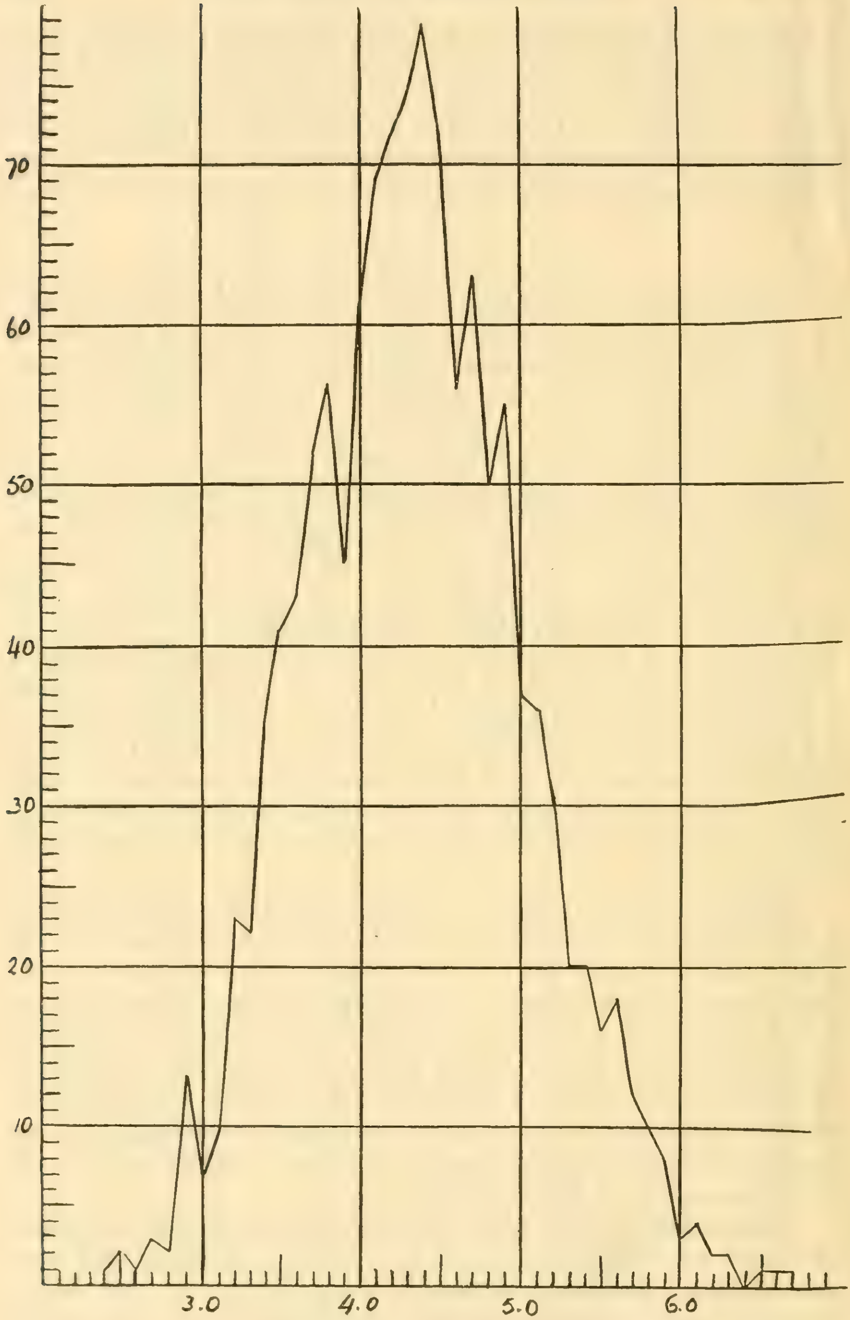


Fig. 22.—Dog. 4th year growth.

A table of comparative growth will show the similarities and differences more clearly:

TABLE OF COMPARATIVE GROWTH BY YEARS

	Sea Type					
	1st	2nd	3rd	4th	5th	6th
Sockeye (Fraser River)...	6·4	8·3	6·5	4·0	1·3	
Spring..................	10·5	9·1	6·8	5·5	2·5	
Dog....................	10·8	7·8	5·8	4·3	3·4	
Humpback (Rivers Inlet)	12·1	9·6				
(Off Comox)	11·0	8·7				
Stream Type, 1 Year						
Sockeye (Rivers Inlet)...	2·5	6·9	9·5	4·1	1·3	
(Fraser River)...	2·9	8·5	7·6	3·2	1·4	
Spring..................	3·7	10·9	8·5	5·9	3·2	
Coho....................	3·6	11·1	7·4			
Stream Type, 2 Year						
Sockeye (Fraser River)..	2·6	3·2	8·2	6·1	3·3	1·1

In considering the year classes in each type of fish nothing definite can be stated concerning the spring salmon as a large percentage of those examined were immature. The sexes were nearly even, with the males slightly predominating. The excess is more noticeable in the younger fish, and thus the excess of the females in the 4-year and 5-year fish is more than balanced.

Of the sockeye, those from Rivers inlet were 4 and 5-year fish, the latter being over two-thirds of the whole number. Nearly two-thirds of the 4-year fish were males and nearly as large a percentage of the 5-year fish were females. Since the 5-year fish were more numerous than the 4-year fish, the females predominated in the whole number. From the Fraser river, in the 2-year stream type, nearly all were 5-year fish. There were no 4-year and very few 6-year. The 1-year stream type were all 4-year or 5-year fish, the 4-year fish making up about five-sixths of the whole number. The sea type were largely 4-year, although the 3-year and the 5-year were represented. The males were somewhat in excess in the sea type, but in the other types the balance was very nearly kept.

Nearly all the mature coho were in the third year, the exceptions being 2-year males. In the 3-year class, the males and females were almost equal in number.

The humpbacks were all in their second year, with almost an equal number of males and females. The Rivers inlet fish averaged 2 inches longer than the Comox fish.

The majority of the dogs were 4-year fish, the majority of the remainder 3-year fish, a few 5-year fish and one 2-year. In the Qualicum dogs there was a larger percentage of 4-year-olds than in the Nanaimo fish. The males were largely in excess in every year, with exception of the 3-year class from Nanaimo. In consequence the total excess of males was large.

In all types of all species the average length of the male slightly exceeded that of the female, although in the coho the difference almost disappeared.

The difference in growth rate of the Rivers inlet and the Fraser river sockeye and the Rivers inlet and Comox humpbacks confirms the statement that each species in each river system is a problem of itself.

In previous papers the problem of feeding young salmon in rearing ponds has been discussed. The detailed examination of so many salmon of each species gives further data for the consideration of this matter. It must be remembered that the feeding of young fish in a rearing pond for a year or more does not produce larger fish than those that have lived the same length of time in fresh water. The only advantage of such retention comes from the protection they receive from enemies during the time they are retained.

In the case of the sockeye, where the great majority remain normally for at least a year in fresh water, and that of the coho, where practically all of them do, such a protection seems desirable. With the humpback and dog salmon, it is entirely different, as these get to the salt water early in the first year and it is not a normal condition to keep them in fresh water. Furthermore, since they grow so rapidly in the sea in the first year, the growth would be much retarded if they were kept in fresh water. Since two-thirds of the spring salmon go down to the sea in the first year and since these that do go down as fry are practically a year ahead of those of the same age that remain in the fresh water for a year or more, the rearing of spring salmon until the second year is of very doubtful benefit.

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Explanation of Graphs

The figures are all length frequency curves, the length being given in inches. In all graphs but 13 and 18 the measurements are given to tenths, and in these two in halves.

Spring

Fig. 1. Sea type. Growth in first year
2. Growth in second year
3. Growth in third year
4. Stream type. Growth in first year
5. Growth in second year

Sockeye

(all stream type, migrating in second year)
Rivers inlet ——— Fraser river........

Fig. 6. Growth in first year
7. Growth in second year
8. Growth in third year
9. Growth in fourth year
10. Length at end of second year
11. Length at end of third year
12. Length at end of fourth year
13. Total length. 4 year and 5 year curve shown separately.

Coho

Fig. 14. Growth in second year
15. Growth in third year

Humpback

Rivers inlet ——— Comox ....

Fig. 16. Growth in first year
17. Growth in second year
18. Total length

Dog

Fig. 19. Growth in first year
20. Growth in second year
21. Growth in third year
22. Growth in fourth year