JOURNAL AND PROCEEDINGS

OF THE

ROYAL SOCIETY

OF

NEW SOUTH WALES

FOR

1926

(INCORPORATED 1881.)

VOL. LX.

EDITED BY

THE HONORARY SECRETARIES.

THE AUTHORS OF PAPERS ARE ALONE RESPONSIBLE FOR THE STATEMENTS MADE AND THE OPINIONS EXPRESSED THEREIN.

SYDNEY:
PUBLISHED BY THE SOCIETY, 5 ELIZABETH STREET, SYDNEY.

ISSUED AS A COMPLETE VOLUME, JUNE, 1927.

CONTENTS.

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NOTICE.

The Royal Society of New South Wales originated in 1821 as the "Philosophical Society of Australasia"; after an interval of inactivity, it was resuscitated in 1850, under the name of the "Australian Philosophical Society," by which title it was known until 1856, when the name was changed to the "Philosophical Society of New South Wales"; in 1866, by the sanction of Her Most Gracious Majesty Queen Victoria, it assumed its present title, and was incorporated by Act of the Parliament of New South Wales in 1881.

TO AUTHORS.

Authors should submit their papers in typescript and in a condition ready for printing. All physico-chemical symbols and mathematical formulæ should be so clearly written that the compositor should find no difficulty in reading the manuscript. Sectional headings and tabular matter should not be underlined. Pen-illustrations accompanying papers should be made with black Indian ink upon smooth white Bristol board. Lettering and numbers should be such that, when the illustration or graph is reduced to 3½ inches in width, the lettering will be quite legible. On graphs and text figures any lettering may be lightly inserted in pencil. Microphotographs should be rectangular rather than circular, to obviate too great a reduction. The size of a full page plate in the Journal is 4 × 6¼ inches, and the general reduction of illustrations to this limit should be considered by authors. When drawings, etc., are submitted in a state unsuitable for reproduction, the cost of the preparation of such drawings for the process-block maker must be borne by the author. The cost of colouring plates or maps must also be borne by the author.

ERRATA.

P. 319, l. 12, for $\sqrt{\frac{k}{\rho}}$ read $\sqrt{\frac{k+\frac{4}{3}n}{\rho}}$

P. 320, l. 16, for 0.09 read 0.9.

FORM OF BEQUEST.

I bequeath the sum of £ to the Royal Society of New South Wales, Incorporated by Act of the Parliament of New South Wales in 1881, and I declare that the receipt of the Treasurer for the time being of the said Corporation shall be an effectual discharge for the said Bequest, which I direct to be paid within calendar months after my decease, without any reduction whatsoever, whether on account of Legacy Duty thereon or otherwise, out of such part of my estate as may be lawfully applied for that purpose.

[*Those persons who feel disposed to benefit the Royal Society of New South Wales by Legacies, are recommended to instruct their Solicitors to adopt the above Form of Bequest.*]

PUBLICATIONS.

The following publications of the Society, if in print, can be obtained at the Society's House in Elizabeth-street:—

Transactions of the Philosophical Society, N.S.W., 1862-5, pp. 374, out of print.

Vols. I—XI	Transactions of the Royal Society, N.S.W.,				1867—1877,			,,
,,	XII Journal and Proceedings			,,	,,	1878, ,,	324,	price 10s.6d.
,,	XIII	,,	,,	,,	,,	1879, ,,	255,	,,
,,	XIV	,,	,,	,,	,,	1880, ,,	391,	,,
,,	XV	,,	,,	,,	,,	1881, ,,	440,	,,
,,	XVI	,,	,,	,,	,,	1882, ,,	327,	,,
,,	XVII	,,	,,	,,	,,	1883, ,,	324,	,,
,,	XVIII	,,	,,	,,	,,	1884, ,,	224,	,,
,,	XIX	,,	,,	,,	,,	1885, ,,	240,	,,
,,	XX	,,	,,	,,	,,	1886, ,,	396,	,,
,,	XXI	,,	,,	,,	,,	1887, ,,	296,	,,
,,	XXII	,,	,,	,,	,,	1888, ,,	390.	,,
,,	XXIII	,,	,,	,,	,,	1889, ,,	534,	,,
,,	XXIV	,,	,,	,,	,,	1890, ,,	290,	,,
,,	XXV	,,	,,	,,	,,	1891, ,,	348,	,,
,,	XXVI	,,	,,	,,	,,	1892, ,,	426,	,,
,,	XXVII	,,	,,	,,	,,	1893, ,,	530,	,,
,,	XXVIII	,,	,,	,,	,,	1894, ,,	368,	,,
,,	XXIX	,,	,,	,,	,,	1895, ,,	600,	,,
,,	XXX	,,	,,	,,	,,	1896, ,,	568,	,,
,,	XXXI	,,	,,	,,	,,	1897, ,,	626,	,,
,,	XXXII	,,	,,	,,	,,	1898, ,,	476,	,,
,,	XXXIII	,,	,,	,,	,,	1899, ,,	400,	,,
,,	XXXIV	,,	,,	,,	,,	1900, ,,	484,	,,
,,	XXXV	,,	,,	,,	,,	1901, ,,	581,	,,
,,	XXXVI	,,	,,	,,	,,	1902, ,,	531,	,,
,,	XXXVII	,,	,,	,,	,,	1903, ,,	663,	,,
,,	XXXVIII	,,	,,	,,	,,	1904, ,,	604,	,,
,,	XXXIX	,,	,,	,,	,,	1905, ,,	274,	,,
,,	XL	,,	,,	,,	,,	1906, ,,	368,	,,
,,	XLI	,,	,,	,,	,,	1907, ,,	377,	,,
,,	XLII	,,	,,	,,	,,	1908, ,,	593,	,,
,,	XLIII	,,	,,	,,	,,	1909, ,,	466,	,,
,,	XLIV	,,	,,	,,	,,	1910, ,,	719,	,,
,,	XLV	,,	,,	,,	,,	1911, ,,	611,	,,
,,	XLVI	,,	,,	,,	,,	1912, ,,	275,	,,
,,	XLVII	,,	,,	,,	,,	1913, ,,	318,	,,
,,	XLVIII	,,	,,	,,	,,	1914, ,,	584,	,,
,,	XLIX	,,	,,	,,	,,	1915, ,,	587,	,,
,,	L	,,	,,	,,	,,	1916, ,,	362,	,,
,,	LI	,,	,,	,,	,,	1917, ,,	786,	,,
,,	LII	,,	,,	,,	,,	1918, ,,	624,	,,
,,	LIII	,,	,,	,,	,,	1919, ,,	414,	,,
,,	LIV	,,	,,	,,	,,	1920, ,,	312,	price £1 1s.
,,	LV	,,	,,	,,	,,	1921, ,,	418,	,,
,,	LVI	,,	,,	,,	,,	1922, ,,	372,	,,
,,	LVII	,,	,,	,,	,,	1923, ,,	421,	,,
,,	LVIII	,,	,,	,,	,,	1924, ,,	366,	,,
,,	LIX	,,	,,	,,	,,	1925, ,,	468,	,,
,,	LX	,,	,,	,,	,,	1926, ,,	470,	,,

Royal Society of New South Wales

OFFICERS FOR 1926-1927.

Patron:

HIS EXCELLENCY THE RIGHT HONOURABLE JOHN LAWRENCE, BARON STONEHAVEN, P.C., G.C.M.G., D.S.O.
Governor-General of the Commonwealth of Australia.

Vice-Patron:

HIS EXCELLENCY SIR DUDLEY RAWSON STRATFORD de CHAIR, K.C.B., M.V.O.
Governor of the State of New South Wales.

President:

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Prof. J. DOUGLAS STEWART, B.V.Sc., M.R.C.V.S.

LIST OF THE MEMBERS

OF THE

Royal Society of New South Wales.

P Members who have contributed papers which have been published in the Society's Journal. The numerals indicate the number of such contributions.

‡ Life Members.

Elected.		
1908		Abbott, George Henry, B.A., M.B., Ch.M., 185 Macquarie-street; p.r. 'Cooringa,' 252 Liverpool Road, Summer Hill.
1904		Adams, William John, M.I.Mech.E., 175 Clarence-street.
1898		Alexander, Frank Lee, William-street, Granville.
1905	P 3	Anderson, Charles, M.A., D.Sc. *Edin.*, Director of the Australian Museum, College-street. (President, 1924.) *Vice-President.*
1909	P 9	Andrews, Ernest C., B.A., F.G.S., Hon. Mem. Washington Academy of Sciences, Government Geologist, Department of Mines, Sydney. (President, 1921.) *Vice-President.*
1915		Armit, Henry William, M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, The Printing House, Seamer-street. Glebe.
1919		Aurousseau, Marcel, B.Sc., 9 Bannerman Street, Cremorne.
1923		Baccarini, Antonio, Doctor in Chemistry (Florence), 12 Roslyndale Avenue, Woollahra.
1878		Backhouse, His Honour Judge A. P., M.A., 'Melita,' Elizabeth Bay.
1924		Bailey, Victor Albert, M.A., D.Phil., F.Inst.P., Assoc.-Professor of Physics in the University of Sydney.
1921		Baker, Rev. Harold Napier, M.A. *Syd.*, St. Thomas' Rectory, North Sydney.
1919		Baker, Henry Herbert, 15 Castlereagh-street.
1894	P 27	Baker, Richard Thomas, The Crescent, Cheltenham.
1894		‡Balsille, George, 'Lauderdale,' N.E. Valley, Dunedin, N.Z.
1926		Bannon, Joseph, Demonstrator in Physics in the University of Sydney; p.r. 'Dunisla,' The Crescent, Homebush.
1919		Bardsley, John Ralph, 'The Pines,' Lea Avenue, Five Dock.
1925		Barker-Woden, Lucien, F.R.G.S., 50 Muston-street, Mosman.
1908	P 1	Barling, John, L.S., 'St. Adrians,' Raglan-street, Mosman.
1918		Barr, Robert Hamilton, 37 Sussex-street.
1895	P 9	Barraclough, Sir Henry, K.B.E., B.E., M.M.E., M. Inst. C.E., M. I. Mech. E., Memb. Soc. Promotion Eng. Education; Memb. Internat. Assoc. Testing Materials; Dean of the Faculty of Engineering and Professor of Mechanical Engineering in the University of Sydney; p.r. 'Marmion,' Victoria-street, Lewisham.
1909	P 2	Benson, William Noel, D.Sc. *Syd.*, B.A. *Cantab.*, F.G.S., Professor of Geology in the University of Otago, Dunedin, N.Z.
1926		Bentivoglio, Sydney Ernest, B.Sc.Agr., 70 Young-street, Annandale.
1923		Berry, Frederick John, F.C.S., 'Roseneath,' 51 Reynolds-street, Neutral Bay.

Elected.		
1919		Bettley-Cooke, Hubert Vernon, 'The Hollies,' Minter-street, Canterbury.
1923		Birks, George Frederick, c/o Potter & Birks, 15 Grosvenor-st.
1916		Birrell, Septimus, c/o Margarine Co., Edinburgh Road, Marrickville.
1920		Bishop, Eldred George, 16 Belmont-street, Mosman.
1915		Bishop, John, 24 Bond-street.
1913		Bishop, Joseph Eldred, Killarney-street, Mosman.
1923		Blair, Kenneth John, 'Mimpi,' Parsley Road, Vaucluse.
1923	P 2	Blakely, William Faris, 'Myola,' Florence-street, Hornsby.
1905		Blakemore, George Henry, Room 32, Third Floor, Commercial Bank Chambers, 273 George-street.
1888		‡Blaxland, Walter, F.R.C.S. *Eng.*, L.R.C.P. *Lond.*, 'Inglewood,' Florida Road, Palm Beach, Sydney.
1893		Blomfield, Charles E., B.C.E. *Melb.*, 'Woombi,' Kangaroo Camp, Guyra.
1917		Bond, Robert Henry, 'Eastbourne,' 27 Cremorne-road, Cremorne Point.
1926	P 1	Booker, Frederick William, B.Sc., 'Dunkeld,' Nicholson-street, Chatswood.
1920	P 4	Booth, Edgar Harold, M.C., B.Sc., F Inst.P., Lecturer and Demonstrator in Physics in the University of Sydney.
1922		Bradfield, John Job Crew, D.Sc. Eng., M.E., M. Inst. C.E., M. Inst. E. Aust. Chief Engineer, Metropolitan Railway Construction, Railway Department, Sydney.
1910	P 1	Bradley, Clement Henry Burton, M.B., Ch.M., D.P.H., 'Nedra,' Little-street, Longueville; 211 Macquarie-street.
1876		Brady, Andrew John, L.K. and Q.C.P. *Irel.*, L.R.C.S. *Irel.*, 175 Macquarie-street, Sydney.
1916		Bragg, James Wood, B.A., c/o Gibson, Battle &Co. Ltd.,Kent-st.
1926		Branch, Kenneth James F., 99 North Steyne, Manly.
1917		Breakwell, Ernest, B.A., B.Sc., Headmaster Agricultural School, Yanco.
1891		Brennand, Henry J. W., B.A., M.D., Ch.M. *Syd.*, V.D., Surgeon Commander R.A.N. Ret., 223 Macquarie-street; p.r. 73 Milsons Road, Cremorne.
1923		Brereton, Ernest Le Gay, B.Sc.. Lecturer and Demonstrator in Chemistry in the University of Sydney.
1919	P 1	Briggs, George Henry, B.Sc., Ph.D., Lecturer and Demonstrator in Physics in the University of Sydney.
1922		Brough, Patrick, M.A., B.Sc., B Sc., (Agr) (Glasgow), Lecturer in Botany in the University of Sydney.
1923		Brown, Herbert, 'Sikoti,' Alexander-street, Collaroy Beach, Sydney.
1906		Brown, James B., Resident Master, Technical School, Granville; p.r. 'Aberdour,' Daniel-street, Granville.
1913	P 10	Browne, William Rowan, D.Sc., Assistant-Professor of Geology in the University of Sydney.
1921		Bull, James Towers, 48 Fort-street, Petersham.
1898		‡Burfitt, W. Fitzmaurice, B.A., M.B., Ch.M. B.Sc., *Syd.*, 'Wyoming,' 175 Macquarie-street, Sydney.
1926		Burkitt, Arthur Neville St. George, M.B, B.Sc., Professor of Anatomy in the University of Sydney.
1919	P 10	Burrows, George Joseph, B.Sc., Lecturer and Demonstrator in Chemistry in the University of Sydney; p.r. Watson-street, Neutral Bay.

Elected		
1909		Calvert, Thomas Copley, Assoc.M.Inst.C.E., Department of Public Works, Sydney.
1904	P 26	Cambage, Richard Hind, C.B.E., L.S., F.L.S., 49 Park Road, Burwood. (President 1912, 1923). *Hon Secretary.*
1923		Cameron, Lindsay Duncan, Hills-street, Mortlake.
1907		Campbell, Alfred W., M.D., Ch.M. *Edin.*, 183 Macquarie-street.
1921		Campbell, John Honeyford, M.B.E., The Royal Mint, Ottawa, Canada.
1876		Cape, Alfred J., M.A. *Syd.*, 'Karoola,' Edgecliff Road, Edgecliff.
1891		Carment, David, F.I.A. *Grt. Brit. & Irel.* F.F.A., *Scot.*, 4 Whaling Road, North Sydney.
1920		Carruthers, Sir Joseph Hector, K.C.M.G., M.L.C., M.A., *Syd.*, LL.D., *St. Andrews*, 'Highbury,' Waverley.
1903	P 3	Carslaw, Horatio S., M.A., Sc. D., Professor of Mathematics in the University of Sydney.
1913	P 3	Challinor, Richard Westman, F.I.C., F.C.S., Lecturer in Chemistry, Sydney Technical College.
1909	P 2	Chapman, Henry G., M.D., B.S., Professor of Physiology in the University of Sydney. *Hon. Treasurer.*
1913	P 14	Cheel, Edwin, Curator National Herbarium, Botanic Gardens, Sydney.
1925		Clark, William E., 'Acacia,' Cambridge-street, Epping.
1909	P 20	Cleland, John Burton, M.D., Ch.M., Professor of Pathology in the University of Adelaide. (President 1917.)
1876		Codrington, John Frederick, M.R.C.S. *Eng.*, L.R.C.P. *Lond.* and *Edin.*, 'Roseneath,' 8 Wallis-street, Woollahra.
1896	P 4	Cook, W. E., M.C.E. *Melb.*, M.Inst.,C.E., Burroway-st., Neutral Bay.
1920		Cooke, Frederick, c/o Meggitt's Limited, 26 King-street.
1913	P 3	Coombs, F. A., F.C.S., Instructor of Leather Dressing and Tanning, Sydney Technical College; p.r. Bannerman Crescent, Rosebery.
1882		Cornwell, Samuel, J.P., 'Capanesk,' Tyagarah, North Coast.
1919		Cotton, Frank Stanley, B.Sc., Chief Lecturer and Demonstrator in Physiology in the University of Sydney.
1909	P 6	Cotton, Leo Arthur, M.A., D.Sc., Professor of Geology in the University of Sydney.
1919		Cowdery, Edward Henry, L.S., 6 Castlereagh-street, Sydney.
1892	P 1	Cowdery, George R., Assoc.M.Inst.C.E., 'Glencoe,' Torrington Road, Strathfield.
1886		Crago, W. H., M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, 185 Macquarie-st.
1921		‡Cresswick, John Arthur, 101 Villiers-street, Rockdale.
1925		Curry, Harris Eric Marshall, 8 Lower Wycombe Road, Neutral Bay.
1912		Curtis, Louis Albert, L.S., F.I.S. (N.S.W.), V.D., No. 1 Mayfair Flats, Macleay-street, Darlinghurst.
1920		Daněs, Jiri Victor, Ph.D. *Prague*, The University, Prague.
1890		Dare, Henry Harvey, M.E., M.Inst.C.E., Commissioner, Water Conservation and Irrigation Commission, Union House, George-street.
1876	P 3	Darley, Cecil West, I.S.O., M.Inst.C.E., 'Longheath,' Little Bookham, Surrey, England; Australian Club, Sydney.
1886	P 23	David, Sir Edgeworth, K.B.E., C.M.G., D.S.O., B.A., D.Sc., F.R.S., F.G.S., Wollaston Medallist, Emeritus Professor of Geology and Physical Geography in the University of Sydney; p.r. 'Coringah,' Sherbroke-road, Hornsby. (President 1895, 1910.)

Elected		
1919	P 2	de Beuzeville, Wilfrid Alex. Watt, Forestry Assessor, Forest Office, Tumut.
1921		Delprat, Guillaume Daniel, C.B.E., 'Keynsham,' Mandeville Crescent, Toorak, Victoria.
1921		Denison, Sir Hugh Robert, K.B.E., 701 Culwulla Chambers, Castlereagh-street.
1894		Dick, James Adam, C.M.G., B.A. *Syd.*, M.D., Ch.M., F.R.C.S. *Edin.*, 'Catfoss,' 59 Belmore Road, Randwick.
1924		Dickinson, Reginald E., B.Sc., Eng. *Lond.*, A.M.I.C.E., Chief Mechanical Engineer's Office, N. S. Wales Railways, Wilson-street, Redfern.
1906		Dixson, William, 'Merridong,' Gordon Road, Killara.
1913	P 3	Doherty, William M., F.I.C., F.C.S., Second Government Analyst, 'Jesmond,' George-street, Marrickville.
1908	P 6	Dun, William S., Palæontologist, Department of Mines, Sydney. (President 1918.)
1924		Dupain, George Zephirin, A.A.C.I., F.C.S., Dupain Institute of Physical Education, Daking House, Pitt-street, p.r. 'Symington,' Parramatta Road, Ashfield.
1924		Durham, Joseph, 120 Belmore Road, Randwick.
1923	P 1	Earl, John Campbell, B.Sc., Ph.D., Lecturer and Demonstrator in Organic Chemistry in the University of Sydney.
1919		Earp, The Hon. George Frederick, C.B.E., M.L.C., Australia House, Carrington-street.
1924		Eastaugh, Frederick Alldis, A.R.S.M., F.I.C., Assistant-Professor in Chemistry, Assaying and Metallurgy in the University of Sydney.
1918		‡Elliott, Edward, c/o Reckitts' (Oversea) Ltd., Bourke-street, Redfern.
1916	P 2	Enright, Walter J., B.A., High-street, West Maitland, N.S.W.
1908		Esdaile, Edward William, 42 Hunter-street.
1896		Fairfax, Geoffrey E., *S. M. Herald* Office, Hunter-street.
1887		Faithfull, R. L., M.D., *New York*, L.R.C.P., L.S.A. *Lond.*, c/o Iceton, Faithfull and Maddocks, 25 O'Connell-street.
1921		Farnsworth, Henry Gordon, 'Rothsay,' 90 Alt-street, Ashfield.
1910		Farrell, John, A.T.C., *Syd.*, Riverina Flats, 265 Palmer-street, Sydney.
1909	P 7	Fawsitt, Charles Edward, D.Sc., Ph.D., Professor of Chemistry in the University of Sydney. (President 1919).
1922		Ferguson, Andrew, 9 Martin Place, Sydney.
1920	P 1	Ferguson, Eustace William, M.B., Ch.M., 'Timbrabongie,' Gordon Road, Roseville.
1923		Fiaschi, Piero, O.B.E., M.D. (Columbia Univ.), D.D.S. (New York) M.R.C.S. (Eng.), L.R.C.P. (Lond.), 178 Phillip-street.
1920		Fisk, Ernest Thomas, Wireless House, 97 Clarence-street.
1888		Fitzhardinge, His Honour Judge G. H., M.A., 'Red Hill,' Pennant Hills.
1922		Fleming, Edward Patrick, Member of the Development and Migration Committee, Melbourne.
1879		‡Foreman, Joseph, M.R.C.S. *Eng.* L.R.C.P. *Edin.*, 'The Astor,' Macquarie-street.

Elected

1920 Fortescue, Albert John, 'Benambra,' Loftus-street, Arncliffe.
1905 Foy, Mark, c/o Hydro Office, 133a Pitt-street, Sydney.
1904 Fraser, James, C.M.G., M.Inst.C.E., Chief Commissioner for Railways, Bridge-street.
1925 Friend, Norman Bartlett, 48 Pile-street, Dulwich Hill.

1918 Gallagher, James Laurence, M.A. *Syd.*, 'Akaroa,' Ellesmere Avenue, Hunter's Hill.
1926 Gibson, Alexander James, M.E., M.Inst.C.E., M.I.E.Aust., 906 Culwulla Chambers, Castlereagh-street, Sydney.
1921 Godfrey, Gordon Hay, M.A., B.Sc., Lecturer in Physics in the Technical College, Sydney; p.r. 262 Johnston-street, Annandale.
1897 Gould, The Hon. Sir Albert John, K.B., V.D., 'Eynesbury,' Edgecliff.
1922 P 5 Grant, Robert, F.C.S., Department of Public Health, 93 Macquarie-street.
1916 Green, Victor Herbert, 19 Bligh-street.
1922 P 1 Greig, William Arthur, Mines Department, Sydney.
1899 P 1 Greig-Smith, R., D.Sc. *Edin.*, M.Sc. *Dun.*, Macleay Bacteriologist, Linnean Society's House, Ithaca Road, Elizabeth Bay. (President 1915.) *Hon. Secretary.*
1923 Gurney, William Butler, Government Entomologist, Department of Agriculture, Sydney.
1919 Grutzmacher, Frederick Lyle, F.C.S., Church of England Grammar School, North Sydney.

1880 P 5 Halligan, Gerald H., L.S., F.G.S., c/o Royal Society, 5 Elizabeth-street, Sydney.
1912 Hallmann, E. F., B.Sc., 72 John-street, Petersham.
1892 Halloran, Henry Ferdinand, L.S., 82 Pitt-street.
1919 Hambridge, Frank, 58 Pitt-street.
1916 P 1 Hamilton, Arthur Andrew, 'The Ferns,' 17 Thomas-st., Ashfield
1912 Hamilton, Alexander G., 'Tanandra,' Hercules-st., Chatswood.
1887 P 8 Hamlet, William M., F.I.C., F.C.S., Member of the Society of Public Analysts; 'Glendowan,' Glenbrook, Blue Mountains. B.M.A. Building, 30 Elizabeth-st. (President 1899, 1908).
1909 Hammond, Walter L., B.Sc., High School, Bathurst.
1916 Hardy, Victor Lawson, 'Tiri Mona,' 11A Gordon-av., Randwick
1905 P 5 Harker, George, D.Sc., F.A.C.I., Chamber of Commerce Building, 35 William-street, Melbourne.
1913 P 1 Harper, Leslie F., F.G.S., Geological Surveyor, Department of Mines, Sydney.
1919 Harrison, Launcelot, B.A. *Cantab.*, B.Sc., *Syd.*, Professor of Zoology in the University of Sydney.
1923 Harrison, Travis Henry, Lecturer in Entomology and Botany at the Hawkesbury Agricultural College, Richmond.
1918 Hassan, Alex. Richard Roby, c/o W. Angliss & Co. Ppty. Ltd., 64 West Smithfield, London, E.C.
1919 Hay, Alexander, Coolangatta, N.S.W.
1916 Hay Dalrymple-, Richard T., L.S.; p.r. Goodchap-rd., Chatswood.
1914 Hector, Alex. Burnet, c/o Hector Bros., Claremont, Marengo, *via* Young.

Elected.		
1916		Henderson, James, 'Dunsfold,' Clanalpine-street, Mosman.
1919		Henriques, Frederick Lester, 208 Clarence-street.
1919	P 2	Henry, Max, D S.O., B.V.Sc., M.R.C.V.S., 'Coram Cottage,' Essex-street, Epping.
1884	P 1	Henson, Joshua B., Assoc.M.Inst.C.E., 28 Barton-street, Mayfield, Newcastle.
1918		Hindmarsh, Percival, M.A., B.Sc. (Agr.), Teachers' College, The University, Sydney; p.r. 'Lurnea,' Canberra Avenue, Greenwich.
1921	P 2	Hindmarsh, William Lloyd, B.V.Sc., M.R.C.V.S., D.V.H., District Veterinary Officer, Armidale.
1916		Hoggan, Henry James, A.M.I.M.E., A.M.I.E. (Aust.), Manchester Unity Chambers, 160 Castlereagh-street; p.r. 'Lincluden,' Frederick-street, Rockdale.
1924		Holme, Ernest Rudolph, O.B.E., M.A., Professor of English Language in the University of Sydney.
1901		Holt, Thomas S., 'Amalfi,' Appian Way, Burwood.
1905	P 3	Hooper, George, F.T.C. *Syd.*, Assistant Superintendent, Sydney Technical College; p.r. 'Nycumbene,' Nielson Park, Vaucluse.
1920		Hordern, Anthony, C.B.E., c/o Messrs. A. Hordern & Sons Ltd., Brickfield Hill.
1919		Horsfall, William Nichols, M.B., B.S. *Melb.*, 10 Morton-street, North Sydney.
1919		Hoskins, Arthur Sidney, Eskroy Park, Bowenfels.
1919		Hoskins, Cecil Harold, Windarra, Bowenfels.
1919		Houston, Ralph Liddle, No. 1 Lincluden Gardens, Fairfax-rd., Double Bay.
1906		Howle, Walter Cresswell, L.S.A. *Lond.*, 215 Macquarie-street.
1913		Hudson, G. Inglis, J.P., F.C.S., 'Gudvangen,' Arden-st., Coogee.
1920		Hulle, Edward William, Commonwealth Bank of Australia.
1923	P 2	Hynes, Harold John, B.Sc., (Agr.), Walter and Eliza Hall Agricultural Research Fellow, Biological Branch, Department of Agriculture, Sydney.
1923		Ingram, William Wilson, M.C., M.D., Ch.B., The University, Sydney.
1922		Jacobs, Ernest Godfried, 'Cambria,' 106 Bland-street, Ashfield.
1904		Jaquet, John Blockley, A.R.S.M., F.G.S., Chief Inspector of Mines, Department of Mines, Sydney.
1925		Jenkins, Charles Adrian, B.E., B.Sc., 'Monterey,' 9 Niblish-street, Bondi.
1917		Jenkins, Richard Ford, Engineer for Boring, Irrigation Commission, 6 Union-street, Mosman.
1918		John, Morgan Jones, M.I.Mech.E., A.M.I.E.E. *Lond.*, M.I.E. *Aust.*, M.I.M. *Aust.*, Olphert Avenue, Vaucluse.
1909	P 15	Johnston, Thomas Harvey, M.A., D.Sc., F.L.S., C.M.Z.S., Professor of Zoology in the University of Adelaide.
1924		Jones, Leo Joseph, Geological Surveyor, Department of Mines, Sydney.
1911		Julius, George A., B Sc., M.E., M.I.Mech.E., Culwulla Chambers, Castlereagh-street, Sydney.

Elected		
1876	P 4	Keele, Thomas William, L.S., M.Inst.C.E., 'Gladsmuir,' Rivers-street, Woollahra.
1924		Kenner, James, Ph.D., D.Sc., F.R.S., Professor of Organic Chemistry in the University of Sydney.
1924		Kenny, Edward Joseph, Field Assistant, Department of Mines, Sydney; p r. 45 Robert-street, Marrickville.
1887		Kent, Harry C., M.A., F.R.I.B.A., Dibbs' Chambers, 58 Pitt-st.
1919	P 3	Kesteven, Hereward Leighton, M.D., Ch.M., D.Sc., Bulladelah, New South Wales.
1896		King, Kelso, 14 Martin Place.
1923		Kinghorn, James Roy, Australian Museum, Sydney.
1920		Kirchner, William John, B.Sc., c/o Burroughs Wellcome & Co., Victoria-street, Waterloo.
1919		Kirk, Robert Newby, 25 O'Connell-street.
1881	P 26	Knibbs, Sir George, Kt., C.M.G., Hon.F.S.S., F.R.A.S., L.S., Member Internat. Assoc. Testing Materials; Memb. Brit. Sc. Guild, 'Cooyal,' 27 Sunnyside Avenue, Camberwell, Victoria. (President 1898).
1877		Knox, Edward W., 'Rona,' Bellevue Hill, Double Bay.
1911	P 3	Laseron, Charles Francis, Technological Museum.
1924		Leech, Thomas David James, B.Sc., *Syd.*, 'Orontes,' Clarke-st., Granville.
1920		Le Souef, Albert Sherbourne, Taronga Park, Mosman.
1916		L'Estrange, Walter William, 7 Church-street, Ashfield.
1909		Leverrier, Frank, B.A., B.Sc., K.C., Wentworth Road, Vaucluse.
1883		Lingen, J. T., M.A. *Cantab.*, K.C., University Chambers, 167 Phillip-street, Sydney.
1923		Lipscomb, Alan Price, L.S., c/o Land Board Office, Goulburn.
1906		Loney, Charles Augustus Luxton, M.Am.Soc.Refr.E., Equitable Building, George-street.
1924		Love, David Horace, Beauchamp Avenue, Chatswood.
1884		MacCormick, Sir Alexander, K.C.M.G., M.D., C.M. *Edin.*, M.R.C.S. *Eng.*, 185 Macquarie-street.
1887		MacCulloch, Stanhope H., M.B., Ch.M. *Edin.*, 26 College-street.
1878		MacDonald, Ebenezer, J.P., c/o Perpetual Trustee Co., Ld., Hunter-street, Sydney.
1923		Mackay, Iven Giffard, C.M.G., D.S.O., B.A., Student Adviser and Secretary of Appointments Board, The University, Sydney.
1921		McDonald, Alexander Hugh Earle, Superintendent of Agriculture, Department of Agriculture, Sydney.
1903		McDonald, Robert, J.P., L.S., Pastoral Chambers, O'Connell-st; p.r. 'Lowlands,' William-street, Double Bay.
1919		McGeachie, Duncan, M.I.M.E., M.I.E. (Aust.), M.I.M.M. (Aust.), 'Craig Royston,' Toronto, Lake Macquarie.
1906		McIntosh, Arthur Marshall, 'Moy Lodge,' Hill-st., Roseville.
1891	P 2	McKay, R. T., L.S., M.Inst.C.E., Commissioner, Sydney Harbour Trust, Circular Quay.
1880	P 9	McKinney, Hugh Giffin, M.E., Roy. Univ. *Irel.*, M.Inst.C.E., Sydney Safe Deposit, Paling's Buildings, Ash-street.

Elected		
1922		McLuckie, John, M.A., B.Sc., (*Glasgow*), D.Sc., (*Syd.*), Lecturer in Botany in the University of Sydney.
1901	P 1	McMaster, Colin J., L.S., 'Crona,' Keydon Avenue, Warrawee.
1916		McQuiggin, Harold G., M.B., Ch.M., B.Sc., Lecturer and Demonstrator in Physiology in the University of Sydney; p.r. 'Berolyn,' Beaufort-street, Croydon.
1909		Madsen, John Percival Vissing, D.Sc., B.E., Professor of Electrical Engineering in the University of Sydney.
1924		Mance, Frederick Stapleton, Under Secretary for Mines, Mines Department, Sydney; p.r. 'Binbah,' Lucretia Avenue, Longueville.
1880	P 1	Manfred, Edmund C., Montague-street, Goulburn.
1920	P 1	Mann, Cecil William, Kent-street, Epping.
1920		Mann, James Elliott Furneaux, Barrister at Law, c/o H. Southerden, Esq., Box 1646 J.J., G.P.O., Sydney.
1908		Marshall, Frank, C.M.G., B.D.S., 151 Macquarie-street.
1914		Martin, A. H., Technical College, Sydney.
1926		Mathews, Hamilton Bartlett, B.A. *Syd.*, Surveyor General of N.S.W., Department of Lands, Sydney.
1912		Meldrum, Henry John, B.A., B.Sc. 'Craig Roy,' Sydney Road, Manly.
1922		Mills, Arthur Edward, M.B., Ch.M., Dean of the Faculty of Medicine, Professor of Medicine in the University of Sydney, 143 Macquarie-street.
1926		Mitchell, Ernest Marklow, 106 Harrow Road, Rockdale
1879		Moore, Frederick H., Union Club, Sydney.
1922	P 9	Morrison, Frank Richard, Assistant Chemist, Technological Museum, Sydney; p.r. Brae-street, Waverley.
1924		Morrison, Malcolm, Department of Mines, Sydney.
1924		Mullens, Arthur Launcelot, c/o Mullens & Co., 115 Pitt-street.
1879		Mullins, John Lane, M.A. *Syd.*, M.L.C., 'Killountan,' Double Bay.
1915		Murphy, R. K., Dr. Ing., Chem. Eng., Lecturer in Chemistry, Technical College, Sydney.
1923	P 2	Murray, Jack Keith, B.A., B.Sc. (Agr.), Principal, Queensland Agricultural College, Gatton, Queensland.
1893	P 4	Nangle, James, O.B.E., F.R.A.S., Superintendent of Technical Education, The Technical College, Sydney; The Observatory, Sydney. (President 1920.) *Vice-President.*
1917		Nash, Norman C., 'Ruanora,' Lucas Road, Burwood.
1924		Nickoll, Harvey, L.R.C.P., L.R.C.S., Barham, via Mudgee, N.S.W.
1891		‡Noble, Edward George, L.S., 8 Louisa Road, Balmain.
1920		Noble, Robert Jackson, M.Sc., B.Sc., (Agr.), Ph.D., Agricultural Museum, George-street, North; p.r. 'Lyndon,' Carrington-street, Homebush.
1903		‡Old, Richard, 'Waverton,' Bay Road, North Sydney.
1921		Olding, George Henry, 4 Bayswater Road, Drummoyne.
1913		Ollé, A. D., F.C.S., 'Kareema,' Charlotte-street, Ashfield.
1925		Ollé, Claude Henry, 30 Martin Place, Sydney.

Elected		
1896		Onslow, Col. James William Macarthur, B.A., LL.B., 'Gilbulla,' Menangle.
1917		Ormsby, Irwin, 'Caleula,' Allison Road, Randwick.
1891		Osborn, A. F., Assoc.M.Inst.C.E., Water Supply Branch, Sydney, 'Uplands,' Meadow Bank, N.S.W.
1921	P 2	Osborne, George Davenport, B.Sc., Lecturer and Demonstrator in Geology in the University of Sydney; p.r. 'Belle-Vue,' Kembla-st., Arncliffe.
1920		Paine, William Horace, State Abattoirs, Homebush Bay, N.S.W.
1880		Palmer, Joseph, 96 Pitt-st.; p.r. Kenneth-st., Willoughby.
1921		Parkes, Varney, Royal Chambers, Castlereagh-street.
1920	P 39	Penfold, Arthur Ramon, F.C.S., Economic Chemist, Technological Museum, Harris-street, Ultimo.
1909	P 2	Pigot, Rev. Edward F., S.J., B.A., M.B. *Dub.*, Director of the Seismological Observatory, St. Ignatius' College, Riverview.
1879	P 8	Pittman, Edward F., Assoc.R.S.M. L.S., 'The Oaks,' Park-street, South Yarra, Melbourne.
1881		Poate, Frederick, F.R.A.S., L.S., 'Clanfield,' 50 Penkivil-street, Bondi.
1919		Poate, Hugh Raymond Guy, M.B., Ch. M. *Syd.*, F.R.C.S. *Eng.*, L.R.C.P. *Lond.*, 225 Macquarie-street.
1917		Poole, William, M.E., (Civil, Min. and Met.) *Syd.*, M. Inst. C.E., M.I.M.M., M.I.E., Aust., M.Am. I.M.E., M. Aust. I. M.M., L.S., 906 Culwulla Chambers, Castlereagh-street.
1896		Pope, Roland James, B.A., *Syd.*, M.D., Ch.M., F.R.C.S.. *Edin.*, 185 Macquarie-street.
1921	P 2	Powell, Charles Wilfrid Roberts, A.I.C., c/o Colonial Sugar Refining Co., O'Connell-street.
1918		Powell, John, 170-2 Palmer-street.
1918		Priestley, Henry, M.D., Ch. M., B.Sc., Associate-Professor of Physiology in the University of Sydney.
1893		Purser, Cecil, B.A., M.B., Ch.M. *Syd.*, 185 Macquarie-street.
1912	P 2	Radcliff, Sidney, F.C.S., Department of Chemistry, The University of Sydney; p.r. Leura.
1922		Raggatt, Harold George, B.Sc., Lord-street, Roseville.
1919	P 3	Ranclaud, Archibald Boscawen Boyd, B.Sc., B.E., Lecturer in Physics, Teachers' College, The University, Sydney.
1909		Reid, David, 'Holmsdale,' Pymble.
1920		Richardson, John James, A.M.I.E.E. *Lond.*, 'Kurrawyba,' Upper Spit Road, Mosman.
1921		Robertson, Frederick Arnold, Science Master, Sydney C. of E. Grammar School, North Sydney.
1924		Robertson, James R. M., M.D., C.M., F.R.G.S., F.G.S., 'Vanduara,' Ellamang Avenue, Kirribilli.
1884		Ross, Chisholm, M.D. *Syd.*, M.B., Ch.M., *Edin.*, 225 Macquarie-st.
1895	P 1	Ross, Herbert E., Equitable Building, George-street.
1925		Roughley, Theodore Cleveland, Technological Museum, Sydney.
1897		Russell, Harry Ambrose, B.A., c/o Sly and Russell, 369 George-street; p.r. 'Mahuru,' Park Road, Bowral.

Elected		
1907		Ryder, Charles Dudley, Assoc.I.R.M., F.C.S., A.A.C.I., Sydney-st., Chatswood.
1922		Sandy, Harold Arthur Montague, 326 George-street.
1926		Saunderson, William. B.Sc. *Dun*,, F.C.S., Licentiate, College of Preceptors *England*, c/o Messrs. H. B. Se.by & Co., Bulletin Place, Sydney.
1917		Sawkins, Dansie T., M.A., 'Brymedura,' Kissing Point Road, Turramurra.
1920		Sawyer, Basil, B E., 'Birri Birra,' The Crescent, Vaucluse.
1920		Scammell, Rupert Boswood, B.Sc., *Syd.*, 18 Middle Head Road, Mosman.
1913		Scammell, W. J., Mem. Pharm. Soc. *Grt. Brit.*, 18 Middle Head Road, Mosman.
1919		Sear, Walter George Lane, c/o J. Kitchen & Sons, Ingles-st., Port Melbourne.
1923	P 1	Seddon, Herbert Robert, D.V.Sc., Director, Veterinary Research Station, Glenfield.
1918		Sevier, Harry Brown, c/o Lewis Berger and Sons (Aust.) Ltd., Cathcart House, Castlereagh-street.
1924		Shelton, James Peel, M.Sc., B.Sc., Agr., Department of Agriculture, Canberra.
1917		Sibley, Samuel Edward, Mount-street, Coogee.
1900		Simpson, R. C., Lecturer in Electrical Engineering, Technical College, Sydney.
1910		Simpson, William Walker, 'Strathford,' Lord-street, Roseville.
1916		Smith, Stephen Henry, Under Secretary and Director of Education, Department of Education, Sydney.
1922	P 1	Smith, Thomas Hodge, Australian Museum, Sydney.
1919		Southee, Ethelbert Ambrook, O.B.E., M.A., B.Sc., Principal, Hawkesbury Agricultural College, Richmond, N.S.W.
1921		Spencer-Watts, Arthur, 'Araboonoo,' Glebe-street, Randwick.
1917		Spruson, Wilfred Joseph, Daily Telegraph Building, King-st.
1916		Stephen, Alfred Ernest, F.C.S., 801 Culwulla Chambers, 67 Castlereagh-street, Sydney.
1921		Stephen, Henry Montague, B.A., LL.B., c/o McCarthy & Marshall, 11A Castlereagh-street.
1914		Stephens, Frederick G. N., F.R.C.S., M.B., Ch.M., 13 Dover Road, Rose Bay.
1920	P 1	Stephens, John Gower, M.B., Royal Prince Alfred Hospital, Camperdown.
1913		Stewart, Alex. Hay, B.E., 'Yunah,' 22 Murray-street. Croydon
1900		Stewart, J. Douglas, B.V.Sc., M.R.C.V.S., Professor of Veterinary Science in the University of Sydney; p.r. 'Berelle,' Homebush Road, Strathfield.
1909		Stokes, Edward Sutherland, M.B. *Syd.*, F.R.C.P. *Irel.*, Medical Officer, Metropolitan Board of Water Supply and Sewerage, 341 Pitt-street.
1916	P 1	Stone, W. G., Assistant Analyst, Department of Mines, Sydney.
1919		Stroud, Sydney Hartnett, F.I.C., c/o Elliott Bros., Ltd., Terry Street, Rozelle; p.r. Fifth-street, South Ashfield.
1918		Sullivan, Herbert Jay, c/o Lewis Berger and Sons (Aust.) Ltd., Rhodes.
1920		Sulman, Sir John, Kt., Warrung-st., McMahon's Point, North Sydney.

Elected		
1918		Sundstrom, Carl Gustaf, c/o Federal Match Co., Park Road, Alexandria.
1901	P 11	Sussmilch, C. A., F.G.S., Principal of the Technical College, Newcastle, N.S.W. (President 1922.) *Vice-President.*
1919		‡Sutherland, George Fife, A.R.C.Sc., *Lond.*, Assistant-Professor in Mechanical Engineering, in the University of Sydney.
1920		Sutton, Harvey, O.B.E., M.D., D.P.H. *Melb.*, B.Sc. *Oxon.*, 'Lynton,' Kent Road, Rose Bay.
1919		Swain, Herbert John, B.A. *Cantab.*, B.Sc., B.E. *Syd.*, Lecturer in Mechanical Engineering, Technical College, Sydney.
1926		Tannahill, Robert William, B.Sc. *Syd.*, 'Astoria,' Kirribilli
1925		Taylor, George Augustine, F.R.A.S., F.R.G.S., 20 Loftus-street, Sydney.
1915	P 2	Taylor, Harold B., D.Sc., Kenneth-street, Longueville.
1893		‡Taylor, James, B.Sc., A.R.S.M. 'Cartref,' Brierly-st., Mosman.
1921	P 2	Taylor, John Kingsley, Hawkesbury Agricultural College, Richmond; p.r. 16 Ferrier-street, Rockdale.
1905		Taylor, John M., M.A., LL.B. *Syd.*, 'Woonona,' 43 East Crescent-street, McMahon's Point, North Sydney.
1921	P 4	Taylor, Thomas Griffith, B.A., D.Sc., B.E., Associate-Professor of Geography in the University of Sydney.
1899		Teece, R., F.I.A., F.F.A., Wolseley Road, Point Piper.
1923		Thomas, David, B.E., M.I.M.M., F.G.S., 15 Clifton Avenue, Burwood.
1919		Thomas, John, L.S., Chief Mining Surveyor, Mines Department Sydney; p.r. 'Remeura,' Pine and Harrow Roads, Auburn.
1924		Thompson, Herbert William, 'Marathon,' Francis-st., Randwick
1913		Thompson, Joseph, M.A., LL.B., Vickery's Chambers, 82 Pitt-st.
1919		Thorne, Harold Henry, B.A. *Cantab.*, B.Sc. *Syd.*, Lecturer in Mathematics in the University of Sydney; p.r. Rutledge-st., Eastwood.
1916		Tillyard, Robin John, M.A., D.Sc., F.R.S., F.L.S., F.E.S., Biological Branch, Cawthron Institute, Nelson, New Zealand.
1923		Timcke, Edward Waldemar, Meteorologist, Weather Bureau, Sydney.
1923		Tindale, Harold, Works Engineer, c/o Australian Gas-Light Co., Mortlake.
1923		Toppin, Richmond Douglas, A.I.C., Parke Davis & Co., Rosebery.
1879		Trebeck, P. C., c/o Box 367 G.P.O., Sydney.
1925		Tye, Cyrus Willmott Oberon, Under Secretary for Public Works, Public Works Dept., Sydney; p.r. 19 Muston-st., Mosman.
1916		Valder, George, J.P., 3 Milner-street, Mosman.
1890		Vicars, James, M.E., Memb. Intern. Assoc. Testing Materials; Memb. B. S. Guild; Challis House, Martin Place.
1921		Vicars, Robert, Marrickville Woollen Mills, Marrickville.
1892		Vickery, George B., 78 Pitt-street.

Elected		
1903	P 5	Vonwiller, Oscar U., B.Sc., F.Inst.P., Professor of Physics in the University of Sydney.
1924		Wade, Rev. Robert Thompson, M.A., Headfort School, Killara.
1919		Waley, Robert George Kinloch, 63 Pitt-street.
1910		Walker, Charles, 'Lynwood,' Terry Road, Ryde.
1910		Walker, Harold Hutchison, Vickery's Chambers, 82 Pitt-st.
1879		Walker, H. O., 'Moora,' Crown-street, Parramatta.
1919	P 1	Walkom. Arthur Bache, D.Sc., Macleay House, 16 College-st.
1903		Walsh, Fred., J.P., Consul-General for Honduras in Australia and New Zealand; For. Memb. Inst. Patent Agents, London; Patent Attorney Regd. U.S.A.; Memb. Patent Law Assoc., Washington; Regd. Patent Attorn. Comm. of Aust.; Memb. Patent Attorney Exam. Board Aust.; George and Wynyard-streets; p.r. 'Walsholme,' Centennial Park, Syd.
1901		Walton, R. H., F.C.S., 'Flinders,' Martin's Avenue, Bondi.
1918		Ward, Edward Naunton, Curator of the Botanic Gardens, Syd.
1913	P 4	Wardlaw, Hy. Sloane Halcro, D.Sc. *Syd.*, Lecturer and Demonstrator in Physiology in the University of Sydney.
1922		Wark, Blair Anderson, V.C., D.S.O., M.I.Q.C., c/o Thompson and Wark, T. & G. Building, Elizabeth-street; p.r. 'Braeside,' Zeta-street, Lane Cove, Sydney.
1921		‡Waterhouse, G. Athol, D.Sc., B.E., F.E.S., Stanhope Road, Killara.
1924		Waterhouse, Leslie Vickery, B.E. *Syd.*, 58 Pitt-street.
1919		Waterhouse, Lionel Lawry, B.E. *Syd.*, Lecturer and Demonstrator in Geology in the University of Sydney.
1919	P 2	Waterhouse, Walter L., M.C., B.Sc. (*Agr.*), 'Hazelsmere,' Chelmsford Avenue, Roseville.
1919		Watkin-Brown, Willie Thomas, F.R.M.S., 33 Renwick-street, Redfern.
1876		Watkins, John Leo, B.A. *Cantab.*, M.A. *Syd.*, University Club, Castlereagh-street.
1910		Watson, James Frederick, M.B., Ch.M., 'Midhurst,' Woollahra.
1911	P 1	Watt, Robert Dickie, M.A., B.Sc., Professor of Agriculture in the University of Sydney. (President, 1925).
1920	P 17	Welch, Marcus Baldwin, B.Sc., A.I.C., Economic Botanist, Technological Museum.
1907	P 1	Welch, William, F.R.G.S., 'Roto-iti,' Boyle-street, Mosman.
1920	P 1	Wellish, Edward Montague, M.A., Associate-Professor in Mathematics in the University of Sydney.
1921		Wenholz, Harold, Department of Agriculture, Sydney.
1881		‡Wesley, W. H., London.
1922		Whibley, Harry Clement, 39 Moore-street, Leichhardt.
1909	P 3	‡White, Charles Josiah, B.Sc., Lecturer in Chemistry, Teacher's College.
1918		White, Edmond Aunger, M.A.I.M.E., c/o Electrolytic Refining and Smelting Co. of Australia Ltd., Port Kembla, N.S.W.
1892	P 1	White, Harold Pogson, F.C.S., Assistant Assayer and Analyst, Department of Mines; p.r. 'Quantox,' Park Road, Auburn.
1923		Whitehouse, Frank, B.V.Sc, (Syd.) 'Dane Bank,' Albyn Road, Strathfield.
1921		Willan, Thomas Lindsay, B.Sc., Gopeng Road, Batu Gayah, Perak, Federated Malay States.

Elected		
1920		Williams, Harry, A.I.C., c/o Whiddon Bros.' Rosebery Lanolines Pty. Ltd., Arlington Mills, Botany.
1924		Williams, William John, 5 Effingham-street, Mosman.
1917		Willington, William Thos., O.B.E., 33 Willington-st., Arncliffe.
1923		Wilson, Stanley Eric, 'Chatham,' James-street, Manly.
1891		Wood, Percy Moore, L.R.C.P. *Lond.*, M.R.C.S. *Eng.*, 'Redcliffe,' Liverpool Road, Ashfield.
1906	P 10	Woolnough, Walter George, D.Sc., F.G.S., 'Callabonna,' Park Avenue, Gordon. *President.*
1916		Wright, George, c/o Farmer & Company, Pitt-street.
1917		Wright, Gilbert, Lecturer and Demonstrator in Agricultural Chemistry in the University of Sydney.
1921		Yates, Guy Carrington, 184 Sussex-street.

Honorary Members.

Limited to Twenty.

M.—Recipients of the Clarke Medal.

1918		Chilton, Charles, M.A., D.Sc., M.B., C.M., etc., Professor of Biology, Canterbury College, Christchurch, N.Z.
1914		Hill, James P., D.Sc., F.R.S., Professor of Zoology, University College, London.
1908		Kennedy, Sir Alex. B. W., Kt., LL.D., D. Eng., F.R.S., Emeritus Professor of Engineering in University College, London, 17 Victoria-street, Westminster, London S.W.
1908	P 57	*Liversidge, Archibald, M.A., LL.D., F.R.S., Emeritus Professor of Chemistry in the University of Sydney, 'Fieldhead,' George Road, Coombe Warren, Kingston, Surrey, England. (President 1889, 1900.)
1915		Maitland, Andrew Gibb, F.G.S., Government Geologist of Western Australia, 'Bon Accord,' 2 Charles-street, South Perth, W.A.
1912		Martin, C. J., C.M.G., D.Sc., F.R.S., Director of the Lister Institute of Preventive Medicine, Chelsea Gardens, Chelsea Bridge Road, London, S.W. 1.
1894	M	Spencer, Sir W. Baldwin, K.C.M.G., M.A., D.Sc., F.R.S., Emeritus Professor of Biology in the University of Melbourne, National Museum, Melbourne.
1900	M	Thiselton-Dyer, Sir William Turner, K.C.M.G., C.I.E., M.A., LL.D., Sc.D., F.R.S., The Ferns, Witcombe, Gloucester, England.
1915		Thomson, Sir J. J., O.M., D.Sc., F.R.S., Nobel Laureate, Master of Trinity College, Cambridge, England.
1921		Threlfall, Sir Richard, K.B.E., M.A., F.R.S., lately Professor of Physics in the University of Sydney, 'Oakhurst, Church Road, Edgbaston, Birmingham, England.
1922		Wilson, James T., M.B., Ch.M. *Edin.*, F.R.S., Professor of Anatomy in the University of Cambridge, England.

* Retains the rights of ordinary membership. Elected 1872.

Obituary 1926-27.

Ordinary Members.

Elected.		Elected.	
1913	Dodd, Sydney	1891	Hedley, Charles
1881	Fiaschi, Thomas	1901	Kidd, Hector
1921	Fletcher, Joseph James	1926	Newbigin, William Johnstone
1907	Freeman, William	1878	Thomas, Francis John
1891	Guthrie, Frederick B.		

AWARDS OF THE CLARKE MEDAL.

Established in memory of

The Revd. WILLIAM BRANWHITE CLARKE, M.A., F.R.S., F.G.S., etc.,
Vice-President from 1866 *to* 1878.

To be awarded from time to time for meritorious contributions to the Geology, Mineralogy, or Natural History of Australia. The prefix * indicates the decease of the recipient.

Awarded
1878 *Professor Sir Richard Owen, K.C.B., F.R.S.
1879 *George Bentham, C.M.G., F.R.S.
1880 *Professor Thos. Huxley, F.R.S.
1881 *Professor F. M'Coy, F.R.S., F.G.S.
1882 *Professor James Dwight Dana, LL.D.
1883 *Baron Ferdinand von Mueller, K.C.M.G., M.D., Ph.D., F.R.S., F.L.S.
1884 *Alfred R. C. Selwyn, LL.D., F.R.S., F.G.S.
1885 *Sir Joseph Dalton Hooker, O.M., G.C.S.I., C.B., M.D., D.C.L., LL.D., F.R.S.
1886 *Professor L. G. De Koninck, M.D.
1887 *Sir James Hector, K.C.M.G., M.D., F.R.S.
1888 *Rev. Julian E. Tenison-Woods, F.G.S., F.L.S.
1889 *Robert Lewis John Ellery, F.R.S., F.R.A.S.
1890 *George Bennett, M.D., F.R.C.S. *Eng.*, F.L.S., F.Z.S.
1891 *Captain Frederick Wollaston Hutton, F.R.S., F.G.S.
1892 Sir William Turner Thiselton Dyer, K.C.M.G., C.I.E., M.A., LL.D., Sc. D., F.R.S., F.L.S., late Director, Royal Gardens, Kew.
1893 *Professor Ralph Tate, F.L.S., F.G.S.
1895 *Robert Logan Jack, LL.D., F.G.S., F.R.G.S.
1895 *Robert Etheridge, Jnr.
1896 *The Hon. Augustus Charles Gregory, C.M.G., F.R.G.S.
1900 *Sir John Murray, K.C.B., LL.D., Sc. D., F.R.S.
1901 *Edward John Eyre.
1902 *F. Manson Bailey, C.M.G., F.L.S.
1903 *Alfred William Howitt, D.Sc., F.G.S.
1907 Walter Howchin, F.G.S., University of Adelaide.
1909 Dr. Walter E. Roth, B.A., Pomeroon River, British Guiana, South America.
1912 *W. H. Twelvetrees, F.G.S.
1914 A. Smith Woodward, LL.D., F.R.S., Keeper of Geology, British Museum (Natural History) London.
1915 *Professor W. A. Haswell, M.A., D.Sc., F.R.S.
1917 Professor Sir Edgeworth David, K.B.E., C.M.G., D.S.O., B.A., D.Sc., F.R.S., F.G.S., The University, Sydney.
1918 Leonard Rodway, C.M.G., Honorary Government Botanist, Hobart, Tasmania.
1920 *Joseph Edmund Carne, F.G.S.
1921 *Joseph James Fletcher, M.A., B.Sc.,
1922 Richard Thomas Baker, The Avenue, Cheltenham.
1923 Sir W. Baldwin Spencer, K.C.M.G., M.A., D.Sc., F.R.S., National Museum, Melbourne.
1924 *Joseph Henry Maiden, I.S.O., F.R.S., F.L.S., J.P.
1925 *Hedley, Charles, F.L.S.

AWARDS OF THE SOCIETY'S MEDAL AND MONEY PRIZE.

Money Prize of £25.

Awarded.

1882 John Fraser, B.A., West Maitland, for paper entitled 'The Aborigines of New South Wales.'

1882 Andrew Ross, M.D., Molong. for paper entitled 'Influence of the Australian climate and pastures upon the growth of wool.'

The Society's Bronze Medal and £25.

1884 W. E. Abbott, Wingen, for paper entitled 'Water supply in the Interior of New South Wales.'

1886 S. H. Cox, F.G.S., F.C.S., Sydney, for paper entitled 'The Tin deposits of New South Wales.'

1887 Jonathan Seaver, F.G.S., Sydney, for paper entitled 'Origin and mode of occurrence of gold-bearing veins and of the associated Minerals.'

1888 Rev. J. E. Tenison-Woods, F.G.S., F.L.S., Sydney, for paper entitled 'The Anatomy and Life-history of Mollusca peculiar to Australia.'

1889 Thomas Whitelegge, F.R.M.S., Sydney, for paper entitled 'List of the Marine and Fresh-water Invertebrate Fauna of Port Jackson and Neighbourhood.'

1889 Rev. John Mathew, M.A., Coburg, Victoria, for paper entitled 'The Australian Aborigines.'

1891 Rev. J. Milne Curran, F.G.S., Sydney, for paper entitled 'The Microscopic Structure of Australian Rocks.'

1892 Alexander G. Hamilton, Public School, Mount Kembla, for paper entitled 'The effect which settlement in Australia has produced upon Indigenous Vegetation.'

1894 J. V. De Coque, Sydney, for paper entitled the 'Timbers of New South Wales.'

1894 R. H. Mathews, L.S., Parramatta, for paper entitled 'The Aboriginal Rock Carvings and Paintings in New South Wales.'

1895 C. J. Martin, D.Sc., M.B., F.R.S., Sydney, for paper entitled 'The physiological action of the venom of the Australian black snake (*Pseudechis porphyriacus*).'

1896 Rev. J. Milne Curran, Sydney, for paper entitled 'The occurrence of Precious Stones in New South Wales, with a description of the Deposits in which they are found.'

PRESIDENTIAL ADDRESS.

By Professor R. D. Watt, M.A., B.Sc.

(Delivered to the Royal Society of N.S. Wales on May 5, 1926.)

The past year has been one of satisfactory progress in the important work of the Royal Society of New South Wales.

At our regular monthly meetings 26 papers were read, all of them distinct contributions to the advancement of science.

The three sections of the Society—Agriculture, Geology, and Industry, held regular meetings throughout the year, and the important new section of Physics has been added to the list.

Four popular science lectures were delivered as follows:

"The Elements and Their Spectra," by Professor Vonwiller;

"Vitamins," by Associate-Professor Priestley;

"The Influence of Organic Chemistry on Economic Conditions," by Professor Kenner;

and "The Hawaiian Islands," by Sir Joseph Carruthers.

The full income resulting from the recent additions to the Society's House came in for the first time during the past year with satisfactory results to the financial position of the Society. The necessity for a further change in the housing of the Society has been obvious for some time, and the Council has given very serious consideration to this matter, although plans have not yet reached such a stage of finality that an announcement can be made.

The best thanks of the President and members are due to the Hon. Secretaries for the very efficient way in which they have carried out their duties, and to the Hon. Treasurer for the very capable manner in which he has looked after the financial interests of the Society.

During the year ten new members have been elected, and ten have resigned, and one honorary member and three of our ordinary members have died. Though the losses through death have not been so numerous as in some previous years, it has been our misfortune to lose three of our oldest members, including two who were for many years intimately connected with the work and progress of the Society—Mr. J. H. Maiden and Professor Warren.

Dr. William Bateson, F.R.S., who has been an Honorary Member since 1914, was born in 1866, and died in February, 1926. He was educated at Rugby and at St. John's College, Cambridge, where he graduated in 1882, gaining first class honours in both parts of the Natural Sciences Tripos. His first researches had to do with the position of Balanoglossus in the phylogenetic scheme, and the results appeared in a series of articles in the "Quarterly Journal of Microscopical Science." These papers immediately attracted attention, and in 1885 he was elected a Fellow of his College. From that time on, his main interests were in evolutionary problems, and he entered vigorously into the controversies which centred round the nature of species, and the facts connected with variation.

In search of evidence, he made collections in the field, and visited museums at home and abroad, and even made a journey to the western parts of Central Asia and Siberia. The outcome was the publication of a book on "Materials for the Study of Variation," which marked a new era in biological thought.

Later on, Bateson started upon another line of research, namely, an elaborate series of breeding experiments to determine how varieties behaved on crossing. He first started with Lepidoptera, but soon concluded that it would be better to use material in which the problem could be reduced to its simplest form. A series of experiments was, therefore, started, with plants, and later with poultry. He emphasised the necessity of examining the outcome of a cross statistically, and of marshalling the offspring in respect to each differentiating character separately. Now this was exactly what led to Mendel's success, and when Mendel's work was re-discovered in 1900, it found Bateson thoroughly prepared. Indeed, some go so far as to say that, even if Mendel's papers had been destroyed, Bateson soon would have supplied those guiding principles which have raised the study of heredity to an exact science. He did much to popularise and emphasise the results of Mendel's famous laws; indeed, one may say that all his subsequent work was concentrated on the further illustration and elaboration of Mendel's principles and the investigation of problems which arose out of them. He was the first to draw attention to the phenomenon of linkage of characters, although it remained for the American school of geneticists to supply the full explanation in terms of chromosomes. Bateson soon gathered round him a band of enthusiastic workers and a Chair of Biology at Cambridge was practically created for him in 1908. In the following year appeared his great book "Mendel's Principles of Heredity"—the standard work on the subject for many years.

He did not occupy his professorial chair for very long, as he was in 1910 invited to be Director of the John Innes Horticultural Institute at Merton, which position he accepted, as it gave him more time and greater opportunities for research.

In 1914 Dr. Bateson was President of the British Association for the Advancement of Science in Australia, and all who came in contact with him were impressed with his vivid personality and the interesting and forceful manner in which he unfolded the wonderful story he had to tell.

He was for a time rather critical of the American geneticists, and sceptical about the chromosome hypothesis, but it is characteristic of him that, when convinced that they were right, he was most generous in appreciation of their work. Although his main motive in life was to get a closer insight into nature's secrets, he was always most anxious and willing to help plant-breeders who consulted him about their problems, and many can testify to the valuable help they received from him. By his death the science of Genetics has lost one of its ablest exponents and workers, and the naturalists of the Empire one of their most inspiring leaders.

Joseph Henry Maiden, I.S.O., F.R.S., F.L.S., was born at St. John's Wood, London, in April, 1859, and died at his residence at Turramurra, Sydney, on the 16th November, 1925.

He received his education at the City of London Middle Class School, and the University of London. As a student he showed a taste for science, and for some time was assistant to the late Professor F. Barff. He never completed the requirements for his science degree as, on account of his health, he was ordered a long sea voyage. He came to Australia in 1880. It is related that he provided himself with a return ticket, but the climate proved so beneficial, and the botanical problems appeared so fascinating, that he decided to remain. Soon after his arrival, Mr. Maiden became associated with the formation of the Technological

Museum, Sydney, of which he was Curator from 1881 to 1896. He soon began to study the native plants, and some of his early botanical instruction was received from the late Revd. Dr. Wm. Woolls, for whom he always cherished the most affectionate memories. He was also a colleague in botanical work of the late Baron Von Mueller, another of the great pioneers of Australian botany. Mr. Maiden was Superintendent of Technical Education from 1894 to 1896, Consulting Botanist to the Department of Agriculture and Forestry from 1890, and Director of the Botanic Gardens, Sydney, and Government Botanist, from 1896 until his retirement in 1924.

The genus which he studied most extensively was that almost exclusively Australian one—*Eucalyptus*—and he added very many new species to the list previously known, his field of investigation extending all over Australia. His enthusiasm and energy enabled him to form the present Herbarium at Sydney Botanic Gardens—one of the finest in the Southern Hemisphere—and to make numerous personal journeys in the various States in search of material to enrich his collections. He also, at considerable trouble, obtained type specimens which were collected in Australia in the early days, but had been housed in herbaria in other parts of the world, including some collected by Sir Joseph Banks in 1770.

Perhaps his greatest work in the field of botanical research is his "Critical Revision of the Genus Eucalyptus," of which 64 parts had appeared at the time of his death, and others are still going through the press. Another valuable publication is his "Forest Flora of New South Wales," of which 77 parts have been issued. Other publications include "Illustrations of New South Wales' Plants" and "Useful Native Plants of Australia." He made numerous contributions on economic plants to the

"Agricultural Gazette of New South Wales," and the service he rendered to forestry in this state was very great indeed.

Although wrapped up in his favourite branch of science—systematic botany—he interested himself in many subjects and in many societies connected with applied botany and with Australian history. For a number of years he lectured to the University agricultural students on "Agricultural Botany" and "Forest Botany." He was also a great admirer of the celebrated botanist, Sir Joseph Banks, whom he styled "The Father of Australia," and his biography of Sir Joseph is considered to be a classic. Mr. Maiden was President of the N.S.W. Horticultural Society for 20 years, and of the Horticultural Association for 18 years. He was also President of the Linnean Society of N.S.W. and of the Royal Australian Historical Society in each case for two years. Mr. Maiden was one of the chief organisers of the National Wattle Day Celebration in the Commonwealth. This has for its main objects the adoption of the wattle as the national floral emblem, and the cultivation of an Australian national sentiment, while keeping in view that this country is part of the British Empire. He was hon. secretary for 14 years of the Australian Association for the Advancement of Science, and in 1921 was offered the Presidency of that body, but declined the honour for health reasons.

We believe, however, that the work of our own Society was the one which was dearest to his heart, and he certainly put into it an immense amount of self-sacrificing devotion. He was a member of the Royal Society of New South Wales for 42 years and attended 41 consecutive annual meetings. He was hon. secretary for 22 years and on two occasions (1896 and 1911) he occupied the Presidential Chair. In addition to that he read 45 papers before the Society—a record of service which is surely unique.

That his work was appreciated far beyond the bounds of Australia was shown by the award of the Imperial Service order, his election as a Fellow of the Royal Society of London, and of the Linnean Society of London. The latter Society awarded him in 1915 the Linnean Medal, this being the first time that the honour had come to an Australian. In 1922 he was awarded the Mueller Medal by the Australasian Association for the Advancement of Science and in 1924 the Clarke Memorial Medal by our own Society.

Mr. Maiden undoubtedly ranks amongst the leading pioneering botanists who have contributed so much to our knowledge of the unique Australian flora, and for many years he was regarded as the doyen of Australian botanists. He was a source of inspiration to very many botanical students, and as some evidence of the affection and esteem in which he was held by his scientific colleagues, he was in 1916 presented with his portrait in oils. Few men have accomplished so much in a lifetime in the way of scientific research and organisation and this is largely attributable to his passion for system and method in all he undertook. Failing health in his later years was a severe handicap, but it could not dim his enthusiasm and it hardly lessened his output of work.

It may be truly said of him that he left the world richer for his labours and his life was filled with greatness, nobility and sincerity.

Mr. Maiden leaves a widow and four daughters, two of whom are married, one to Dr. J. Paton, of Orange, and the other to Dr. Brown Craig, of Sydney.

Dr. Eric Sinclair, Inspector-General of Mental Hospitals, who was a member of the Royal Society for 43 years, died suddenly in the mail train between Mount

Victoria and Lithgow in the early hours of the 19th May, 1925, in his 66th year. He was a native of Greenock, Scotland, and received his education at Glasgow University, where he graduated M.B. and Ch.M. in 1881 and M.D. five years later. Before leaving Scotland he filled the posts of house-surgeon and house-physician in the Western Infirmary, Glasgow. Coming to Australia, he was appointed to the New South Wales Public Service in 1882 and two years later was promoted to the position of Medical Superintendent of Gladesville. In 1898 he was appointed Inspector-General of Mental Hospitals, which position he retained up to the time of his death. During his tenure of this office the following mental hospitals were opened: Morriset, Stockton, Rabbit Island, Millson Island, Broughton Hall, and the greater part of Kenmore. The institution at Orange was almost complete at the time of his death, and he was on his way to inspect this when the sad event occurred.

Throughout his official career Dr. Sinclair insisted on a systematic training for nurses and attendants and removed many of the mechanical means of restraining patients, as well as introducing the "open door" treatment. He further instituted the system of admitting patients voluntarily to the mental hospitals. The first volunteer patient was received in 1915, and before his death there were over 300 patients in the various institutions. In 1921 Dr. Sinclair established the Broughton Hall Psychiatric Clinic for voluntary patients only, and this is recognised as one of the most modern institutions of its kind in the world.

His persistent advocacy was one of the main factors in the establishment of the Chair of Psychiatry in the University of Sydney.

Dr. Sinclair was keenly interested in scientific and educational matters beyond the range of his particular subject. He was a trustee of the Australian Museum and for many years president of its scientific publications committee. He was also a councillor of St. Andrew's College, a member of the committee of the Sydney Industrial Blind Institution, a councillor of the Presbyterian Girls' Hostel, a director of the Nurses' Club, and a member of the council of the Dental Hospital.

His wide interest in other bodies prevented his taking a very active part in the affairs of the Royal Society, although he was in entire sympathy with its aims, and he was one of our oldest members.

He was a man of sterling worth, of great uprightness of character, with a keen sense of duty. His work was so greatly appreciated that he was asked to retain his Government position for another year after the usual age for retirement. This he consented to do, although he knew that he might be sacrificing his health at the expense of duty which, unfortunately, proved to be the case.

Dr. Sinclair was a man who, by his life, by his work and even by his death, personified the best qualities expected of a scientific man in the service of the State.

He was a widower and is survived by two sons, who have both followed in their father's profession—Dr. George Sinclair, of Eastwood, and Dr. Callander Sinclair, of Longueville.

William Henry Warren, LL.D., M.Inst.C.E., A.Am.Soc.C.E., Professor Emeritus of the University of Sydney, died at his residence at Elizabeth Bay, Sydney, on the 9th January, 1926. He was 73 years of age and had resigned from the active duties of the Chair of Engineering only a few days before his death. A native of Somerset, England, he was educated at the Royal College of Science, Dublin, and at Owen's College, Manchester.

After a brilliant scholastic career, he entered the service of the London and North-Western Railway Company and spent five years at the workshops, Wolverton, where he designed many bridges and other structures. Arriving in Australia in 1881, he entered the Public Works Department, where he remained for two years. He was then invited by the University of Sydney to organise a School of Engineering, and in 1884 he was appointed as the first Professor of Engineering in Australia. His occupation of the Chair for 42 years has been the longest in the history of the University. The growth of the School of Engineering from a small Department with one permanent lecturer and four students to a Faculty with three full professors, two assistant professors, fourteen lecturers, six demonstrators and three honorary lecturers, housed and equipped for the teaching of every branch of engineering, has been largely due to his capacity and industry. Many of the graduates of the School hold important and responsible positions in the service of the State, while others have made their mark in other parts of the Commonwealth and overseas.

Professor Warren was a member of the Council of the International Society for the Testing of Materials, and was Australian representative of the Institute of Engineering in Great Britain. He was also the first President of the Institute of Engineers of Australia. As a young man he gained the Whitworth Scholarship, and in 1913 he was awarded the honorary degree of LL.D. of the University of Glasgow in recogntion of his great work as an engineer and educationalist.

Amongst the works for which Professor Warren was responsible is the handsome suspension bridge at Northbridge, over an arm of Middle Harbour. He was frequently consulted by the State Government on engineering matters, and acted on many committees and commissions. He was a world authority on the testing of the strength of materials of construction, including steel, concrete and timber. Indeed, we owe most of our reliable information about the suitability of our native Australian timbers for constructional purposes to his elaborate investigations. During the war he was the chief inspector of steel, and in connection with that appointment he conducted upwards of 10,000 tests of munition steel intended for export. He was the author of more than 50 papers dealing chiefly with structures in steel, concrete, and timber, and of a standard work in two volumes on "Engineering Construction."

Professor Warren was elected a member of the Royal Society in 1883 and was a member for 42 years. For many years he was a member of the Council, and he was twice (in 1892 and 1902) elected to the office of President. He read 17 papers before the Society, and did much to uphold its dignity and prestige.

He was passionately fond of music, and even at a fairly advanced age frequently sang gems from grand opera with obvious delight both to himself and his audience. He was also a keen golfer and took a great interest in bull-dogs, he himself possessing several noted prize-winners.

To his friends who knew him well he had a very likeable personality, and it was pleasing to see the affection in which he was held by his students and graduates.

He is survived by a son—Mr. E. W. Warren, solicitor, Sydney.

Without question each of the three ordinary members deserves a worthy permanent memorial in Australia, and in the case of Mr. Maiden, the initiative, in my opinion, should come from the Royal Society. I commend the idea to the incoming Council.

The congratulations of the Society are cordially offered to Mr. R. H. Cambage, our indispensable senior Hon. Secretary, on the honour of Commander of the Order of the British Empire, conferred on him by His Majesty the King, and to our distinguished former President, Sir Edgeworth David, on adding to his long list of well-deserved honours the honorary degree of Doctor of Science of the University of Cambridge, the Patron's Medal of the Royal Geographical Society, and his election as Fellow of New College, Oxford.

At a very pleasant function held conjointly with the Linnean Society of New South Wales and the Institute of Mining and Metallurgy, an opportunity was taken of paying a friendly tribute to Sir Edgeworth David at the time of his departure for England to make arrangements for the publication of his book on the Geology of Australia.

The Society also had pleasure in according a hearty welcome to Sir Ernest Rutherford, K.C.B., O.M., D.Sc., etc., on the occasion of his visiting Sydney to give a course of lectures under the auspices of the University Extension Board. The visit of Sir Ernest Rutherford was a source of great stimulus to all the scientific workers in Australia, and especially to those in Physics and Chemistry.

An informal welcome was also given to several other distinguished visitors, including Dr. Clark Wissler and Professor Embree, who visited Australia as representatives of the Rockefeller Foundation in connection with the endowment of Anthropological research, and Sir Frank Heath, who had been invited to Australia to advise the Federal Government regarding the re-organisation of the Commonwealth Institute of Science and Industry. It is pleasing to have the opportunity to meet such distinguished visitors from abroad from time to time, to give them the right hand of fellowship and to assist them to obtain the information they require.

The decision of the Federal Government to increase the scope of work of and the annual appropriations for, the Institute of Science and Industry, is one that has given general satisfaction, as there are many problems of an economic, scientific nature to which such an Institute can give serious attention with great prospective benefit to the Commonwealth. It has been found necessary to modify the system of control and the policy of the Institute, so as to ensure more harmonious co-operation with State authorities and Institutions. The Royal Society has been indirectly honoured by the choice of one of its members (Mr. G. A. Julius, B.Sc., B.E., etc.) as Chairman of the Executive Committee of the Institute. Under his energetic and capable leadership, a great forward move is confidently anticipated.

The Australian National Research Council last year held its annual meeting in Sydney on the 25th and 26th of August, and transacted important business. There seems to be a feeling in some quarters that the Research Council is a somewhat superfluous body, but it already has two notable achievements to its credit, viz., the successful running of the Second Pan-Pacific Science Congress, and the securing of the necessary co-operation between the States to enable a Chair of Anthropology to be established in the University of Sydney. There is plenty of scope for its continued usefulness especially in connection with international co-operation in regard to scientific investigations and maintaining the prestige of Australian Science. There is indeed reason to hope that it will extend its functions in the near future without any overlapping with the Institute of Science and Industry or any other organisation.

Members of the Royal Society, all of whom have at heart the advancement of science in every form, received a rude shock when an announcement appeared in the daily press that it had been decided to close the Sydney Observatory as from June 30th next. The Council asked the Premier to receive a deputation on the subject and, as a result, representatives of the Royal Society and the New South Wales branch of the British Astronomical Association interviewed the Minister for Justice on the third of December, 1925, and put the case for the retention of the Observatory so strongly that there is reason to hope that the decision of the Cabinet may be reversed, and the calamity of the closing of the Observatory averted.

The Influence of Science on the Progress of the Land Industries in Australia.

I have selected as the subject of the main part of my address, "The Influence of Science on the Progress of the Land Industries in Australia."

The Royal Society's main concern is with the advancement of science and the extension of the bounds of knowledge irrespective of whether that knowledge has or has not a practical application; but the fact that you have been good enough to elect a representative of an applied science as your President indicates that you are not unmindful of what one might call the utilitarian side of science, and consequently you may bear with me while I relate something of the story of the effects which the application of scientific principles and scientific knowledge has had, and is likely to have, on the most ancient and honourable of human occupations as practiced in this progressive young country.

We have in our midst pessimists who are continually lamenting our slow rate of national progress. When one considers the history of the land industries, one sees very little reason for such an attitude. Impartial observers, on the contrary, can hardly fail to be impressed by the very remarkable achievements of the man on the land in the short space of 138 years. Australia possesses more sheep and produces more wool and better wool than any other country in the world; she produces enough bread and butter to supply a population of 6,000,000 people, and at the same time, is the third greatest exporter of these essential foodstuffs; such facts surely afford sufficient evidence of real progress.

This satisfactory record is largely due, of course, to the size of our island continent, to its natural resources in soil and climate, and to a hardy race of pioneers. All honour to these pioneers, to the courageous men and lion-hearted women folk who braved the dangers and difficulties, the isolation and the loneliness, the time of drought, and the time of flood, to lay the foundations of our land industries which are still the main basis of our prosperity!

The progress would, however, have been nothing like so rapid had not our farmers and graziers been aided in their task by the advancement of science in countless ways.

If this address is to be of reasonable length, reference can only be made to a few of the more important.

At the time of the first occupation of our island continent by a white race, the first glimmerings of exact knowledge of the composition of the material universe were just becoming perceptible; the dawn of the new era of scientific advancement had just commenced to break. In the early days of the development of our land industries, therefore, the effect of the application of science could not be very great, and progress was largely confined to the gradual increase in our flocks and herds, and their spread outwards in all directions from the main settlements, with agriculture proper practised in rather primitive fashion in a few specially favoured localities. Indeed, one may say that the benefits to be derived from the application of science were not great in Australia, or in any other country, during the period represented by the first 50 or 60 years of our history. Amongst the white races, indeed, it may be said that there has been more progress in agriculture and the allied industries during the past 70 or 80 years, than during all the preceding centuries. In spite of the fact that we are even now just emerging from the pioneering stage of the development of our land industries, it is perhaps as true of Australia as of any other country, and as true of agriculture as of any other realm of human activity, that science, the wizard, has wrought incredible transformations during the last three-quarters of a century. There are some directions in which the application of science may be more obvious to the man in the street in these days when electric energy is harnessed to the service of man for lighting and traction and other forms of power, when men fly in the air like birds, and communicate with one another through unseen channels, from one end of the earth to the other; but the advantages gained by the primary industries have been none the less real.

Pastoral Industry.

The first century of the occupation of Australia by the British race was largely an era of pastoral development in which the merino sheep, introduced and fostered by Capt. John McArthur, played the most important part. Owing to the demand for the fine quality wool produced by this hardy breed, so well adapted to its new home, there was no difficulty in finding a market for all that Australia could produce, and flocks continued to expand farther and farther inland. But the inevitable time arrived when there was a greater number of sheep and cattle than could be accommodated and properly tended on the pastures in the explored regions, and the problem of the disposal of the carcases of the surplus stock, other than what was required for local consumption, became very serious. The first expedient adopted was to boil down the carcases for their tallow, but this brought in a comparatively low return per head. Science came to the rescue with the application of refrigeration to the preserving and transporting of beef and mutton. It is a pleasure to record that an Australian —Mr. Harrison, of Geelong—was the first to evolve successfully a cold storage system, based on the evaporation of a volatile liquid, and that to the late Thomas S. Mort, of New South Wales, must be largely given the credit for making it a commercial success.

What this one application of science alone has meant to the pastoral industry in Australia would be difficult to estimate accurately, but some idea may be gained from the fact that in a single year Australia has exported over £9,000,000 worth of frozen beef, mutton, and other products of her extensive pastures.

By the vigilance of our veterinary scientists Australian flocks and herds have been kept free from many diseases which cause great havoc in other parts of the world, and several maladies which had gained a footing have been eradicated. Legislators and the general public, and even the pastoralists themselves, have been slow in showing their appreciation of the very great services rendered to the Commonwealth by the veterinary profession. There is still need for them to continue, and even increase their vigilance, and it is satisfactory to note that recent changes in Commonwealth quarantine administration aim in that direction. There is also great need for research into methods of combating the diseases which still take a large annual toll of our live stock, and for training more and more men for this all-important work. The establishment of the Glenfield Veterinary Research Station is an indication that this aspect is receiving attention, but further inducements are necessary to encourage a larger percentage of our ablest young men to qualify for the veterinary profession, and especially for research and investigational work.

Agriculture.

Just as in the secondary industries and in the vehicles of commerce, one of the most obvious directions in which science has affected the agricultural industry, is in its application to mechanical devices, which greatly lessen human labour and expedite the necessary operations.

It is hard to believe, for instance, that less than a century ago the usual method of harvesting grain was with the sickle or the scythe, and the usual implements of threshing, the flail and the winds of heaven. Contrast that with the scene on a modern Australian harvest field, where a machine drawn by a horse-team or a tractor, passes through the crop, removes the heads, threshes them as it goes along, and collects the golden grain in a box from which it can gravitate into bags, or even into a special waggon ready to take to the silo at the nearest railway station. The history of the evolution of the modern Australian harvesting machinery—through the stripper invented by that grand old pioneer, John Ridley, of Adelaide, the combined harvester, in the development of which the present head of the well known McKay firm took a leading part, to the header or reaper-thresher evolved by two other Australians, East and Chapman—is a fascinating story into which time will not permit one to enter. In harvesting cereals for hay the progress has been equally striking, though the ideas in this case are borrowed from other parts of the world. The modern self-binder cuts the crop, binds it into sheaves, and leaves the sheaves in a handy position for stooking. In the harvesting of other crops like maize, potatoes and lucerne, equally remarkable labour-saving devices are now in use by progressive farmers.

Expeditious methods of harvesting would be of little use if not accompanied by corresponding arrangements for rapidly cultivating the soil and sowing the seed. The multiple-furrow plough, wide harrows and cultivators of various types, combined seed and manure drills, all suitable to large horse teams or tractor work, have solved the problem. There are many cases in which it is impracticable to thoroughly clear the land of roots and stumps before a crop is sown, and the invention by another South Australian, Mr. R. B. Smith, of the stump-jump plough, paved the way to the utilisation of millions of acres of land which otherwise could not have been brought under cultivation.

Many people are puzzled to know how it is possible for Australia, with an average yield per acre of about 11½ bushels, to send her wheat half way round the world, and compete on the British market with grain grown in the homeland, where the yield per acre is nearly three times as great. Part of the explanation is that Australian climatic and other conditions permit of large-scale production, and of the use of more labour-saving devices than in England, and, although the average yield per acre is low, the "average yield per man engaged" is much higher in Australia. Incidentally, these labour-saving devices on the farm help to account for the more rapid growth of the urban than the rural population.

Wheat growing on an extensive scale would have been impossible in Australia without the adaptation of scientific principles to transportation by land and sea; for as one of our poets has said:—

"Princes, Potentates, Kings and Czars
They travel in regal state.
But old King Wheat has a thousand cars
For his trip to the water-gate;
And his thousand steamships breast the tide
And plough through the wind and sleet
To the land where the teeming millions bide
That say 'Thank God for wheat'."

In most progressive agricultural countries which grow wheat on an extensive scale, King Wheat has now a new kind of car to ride in to the water-gate, and New South Wales has been the first State in Australia to adopt the modern method of bulk-handling, which further expedites its transportation, saves labour, and does away for the most part with the use of bags.

It is not only in connection with the growth of wheat, our main agricultural product, that that important applied scientist, the engineer, has helped to smooth the path of the Australian primary producer. The pastoralist has his power-driven shearing machinery, the dairy farmer his cream-separator and milking-machine, often operated by electricity, and the orchardist his labour-saving cultivation and spraying devices and his mechanical grader; while irrigation farming, which is playing an increasingly important part in our development, would be impossible without the brain of the engineer behind it all.

To resume the story of the agriculturist, and particularly of the wheat grower, South Australia was the first State to develop the industry on an extensive scale, though she was closely followed by Victoria. Continuous wheat growing was at first the almost universal practice, with the inevitable result that yields began to decline. This was due partly to the prevalence of weeds, partly to an insufficiency of moisture, and partly to a deficiency of available plant food material in the soil. To such a pass had matters come that there was serious talk of abandoning wheat altogether, and throwing the land back to pasture.

They had plenty of pluck and perseverance, however, those South Australian agriculturists, and some of them started to let the land lie without a crop for a year and cultivate it at intervals, so as to get rid of weeds. This resulted in greatly increased yields. It was not realised at first that a large part of the benefit had come through the conservation of the rain which fell during the months of fallow by keeping down weed growth, and preserving a mulch of loose dry soil on the surface. The practice of the cultivated fallow, which has meant so much to the Australian farmer, was thus an accidental introduction, and the scientific explanation of its favourable results came only after it was partially established. A fuller understanding of the scientific principles underlying the conservation of soil moisture has, however, led to its more universal adoption as well as to improvements in the practice based on the new knowledge.

Twenty years ago there were only a few thousands of acres fallowed in preparation for the wheat crop in New South Wales. To-day there are nearly 1,500,000 acres and, although this last figure probably includes land under "short fallow," and also much land which is not worked as it ought to be during the resting period, it shows a tremendous advance.

Some slight idea of what the practice of the cultivated fallow means in the way of the conservation of the soil moisture may be gleaned from some experimental work carried out at Wagga Experiment Farm in 1924-25, by Mr. R. D. Lees, Farrer Research Scholar.

Shortly before seeding time he determined the amount of moisture present in the top 45 inches of soil and subsoil, in land which had been cropped the previous year, and in an adjoining plot which had been fallowed on up-to-date lines. He found that the latter (the fallowed plot) contained moisture equivalent of 4½ inches of rain more than the previously cropped plot. Now just think what this means! The crop on the fallowed land had access to the rain which fell during its growth and, in addition, to an amount of moisture conserved in the soil and subsoil equivalent to an additional 4½ inches of rain. It can readily be understood that in a dry season that 4½ inches might make all the difference between success and failure, and that even in a normal season it could be expected to greatly increase the yield of the crop. A still more striking difference would probably have been shown if the samples had been taken to a depth of 6 feet; and, when one considers the great depth to which some of the wheat roots penetrate under our conditions, and makes allowance for the rise of water by surface tension as the soil becomes depleted of its moisture, it must be seen that 6 feet would be a fairer criterion.

In the early nineties of last century the yield of wheat again seriously declined from what was found to be the lack of a sufficient amount of available phosphoric acid in the soil. The remedy lay in the use of superphosphate, a fertiliser which had been patented independently by Lawes in England, and Liebig in Germany, some 50 years before. The response to superphosphate in South Australia and Victoria was almost magical, and yields rapidly increased, accompanied by a great stimulus to the farming industry. This is reflected in the average yield of wheat per acre in South Australia over four decades, which were as follows:—

		Average yield per acre.
1878-1887	.. ..	6.45 bushels.
1888-1897	.. ..	4.89 ,,
1898-1907	.. ..	7.06 ,,
1908-1917	.. ..	10.59 ,,

Over 90 per cent. of the wheat crop in South Australia, Victoria, and Western Australia, and over 50 per cent. in New South Wales, now receive a dressing of superphosphate, and the man who deserves the greatest credit for introducing it into general farming practice is Mr. William Lowrie, B.Sc., formerly Director of Agriculture in South Australia.

Owing to soil and climatic differences, the response to superphosphate is not quite so marked in New South Wales as in the other wheat-growing States, especially in the northern half of our wheat-belt, but there is still room for its use on larger areas of our own State, and for its application in larger quantities in many instances. The New South Wales wheat growers are quickly realising the position; for in the past five years there has been an increase of 600,000 acres, or 35 per cent., in the area manured, and 52 per cent. in the quantity of artificial fertiliser used annually.

The beneficial effect of the superphosphate was shown on the subsequent pasture crop, and greater and greater attention is now being focussed on the use of this and other phosphatic fertilisers directly to the pastures with very promising results, especially in the cooler and moister districts. With the exception of sulphuric acid, which can economically be made locally, the only ingredient necessary for the manufacture of superphosphate is rock phosphate, a high grade of which Australia fortunately obtains in practically unlimited quantities from Nauru and Ocean Island in the Pacific, and Christmas Island in the

Indian Ocean, so that Australian manufacturers are able to supply an excellent article at a reasonable cost. The use of superphosphate for wheat brought in its train the use of the combined seed and manure drill, which has been developed to a much greater extent in Australia than in any other country. The response of our wheat crops to small quantities of superphosphate is partly accounted for by the ideal distribution of the fertiliser brought about by this mechanical device but, as I have shown, is partly due to the effect of the fertiliser in increasing the depth of root-penetration, thereby making it possible for the crop to tap the moisture in deeper layers of the subsoil, and thus enabling it to withstand dry conditions better. The practice of the cultivated fallow and the use of superphosphate applied by the combined seed and manure drill, have been exceedingly potent factors in the success of wheat growing in Australia, and the combined practice is enabling wheat to be grown successfully here under more arid conditions than in any other part of the world.

These have indeed been the most important *soil* factors associated with the progress of our agricultural industry, but even these would not have had their full effect, had they not been supplemented by important scientific work of quite a different kind.

The tendency amongst agricultural scientists of last century was to concentrate on the amendment of the *soil*. Since the beginning of the 20th century greater attention has been given to the second factor in production, viz., the *plant*, as the idea gradually gained ground that it could be modified in just as remarkable a manner as the soil, and the plant breeder and the plant pathologist have come into their own.

The varieties of wheat and other cereals grown in Australia in the early days were derived from Europe, Africa and America, where they had become adapted to climates entirely different from those existing here, and, therefore, did not attain the highest possible efficiency as grain producers under Australian conditions.

There is scarcely any need to tell again the oft-told story of the remarkable success achieved by one of the greatest wheat breeders the world has ever known, the late William Farrer. It is enough to remind you that Farrer produced varieties which were more prolific yielders of grain, more drought-resistant, earlier in maturing, more disease-resistant, of better milling and baking quality, and more suitable for hay than any of the older varieties, with the result that they largely replaced all others in New South Wales and the other leading wheat growing States, and almost their own rivals to-day are varieties produced by Farrer's successors, who gained most of their inspiration from him. The financial benefit of Farrer's varieties to the Australian harvest *through increased yield alone* can hardly be less than £1,000,000 annually. But increased yield is only one of the benefits Farrer conferred, and perhaps not even the greatest. Improvement in that elusive quality "strength" so much desired by the baker and consumer, has been at least as important, with the result that Australian wheat is now eagerly sought after by all the leading wheat-importing countries, and frequently sells at a higher price than the best from Canada and the Northern States of America, where the climatic and soil conditions tend to produce an even stronger flour. In the improvement of quality it is only fair to say that Farrer was greatly assisted in his work by a previous honorary secretary of this Society, Mr. F. B. Guthrie, formerly chemist to the Department of Agriculture.

Farrer's varieties have also been a factor in extending the wheat belt on its western boundary in New South

Wales, and for every ten miles the western limit is pushed back about 3,000,000 acres are added to the potential wheat belt.

The stimulus to wheat breeding and plant breeding generally came in other countries through the re-discovery of Mendel's historic papers in 1900. Farrer died in 1906, and his life-work was practically completed before a knowledge of Mendel's laws reached him. But Farrer's genius rose to such a height that he almost assumed as axiomatic some of the main principles enunciated by Mendel. Wheat breeders who have worked here since Farrer's time have had the disadvantage of having something better to make improvements on than Farrer had, but they have had the advantage of the newer knowledge of Genetics, which has arisen out of Mendelism. Amongst the contemporaries of Farrer, and the people who have used his methods, the most successful wheat breeders, judged by the farmers' estimate of their varieties, have been Pye in Victoria, Marshall in South Australia, and Pridham in New South Wales, and the Australian farmer owes a great debt to them as well as to many others. Some of the more recent workers have been using Mendelian methods with very definite objectives, but it is yet too early to say that they have achieved, or even will achieve, results of such importance as those obtained by Farrer here or by the most prominent Mendelian wheat-breeder of England—Professor Biffen of Cambridge.

A good example of this newer genetical work is at present being carried out at the School of Agriculture at Sydney University, by Mr. W. L. Waterhouse, whose main objective is the production of a wheat or wheats resistant to rust, and at the same time possessing the good agronomic character of Farrer's best wheats. This has involved a study of the genetics of rust resistance, and has proved to be complicated by the fact that there are two species of rust, *Puccinia graminis* and *Puccinia tritici,* and that there are at least three biologic forms or parasitic strains of the former, and there may be more than one of the latter prevalent in Australia. Now, a particular variety may show resistance to one species and susceptibility to the other, and may even be resistant to one biologic form of *Puccinia graminis* and quite susceptible to another. An interesting technique, developed at the University of Minnesota, is being followed for determining susceptibility to the various forms of rust at an early stage in the life of the plant, and this has greatly simplified the work, though it still has sufficient complications to necessitate years of patient endeavour. But as far as it is humanly possible to predict, ultimate success seems assured. Now the various forms of the wheat-rust fungus take an annual toll of the crop which the Australian farmer can ill afford to pay, and in particular years the havoc from rust may be extremely serious. A reliable estimate made by the chief field officer of the Department of Agriculture, for instance, placed the loss through wheat-rust in New South Wales at £2,000,000 in 1916. The importance of our little effort at the University will therefore be readily realised.

Considerable success has been achieved in evolving improved varieties of other farm crops; Mr. Pridham's work with oats, and Mr. Wenholz's work with maize, are excellent examples from New South Wales. If cotton should ever become an important crop in this State, the work of the plant-breeder is almost certain to be an important factor, and it is difficult to set a limit to the possibilities in the way of evolving improved varieties or strains of all our cultivated crops. In this regard the future is full of hope, if sufficient encouragement is given to the training of men for this particular work, and if adequate facilities are afforded for them to carry their researches to fruition.

The annual losses to Australian wheat and other field crops from plant diseases must amount to several millions of pounds annually. The rusts, the smuts, and the diseases classed under the heading of "foot-rot" and "take-all," are the worst in wheat crops, although there are several others of minor importance. The only hope of overcoming the losses through rust seems to rest, as already indicated, with the plant breeder. What was previously our worst smut disease (Bunt or Stinking Smut), can now be successfully prevented by means of various fungicides applied to the seed wheat. Most of the methods formerly recommended had unfortunately a harmful effect on the germination of the grain, and it is again to the credit of Australia that a greatly improved method—the use of dry copper-carbonate—which is now rapidly replacing all other methods, both in Australia and elsewhere, was the result of work carried out by our Government Botanist, Dr. Darnell Smith. Flag Smut in some recent years has done much more damage than bunt. A close study of the life-history of the causal organism by Dr. R. J. Noble, has shown how this disease can be partly controlled by cultural methods, but the final solution of this problem also probably lies with the plant breeder.

Agricultural methods have also done much to lessen the damage done by the group of diseases included under the general heading of "Take-all" and "Foot-rot." There is still a good deal of obscurity surrounding the identity and life-history of the organisms concerned, although some important new facts concerning them have been brought to light by the work of the late C. O. Hamblin and Mr. H. J. Hynes. Further research however is necessary, as a full understanding of the nature of the cause, and of the environmental conditions under which infection can take place, is a necessary preliminary to any certain remedy.

Science and its applications are playing an increasingly important part in enabling the producer to cope with fungus, bacterial, and allied diseases of the farm, orchard, and vegetable garden, although there is room still for plenty of investigation and research into causes and remedies.

There is perhaps no plant malady of recent years which has wrought such obvious havoc to a flourishing industry in Australia as Bunchy-top of bananas. Dozens of remedies have been suggested and tried without any success, as one would expect since, until quite recently, we have been only guessing at the cause. As a result of a thoroughly scientific investigation on the spot, due to combined effort by the Commonwealth Institute of Science and Industry and the Governments of New South Wales and Queensland, Goddard and Magee have shown beyond all reasonable doubt that it is a virus disease carried from affected to healthy plants by the banana aphis (*Pentalonia nigronervosa*). The result is that we are now no longer groping in the dark, and can at least suggest methods of control which are worth trying out. This single instance is an example of what co-operative effort and concentration can do for the solution of the problems of the primary producer, provided the trained men are available for the work, and this success causes one to hope that other problems of a like nature can be solved in a similar manner.

The havoc wrought by such minute vegetable parasites is probably not more disastrous than that brought about by representatives of the animal kingdom, the most important group being the insects, although the cattle-tick belonging to a closely allied group, the rabbit and the dingo, do tremendous damage.

The losses brought about by the attacks of insects on crops and animals must again run into several millions of pounds per annum in New South Wales alone, though the damage would have been very much greater but for scientific investigation and research. By a close study of life-histories, the economic entomologist has enabled the primary producer to cope successfully with many of these troubles, and to appreciably lessen the damage done by others, while quarantine legislation has been the means of confining some to limited districts, and of preventing the entrance of others from abroad. In connection with those attacking plants, the most effective remedies have been spraying, fumigating, the use of poison baits, and the destruction of infected plants or parts of plants. A promising new line of attack is the introduction of parasites, which either keep the harmful insect in check or destroy it altogether. The success achieved by Dr. Tillyard in banishing the woolly aphis, from the apple orchards of the Nelson Province of New Zealand by means of the parasite *Aphelinus,* gives ground for hope that similar results will follow its introduction into Australia, and that some other harmful insects may be eradicated by similar agencies.

With regard to insects attacking domesticated animals, the most harmful group are the sheep blow-flies. A more thorough putting into practice of all known methods of control would greatly lessen the ravages of this terrible scourge, and persistent research can hardly fail to result in greater refinements and greater effectiveness in preventive and remedial measures.

Weeds represent another formidable group of enemies with which the pastoralist and farmer have to contend. In the case of arable land, control can usually be obtained by wise methods of cultivation based on a knowledge of the habits of the plants, and especially of the conditions necessary for the germination of the seed. Where weeds find a congenial environment on pastoral lands the problem is much more difficult. A striking example is the Prickly-pear, which in Queensland and New South Wales, has been spreading at the alarming rate of something like a million acres a year. The species chiefly concerned are nothing like such a serious pest in other parts of the world, and a close study of the problem by biologists has resulted in the conclusion that one of the reasons for this is that we have introduced plants which thrive under our conditions without introducing their natural enemies, which tend to limit their spread elsewhere. The obvious remedy is to introduce these enemies, provided that we are satisfied that they will not damage economic plants. As the result again of co-operative effort between the Commonwealth Institute of Science and Industry and the Governments of Queensland and New South Wales, some of these insect enemies have been introduced, propagated and distributed. What the final result will be, it would be unwise to predict, but I think it can safely be said, from results already achieved, that this biological method of control is going to be an extremely important factor in coping with the worst of all weed pests in Australia.

Dairying.

One of the most pleasing features in the primary production of Australia has been the rapid growth of the dairying industry during the last few decades. It is no exaggeration to say that, but for the advancement of science and its application, such progress would have been an impossibility. Where milk is supplied to towns and cities, cleanliness in production and temperature-control, including pasteurisation, have been important factors in the supply of a wholesome, essential food, and the basis of the whole system of management is a knowledge of bacteriology.

The chief dairy product which we export is butter. Now, the successful production of good quality butter in a warm climate such as ours would have been regarded some time ago as an absolute impossibility. Refrigeration machinery enabled us to cope with the initial difficulties, but the very existence of the industry from an economic point of view is dependent on the evolution, as a result of a study of scientific principles, of the cream separator, the milk and cream tester, and to a less extent, the milking machine. The quality of the product is again dependent on a knowledge of bacteriology, which has resulted in resort to neutralisation and pasteurisation of the cream, the use of pure culture "starters," improvements in factory design, and control of temperature during manufacture, storage, and transportation.

The effect of these on the quality of our butter in recent years has simply been phenomenal. In 1915, only one butter factory in the State had a pasteurising plant. To-day, every up-to-date factory in the land (and that includes the vast majority), has facilities for the neutralisation and pasteurisation of the cream before churning. And what has been the result?

Up to 1916, less than half the butter produced in New South Wales came up to "First Grade" standard. For the year ended 30th June, 1920, 96.2% (including 85.9% classed as choicest), was first grade or better, leaving only 3.8% in the second grade. The Dairy Expert of the Department of Agriculture estimates the monetary value of this improvement in quality, brought about in four or five years at £180,000 per annum, to the dairy farmers of New South Wales.

Mainly as a result of a study of bacteriology, again, the principles underlying the manufacture, maturing and storage of cheese have been fairly completely worked out, and are being applied more and more in our factories with the result that we may hope to see in the near future the standard of quality raised to something approximately equivalent to that of our choicest butter. The advancement of science has in recent years brought about improvements in the processes for the manufacture of condensed milk, milk powders, and ice cream, and these improvements have been reflected in an increased demand, so that other avenues are opening out for the dairy farmer who produces milk and cream under clean, wholesome conditions. Scientific investigation, too, has found in recent years increasing uses for casein, which provides another source of demand for by-products of the dairy.

The same principle applies to many other products of our farms and orchards. Every new idea, the result of scientific research, and its application, which improves methods for the canning, dehydration or processing of our fruits, increases the demand for the latter. The introduction of flue-curing has greatly improved the quality of local tobacco, and consequently the price the manufacturer is prepared to pay for the leaf. The taking out of the last ounce of extractable sugar from our sugar-cane, and the fuller utilisation of the by-products have enabled a higher price to be paid for the cane, as it is delivered to the mill, than would otherwise have been possible.

Examples of this kind could be multiplied, but why dwell on them, as they are simply illustrations which are common to every aspect of commercial and manufacturing pursuits in these wonderful days in which we are privileged to live and work.

The Australian primary producer is fortunate in many ways, but, compared with some of his competitors, he is at a serious disadvantage in the all-too-frequent occurrence of droughts and dry spells, with the general result that his holding has a very variable carrying capacity, if he does not prepare for the lean periods.

Taking the country as a whole, the water supply obtained from nature is more than adequate for a very much larger stock population if only it were conserved and distributed as required. Matters in this respect are improving year by year, and the rate of improvement is only limited by the national and individual capital available for expenditure on such projects. With regard to food-supply for stock in times of scarcity, the problem is in many ways no more difficult than in countries with a severe winter. Owing to its succulence, safety against damage by fire and mice and for other reasons, the best way to conserve a large part of that reserve is in the form of silage. Now, the process of ensilage is of very ancient origin, but it is only in recent years again that the scientific principles underlying the conservation of fodder in this form have been anything like thoroughly understood. The principles are now being put into practice by progressive men in nearly all the leading divisions of the State, and when their example is followed by the great majority of stock owners New South Wales and Australia generally will be in a very much sounder position, and much freer from those fluctuations in prosperity which are common in every new country.

This last example is an illustration of the fact that there are many achievements of science that have not been taken advantage of to anything approaching the greatest possible extent by our primary producers; but, of course, the same is true of every country, and of every occupation in the world. Indeed, taken as a whole, our primary producers are more resourceful and more ready to adopt new ideas than any similar body of men in any part of the world known to me. As they have to compete in European and Asiatic markets with farmers and graziers from countries which expend much larger sums in proportion to their population on agricultural education and research, it is due to our producers that we increase our efforts in these directions and lag not behind in the race. Nearly all scientific research becomes the general property of the whole civilised world, and often one European country will benefit immediately and directly by scientific, agricultural investigations carried out by a near neighbour. Australia, however, is so isolated, and her climatic and other conditions are so different, that she does not benefit to the same extent, and she must work out many of her own problems for herself, and these problems are so numerous that there is room for an indefinite increase in the number of her research workers.

Looking into the future, one sees no reason to believe that the fruits of scientific research will be any less important than they have been in the past. There is every probability, indeed, that in 50 or 100 years from now our successors will be looking back at our methods and our achievements in much the same way as we now regard those of our ancestors who wielded the scythe and the flail. They may, indeed, look back with pity, if not with scorn, at the ignorant and unenlightened people of the early decades of the 20th century, who were only able to average 11½ bushels of wheat per acre over a period of years, who could not grow wheat west of Hillston, Condobolin and Trangie; who depended mainly on the horse as a source of power; who allowed millions of sheep and cattle to die during a drought, tuberculosis to decimate their dairy herds, contagious abortion to reduce the value of their returns, rabbits to rob the live-stock of their pastures, the cattle-tick to infest their cattle, and inoculate them with a serious disease; who were satisfied with cows which only averaged 300 gallons of milk in the lactation period, sheep that gave an annual average clip of 7½lb. of wool; who permitted codlin moth, woolly aphis and fruit flies to take their toll of the orchard crops, and who were worried by such trifling pests as the blow-fly and the prickly-pear, rust of wheat, brown-rot of fruits, downy mildew of the vine, Irish blight of potatoes, blue-mould of tobacco, tomato-wilt, and bunchy-top of bananas.

Whatever the result may be, it is our bounden duty to tackle these and similar problems in a true scientific spirit, bringing to bear on them all the resources at our disposal; for on our success the material prosperity of Australia, and its maintenance as a bulwark of the white races largely depend.

Advancing science is daily putting new weapons into our hands. The application of the new knowledge of genetics to the breeding of animals may yet be as fruitful of results as in the kingdom of the plants; our growing knowledge of the countless hosts of microscopic organisms existing in the soil may lead to helpful amendments in agricultural practice; electricity as a plant stimulant may not be out of the question with intensively cultivated crops; a fuller understanding of the reaction between parasitic fungi and their host plants may lead to methods of control of which we have no present conception. We must push on with research and multiply experiments, and increase the efficiency of the agencies by which the lessons gained may be brought prominently before the farming community. Finally, the whole question of the application of science to the land industries is not the concern of Australia alone. It is to my mind the problem of problems for the world as a whole; for from the land comes all our food, except the negligible quantity which we extract from the sea, and the future food supply of the world is giving very serious concern to many thoughtful men. If the world's population is to continue increasing at anything like the present rate, there is not sufficient land in sight with suitable soil and climate to grow the essential foodstuffs for more than two or three generations *if the standard of production does not greatly improve.* My personal view is that the rate of population increase will not continue at the relatively high figure of recent decades (about 1% or 18,000,000 per annum); indeed, there is evidence that it has already begun to slow down. But even if it did continue, I have every confidence that the advancement of science and its applications would so stimulate efficiency in production that the dread time of a world's food famine would continue to vanish over the dim and distant horizon of the future.

NOTE ON THE RATE OF DECOMPOSITION OF COMMERCIAL CALCIUM CYANIDE.

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Communicated by G. HARKER, D.Sc.

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The growing use of calcium cyanide as an insecticide makes the study of its rate of decomposition, and the factors which influence it, of practical interest and importance.

A short time ago an inquiry relative to this matter was made, but, as no definite data could be obtained after searching the literature available, the following investigation, which was suggested by Principal E. A. Southee, of Hawkesbury Agricultural College, New South Wales, was undertaken in order to determine the actual rate at which the decomposition of the substance occurs under controlled conditions.

Commercial calcium cyanide "A" Dust, prepared by the American Cyanamide Company, New York, was used for the experiments. This material, which is a by-product of the cyanamide industry, contains a number of impurities, and is guaranteed to contain 48%-50% cyanide of lime.

A chemical examination of the substance showed it to contain 27.34% combined cyanogen corresponding to 28.40% hydrocyanic acid and 48.38% cyanide of lime.

In a few preliminary experiments with the substance it was found, contrary to expectation, that the theoretical yield of hydrocyanic acid could not be obtained when it was treated directly with sulphuric acid 1:4 at ordinary atmospheric pressure. By generating the gas in a flask cooled by a freezing mixture and under reduced pressure the yield of hydrocyanic acid was however greatly increased, while on boiling the substance with water, ammonia was evolved in considerable quantity.

The explanation of these observed facts is doubtless to be found in the ease with which hydrocyanic acid forms secondary and polymerisation products under certain conditions.

The hydrolysis of hydrocyanic acid with the formation of ammonium formate is readily effected in the presence of alkalies and mineral acids. The subsequent dissociation of ammonium formate would account for the liberation of free ammonia on boiling.

The studies of Dr. G. Harker on the decomposition of potassium cyanide ("Acid and Alkaline Decomposition of Potassium Cyanide," Journ. Soc. Chem. Ind., 1921, **40**, 182) are of interest in connection with this matter and help to explain the behaviour of calcium cyanide just noted.

When the substance was treated with water alone (5 c.c.) at ordinary temperature (20°C.) the yield of hydrocyanic acid obtained was very low. Treatment with water and carbon dioxide was found, however, to greatly increase the yield, although the full theoretical yield was not obtained by the method employed.

The percentages of hydrocyanic acid obtained by these respective treatments were as follows:—

With water alone (5 c.c.) at 20° and air gently aspirated for 30 minutes 1.62%

With water (5 c.c.) at 20° and carbon dioxide gently aspirated for 30 minutes 8.10%

In order to ascertain the rate of decomposition of the material and the proportion of gas evolved under conditions somewhat similar to those which obtain when it is used for fumigation in the field, the apparatus described below was designed and assembled:—

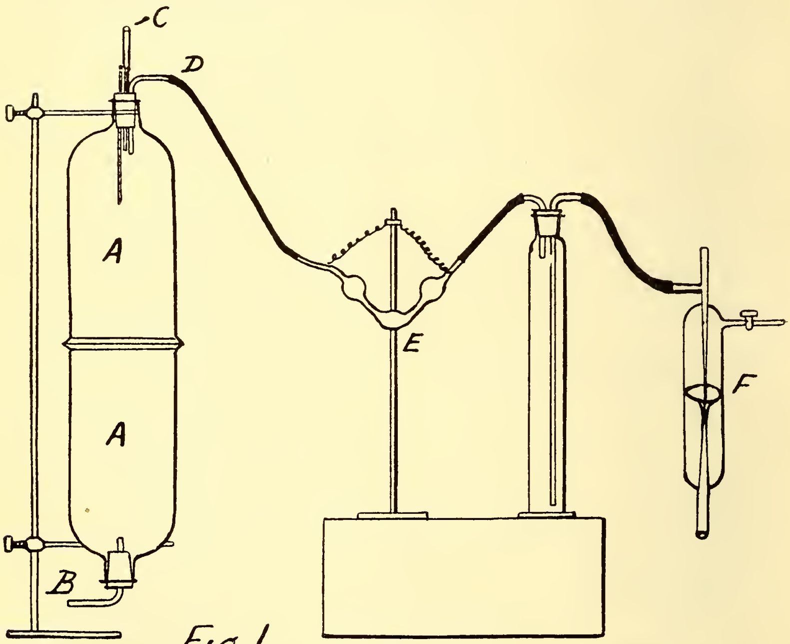


Fig. 1.

Two bell-jars A, as shown in Fig. 1, were cemented together with plasticine. A single delivery tube B, bent at a right angle, was passed through a rubber cork in the neck of the lower jar, while the cork in the upper jar carried a thermometer. A small expanded tube C (for the introduction of the cyanide) and another tube D, bent at a right angle for the aspiration of the liberated gas, were also passed through the cork in the upper bell-jar.

The delivery tube D in the neck of the upper jar was attached by a rubber connection to a series of bulbs E containing a normal solution of potassium hydrate. Aspiration of the gas contents of the jars was effected by means of the filter pump F.

In order to introduce the calcium cyanide and to get it distributed within the bell-jars as a fine dust, the apparatus was partly exhausted and one gram of the material was carefully placed in the expanded tube C. By opening the stopcock attached to the latter, the charge of cyanide was rapidly drawn in and uniformly distributed. After the air within the jars had again reached atmospheric pressure, the stopcocks were all closed.

At intervals the stopcocks attached to the tubes B and D were opened and the gas contents of the jars aspirated through the potash bulbs E.

After aspiration for a definite period, the contents of the bulbs were emptied into a beaker. Distilled water was added and the solution titrated with a decinormal solution of silver nitrate, using 1% solution of sodium chloride as indicator.

Cotton wool soaked in water and placed within the jars ensured maximum saturation of the air enclosed at the particular temperature at which the experiments were carried out.

A series of trials in which this method was used was carried out as follows:—

(a) In a saturated aqueous atmosphere.

(b) In a saturated aqueous atmosphere and in the presence of a small growing plant.

(c) In a saturated aqueous atmosphere of carbon dioxide.

The general results of these trials are summarised in graph shown in Fig. 2.

The figures in the ordinate of the graph refer to parts by weight of hydrocyanic acid, which were obtained from

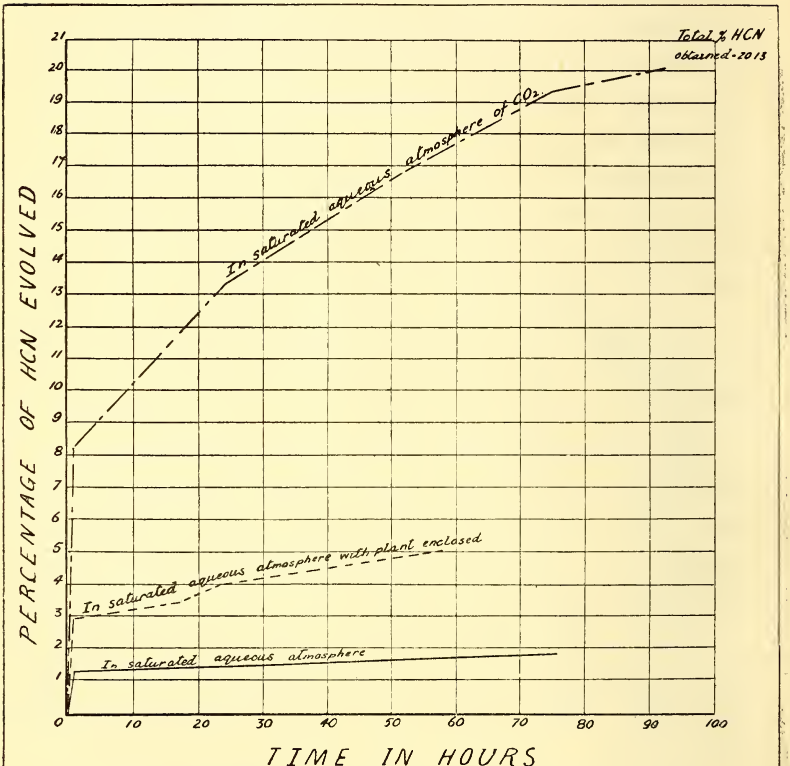


Fig. 2. Percentage of HCN evolved in enclosed space from Commercial Calcium Cyanide Temperature 20° C

one hundred parts by weight of commercial calcium cyanide.

It is probable, of course, that in actual fumigation with the material in the field, the percentage yield of free hydrocyanic acid would appreciably differ from that obtained in the experiments. The reason of this will be clear if we assume that, in the presence of water, hydrolysis of calcium cyanide occurs according to the following equation:—

$$Ca(CN)_2 + 2H_2O = Ca(OH)_2 + 2HCN.$$

As this reaction is reversible, it is obvious that variations in conditions, such as temperature, pressure, and the amount of water present, will effect corresponding variations in the yield of free hydrocyanic acid.

From the consideration of the experimental data it appears that the amount of carbon dioxide present is an important factor in influencing the rate at which decomposition of the cyanide and the evolution of hydrocyanic acid gas occurs.

Furthermore, field experiments conducted with calcium cyanide have shown that, weight for weight, it has a higher efficiency than potassium cyanide, when the latter is employed in the usual way adopted in fumigation practice, that is, by the liberation of the hydrocyanic acid by means of sulphuric acid.

This observed difference is quite probably due to the fact that in the case of fumigation with calcium cyanide, the hydrocyanic acid is evolved actually on the leaves, and vegetative structures, and there is thus a relatively greater concentration of the gas on these parts than is the case where either potassium or sodium cyanides are used for the fumigation.

Moreover, the work of Harker already referred to has shown that only a fraction, probably not more than 30% of the hydrocyanic acid contained in potassium cyanide is evolved when the latter is treated with sulphuric acid at ordinary atmospheric pressure.

The fact that commercial calcium cyanide, which contains a lower percentage of combined cyanogen than potassium cyanide, is yet in field practice more efficient as a fumigant than the latter, is thus readily accounted for.

A simple and practical means whereby the efficiency of a given dose of commercial calcium cyanide could be still further increased, is suggested by the experiments so far performed. This would consist of increasing the concentration of carbon dioxide in the confined space by the simple expedient of burning a small quantity of twigs or pine needles under the tent immediately before treatment with the cyanide.

A field trial in which fumigation of the trees is effected by this slightly modified method might be found to confirm the above suggestion, and so point the way to the more efficient use of the material as a fumigant in ordinary field practice.

REACTIONS DEPENDING UPON THE VAPOUR AT THE INTERFACE OF TWO IMMISCIBLE LIQUIDS.

By G. HARKER, D.Sc., F.A.C.I., and R. K. NEWMAN, B.Sc.

(Read before the Royal Society of New South Wales, June 2, 1926.)

In a former communication (Harker, Jour. Chem. Soc., 1924, **125**, 500) experiments were described, dealing with the reactions taking place at the interface of two immiscible liquids, water and benzyl chloride. It was found that for a given temperature the hydrolytic action between the two liquids depended upon the area of surface between them, and was of approximately the same value per unit area as that obtained when the mixed saturated vapours of benzyl chloride and water were brought into contact with a surface of water under the same temperature conditions. The conclusion was, therefore, drawn that at the interface of the two liquids there must exist the mixed saturated vapours of each constituent. It was recognised, however, that further experimental work was necessary to confirm the agreement obtained; and the present paper deals with the reaction between acidulated water and amyl acetate. Previously the reaction between the mixed vapours on water was studied by a dynamic method, whilst in this communication a simpler static method is described. The reaction between the two liquid substances was also capable of more exact measurement in the present instance, since the contact surface between the two liquids was flat instead of being convex. There was the further advantage in using this ester, that the possibility of error in the vapour experiments was reduced by the fact that condensation of water on the sides of the reaction vessel could be disregarded, since the ester and water alone did not react. Unlike benzyl chloride, amyl acetate is not hydrolysed by water at 100°, but gives a definite surface reaction with water acidulated with a mineral acid. Comparisons were made of the hydrolytic action of varying strengths of acid solutions on the liquid ester, and on its saturated vapour.

EXPERIMENTAL.

Selection of a suitable Ester.

About a dozen esters were subjected to treatment with water at 100°, the area of contact being 10-18 sq. cm. Most showed no appreciable hydrolysis at the end of one to two hours; others were far too rapidly hydrolysed, whilst a few were hydrolysed but failed to give surface reactions. Amongst those in the first-mentioned class, amyl acetate presented a very flat surface to water and seemed to be practically immiscible, so its hydrolysis with alkaline and acid solutions was tested. Using 10 c.c. of caustic soda solution and 5 c.c. ester, the action was so rapid with *N*/10, *N*/25, and *N*/50 solutions that neutralisation was effected in one hour, or less. With acid solutions of corresponding strength the hydrolysis was much less rapid, and the reaction proved to be a surface one. Thus in a four-hour contact with *N*/10-hydrochloric acid the rates were 0.259, 0.244, 0.246 c.c. *N*/10-acid per sq. cm., per hour, when the amounts of ester and acid and the area of contact of the two liquids were considerably varied.

In preparing the ester the once distilled commercial article was washed with sodium carbonate solution then with water and dried well over sodium sulphate or calcium sulphate. It was then distilled under reduced pressure, and the fraction boiling at 43°-50° at 16 mm. collected. The neutral liquid so obtained is generally referred to as amyl acetate, but, strictly speaking, is iso-amyl acetate.

Hydrolysis produced by Contact of the two Liquids Acidulated Water and Amyl Acetate.

When water and amyl acetate are heated together at 100° considerable pressure is developed owing to the separate effect of the vapour pressure of each constituent and the effect of this pressure was measured. Two bottles were taken, each with a cross-section of 12.5 sq. cms. Through the cork of each was fitted a long glass tube passing to the bottom; the cross-section of this tube was 0.26 sq. cm., leaving an effective area of 12.24 sq. cm. Into each bottle a little mercury was introduced, and then into one bottle 10 c.c. *N*/10-hydrochloric acid and 16.5 c.c. ester and into the other 25 c.c. acid and 21 c.c. ester. The bottles were heated in the steam bath at 100° for three hours. The pressure developed in the bottles was 63 and 58 cm. of mercury respectively. On titration each showed an increased acidity of 9.9 c.c. *N*/10-acid, equivalent to a rate of 0.27 c.c. per sq. cm. per hour. Other figures obtained for three hours' contact varied between 0.27 and 0.30 in five experiments. Mean rate for three hours, 0.275 c.c. *N*/10-acid per sq. cm. per hour. Similarly for two hours, 0.29 c.c. per sq. cm. per hour; for one hour, 0.365, and for half-an-hour, 0.41; whilst for four hours the rate obtained was 0.25. It was more difficult to obtain reliable figures for the shorter periods, as in plunging the bottle into the steam chamber the temperature dropped to the neighbourhood of 80°, and about ten minutes were taken in reaching 100°, so that an allowance had to be made for this period. Nevertheless, it was evident that the products of reaction diminished the rate to a marked extent.

In all these experiments, the pressure developed varied from 50 to 76 cm. of mercury, and, in passing, it was thought desirable to test the effect of increased pressure on the speed of reaction. This comparison was carried out at a temperature below the boiling point of the mixed liquids, and showed that an additional pressure of one atmosphere had but little effect; if anything, the rate of hydrolysis was slightly lowered.

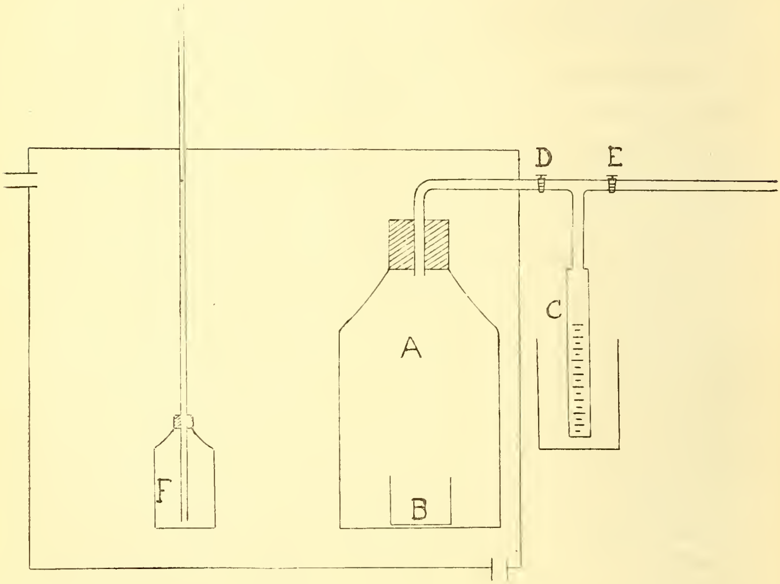
Passage of the Mixed Vapours over Acidulated Water.

Following along the lines of the previously described work on benzyl chloride (loc. cit.), and using the same apparatus, the mixed vapour of water and amyl acetate was led over both *N*/10- and *N*/20-hydrocloric acid, contained in a vessel of known cross-section, for three hours in each case. In the apparatus referred to a series of vessels is kept at constant temperature by surrounding them with steam in a steam chamber; the steam in the chamber being maintained at any desired temperature between 100° and 103°. Steam generated in a small flask outside the main chamber passes into this series of vessels, and is led first into a trap vessel, to remove any contained water, and then into one or two vessels containing the ester, from which the mixed vapours are led over the surface of the acidulated water. The vapours from the last vessel pass out of the chamber, and are condensed. The hydrolytic effect of the mixed vapour is shown by the increase in acidity of the acidulated water, together with the acidity of the distillate. In the case of amyl acetate the hydrolytic effect obtained was much greater than when the two liquids were in contact for the same period. Most of the acidity produced, however, was found in the distillate, the acetic acid coming over in a regular manner. To prove that it was the acetic acid which was being removed, steam was passed over *N*/10-hydrochloric acid for two hours, when the distillate remained perfectly neutral, whilst when *N*/15-acetic acid was used the acid came over freely in the current of steam. Dunn and Rideal (Jour. Chem. Soc., 1924, **125**, 684) have already shown that at 100° the vapour pressure of hydrochloric acid arising from an *N*/10-acid solution is not measurable. The conclusion was reached that when the mixed vapours of amyl acetate and water are passed over a surface of acidulated water the acetic acid formed (and probably the amyl alcohol also) is constantly distilled off, thus permitting a constant rate of hydrolysis; but when the liquids are brought into contact the products accumulate and slow down the reaction.

A comparison of the hydrolytic effect of the ester in the liquid and vapour state upon a surface of acidulated water could therefore not be attained by the means previously used for benzyl chloride. A static method was devised, however, which provided a more direct comparison than was possible with this earlier method. Before proceeding to describe this, it should be noted that the ratio of the constituents in the mixed saturated vapour of water and amyl acetate was determined with great care. This was done by rapidly agitating equal volumes of water and ester in a vessel provided with a stirrer and delivery tube. The vessel was placed in the steam chamber, and the vapours passed directly through a condenser into a graduated cylinder. The distillation took place slowly and regularly, and constant figures were obtained. At 100° the ratio of water to ester found was 1 : 2.32, equivalent to a ratio of 3.58 molecules of water to one molecule of ester in the vapour. It was further shown that the mixed vapour had no action either itself or in presence of water by passing it over distilled water in the reaction vessel above referred to for a period of four hours; the distillate was neutral, whilst the water in the reaction vessel showed a mere trace of acidity, viz., 0.55 c.c. *N*/50-acid.

Direct Comparison of the Hydrolytic Effect of liquid Amyl Acetate and of the Mixed Saturated Vapour of Amyl Acetate and Water upon a surface of Acidulated Water.

This was effected by carrying out tests on the hydrolysis of the liquid simultaneously with tests dealing with the vapour. Assuming that the falling off of the rate with time when the liquids were in contact was due largely to the accumulation of the products of the reaction at the seat of



reaction, it seemed advisable, in making comparisons of the effect of vapour, to keep the products in as confined a space as possible.

A wide-mouthed bottle, A, was accordingly taken and connected by tubing of narrow bore with a graduated cylinder, C, which was placed outside the steam chamber and which could be cooled with ice. On the bottom of A, a small flat-bottomed vessel, B, rested, and in this was placed a measured quantity of hydrochloric acid solution, the remainder of the area of the bottom of A was occupied by the ester. The apparatus was connected up as shown in the text figure, evacuated to remove air, and the tap E closed. A bottle of known cross-section, provided with a pressure tube, and containing the two liquids in contact, was then placed in the steam chamber, after which steam was turned into the chamber. The acidulated water in the vessel B was subjected to the action of the mixed vapour, whilst at the same time the acidulated water in the bottle F was in contact with liquid amyl acetate, thus providing a direct comparison of the effect of each. The composition of the vapour mixture in the bottle A was analysed by allowing a small stream of vapour to pass through the tap D into the cylinder C, which was surrounded with ice, and in which it was condensed. The first few experiments showed that when the surface area of the ester was considerably larger than that of the acidulated water, the composition of the vapour mixture in the bottle was identical, within the limits of experimental error, with that of the saturated vapour as previously determined; consequently it was unnecessary to resort to a distillation test in every case. The results of this direct comparison of the liquid ester and of the mixed saturated vapour are given in the table. Details of one of the experiments follow:—

In the vapour test 10 c.c. of ester were placed in the bottle, and presented a cross-section of 32 sq. cm., 10 c.c. $N/2$-hydrochloric acid were placed in the inside vessel, which had a cross section of 6.29 sq. cm.; the contents were evacuated. The steam took 20 minutes to heat the chamber to 100°, and the reaction was then continued for two and one-half hours. Shortly after the temperature rose to 100° the tap D was opened, and so regulated as to allow a small amount of vapour to continuously distil throughout the period into the small graduated cylinder. The composition of the distillate was 0.9 c.c. water, and 2.05 c.c. ester, i.e., a ratio of 1: 2.28, which compared very well with the ratio of 1: 2.32 previously determined for the saturated mixture. On the completion of the reaction the acid required 60.2 c.c. *N*/10-caustic soda solution, the distillate 0.2 c.c. and the ester (which always absorbed some of the acetic acid formed), 1.5 c.c.—total 61.9 c.c., i.e., an increase of 11.9 c.c. *N*/10-acid. In the liquid test 10 c.c. *N*/2-hydrochloric acid and 9 c.c. ester were taken, the area of contact being 6.37 sq. cm. The bottle was heated in the steam chamber as above, and the pressure reached 42 cm. of mercury. On titration, 63.1 c.c. *N*/10-caustic soda solution were required, i.e., an increase of acidity of 13.1 c.c. *N*/10-acid. Neglecting the preliminary heating-up period, the rates per sq. cm. per hour were 0.76 for the vapour and 0.82 for the liquid. In these experiments, in which the action was started from cold, a film of liquid formed on the acid surface during the preliminary heating, but always vanished at 100°. No film could have been present during the continuous distillation.

Hydrolysis produced at the Surface of Solutions of Hydrochloric Acid with liquid Amyl Acetate and with the Mixed Saturated Vapour of Amyl Acetate and Water.

Conc. of HCl Sol.	Condition of Amyl Acetate	Area of Reaction sq. cm.	Time, hrs.	Increase in Acidity	Rate per sq. cm. per hr.	Remarks
N/10	Liquid	6.1	1½	3.05 c.c. *N*/10	0.333 *N*/10	
,,	Vapour	6.33	1½	3.45 ,, ,,	0.363 ,,	Distillation
N/10	Liquid	6.9	2½	4.65 c.c. *N*/10	0.266 ,,	
,,	Vapour	6.33	2½	4.25 ,, ,,	0.269 ,,	No Distillation
N/20	Liquid	6.9	1	3.6 c.c. *N*/20	0.26 ,,	
,,	Vapour	6.33	1	3.8 ,, ,,	0.30 ,,	No Distillation
N/2	Liquid	6.37	2½	13.1 c.c. *N*/10	0.822 ,,	
,,	Vapour	6.29	2½	11.9 ,, ,,	0.758 ,,	Distillation

Looking at the figures in the table, it is seen that a very close agreement was obtained for the hydrolytic action of the liquid and vapour per unit area of surface exposed. Assuming that the mixed vapours are present at the interface of the two liquids, the object in the vapour experiments was to simulate these conditions as closely as possible. The vapour space, however, in such experiments is large compared with the space at the interface of the two liquids and an absolute agreement in the figures is not to be expected. With the larger space, on the one hand, time must lapse before the mixture of vapours reaches saturation, and equilibrium in its composition cannot be maintained so readily at the surface of the acidulated water during the reaction. This tends to make the vapour figures smaller. On the other hand, the fact that the vapour space is larger, means that the products of reaction are not so concentrated at the surface of reaction, thus tending to make the vapour figures larger. This effect seemed more in evidence in the earlier stages of the reaction. The figures given in the table for rate per hour are not strictly comparable with those obtained previously for hydrolysis at the liquid-liquid surface, because no allowance is made for the action taking place during the preliminary heating.

CONCLUSIONS.

A careful comparison of the hydrolytic effect of liquid amyl acetate and of the mixed saturated vapour of steam and amyl acetate at 100°, upon a surface of given area of dilute hydrochloric acid of varied strengths, reveals a close agreement in the rate of hydrolysis. Taken in conjunction with results previously obtained for benzyl chloride, it is evident that at the interface of the two liquids the mixed saturated vapours of both liquids are present. This is in agreement with the view of Van der Waals, that there exists a continuous transition from the liquid to the vapour state at the boundary. When pressure was applied to the two immiscible liquids, the rate of reaction at the interface was but little affected. Under these conditions, the molecules of vapour must be brought closer together than in the ordinary saturated state, but the free molecular condition must still exist. Just as in the case of benzyl chloride vapour and steam, it has been shown that no appreciable hydrolysis takes place between amyl acetate vapour and steam. An appreciable reaction does take place, however, when the mixed vapours are in contact with acidulated water. Norrish (J. 1923, **123**, 3006) has conclusively shown in the reaction between ethylene and bromine vapour that the rate of reaction is largely accelerated when the two vapours are brought into contact with a polarising surface. In the present instance the polarising effect of the water surface was increased by the addition of a mineral acid.

The authors desire to express their thanks to the McCaughey Research Fund of the University of Sydney for a grant in aid of the work.

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"NOTES ON THE ESSENTIAL OILS FROM SOME CULTIVATED EUCALYPTS."

Part 1.

By A. R. PENFOLD, F.A.C.I., F.C.S.
Economic Chemist, Technological Museum, Sydney.

(Read before the Royal Society of New South Wales, June 2, 1926.)

Beyond the few references in "Eucalypts and their essential Oils" (2nd edition) by Baker & Smith, and Bulletin No. 5 (Technological Museum), "Some valuable essential oil-yielding Plants of Australia worthy of Attention" by the author, very little information has been published concerning essential oils obtained from eucalyptus trees cultivated in Australia. Various reports have been published from time to time regarding oils distilled from trees grown in various parts of Africa, such as in Algeria, Nigeria, Rhodesia, etc., but some of the authors have erred in their summarisation of the results.

In comparing the yields and composition of the African oils with the published figures for Australian trees they have failed to make due allowance for the variations which occur with differences in the composition of the soil, altitude, climatic conditions (whether wet or dry seasons preceded the cutting of the leaves), season of year when leaves cut, accessibility to moisture, etc. On this account I purpose recording from time to time the results obtained in the examination of a number of oils distilled from trees cultivated in New South Wales. The present investigation treats of the oils obtained over a period from trees grown from seed by Mr. E. Cheel at his residence at Ashfield, near Sydney, and to whom I am indebted for the opportunity thus presented of examining such material. The trees were all grown in good garden soil having access to a moderate quantity of moisture.

Eucalyptus Australiana.

(Seed collected at Wyndham, N.S. Wales and sown at Ashfield in 1917.)

The leaves and terminal branchlets, cut as for commercial purposes, on distillation with steam, yielded crude oils, which on examination gave the following results:—

Date.	Yield of oil.	$d\frac{15^\circ}{15}$	a_D^{20}	n_D^{20}	Solubility in 70% alcohol.	Percentage of cineol.	Presence of phellandrene
24/10/1922	2.6%	0.9221	+2.5°	1.4634	1.1-volumes	60%	absent
16/12/1925	2.4%	0.9223	+3.0°	1.4640	1.1 do.	56%	do.

The freshly cut leaves were weighed and distilled within a few hours after removal from the tree.

The oil of *Eucalyptus Australiana,* probably the best cineol oil for pharmaceutical purposes, has been distilled for a number of years in the Nerrigundah, Yourie, Burraga, and Wyndham districts of N.S. Wales. The bulk of the oil came from Nerrigundah and Yourie, and possessed chemical and physical characters identical with those given above for cultivated material. Unfortunately, the oil procured at Wyndham always possessed a slight laevo-rotation, usually about -3.6°, and although it contained from 56-60% cineol, yet phellandrene was present in small quantity, quite sufficient to prohibit its use for medicinal purposes. A typical analysis was, as follows:—specific gravity, 0.9155; optical rotation, — 3.6°, refractive index, 20°, 1.4628, cineol, 60%, phellandrene present in moderate amount. Consequently, as it failed to meet the requirements of the various pharmacopœias, the distillers were compelled to give up its distillation and vacate the district. It was considered that probably some constituent of the soil was responsible for the production of phellandrene, and on a visit to the district in 1917, Mr. Cheel collected seeds of the tree for testing purposes. The results obtained from the cultivated tree appear to confirm the above assumption as the oil yielded chemical and physical constants identical with that of *Eucalyptus Australiana* from other parts of the State, the phellandrene having dropped out with consequent alteration in the optical activity. The crude oil was of a pale lemon-tint, which became water-white on rectification. The aroma was excellent on account of the small quantity of citral present, a characteristic feature of the fine grades of this oil.

EUCALYPTUS MACARTHURI.

(Seed collected at Wingello, N.S. Wales and sown at Ashfield in 1920.)

The freshly-cut leaves and terminal branchlets, cut as for commercial purposes, yielded on distillation with steam, crude oils, possessing the following characters:—

Date.	Yield of oil	$d\frac{15°}{15}$	α_D^{20}	n_D^{20}	Sollbility in 70% alcohol.	Geranyl acetate.	Ger-aniol	Eudes-mol.
7/3/1923	0.74%	0.9257	+3.5°	1.4696	1.2-vol.	70.2%	6%	16.2%
19/8/1925	0.5%	0.9356	+4.8°	1.4771	1.3-vol.	61.9%	3%	25.0%

Attention was drawn to the remarkably high yield of 0.74% for this oil in Bulletin No. 5, and the results are reproduced herewith for purposes of comparison, but the second cutting of the leaves from the same tree yielded 0.5% of oil containing a lower percentage of geranyl acetate and geraniol with a corresponding increase in eudesmol. Even so, the latter yield is a very good one for this species, as trees grown in other situations, such as at Longueville and Croydon, from the same batch of seedlings, the leaves from which were cut during the same season as the first distillation mentioned above (yield 0.74%), gave 0.2% and 0.26% of oil respectively. The ester content calculated as geranyl acetate was found to be 75% and 67% respectively. The increased yield of oil from material cultivated at Ashfield is doubtlessly due to the richer soil and greater accessibility to moisture, and shows in a very striking manner the influence of ecological conditions not only in regard to yields of oil but variations in composition. The oils from cultivated trees were all of a pale yellow colour, very much superior, not only in this respect, but especially in odour, to the usual commercial samples.

Eucalyptus radiata (numerosa Maiden).

(Seed collected at Hill Top and sown at Ashfield in 1918.)

The leaves and terminal branchlets, cut as for commercial purposes, yielded on distillation with steam a bright yellow oil of excellent aroma, which gave the following results on examination:—

Date.	Yield of oil.	$d\frac{15°}{15}$	α_D^{20}	n_D^{20}	Solubility in 80% alcohol.	Piperitol ester.	Piperitol.
March, 1923	2.7%	0.8884	—55.4°	1.4771	0.6-volume	19.5%	20%

These results are in good agreement with those recorded for distillations made from ordinary material collected in various parts of the southern districts of this State, with the exception that the piperitol content is the highest that has yet been observed for this oil. The age of the tree and the favourable conditions of cultivation readily account for the high yield of this alcohol.

Eucalyptus citriodora.

(Seed sown in 1916.)

Leaves and terminal branchlets, cut as for commercial purposes, yielded on distillation with steam, crude oils, possessing the following characters:—

Date.	Yield of oil.	$d\frac{15°}{15}$	α_D^{20}	n_D^{20}	Solubility in 70% alcohol.	Citronellal Content.
May, 1918	0.84%	0.8607	—1°	1.4498	1.2-vols.	98%
Oct., 1919	1.00%	0.8657	—1.1°	1.4515	1.2 „	95%
Nov., 1921	0.5%	0.8692	±0°	1.4536	1.2 „	95%
Aug., 1925	0.61%	0.8667	—0.85°	1.4558	1.3 „	90%
May, 1926	0.5%	0.8705	—0.25°	1.4547	1.3 „	90%

All the oils thus obtained were of a pale lemon tint, some almost water-white, and of superior aroma to the ordinary commercial oils. The first two distillations were carried out on material from one particular tree, whilst the other three represent the distillates obtained from leaves collected from four trees. In view of the fact that the trees were obtained from the one lot of seed which were planted at the same time in the one allotment at Ashfield, there is a wide variation in the yields of the two groups, and to a lesser extent in the characters of the oils. The writer has published figures showing the ordinary field material to average about 0.75% in yield of oil, whilst that of cultivated material varies from 1% to 1.5%. In the analyses given in the above table, a series of yields are recorded lower than those obtained from the trees in Queensland. The difference may, however, be due to a particular race existing within the species, as a number of distillations made from material collected from aged trees growing in the western suburbs of Sydney yielded nothing under 1% of oil, calculated on the fresh material, the greater proportion of yields being from 1.2% to 1.8%, whilst the oils contained from 95 to 98% of citronellal.

In conclusion, my best thanks are due to Mr. E. Cheel, who is doing so much valuable pioneering work in this particular sphere, and to Mr. F. R. Morrison, A.A.C.I., F.C.S., Assistant Economic Chemist, for his usual assistance in the examination of the oils.

AN INVESTIGATION OF THE OPTICAL PROPERTIES OF SELENIUM IN THE CONDUCTING FORM.

By Phyllis M. Nicol, M.Sc.

Science Research Scholar of the University of Sydney.

Communicated by Professor O. U. Vonwiller, B.Sc.

(Read before the Royal Society of New South Wales, June 2, 1926.)

The resistance of selenium in the conducting form depends on the temperature at which transformation from the vitreous form occurred, changes with the length of time of exposure to light and shows an age effect. Since the optical properties of a metal are connected with the conductivity, in the case of selenium it is not unreasonable to look for some variations in the optical constants similar to those that occur in the conductivity, though as the conductivity is small the variations, if any, may also be very small. In this connection an investigation of the optical properties of selenium was undertaken.

For selenium the value of the coëfficient of extinction is low, and the usual katoptric methods of determining the optical constants do not yield accurate results, since the angles to be measured are small. The method of Drude using a Babinet compensator had been tried previously by Mr. R. J. Gillings in this laboratory. The quarter wave plate method was tested and, by suitable choice of the angle of incidence and of the azimuth, values of the optical constants were obtained which at best had an error of 5%.

The principal azimuth method was found unsatisfactory, because at the polarising angle the ratio of the reflection coefficient for the light polarised perpendicular to the plane of incidence to that for light polarised in the plane of incidence is very small. Also a method using multiple reflections was inapplicable because the reflecting power for the horizontal component is small, and on a second reflection the light is practically plane polarised.

Employing a method due to Jamin (Annales de Chimie et Physique Vol. 19, 3rd series 1847), it was possible to measure the angles involved with considerable accuracy. In spite of the fact that individual readings were dependent on the position of the eye, a difficulty that could not be overcome, it is reasonably certain that the angles finally obtained, each the mean of eighty readings, were correct to 15-20 minutes, but unfortunately the form of the expression used to calculate the optical constants was such that the method does not lend itself to accurate determinations with substances for which the phase difference set up between the horizontal and the vertical components of the reflected light is small; this is the case for selenium, except for angles near the polarising angle, and here the method is unsuitable on account of the smallness of the ratio of the horizontal to the vertical component of the reflected light.

An attempt was also made to use a Boys radiomicrometer as detector of the light energy; however the instrument was not sufficiently sensitive to be used in the visual spectrum.

The method finally adopted was a modification of the quarter-wave plate method, a Babinet compensator, with attached Nicol prism, being used as an analyser. If plane polarised light falls on a Babinet compensator, so that the plane of polarisation coincides with one of the principal planes of the compensator, when the field is viewed through a Nicol prism bands will not be seen no matter how the Nicol prism is turned. Thus a Babinet compensator may be used as an analyser and is capable of yielding a very much higher degree of accuracy than a simple Nicol prism, because it is easier to decide when the bands disappear, or most nearly disappear, than to fix a position of extinction, which in practice means fixing a position of minimum brightness.

The figure shows the arrangement of the apparatus which consisted of a spectrometer fitted with a Nicol prism P, the polariser, and a Babinet compensator and Nicol prism C, the analyser, each mounted in a graduated vertical circle with a vernier reading to one minute, and a holder for a quarter-wave plate Q similarly mounted and reading to a twelfth of a degree. The source was a pointolite lamp S and combinations of Wratten filters F were used to give suitable spectral regions. A sodium flame was sometimes used instead and was placed close to A. M is the selenium mirror.

The following notation will be used:—

- ϕ, the azimuth of the plane of polarisation of the incident light with the plane of incidence.
- θ, the angle of incidence.
- δ, the phase difference between the vertical and horizontal components of the reflected light.
- ψ, the ratio of the minor axis of the vibration ellipse to the major axis.
- γ, the inclination of the major axis to the vertical.
- ν_0, the refractive index.
- κ_0, the coefficient of extinction.
- χ, the ratio of the reflection coefficient for light polarised perpendicular to the plane of incidence to that for light polarised in the plane of incidence.

The quarter-wave plate and compensator are rotated in turn until the bands disappear, then γ is given by the inclination of an axis of the quarter-wave plate to the vertical and ψ by the angle between a principal plane of the compensator and an axis of the quarter-wave plate. In practice there was no difficulty in deciding whether an angle or its complement should be taken. κ_0 and ν_0 were calculated by means of the equations below (see Schuster, Theory of Optics, Chapt. XI.).

$$\kappa_{\circ} = K\left(1 - \frac{1}{2}\frac{\sin^2\theta}{M^2 + K^2}\right)$$

$$\qquad \ldots\ldots\ldots\ldots \quad (1)$$

$$\nu_{\circ} = M\left(1 + \frac{1}{2}\frac{\sin^2\theta}{M^2 + K^2}\right)$$

where M and K are given by

$$M = \frac{\sin\theta\tan\theta\cos 2\gamma\cos 2\psi}{1 - \sin 2\gamma\cos 2\psi}$$

$$\qquad \ldots\ldots\ldots\ldots \quad (2)$$

$$K = \frac{\sin\theta\tan\theta\sin 2\psi}{1 - \sin 2\gamma\cos 2\psi}$$

Equations (2) above are only true if $\phi = 45^\circ$; when ϕ has any other value they take the form:—

$$M = \frac{\sin\theta\tan\theta(\cos 2\psi\cos 2\gamma - \cos 2\phi)}{1 - \cos 2\phi\cos 2\psi\cos 2\gamma - \sin 2\phi\cos 2\psi\sin 2\gamma}$$

$$K = \frac{\sin\theta\tan\theta\sin\phi\sin\psi}{1 - \cos 2\phi\cos 2\psi\cos 2\gamma - \sin 2\phi\cos 2\psi\sin 2\gamma}$$

Serious instrumental errors were found in the spectroscope and in order to eliminate them it was necessary to take readings in sixty-four different positions. For any given azimuth there are four positions of the polariser, for each of which there are four positions of the quarter-wave plate and for each of these there are four positions of the Babinet compensator, making in all sixty-four positions. One reading was taken in each.

The necessity for finding zero readings for the quarter-wave plate and the compensator is eliminated and the calculation very greatly reduced by the fact that 2γ and 2ψ can be found directly from the readings. For positions of the polariser 90° apart, the axis of the vibration ellipse are equally inclined to the vertical, but are on opposite sides of it, so that the difference between corresponding readings of the quarter-wave plate give 2γ directly. Similarly with the polariser fixed, for two positions of the quarter-wave plate separated by 90°, the directions of vibration for the restored plane polarised light are equally inclined to an axis of the quarter-wave plate, but on opposite sides, so that the difference between the compensator readings gives 2ψ.

It was necessary to take the values of γ in two sets as the quarter-wave plates were not accurate and the values of γ obtained with the quarter-wave plate in two positions differing by approximately a right angle were not equal. It is easy to show that the mean of these two values gives the correct value of γ and that the observed value of ψ must be corrected as follows:—

$$\tan \psi_c = \frac{\tan \psi_o}{1 + \frac{1}{2} \tan^2 \alpha \left(\frac{1}{\tan^2 \psi_o} - \tan^2 \psi_o\right)}$$

where ψ_c is the corrected and ψ_o the observed value of ψ, and 2α is the difference between the observed values of γ.

In most of the work this correction was small and could be neglected.

Portion of a typical set of readings is given in tables I, II and III, and the method of finding γ and ψ is shown. The set was obtained with red light ($\lambda = 6470 - 7100$) for a pure selenium mirror transformed at 190°, the angle of incidence was 60° and the azimuth 45°. Table I. gives one fourth of the readings obtained for the quarter-wave plate, namely those for one position of the quarter-wave plate and sixteen different positions of the polariser and Babinet compensator. The first row in table III. (a) is obtained by subtracting (2) from (1) in table I. and the second, third and fourth rows from the corresponding readings taken for positions of the quarter-wave plate 180°, 90° and 270° respectively, from the first position. The results are arranged in two groups as shown, on account of the inaccuracy in the quarter-wave plate mentioned above. In table II. are found the readings for the four positions of the Babinet compensator for two positions of the polariser 180° apart from one another and for all four positions of the quarter-wave plate; from this table by subtracting (1) from (2) and (5) from (6) the first and third rows of table III. (b) are obtained, and the second and fourth rows are similarly obtained from the corresponding readings for positions of the polariser 90° from the first positions.

The errors in 2ψ and 2γ are partly due to instrumental faults. It was assumed that in taking a complete set of readings they would be eliminated, and as no means of allowing for them could be found, in estimating the probable error they were treated as errors of observation, the probable error being calculated by means of a formula:

$$\text{Error} = \frac{3\Sigma r}{n\sqrt{n}}$$

Usually it is necessary to find the positions in which the bands most nearly disappear, for it is exceptional for them to vanish completely. This seems to be due partly to imperfections in the mirrors, and partly to irregularities in the quarter-wave plate and Babinet compensator.

A circular aperture large enough for the whole field of view to be illuminated is placed at A (see fig.), and sharp focussing of the telescope is not necessary, a fact which enables the method to be used for the study of very poor mirrors, which would not give a sharp image. A slit is placed at A when fixing the angle of incidence.

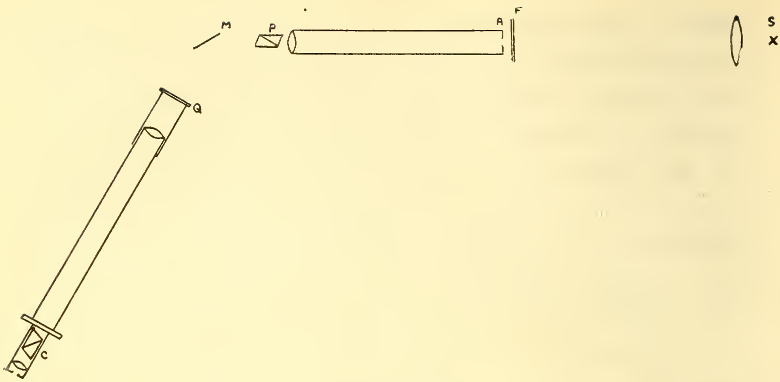

TABLE I.

QUARTER WAVE PLATE.

Polariser.	B.C. (1).	B.C. (2).	B.C. (3).	B.C. (4).
64° 31′	77° 25′	77° 25′	77° 40′	77° 25′
244° 56′	78° 5′	77° 30′	77° 58′	77° 0′
Mean	77° 45′	77° 28′	77° 49′	77° 12′ - (1)
154° 31′	41° 50′	41° 5′	41° 35′	41° 15′
334° 56′	41° 20′	41° 5′	41° 5′	41° 15′
Mean	41° 35′	41° 5′	41° 20′	41° 15′ - (2)

TABLE II.

BABINET COMPENSATOR.

Polariser.	Q.W. P.	B.C. (1).	B.C. (2).	B.C. (3).	B.C. (4).
64° 31′	77° ..	17° 19′	107° 28′	196° 48′	287° 44′
	257° ..	17° 12′	107° 20′	196° 57′	287° 32′
	Mean	17° 15′	107° 24′	196° 53′	287° 38′ - (1)
	169° ..	28° 24′	119° 4′	208° 56′	298° 33′
	249° ..	28° 58′	118° 50′	208° 53′	298° 54′
	Mean	28° 41′	118° 57′	208° 54′	298° 44′ - (2)
244° 56′	77° ..	17° 3′	107° 33′	197° 4′	288° 15′
	257° ..	16° 51′	107° 21′	196° 55′	287° 55′
	Mean	16° 57′	107° 27′	197° 0′	288° 5′ - (5)
	169° ..	28° 26′	118° 47′	208° 30′	299° 8′
	249° ..	28° 14′	119° 21′	208° 26′	299° 6′
	Mean	28° 20′	119° 4′	208° 28′	299° 7′ - (6)

TABLE III. (a) 2γ

36° 10′ 36° 25′	36° 23′ 36° 6′	36° 29′ 36° 29′	35° 57′ 35° 40′
Mean 36° 12′ ± 15′.			
40° 31′ 40° 17′	39° 54′ 39° 53′	40° 7′ 40° 6′	39° 27′ 39° 43′
Mean 39° 57′ ± 19′.			

$$2\gamma = 38°\,4' \pm 17'.$$
$$4\delta = 3°\,45'.$$

TABLE III. (b) 2ψ.

11° 26′	11° 33′	12° 1′	11° 6′
10° 0′	11° 21′	10° 14′	11° 45′
11° 23′	11° 37′	11° 28′	11° 2′
10° 18′	11° 23′	10° 47′	10° 51′

$$2\psi = 11°\,8' \pm 21'.$$

Preparation of Mirrors.

As the supply of pure selenium was limited, the commercial material was used during the earlier part of the work. Molten selenium was poured on a hot glass plate and covered with another hot glass plate, allowed to cool, and then transformed in an electric oven at a definite temperature. A few mirrors were obtained by this method of casting, but it was not satisfactory. Some mirrors were prepared by grinding and polishing, but an objection to grinding is, that owing to the contraction on transformation, the selenium is full of cavities and the ground surface is pitted; however, by grinding a large number of pieces some were obtained fairly free from pits, which on polishing gave moderately good mirrors, but not as good as those that were cast. An attempt to burnish was a failure. The best method of preparation of mirrors using the commercial selenium was to pour molten selenium on glass and to leave it uncovered; on transformation one or two out of half a dozen preparations had flat dull under-surfaces that on polishing gave fairly good mirrors. It was much more difficult to obtain satisfactory results with pure selenium; the method described above did not yield flat mirrors, and it was practically impossible to obtain ground mirrors sufficiently free from pits, and in any case it was desirable to avoid grinding, for if the specimen proved worthless the selenium was no longer pure and so could not be used again. None of the mirrors of pure selenium were really good. Different results were obtained with pure selenium from those obtained with the commercial material when the same method was employed. Some of the mirrors prepared by pouring selenium on hot glass and leaving it uncovered, as described above, had bright smooth under-surfaces, somewhat curved, which could be ground slightly to give moderately flat surfaces without many pits forming, though care had to be taken that the grinding was not carried too far. Mirrors obtained by this means are described as partly ground. They had, of course, to be polished.

Some pieces of selenium that had been ground and had not given satisfactory mirrors were cleaned as well as possible and made again into mirrors. The nature of the surfaces of these specimens was entirely different from those of pure selenium, and seemed to indicate that small quantities of impurities very materially change the nature of the surfaces.

A number of mirrors prepared at various temperatures were finally obtained.

The Results.

The aim of the investigation as mentioned above was to ascertain whether there is any dependence of the optical properties upon the temperature of transformation. The results obtained for a number of mirrors prepared at different temperature are given in table IV., and it will be seen that there is no regular variation of κ_0 and ν_0 with the temperature of preparation, although κ_0 and ν_0 vary within fairly wide limits. There is an indication that the values of ν_0 for mirrors prepared by grinding are less, and the values of κ_0 greater than for mirrors that have only been polished.

An age effect was also looked for, by determining ν_0 and κ_0 for a mirror on the day on which it was prepared, and again on the following day, but the differences between the values of ν_0 and κ_0 were within the experimental error; of course a change occurring very quickly could not be detected by this means. At one time it was thought that in the case of some mirrors, a change of optical properties with time of exposure had been detected, but further investigation showed that this was not the case.

As Mr. Gillings, using Drude's method, obtained results which indicated that there was a variation in the optical constants with the angle of incidence, this point was investigated; results were obtained for a mirror of commercial selenium, using green light for angles of incidence 50°, 60° and 70°, and for a mirror of pure selenium using green light for angles of incidence, 40°, 50°, 60°, 65° and 70°, and red light for angles of incidence of 50°, 60°, 70°; in all cases the variations in ν_0 and κ_0 with the angle of incidence lie within the experimental error. Much greater accuracy can be obtained by this method than by Drude's, so that it appears that the variations noted by Mr. Gillings must be attributed to experimental error due to instrumental limitations.

From table IV. it will be seen that κ_0 decreases and ν_0 increases as λ increases. From the work done with the Boys radiomicrometer, some indication of the values of κ_0 and ν_0 in the infra-red was obtained. κ_0 is certainly

TABLE IV.

Mirror.	θ	ϕ	$\lambda=$ 6470–7100		$\lambda=$ 5890–5896		$\lambda=$ 4900–5190		$\lambda=$ 4400–4800	
			ν_0	κ_0	ν_0	κ_0	ν_0	κ_0	ν_0	κ_0
Pure Se	60°	45°	2.94	0.79	2.75	1.03	2.77	1.09	2.74	1.18
158–159°			2%	4%	2%	2½%	2%	2%	2%	3%
ground and	60°	45°	2.94	0.82						
polished			3½%	4%						
159.5–160.5°	60°	45°					3 02	1.00		
Pure Se							1½%	4%		
Partly gr.	60°	45°	3.18	0.74			3.00	1.04	3.04	1.05
and polished			2½%	6%			3%	5%	2%	2%
177–180°	60°	45°	2.93	0.79	2.89	0.90	2.74	1.02		
Pure Se			1½%	3%	2%	4%	3%	3%		
ground and	68°	70°	3.04	0.75			2.8	1.03		
polished			2½%	3%			2½%	2½%		
178–180°	60°	45°	3.06	0.56						
Se may			1%	5%						
contain										
polishing										
material										
189.5–190°	60°	45°	3.02	0.69			2.76	1.046		
Pure Se			1½%	5%			2%	3%		
partly gr.	60°	45°	3.05	0.70			2.78	1.048		
and polished			2%	5%			2%	3%		
186–190°	60°	45°	3.00	0.66						
Commercial			1½%	5½%						
Se. ground										
and polished										
190–192°	40°	45°					2.82	1.172		
Pure Se.							3½%	5%		
ground and	50°	45°	3.05	0.82			2.80	1.176		
polished			3%	8%			3%	5%		
	60°	45°	3.04	0.81	2.91	1.07	2.78	1.15	2.75	1.27
			1%	9%	1½%	2½%	3%	4%	4½%	4½%
	65°	55°					2.78	1.16		
							5%	5%		
	70°	45°	3·02	0.78			2.75	1.14		
			1%	3%			3%	4%		
190–192°	60°	45°	3.04	0.48	3.06	0.77	2.91	0.90		
Pure Se			3%	6%	2%	4½%	2½%	3%		
polished	60°	45°	3.02	0.45						
			1½%	6%						
199–200°	60°	45°	2.7	0.93			2.59	1.06		
Pure Se.			2%	4%			4%	2%		
polished	60°	45°	2.8	0.87						
			2%	4½%						
200–201°	60°	45°					2.73	0.98		
Pure Se.							3%	4%		
partly gr.	60°	45°					2.80	1.02		
and polished							3%	4%		
197–201°	60°	45°	3.36	0.52			3.02	3.96		
Commercial			3%	7%			2%	4%		
Se. cast.										
200–202°	60°	45°	3.06	0.62			2.87	0.94		
Pure Se.			4%	8%			3%	4%		
polished										

Below each reading is given the estimated possible error expressed as a percentage.

very small in that region, and all that could be done was to assign an upper limit to it and to find an approximate value for ν_0.

The values obtained for a mirror of commercial selenium transformed at 186 to 189° were—

$$\nu_0 = 2.6.$$

κ_0 is less than 0.1.

These results indicate that the refractive index in the near infra-red is not very different from that in the visible red, and that κ_0 decreases rapidly in that region. In the work with the Boys radiomicrometer the source was the pointolite lamp and a water cell of one centimeter thickness was used, so that the effective radiation was a wide band in the near infra-red, together with visible light, but it was shown that the latter did not affect the instrument appreciably. It is hoped to extend the work in the infra-red.

The result found for visible light that the optical properties do not depend on the temperature of preparation was confirmed in the infra-red, for tan χ was determined for a number of mirrors prepared at different temperatures, and no regular variation with temperature of preparation was found, but the experimental error was greater in this case. An attempt to ascertain whether the optical properties varied with time of exposure to the light yielded a negative result. There was an indication that the reflective power increased with the time of exposure, but the change was within the experimental error.

It has recently been found possible to obtain good mirrors by casting the selenium on glass and transforming over a Bunsen burner. Of course, if this method is used, the temperature of transformation is not known, but it has been shown that this is not important. Several mirrors prepared in this way were examined for an age effect. The first reading was usually taken not later than fifteen minutes after transformation had occurred, but no definite effect was observed.

Summary.

A katoptric method suitable for the investigation of the optical properties of selenium in the conducting form has been devised. Methods of preparing mirrors are described. The values of ν_0 and κ_0 depend on the method of preparation of the reflecting surface (casting on glass, polishing, grinding, etc.), the values obtained being as follows:—

λ = 6470-7100	ν_0 = 2.7-3.18	κ_0 = 0.45-0.93
λ = 5890-5896	ν_0 = 2.75-3.06	κ_0 = 0.77-1.07
λ = 4900-5190	ν_0 = 2.59-3.02	κ_0 = 0.90-1.18
λ = 4400-4800	ν_0 = 2.74-3.04	κ_0 = 1.05-1.27

The error in any determination was usually not more than 3 per cent. for ν_0 and 5 per cent. for κ_0. There is an indication that in the infra-red $\nu_0 = 2.6$, and κ_0 is less than 0.1.

It was found that the optical properties do not depend on the temperature of transformation to the conducting form, and that the changes, if any, in the optical constants with length of exposure to light or with age lie within the experimental error.

This investigation was carried out in the Physical Laboratory of the University of Sydney under the direction of Professor Vonwiller, whom I wish to thank heartily for his constant advice and interest.

THE ESSENTIAL OILS OF *LEPTOSPERMUM LANIGERUM* (SMITH).

(Part 1.)

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(Read before the Royal Society of New South Wales, July 7, 1926.)

The botany of this Myrtaceous shrub has been very fully described in Bentham's "Flora Australiensis," Vol. III., p. 106. It is a tall shrub, fairly widely distributed throughout N.S. Wales, Victoria, South Australia and Tasmania, and is usually found on the banks of creeks and water courses, being extremely plentiful in the southern district of New South Wales. It appears to possess very variable botanical characters, and on that account, the present investigation treats of the material collected from one district, Monga, 12 miles on the Clyde Road from Braidwood, New South Wales. The writer seems to have been successful in observing two very distinct and extreme forms of this plant, as apart from the marked differences in the chemical and physical characters of the oil, the material is readily differentiated in the field. Two collections were made by the Museum collector and one by a local resident, Mr. H. McRae, and in each case the collectors were able to secure supplies of the two forms without apparent admixture, from hand specimens of herbarium material.

The material which is being accepted as the type has long, somewhat narrow leaves from 1 to 1½ inches in length, well protected with long silky hairs on both sides. From a distance the plant possesses a characteristic "silvery" sheen which readily differentiates it from the form

"A," having shorter and more obovate leaves, about ½ inch in length, of a bright green colour. The calyx, too, is much more woolly than in the type form.

Both forms have ready accessibility to water, and grow in close proximity to one another, although the "silvery" type is the only one so far observed which follows the banks or creeks for many miles. The leaves of the "silver" leaf or type form when crushed between the fingers, do not emit any particularly characteristic odour, whereas the "green" leaf (form "A") yields a pleasant ester-like odour, typical of darwinol and its acetic acid ester, and pinene. Botanists do not appear to be able to separate these two forms on morphological grounds, preferring to view them as extreme forms of one another, an opinion with which I am in agreement for the present, until such time as further careful botanical investigation proves the "green" leaf form to be worthy of specific, or at least, varietal rank. The general chemical and physical characters readily differentiate them from one another, the chemical composition being of exceptional interest.

The Essential Oils.

The essential oils obtained from the three consignments of leaves and terminal branchlets from Monga, New South Wales, varied from a bright yellow to a deep brownish yellow in colour, the silver leaf type possessing a cinnamon-like odour, whilst the green leaf form was more mobile and possessed an extremely pleasant odour of pinene mingled with that of darwinol and its acetic acid ester. The principal constituents which have so far been identified are as follows:—

Silver leaf.—Sesquiterpenes (aromadendrene and eudesmene), 60-75%, *d-a*-pinene, 16-20%, with small quantities of sesquiterpene alcohol and isovalerianic acid ester, geraniol, geraniol formate and cinnamate, citral, cineol, and unidentified phenolic bodies.

Green leaf.—*d*-*a*-pinene, 40-60%, darwinol and its acetic acid ester 40-45%, with small quantities of sesquiterpene, sesquiterpene alcohol and esters, and unidentified phenolic bodies.

Experimental.

A total collection of 578 lbs. and 626 lbs. respectively of both kinds of leaves and terminal branchlets collected from Monga, New South Wales, yielded on distillation with steam, crude oils possessing the chemical and physical characters, as shown in table:—

SILVER LEAF.

Date.	Weight of leaves	% Yield of oil	$d\frac{15}{15}$	a^{20}_D	n^{20}_D	Solubility in 80% alcohol (by wt.)	Ester No. 1½ hours hot sap	Ester No. after acetylation 1½hrs. hot.
10.4.1922	135lbs	0·28	0·9178	±0°	1·4928	insol. in 10 vols.	12·81 (acid No. 2)	62·59
23.4.1924	215lbs	0·33	0·9152	+10·5°	1·4890	partly sol. do.	16·29	83·17
28.8.1925	228lbs	0·33	0·9231	+6·5°	1·4904	sol. in 7 vols.	29·63	100·08

GREEN LEAF (Form "A")

6.4.1922	172lbs	0·46	0·9047	+30·5°	1·4756	6·5 vol	42·67 (acid No. 2)	92·15
23 4.1924	231lbs	0·47	0·9242	+32·2°	1·4783	1·0 vol.	56·89	150·32
28.8.1925	223lbs	0·67	0·9148	+30·1°	1·4770	1·0 vol.	49·13	140·22

Each consignment of oil was examined in detail, the oils being first treated with 8% sodium hydroxide solution to remove free acid and phenolic constituents, and then with alcoholic potash solution to decompose the esters present. On distillation, these treated oils behaved as follows:—

Boiling point.	Volume	d_{15}^{15}	a_D^{20}	n_D^{20}
230 c.c. (1924 lot).				
56-60° at 20 mm.	40 c.c.	0.8643	+28°	1.4661
60-65° do.	15 c.c.	0.8682	+21.6°	1.4667
up to 120° 10 mm.	27 c.c.	0.9005	+ 2°	1.4846
120-150° at 10 mm.	110 c.c.	0.9274	+ 1.75°	1.4986
190 c.c. (1925 lot).				
Below 60° at 10 mm.	28 c.c.	0.8653	+24.7°	1.4660
60-120° do.	25 c.c.	0.9005	± 0°	1.4841
120-135° do.	63 c.c.	0.9187	— 2.6°	1.4949
135° (10 mm.) to 143° at 5 mm.	50 c.c.	0.9516	+ 5.7°	1.5039

Determination of Terpenes.—The fractions boiling below 65° at 20 mm. were repeatedly distilled over metallic sodium at 769 mm., when the following fractions were obtained:—

Boiling point.	d_{15}^{15}	a_D^{20}	n_D^{20}
154-156°	0.8641	+29.65°	1.4660
157-159°	0.8656	+25.90°	1.4662
159-168°	0.8678	+21.0°	1.4672

The fraction distilling at 154-156° was used in the following experiments for the determination of *d-a*-pinene:—

32 c.c. were shaken with 67 g. powdered potassium permanganate, 800 c.c. water and 450 g. ice, until the reaction was completed. On subsequent treatment (See this Journal, 1923, p. 52, 242), about 15 g. pinonic acid were obtained distilling at 176-182° at 5 mm. On prolonged cooling in the ice-chest crystals of the solid acid separated, which on purification from petroleum ether (B. pt., 50-60°), melted at 70°. The semicarbazone prepared therefrom melted at 207°; 0.7244 g. of the acid in 10 c.c. chloroform gave $[a]_D^{20}$ + 90°.

Examination for β-pinene.—Oxidation of fraction 159-168° with alkaline potassium permanganate yielded a small quantity of a sparingly soluble sodium salt, from which an acid resembling nopinic acid was separated. The melting point, however, could not be raised above 112°.

Determination of Cineol.—The above mentioned fraction was found to contain a small quantity of a constituent which was not oxidised under the conditions of the experiment. It was available in too small a quantity for the determination of its constants, but it possessed an odour much like cineol, confirmation of which was obtained by the preparation of the iodol compound melting at 112°.

Determination of Geraniol.—Fraction No. 3 (1925 Lot) 63 c.c., on treatment with phthalic anhydride in benzene solution was found to contain about 10% geraniol. It was confirmed by oxidation to citral, and the preparation of the silver salt of the phthalic acid ester which on purification from methyl alcohol melted at 133°.

In order to determine if this alcohol were present in the free condition as well as in the form of an ester, a separate portion of the crude oil was fractionated at 5 mm., and the portion boiling between 85-128° (40 c.c), was reserved for examination. On treatment in the usual way with phthalic anhydride in benzene solution, about 1 c.c. of alcohol resembling geraniol was obtained. It was inactive, and possessed a refractive index of 1.4760 at 20°. It yielded citral on oxidation, and the silver salt of the phthalic acid ester melted at 133°. The crude oil was then treated with alcoholic potash solution to decompose any ester present, and on further treatment with the phthalic anhydride in benzene a further ½ c.c. of geraniol was obtained, which was similarly identified as mentioned. The geraniol is thus present in the uncombined condition as well as in the form of ester.

Determination of acids (cinnamic and formic) in combination with the geraniol.—The alkaline liquor resulting from the saponification of the special lot of oil used for the determination of geraniol was evaporated to small bulk and acidified with dilute sulphuric acid. The small quantity of solid acid which separated was filtered, dried, and recrystallised from ethyl alcohol. It melted at 133°, and gave all the general reactions for cinnamic acid. Its identity was confirmed by the method of mixed melting point, using a specimen of Kahlbaum's, there being no depression, the melting point remaining at 133°. The filtrate was subjected to steam distillation, and the water soluble acid neutralised with ammonia solution. The preparation of the silver salt, its colour reaction with ferric chloride, and its reducing action upon mercury and silver salts left no doubt as to its being formic acid.

Determination of citral.—On account of the cinnamon-like odour of the crude oil, a portion, 118 c.c., was shaken with 35% neutral sulphite solution, but only ½ c.c. of citral was removed. Its identity was confirmed by the preparation of citryl-β-napthocinchonic acid melting at 197°. Cinnamic aldehyde was not detected.

Determination of Sesquiterpenes.—The high boiling fractions of the 1924 and 1925 consignments were repeatedly distilled over metallic sodium until the following final fractions were obtained:—

Boiling Point, 10 mm.	d_{15}^{15}	a_D^{20}	n_D^{20}
1924 Consignment:—			
121-129°	0.9126	−3.75°	1.4981
130-135°	0.9281	+10°	1.5000
1925 Consignment:—			
126-129°	0.9130	−5°	1.4975
130-135°	0.9255	−3.1°	1.5002
150-160°	0.9685	+7.5°	1.5052 (Ester No. after acetylation 142.)

The first four fractions failed to yield any of the solid derivatives characteristic of sesquiterpenes, but gave the well-known colour reactions with bromine in acetic acid, and sulphuric acid in acetic anhydride solutions.

Judging from previous experience with the sesquiterpenes from Australian Myrtaceous plants, and the fact that under the conditions of the experiments no solid hydrochlorides were obtained, the writer feels justified in concluding that they represent a mixture of aromadendrene and eudesmene.

Determination of Sesquiterpene alcohol.—The fraction distilling at 150-160° at 10 mm., measuring only about 23 c.c. and apparently consisting of a mixture of sesquiterpenes with sesquiterpene alcohol, was treated on the water bath with twice its volume of 100% formic acid. The sesquiterpene thus prepared on purification and repeated distillation over metallic sodium yielded the following chemical and physical characters:—

Boiling point, 130-132° at 10 mm., $d\frac{15}{15}$ 0.9251, α_D —1.4° n_D^{20} 1.5066. It gave indigo-blue colorations with bromine in acetic acid and sulphuric acid in acetic anhydride solutions. The quantity available was too small for attempting the preparation of derivatives.

Determination of acids present as Esters.—The crude potassium salts resulting from the decomposition of the esters were acidified with dilute sulphuric acid, when on standing a small quantity of a solid acid separated. This was filtered off, dried, and recrystallised from ethyl alcohol when it melted at 133°. It was confirmed as cinnamic acid by the method of mixed melting point. The filtrate was subjected to steam distillation and the volatile acids fractionally separated. On neutralisation with ammonia solution, the silver salts were prepared in the usual way.

On ignition of the various fractions the following results were obtained.

Water-soluble acids.

1st fraction. 0.6024 g. silver salt gave 0.3588 g. silver = 59.06% Ag.

2nd fraction. 0.3886 do. gave 0.2243 g. silver = 57.72% Ag.

3rd fraction. 0.0810 do. gave 0.0412 g. silver = 50.86% Ag.

Oily acid.

0.1560 g. silver salt gave 0.0534 g. silver = 34.23% Ag.

Judging from the above results, the general chemical deportment of the acids, and the difficulty of exact identification, the writer has deduced that they probably represent a mixture of isovaleric acid and formic acids. That formic acid is present has been definitely proved and the silver salt of the volatile acid separated in the course of one of the examinations was found to yield 68% silver. The silver salt of formic acid contains 70.60% Ag. The oily acid gave results closely approximating to lauric acid (silver salt of lauric acid contains 35.1% Ag.), although it might possibly be due to impure capric acid.

Unidentified Phenolic bodies.—The crude oils on washing with 8% sodium hydroxide solution yielded the following quantities of unidentified liquid phenolic bodies:—

1924 lot. 200 c.c. gave 0.59 g.

1925 lot. 200 c.c. gave 2.73 g.

The colour reactions with ferric chloride in alcoholic solution were very indefinite, although they appeared to belong to the tasmanol-leptospermol group.

GREEN LEAF (Form "A").

Each consignment of oil was examined in detail, some of the distillations being conducted upon the crude oil, whilst others were first treated with 8% sodium hydroxide solution and alcoholic potash solution for the removal of phenolic constituents and esters.

On distillation the following results were obtained, viz.:

Boiling point.	Volume	d_{15}^{15}	a_D^{20}	n_D^{20}
1922 lot (crude oil)—100 c.c. at 10 mm.—				
45-49°	57 c.c.	0.8643	+39.5°	1.4657
49-99°	5 c.c.	———	+28.3°	1.4686
99-110°	14 c.c.	0.9550	+28.0°	1.4823
110-120° 120-155°	1 c.c. 20 c.c.	0.9575	+15.4°	1.4915
1924 lot (oil after treatment). 280 c.c. distilled.				
Below 60° at 20 m.m.	93 c.c.	0.8653	+39.1°	1.4654
60° at 20 mm. to 90° at 10 mm.	15 c.c.	0.8852	+33.2°	1.4705
90-100° at 10 mm.	93 c.c.	0.9487	+31.8°	1.4894
110-120° do.	15 c.c.	0.9613	+28.5°	1.4944
120-130° do.	40 c.c.	0.9684	+17.0°	1.5016

Determination of Terpenes.—The fractions boiling below 60° at 20 mm. were repeatedly distilled over metallic sodium at atmospheric pressure when the greater portion was obtained distilling at 155-157° at 770 mm. The *d*-*a*-pinene thus obtained in each of the three distillations possessed the following average characters:—

d_{15}^{15} 0.8635 to 8644, a_D^{20} +39.8° to +40.5°
n_D^{20} 1.4652 to 1.4656.

On oxidation of 32 c.c. with potassium permanganate under the conditions described under "silver" leaf in the early part of this paper, pinonic acid was obtained distilling at 176-182° at 5 mm. It readily solidified upon cooling in the ice-chest and an excellent yield of crystals was separated. On purification by means of petroleum ether (B.pt. 50-60°) they melted at 70°; 0.1076 g. of the acid in 10 c.c. chloroform gave $[a]_D^{20}$, +92°. The semicarbazone melted at 207°.

The hydrochloride of the terpene was also prepared, and this on recrystallisation from ethyl alcohol melted at 131-132°. 0.8470 g. in 10 c.c. ethyl alcohol gave a reading of +2.8° $=[a]_D^{20}$ +33.06°

Determination of Darwinol and its Ester.—It was found that an acetic acid ester was concentrated in the fraction distilling between 100-110° at 10 mm., $d\frac{15}{15}$ 0.9563, a_D +28.5°, n_D^{20} 1.4819, and that it was saponifiable with alcoholic potash solution at room temperatures. The alcohol was, therefore, found to be concentrated in the saponified oil (1924 lot) in the fraction boiling at 90-110° at 10 mm. 93 c.c., as shown in table above. This fraction on heating with an equal weight of phthalic anhydride in an oil bath at temperatures between 110-120°, or preferably in benzene solution on the water bath for a prolonged period, and working up in the usual way, yielded a solid phthalate of melting point 112°. On decomposition with sodium hydroxide solution and subsequent steam distillation, a water-white, viscous oily alcohol was obtained possessing the following characters (the mean of three determinations):—

Boiling point at 10 mm. ..	107-110°
Specific gravity	0.9802 to 0.9803
Optical rotation	+43.7° to +45.5°
Refractive index 20°	1.4924 to 1.4943

In general chemical and physical characters it very closely resembled darwinol, an alcohol, $C_{10}H_{18}O$, separated from the oil of *Darwinia grandiflora* (See This Journal, 1923, **52**, 244) and the preparation of its characteristic derivative, the napthyl*iso*cyanate, confirmed its identity. This napthyl*iso*cyanate prepared (as described on p. 245, l.c.), melted at 87-88° when recrystallised from ethyl alcohol. Although this particular derivative of the alcohol has been prepared from three different sources, its melting point has always been found to be either 86-87° or 87-88°. It was found, in this instance, however, that if the derivative be more rigorously purified the melting point could be raised to 90-91°. The variation between the constants of the alcohol from the respective oils is doubtlessly due to the preparation from the Darwinia oil being contaminated with geraniol, a circumstance which was thought probable (see p. 238, l.c.), but which could not be proved experimentally.

Determination of Combined Acids.—The potash salts resulting from the saponification of the esters were separated, decomposed with dilute sulphuric acid and steam distilled. The volatile acids thus obtained were collected in fractions and neutralised with ammonia solution and the silver salts prepared therefrom. The following results were obtained on ignition:—

Water soluble acid:—

1st fraction. 0.6383 g. silver salt gave 0.3954 g. silver = 56.30% Ag.

2nd fraction. 0.4933 g. silver salt gave 0.3068 g. silver = 62.19% Ag.

3rd fraction. 0.4719 g. silver salt gave 0.3002 g. silver = 63.62% Ag.

4th fraction. 0.1687 g. silver salt gave 0.1086 g. silver = 64.38% Ag.

5th fraction. 0.4768 g. silver salt gave 0.3066 g. silver = 64.30% Ag.

6th fraction. 0.2986 g. silver salt gave 0.1934 g. silver = 64.76% Ag.

The potash and ammonium salts, on examination, gave all the ordinary qualitative reactions for acetic acid. The anhydrous sodium salt on distillation with phosphoric acid yielded only acetic acid of boiling point 116° (u.c.) at 760 mm. The principal acid of the ester is, therefore, acetic acid, contaminated with a small quantity of another acid unidentified.

Oily Acid.—A very small quantity of oily (water insoluble) acid was obtained, and converted into the silver salt: 0.0976 g. yielded on ignition 0.0372 gram silver—38.1% Ag. (The silver salt of capric acid requires 38.7% Ag.)

Determination of Sesquiterpene and Sesquiterpene alcohol.—The fraction 120-130° at 10 mm., 40 c.c. (1924 consignment), was further distilled, but on account of the difficulty of completely removing the darwinol from it (even with phthalic anhydride), it was impossible to obtain sufficient of the sesquiterpene in a pure enough condition for examination. Its presence could only be demonstrated by means of the well-known colour reactions referred to under "silver leaf." A fraction boiling at 130-150° at 10 mm. was, however, separated. It possessed the following characters:—

$$d_{15}^{15}\ 0.9612,\ \alpha_D + 9.25°,\ n_D^{20°}\ 1.5000,$$

and it was found to contain about 50% of sesquiterpene alcohol.

Unidentified phenolic constituents.—The crude oils on washing with 8% sodium hydroxide solution yielded the following quantities of unidentified phenolic constituents:

1924 lot. 300 c.c. yielded 1.2 g.
1925 lot. 300 c.c. yielded 1.84 g.

The colour reactions with ferric chloride in alcoholic solution were very indefinite, although they bore a very close resemblance in general characters to the tasmanol-leptospermol series.

In conclusion, I have to express my thanks to Mr. F. R. Morrison, A.A.C.I., F.C.S., Assistant Economic Chemist, for his usual helpful assistance in these investigations.

ACACIA SEEDLINGS, Part XII.

By R. H. Cambage, C.B.E., F.L.S.

(With Plates I.-IV.).

(Read before the Royal Society of New South Wales, August 4, 1926.)

SYNOPSIS:

Nocturnal Movement of Early Leaves.
Vitality of Leaf Severed from Plant.
Vitality of Seeds in the Soil.
Sequence in the Development of Leaves.
Description of Seedlings.

Nocturnal Movement of Early Leaves.

In Part XI. of this series reference is made to the fact that many of the very early leaves of some *Acacia* seedlings rest on the ground at night, and each morning raise themselves and resume their normal daily position.* Darwin made many observations regarding general plant movements which he terms circumnutation, and refers to the movement of the leaves of *A. Farnesiana* and of a phyllode of *A. retinodes.*†

Recently observations were made of the movement of the early leaves of a seedling of *Acacia ericifolia* from Western Australia, and it was found that some of the leaves sank down at night until they became almost vertical, while the following morning they returned to their daily position and pointed considerably above the horizontal. The

* This Journ. 1925, 59, 230.

† "The Power of Movement in Plants" by Charles Darwin (1882).

amplitude of this movement was such that a No. 7 leaf, 1.5 cm. long, passed through an arc of about 120 degrees, while a No. 6 leaf, 1.1 cm. long, of a second plant, described an arc of about 130 degrees.

Nos. 10 to 20 on one of these plants were phyllodes, and closed upwards towards the stem at night, but curiously Nos. 8 and 9, which were the first two phyllodes, went neither up nor down, but remained in a horizontal position, while Nos. 1 to 6 closed downwards.

Vitality of Leaf Severed from Plant.

From a plant of *Acacia polybotrya* about one foot high, one pinna of a leaf was broken off at 9 p.m. on the 27th June, 1926, when all the leaves were asleep and the leaflets closed up. It was placed on the ground in a shady spot, and some rain fell nearly every day for the next ten days. The pinna was 6 cm. long, with 25 pairs of leaflets ranging from about 5 to 7 mm. long. On the following morning all the leaflets expanded as if still attached to the plant, and closed up again in the evening. This action, with slightly diminishing vigour, was repeated daily until the 7th July, when, at 8 a.m., the pinna was placed in a small box for about one hour. When taken from the box at 9 a.m., and left in a room, the leaflets were expanded in accordance with their daily custom, and their terminals were 1 cm. apart, but at 10.30 a.m. they were only 5 mm. apart, while by 11 a.m. they had closed up to such an extent that the terminals were only 3 mm. apart, nor did they open any more on succeeding days. It seems likely that, had the pinna been left on the ground, and the damp weather had continued, the leaflets would have functioned for several days more.*

* The question of the movements of plants is discussed by Sir Jagadis Chandra Bose in his new book, "The Nervous Mechanism of Plants". See abstract in "The Pharmaceutical Journal and Pharmacist" (No. 3265, Vol. 116, May 29th, 1926).

Vitality of Seeds in the Soil.

That *Acacia* seeds may retain their vitality after having been in the soil for many years is well known to settlers in various parts of Australia, but the following examples are of considerable interest.

Quite recently four seedlings of *A. falcata* appeared in my own garden, and it is now 35 years since two trees of this species grew near the spot. Ever since the trees were cut down, one or two seedlings have appeared every year.

In 1924, at Milton, New South Wales, two hundred seedlings of *Acacia mollissima* were counted in an enclosure of four acres which had been recently ploughed, but which previously had not been cultivated for 60 years. Although there are trees of the same species growing a few hundred yards away, and one tree just on the edge of the enclosure, there is no reason to suppose that birds had recently carried the seeds to this particular area, but the general conclusion is that the seeds had been lying in the ground for 60 years, and having been disturbed and brought to the surface by the plough, they had responded to the rain, and heat of the sun, and germinated.

A more remarkable instance occurred a short distance away in 1925, where six acres of grass land had been enclosed and ploughed. No wattle trees (*Acacia*) had grown on the area since it was cultivated 68 years before, but after this recent ploughing, much more than one thousand *Acacia* seedlings sprang up on one particular acre of the enclosed area, evidently at a spot where many trees of this species (*A. mollissima*) formerly grew. There seems no doubt that the seeds had retained their vitality for a period of at least 68 years, while lying in the soil.

Seeds of this species ripen in midsummer, and during very dry years the ground cracks considerably at this period, and many seeds would be likely to fall into the crevices, and so get beyond the influence of the necessary combined heat and moisture required to cause their germination, which, however, takes place when the seeds are brought near the surface by the upturning of the soil. It is known, however, that *Acacia* seeds may retain their vitality in the soil for at least five years without germinating, even though they are close to the surface and regularly watered.

Sequence in the Development of Leaves.

In Part IX. (p. 283), it was mentioned that 112 species had been found to commence with one simply pinnate leaf. The following ten may now be added to the former list, which brings the total to 122:—*A. Burkittii* F.v.M., *A. Cuthbertsoni* Luehmann, *A. ericifolia* Benth., *A. gladiiformis* A. Cunn., *A. latipes* Benth., *A. merinthophora* Pritzel, *A. obliqua* A. Cunn., *A. retinodes* Schlecht, *A. rupicola* F.v.M.

To the 21 commonly having an opposite pair of simply pinnate leaves the following five may be added:—*A. bidentata* Benth., *A. bivenosa* DC., *A. Cambagei* R. T. Baker, *A. georginæ*, Bailey, *A. restiacea* Benth., making the total 26.

Description of Seedlings.

Pungentes—(Plurinerves).

Acacia latipes Benth. Seeds from Wongan Hills, Western Australia (C. A. Gardner, per W. M. Carne). (Plate I., Numbers 1-3.)

Seeds black, almost cylindrical but flattened towards the edge, about 3 mm. long, 2.5 to 3 mm. broad, 2 mm. thick.

Hypocotyl terete, green, 1 to 2 cm. long, 1.5 to 2 mm. thick at base, 1 mm. at apex.

Cotyledons sessile, obovate to almost oval, auricled, 4 to 4.5 mm. long, 3 to 3.5 mm. broad, upperside green, underside reddish-brown, with raised line along centre.

Stem terete, brownish-green, hirsute. First internode 0.5 mm.; second 0.5 to 1 mm.; third and fourth 0.5 to 2 mm.; fifth to seventh 1 to 3 mm.

Leaves—No. 1. Abruptly pinnate, petiole 3 to 4 mm., glabrous; leaflets two pairs, oblong-acuminate, the apical pair sometimes obovate, 2.5 to 3.5 mm. long, 1 to 1.5 mm. broad, upperside green, underside pale green; rachis 2 mm., with terminal seta.

No. 2. Abruptly bipinnate, petiole 4 to 7 mm., glabrous to pilose, with terminal seta,; leaflets two pairs, the basal pair oblong-acuminate, the apical pair obovate, margins ciliate, up to 2 to 3 mm. long, 1 to 1.5 mm. broad, upperside green, underside pale green; rachis 3 mm., with terminal seta; stipules 0.5 mm.

Nos. 3 to 5. Abruptly bipinnate, petiole 6 mm. to 1 cm., pilose; leaflets two to three pairs, slightly mucronate, margins often ciliate; rachis 3 to 6 mm.; stipules acuminate, 1 mm.

Nos. 6 to 8. These may be phyllodes, or abruptly bipinnate, petiole 7 mm. to 1.5 cm. long, up to 0.5 mm. broad, pilose; leaflets two to three pairs; rachis 3 to 7 mm.

Nos. 9 to 20. Rigid, linear-lanceolate phyllodes, broad at the base, tapering into a pungent point, about 7 mm. to 1 cm. long, 1 to 1.5 mm. broad, with three fairly prominent nerves; stipules developed into spines 1 mm. long. A plant two feet high may have falcate phyllodes up to about 8 mm. long and 3 mm. broad.

A seedling raised in a seven-inch pot flowered when 18 months old.

Pungentes—(Uninerves).

Acacia rupicola F.v.M. Seeds from Morialta, Adelaide (J. A. Hogan, per E. H. Ising). (Plate I., Numbers 4-6.)

Seeds shiny black, oblong, about 5 mm. long, 2.5 to 3 mm. broad, 1.5 mm. thick.

Hypocotyl terete, brownish-red above soil, 1.5 to 2 cm. long, about 2 mm. thick at base, 1 mm. at apex.

Cotyledons sessile, auricled, oblong, apex rounded, 6 to 7 mm. long, 3 to 3.5 mm. broad, upperside green, underside pale green to brownish-red, often with raised centre line, becoming revolute but not cylindrical, remaining until phyllodes appear.

Stem at first angular, becoming terete, green, glabrous. First internode 0.5 to 2 mm; second 1 to 3 mm.; third and fourth 1 to 4 mm.; fifth to ninth 1 to 5 mm.

Leaves—No. 1. Abruptly pinnate, petiole 3 to 6 mm., glabrous; leaflets three to five pairs, oblong-acuminate, 3 to 5 mm. long, 1 to 2 mm. broad, upperside green underside pale green, with distinct venation; rachis 3 mm. to 1.1 cm., with terminal seta; stipules small.

No. 2. Abruptly bipinnate, petiole 6 mm. to 1.5 cm., with terminal seta; leaflets three to five pairs, oblong-acuminate, the apical pair sometimes obovate, 3 to 4 mm. long, 1 to 1.5 mm. broad; rachis 7 mm. to 1.1 cm., with terminal seta.

Nos. 3 and 4. Abruptly bipinnate, petiole 1 to 1.7 cm. long, sometimes up to 0.7 mm. broad, glabrous; leaflets three to five pairs, often mucronate, 3 to 6 mm. long, 1 to 2.5 and rarely 4 mm. broad; rachis 7 mm. to 1.3 cm.; stipules acuminate, 1 mm. long.

No. 5. Usually a phyllode but may be abruptly bipinnate, petiole about 1.3 cm.; leaflets 4 to 5 pairs; one pinna developed as a leaflet 6 mm. long, 2 mm. broad, with two small leaflets on one side.

Nos. 6 to 20. Fairly rigid, linear-lanceolate, prominently 1-nerved phyllodes, tapering into a pungent point, about 1 cm. long and 1.5 mm. broad.

CALAMIFORMES—(Subaphyllæ).

ACACIA RESTIACEA Benth. Seeds from Wongan Hills, Western Australia (C. A. Gardner, per W. M. Carne). (Plate II., Numbers 1-3.)

Seeds black, oval to obovate, about 3 mm. long, 2 to 2.5 mm. broad, about 1.5 mm. thick.

Hypocotyl terete, brownish-red above soil, 1.5 to 2 cm. long, about 1.5 mm. thick at base, 0.7 mm. at apex.

Cotyledons sessile, auricled, oblong, 3 to 4 mm. long, 1.5 mm. broad, upperside reddish-green, underside brownish-grey, remaining erect and very soon falling.

Stem terete, striated, green, glabrous. First to fifth internodes 0.5 mm.; sixth to ninth 0.5 to 2 mm.; tenth to twelfth 1mm. to 2 cm.; thirteenth to fifteenth 5 mm. to 2.7 cm.

Leaves—No. 1. Abruptly pinnate, forming an opposite pair, petiole 4 to 6 mm., glabrous; leaflets two pairs, oblong-acuminate, 3 to 5 mm. long, 1 to 2 mm. broad, upperside green, underside pale green; rachis 1 to 2 mm., with terminal seta.

No. 2. Abruptly bipinnate, petiole 5 mm. to 1 cm., green, glabrous, with terminal seta; leaflets three pairs, obovate, 2 to 3 mm. long, 1 to 1.5 mm. broad; rachis 4 to 6 mm., with terminal seta.

Nos. 3 and 4. Abruptly bipinnate, petiole 7 mm. to 2 cm.; leaflets three to four pairs; rachis 4 mm. to 1.2 cm.

Nos. 5 to 9. Abruptly bipinnate, petiole 1.3 to 4.3 cm., slender; leaflets four to six pairs, oblong-acuminate to obovate, 3 to 6 mm. long, 1 to 2.5 mm. broad; rachis 6 mm. to 2.4 cm.

Nos. 10 to 16. Abruptly bipinnate, petiole 1.8 to 5.3 cm., slender, pilose; leaflets four to six pairs; rachis 1 to 2 cm.; stipules reduced to acuminate scales 1 mm. long.

Nos. 17 to 20. These may be phyllodes, or abruptly bipinnate, petiole 1.7 to 4 cm., pilose; leaflets four to five pairs; rachis 5 mm. to 1.4 cm.; stipules reduced to acuminate scales ·2 mm. long.

On a few plants Nos. 17 to 22 are in some cases terete, slender phyllodes, 7 mm. to 2 cm. long, with what appears to be the terminal seta on the lower portion of the truncated apex. Above No. 22 the rush-like stems are leafless, but often with scales at the base of the branches.

A seedling raised in a seven-inch pot flowered when 19 months old, and had retained many bipinnate leaves.

UNINERVES—(Racemosæ).

ACACIA SALICINA Lindl. Seeds from Garah (A. W. Bucknell), Boggabri (R.H.C.) both in New South Wales, and Geera, near Central Queensland (H. C. Cullen). (Plate III., Numbers 1-3.)

Seeds shiny dark brown to black, oval to oblong-oval, 4.5 to 6 mm. long, 3.5 to 4 mm. broad, 2 mm. thick.

Hypocotyl terete, at first pale green, becoming brownish-red, 2 to 3 cm. long, about 2.5 mm. thick at base, 1 to 1.5 mm. at apex.

Cotyledons sessile, slightly auricled, oval to oblong-obovate, 6 to 9 mm. long, 4 to 5 mm. broad, upperside yellowish-green, underside pale green, with one or two raised central lines, remaining erect, becoming revolute and soon falling.

Stem at first slightly angular, becoming terete, brown, glabrous. First internode 0.5 to 1 mm.; second 1 to 2 mm.; third to sixth 1 to 7 mm.; seventh to tenth 1 mm. to 1 cm.; eleventh to fourteenth 3 mm. to 1.2 cm.

Leaves—No. 1. Abruptly pinnate, forming an opposite pair, petiole 4 to 9 mm., green, glabrous; leaflets four to five pairs, oblong-acuminate, 6 mm. to 1 cm. long, 1.5 to 3 mm. broad, upperside green, underside pale green; rachis 7 mm. to 1.2 cm., with terminal seta.

No. 2. Abruptly bipinnate, petiole 1 to 3.8 cm., often vertically dilated to 1 mm. broad, green, glabrous, with terminal seta; leaflets four to five pairs, oblong-acuminate, 2 to 7 mm. long, 1 to 2 mm. broad, in one case all the leaflets of a pinna had fused into one leaflet 6 mm. long, 3.5 mm. broad; rachis 9 mm. to 1.6 cm., with terminal seta; stipules minute or none.

Nos. 3 to 5. Abruptly bipinnate, petiole 1.2 to 4.5 cm. long, 1.5 to 3 mm. broad; leaflets three to five pairs; rachis 6 mm. to 1.6 cm.

Nos. 6 to 10. Abruptly bipinnate, petiole 2 to 7.3 cm. long, 2 to 4 mm. broad, with the midrib very slightly below the centre of the lamina; leaflets three to five pairs; rachis 5 mm. to 2 cm.

Nos. 11 to 20. These may be phyllodes, or abruptly bipinnate, petiole 4.2 to 11.6 cm. long, 3 to 6 mm. broad, with the midrib at or near the centre of the lamina; leaflets four and five to rarely six pairs; rachis 7 mm. to 2.5 cm.

Nos. 21 to 50. These may be phyllodes, or abruptly bipinnate, petiole 7.2 to 11 cm. long, 4 to 8 mm. broad in the Boggabri and Garah specimens, and up to 1.4 cm. in the Geera (near central Queensland*) specimens; rachis 8 mm. to 2.4 cm.

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* This is possibly the form found by Sir Thomas Mitchell in 1846 in Southern Queensland, and referred to by Bentham as variety *varians,* with the lower phyllodes broader than in the type. Flora Australiensis p. 367.

Nos. 51 to 70. Usually oblong-linear phyllodes, narrowed at the base, particularly in the Geera seedlings, about 7 to 10 cm. long.

The Geera specimens with wider phyllodes evidently represent the variety *varians*, described as a species by Bentham, and was discovered in Queensland in 1846 by Sir Thomas Mitchell.

PLURINERVES—(Oligoneuræ).

ACACIA BIVENOSA DC. Seeds from Claremont, Swan River, Western Australia (W. M. Carne). (Plate III., Numbers 4-6.)

Seeds black, oblong to oblong-oval, 5 to 6 mm. long, 3 mm. broad, 2 mm. thick.

Hypocotyl terete, reddish-brown above the soil, 1 to 2 cm. long, 2 mm. thick at base, 1 mm. at apex.

Cotyledons sessile, auricled, oblong, apex rounded, 7 to 8 mm. long, 3 mm. broad, reddish-brown on both sides, underside somewhat striated.

Stem at first angular, becoming terete, green, glabrous. First internode 0.5 mm.; second 0.5 to 1 mm.; third and fourth 0.5 to 2 mm.; fifth to seventh 1 mm. to 1.1 cm.; eighth to twelfth 4 mm. to 2.4 cm.

Leaves—No. 1. Abruptly pinnate, forming an opposite pair, petiole 3 to 5 mm., glabrous; leaflets three to five pairs, oblong-acuminate, apical pair often obovate, 4 to 5 mm. long, 1 to 2 mm. broad, upperside green, underside pale green; rachis 6 to 8 mm., with terminal seta.

No. 2. Abruptly bipinnate, petiole 6 mm. to 1 cm., green, glabrous, with terminal seta; leaflets four to six pairs, oblong acuminate, 2 to 5 mm. long, 1 to 2 mm. broad; rachis 7 mm. to 1.3 cm., with terminal seta.

Nos. 3 and 4. Abruptly bipinnate, petiole 8 mm. to 2.7 cm.; leaflets six to seven pairs; rachis 1 to 2.1 cm.

Nos. 5 to 9. Abruptly bipinnate, petiole 1.8 to 4.2 cm., sometimes dilated in the case of Nos. 8 and 9 to 1.5 mm. broad, with a strong nerve along or near the lower margin; leaflets six to ten pairs, oblong-acuminate to slightly obovate, often mucronate, 5 to 8 mm. long, 2 to 3 mm. broad; rachis 1.6 to 3.6 cm.; stipules reduced to scales about 1 mm. long.

Nos. 10 to 12. These may be phyllodes, or abruptly bipinnate, 2.4 to 3.5 cm. long, 1 to 8 mm. broad in the case of No. 10, with the midrib usually close to the lower margin, to 1 cm. in some instances in the case of No. 12, with the midrib slightly below the centre of the lamina, with sometimes a fairly definite nerve above for nearly the full length of the flattened petiole; leaflets seven to ten pairs; rachis 2.2 to 3.6 cm.

Nos. 13 to 20. Obovate to oblong-lanceolate phyllodes, penniveined, with a strong midrib about the centre of the blade, and a fainter one above, mucronate, the point slightly recurved, but not so much so as in later phyllodes, and pointing downwards.

PLURINERVES—(Microneure).

ACACIA CAMBAGEI R. T. Baker,* "Gidgea or Gidgee". Seeds from Cunnamulla, Queensland (Mr. Gwydir, per Dr. T. L. Bancroft). (Plate I., Numbers 7-9.)

Seeds brown, oblong to almost irregularly orbicular, flat, 5 to 8 mm. long, 4 to 6 mm. broad, 1 to 1.5 mm. thick.

Hypocotyl terete, green to brownish-green above soil, 2 to 3 cm. long, 1.5 to 2 mm. thick at base, 1 mm at apex.

Cotyledons sessile, auricled, oblong-oval to ovate, 7 to 9 mm. long, 6 to 6.5 mm. broad, upperside at first yellowish-green, becoming green, underside, yellowish-green.

* Proc. Linn. Soc. N.S. Wales, 1900, 25, 661.

Stem terete, green, glabrous, or with scattered hairs. First internode 0.5 to 1 mm.; second 1 to 4 mm.; third to fifth 2 mm. to 1.3 cm.; sixth and seventh 5 to 8 mm.

Leaves—No. 1. Abruptly pinnate, forming an opposite pair, petiole 4 to 7 mm., green, glabrous; leaflets two to four pairs, oblong-acuminate, 4 to 9 mm. long, 1 to 2.5 mm. broad, upperside green, underside pale green; rachis 5 mm. to 1 cm., with terminal seta.

No. 2. Linear-lanceolate phyllode, 1 to 5.2 cm. long, 1.5 to 2.5 mm. broad, with a definite central nerve, and sometimes a faint one on each side of it but not reaching the apex.

Nos. 3 to 10. Lanceolate phyllodes, 1.5 to 6 cm. long, up to 1 cm. broad, usually with three fairly definite veins and many much finer ones between them. Later phyllodes are often falcate.

This is the second seedling described in this series where the No. 2 leaf may be reduced to a phyllode, the previous case being *A. alata*.* It seems remarkable that these two species, also *A. georginæ* Bailey, the seedling of which has not yet been described, should, so far as examined, show no bipinnate leaves whatever. The same applies also to *A. Oswaldi* in some cases.†

JULIFLORÆ—(Rigidulæ).

ACACIA CUTHBERTSONI Luehmann.‡ Seeds from Carnarvon, Gascoyne River, Western Australia (E. C. Andrews). (Plate I., Numbers 10-12.)

Seeds brown, oblong-oval to ovate, depressed, with small fairly distinct horse-shoe areole, 7 to 8 mm. long, 6 to 7 mm. broad, 2 to 2.5 mm. thick.

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* This Journ., 1918, 52, 413.
† This Journ., 1921, 55, 115.
‡ The Victorian Naturalist, 13, 117.

Hypocotyl terete, pale green, spreading into flange at root, up to 3.7 cm. long, 3 to 4 mm. thick at base, 2 mm. at apex.

Cotyledons sessile, auricled, oblong to oblong-oval, 1 to 1.3 cm. long, 6 to 8 mm. broad, upperside green, underside pale green.

Stem terete, greenish-grey, pilose to pubescent. First internode 0.5 mm.; second 1 to 2 mm.; third to seventh 1 to 4 mm.

Leaves—No. 1. Abruptly pinnate, petiole 4 to 9 mm., green, glabrous; leaflets four to six pairs, oblong-acuminate, the apical pair sometimes obovate, 4 to 9 mm. long, 2 to 3 mm. broad, upperside green, underside pale green; rachis 1 to 2 mm., with terminal seta.

No. 2. Abruptly bipinnate, petiole 1.3 to 1.6 cm. long, vertically dilated to sometimes 1 mm. broad, pilose, with terminal seta; leaflets three to seven pairs, oblong-acuminate to obovate, 3 to 5 mm. long, 1 to 2.5 mm. broad, upperside green; rachis 6 mm. to 1.6 cm.; with terminal seta.

No. 3. Lanceolate phyllode, 2 to 3.5 cm. long, about 2.5 to 4 mm. broad, with a definite midrib, a faint vein close to both margins and almost confluent with the midrib at the apex, a few fine veins diverting from the mibrib, pilose.

Nos. 4 to 10. Lanceolate phyllodes, narrowed at both ends, small oblique points, 4 to 8 cm. long, up to 5 mm. broad, with a definite midrib and intramarginal veins as in No. 3, but with a few finer longitudinal veins on both sides of the central nerve, ash-grey, silky pubescent.

JULIFLORÆ—(Stenophyllæ).

ACACIA BURKITTII F.v.M. Seeds from Broken Hill, New South Wales (A. Morris, per Sydney Botanic Gardens) and Iron Knob, South Australia (Sydney Botanic Gardens). (Plate II., Numbers 4-6.)

Seeds dark brown, obovate to oval, 4 to 6 mm. long, 3 to 4 mm. broad, 1 to 1.5 mm. thick.

Hypocotyl terete, green to brownish, 1.5 to 2.2 cm. long, 1 to 1.7 mm. thick at base, 0.7 to 1 mm. at apex.

Cotyledons sessile, slightly auricled, lobes about 0.5 mm. oblong to ovate or sometimes slightly obovate, about 6 mm. long, 3 to 4 mm. broad, upperside green, underside pale green, with one or two raised lines, gradually becoming revolute.

Stem terete, greyish-brown to greenish-brown, glabrous, or with a few scattered hairs. First internode 0.5 mm.; second 1 mm.; third and fourth 1 to 3 mm.; fifth to seventh 2 to 6 mm.; eighth to tenth 4 mm. to 1.5 cm.

Leaves—No. 1. Abruptly pinnate, petiole 4 mm. to 1 cm., green, glabrous; leaflets two to three pairs, oblong-acuminate, the apical pair often obovate, 5 to 7 mm. long, 1.5 to 3 mm. broad, upperside green, underside pale green, margins slightly ciliate; rachis 2 to 9 mm., with terminal seta.

No. 2. Abruptly bipinnate, petiole 4 mm. to 2 cm., with terminal seta; leaflets two to three pairs, oblong-acuminate to obovate, 3 to 5 mm. long, 1 to 2 mm. broad, upperside green; rachis 2 to 6 mm., with terminal seta.

Nos. 3 to 5. Abruptly bipinnate, petiole 1 to 3.4 cm.; leaflets one to five pairs; rachis 1 to 8 mm.; stipules 1 mm. long.

Nos. 6 to 13. These may be phyllodes, or abruptly bipinnate, petiole 2.4 to 11.3 cm.; leaflets three to four pairs, 1 to 3 mm. long, about 1 mm. broad; rachis 2 to 4 mm.

Nos. 14 to 18. Linear-subulate phyllodes, slightly flattened or compressed, scarcely terete, 7 to 11 cm. long, sometimes up to 1.7 mm. broad, the point sometimes much recurved but not pungent.

Lubbock described a seedling supposed to be of this species and recorded the first leaf as bipinnate, but from his description and figure it seems to be a different plant from that described in the present paper, and is suggestive of belonging to some other genus. The cotyledons of Lubbock's plant are very much larger than those of the Broken Hill and South Australian examples, and of quite a different shape, while the leaflets shown by Lubbock are about double in number on each leaf.*

BIPINNATÆ—(Botryocephalæ).

ACACIA PRUINOSA A. Cunn. Seeds from Gosford (J. H. Maiden) and Kurnell (cultivated). (Plate IV., Numbers 1-3.)

Seeds black, obovate to almost orbicular, 4 to 5 mm. long, 3 to 4 mm. broad, 1.5 to 2 mm. thick.

Hypocotyl terete, at first pale green, becoming reddish-brown, 1 to 2.5 cm. long, about 2 mm. thick at base, 0.7 to 1 mm. at apex.

Cotyledons sessile, auricled, obovate to oblong-oval, about 5 mm. long, 3.5 to 4 mm. broad, upperside reddish-green to brownish-red, underside reddish to red, becoming revolute and cylindrical in a few days.

Stem at first slightly angular, becoming terete, green to greenish-brown, glabrous. First internode 0.5 mm.; second and third 2 to 5 mm.; fourth to sixth 4 mm. to 2.4 cm.; seventh and eighth 8 mm. to 2 cm.

Leaves—No. 1. Abruptly pinnate, petiole 2 to 7 mm., sometimes with a small gland, green, glabrous to pilose,

* "Seedlings" by Sir John Lubbock, 1892, 1, 471.

leaflets four to five pairs, oblong-acuminate, the apical pair often obovate, 4 to 8 mm. long, 1 to 2.5 mm. broad, upperside at first reddish-green, becoming green, underside deep red, often becoming green; rachis 6 mm. to 1 cm. long, with terminal seta.

No. 2. Abruptly bipinnate, petiole 7 mm. to 1 cm., sometimes with a gland on the upper margin, glabrous, or with a few hairs, with terminal seta; leaflets four to six pairs, oblong-acuminate, the apical pair sometimes obovate, 4 to 8 mm. long, 1 to 3 mm. broad, upperside green, underside reddish-green to red; rachis 9 mm. to 1.5 cm., with terminal seta.

Nos. 3 and 4. Abruptly bipinnate, petiole 1.1 to 2 cm., glabrous to pilose, often with a gland on the upper margin; leaflets six to fourteen pairs; rachis 1.5 to 3.8 cm.

Nos. 5 and 6. Abruptly bipinnate, often with two pairs of pinnæ, common petiole up to 3.5 cm., usually with gland below basal pair of pinnæ; leaflets thirteen to fifteen pairs; rachis 1.8 to 4.2 cm.

Nos. 7 to 9. Abruptly bipinnate, with from three to seven pairs of pinnæ, common petiole up to 6.5 cm., glabrous to pilose, with a gland below the basal pair and also at the base of the apical pair of pinnæ; leaflets nineteen to twenty-three pairs; rachis 2.7 to 4.4 cm.

Leaflets on a mature tree may measure up to 1.7 cm. long, and 5 mm. broad, with the midrib and secondary vein showing very distinctly.

BIPINNATÆ—(Botryocephalæ).

ACACIA LEPTOCLADA A. Cunn. Seeds from Howell, New South Wales (T. S. McCrae) and Kurnell (cultivated). (Plate IV., Numbers 4-6.)

Seeds shiny black, oblong-oval to oblong, rim thin, about 5 mm. long, 3 to 3.5 mm. broad, 2 mm. thick.

Hypocotyl terete, pale green to reddish-pink, 1.2 to 4.5 cm. long, 1 to 1.5 mm. thick at base, 0.6 to 1 mm. at apex.

Cotyledons sessile, auricled, oblong to oblong-oval, 5 to 6.5 mm. long, 3 to 3.5 mm. broad, upperside brownish-green, underside brown to reddish-brown.

Stem terete, at first green, becoming brown to reddish-brown, hirsute to hoary. First internode 0.5 mm.; second 1 mm.; third to fifth 2 mm. to 1.3 c.m.; sixth to seventh 7 mm. to 2 cm.

Leaves—No. 1. Abruptly pinnate, petiole 3 to 6 mm., brownish-green, glabrous; leaflets four to seven pairs, oblong-acuminate, 5 to 8 mm. long, 1 to 2.5 mm. broad, upperside green, underside reddish-green; rachis 8 mm. to 1.4 cm., with terminal seta.

No. 2. Abruptly bipinnate, petiole 8 mm. to 1.3 cm., pilose, with terminal seta; leaflets four to six pairs, oblong-acuminate, the apical pair obovate, 3 to 6 mm. long, 1 to 2 mm. broad, upperside green, underside green to reddish-green; rachis 7 mm. to 1 cm., with terminal seta.

Nos. 3 and 4. Abruptly bipinnate, sometimes with two pairs of pinnæ, common petiole 1 to 2.8 cm., pilose to seven pairs; rachis up to 1.4 cm.; stipules acuminate, 1 to 2 mm.

Nos. 5 and 6. Abruptly bipinnate, with two to three pairs of pinnæ, common petiole 1 to 2.8 cm., pilose to hirsute; leaflets six to nine pairs, 3 to 4 mm. long, 0.5 to about 1 mm. broad; rachis 1 to 1.7 cm.

Nos. 7 to 10. Abruptly bipinnate, with from two to five pairs of pinnæ, common petiole 1.5 to 2.7 cm., sometimes with a few glands, hirsute; leaflets eight to eleven pairs; rachis up to 1.6 cm.

EXPLANATION OF PLATES.

Plate I.

Acacia latipes Benth.

1. Cotyledons, Wongan Hills, Western Australia (W. M. Carne).
2. Pinnate leaf, bipinnate leaves and phyllodes.
3. Seeds.

Acacia rupicola F.v.M.

4. Cotyledons, Morialta, Adelaide (E. H. Ising).
5. Pinnate leaf, bipinnate leaves and phyllodes.
6. Seeds.

Acacia Cambagei R. T. Baker.

7. Cotyledons, Cunnamulla, Queensland (Dr. T. L. Bancroft).
8. Opposite pair of pinnate leaves and phyllodes.
9. Pod and seeds.

Acacia Cuthbertsoni Luehmann.

10. Cotyledons and pinnate leaf, Gascoyne River, Western Australia (E. C. Andrews).
11. Pinnate leaf, bipinnate leaf and phyllodes.
12. Pod and seeds.

Plate II.

Acacia restiacea Benth.

1. Cotyledons and opposite pair of pinnate leaves, Wongan Hills, Western Australia (W. M. Carne).
2. Pinnate leaf, bipinnate leaves and two phyllodes.
3. Seeds.

Acacia Burkittii F.v.M.

4. Cotyledons and pinnate leaf, Iron Knob, South Australia (J. M. Black).
5. Pinnate leaf, bipinnate leaves and phyllodes.
6. Pod and seeds.

Acacia latipes (1-3); *Acacia rupicola* (4-6); *Acacia Cambagei* (7-9); *Acacia Cuthbertsoni* (10-12).

Three-fifths Natural Size.

Acacia restiacea (1-3); *Acacia Burkittii* (4-6).

Three-fifths Natural Size.

Acacia salicina (1-3) ; *Acacia bivenosa* (4-6).

Two-fifths Natural Size.

Acacia pruinosa (1-3) ; *Acacia leptoclada* (4-6).

Nearly Half Natural Size.

Plate III.

Acacia salicina Lindl.

1. Cotyledons, Geera, Queensland (H. C. Cullen).
2. Opposite pair of pinnate leaves, bipinnate leaves and phyllodes (Boggabri).
3. Pod and seeds (Boggabri).

Acacia bivenosa DC.

4. Cotyledons, Swan River, Western Australia (W. M. Carne).
5. Opposite pair of pinnate leaves, bipinnate leaves and phyllodes.
6. Pod and seeds.

Plate IV.

Acacia pruinosa A. Cunn.

1. Cotyledons, Gosford (J. H. Maiden).
2. Pinnate leaf and bipinnate leaves.
3. Pod and seeds, Kurnell (Cultivated).

Acacia leptoclada A. Cunn.

4. Cotyledons, Howell, New South Wales (T. S. McCrae).
5. Pinnate leaf and bipinnate leaves.
6. Pod and seeds, Kurnell (Cultivated).

THE ESSENTIAL OIL OF *ZIERIA MACROPHYLLA* (BONPLAND) AND THE PRESENCE OF A NEW CYCLIC KETONE.

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(*Read before the Royal Society of New South Wales, August 4, 1926.*)

The author has been engaged upon an investigation of the essential oils from *Zieria Smithii* for a number of years past, and when supplies of leaves and terminal branchlets were secured from Tasmania for comparison with the New South Wales and Queensland material, it was readily observed that the former presented marked differences, the leaves especially being much larger. The investigation of the essential oil offered ready confirmation, the differences in the chemical composition being quite remarkable. The Forestry Department, Hobart, Tasmania, which so kindly furnished the excellent supplies of material for the investigation, whilst referring to the plant as *Zieria Smithii*, gave the following information:—

> "The leaves referred to were obtained from Herrick, North-East Tasmania, and were gathered from the sides of a valley near the Pioneer Mill. Although it grows in the valleys, yet it seems to be more prolific on the slopes above the valleys. It usually attains an average height of about 3-feet, and is of fairly dense growth. It is very noticeable that where the plant is growing on any kind of a rich flat, the crop is extremely dense, although perhaps not nearly so tall as that growing on the slopes of the gullies."

Although the writer so readily observed the marked distinction between the Tasmanian and New South Wales *Zieria* (N.O. Rutaceæ) he considered it advisable to obtain the opinion of Mr. E. Cheel, Curator of the National Herbarium, Sydney, who has probably devoted more time and research to the various species of *Zieria* than any other botanist. He has kindly conveyed his opinion in a private communication, as follows:—

> "With reference to the *Zieria* from Tasmania, I have arrived at the conclusion that it is *Zieria macrophylla* of Bonpland. It was described as a distinct species in 1813, and is well figured under this name in "Botanical Magazine", tab. 4451. Bentham (Flora Australiensis, Vol. 1, page 307 (1863) includes it as a variety *macrophylla* under *Zieria Smithii*, but I am of the opinion that it is sufficiently distinct and had best be regarded as a species. I propose to deal with this and other species of the genus at an early date."

The result of the examination of the essential oil confirms beyond any doubt the opinion herein expressed that the plant is worthy of specific rank.

THE ESSENTIAL OIL.

The leaves on crushing between the fingers emitted a rather unpleasant odour, hence the vernacular name of "Stinkwood". The essential oils obtained from the various consignments were of a deep reddish-brown colour, and possessed the unpleasant odour referred to in connection with the leaves, which appeared to be mainly due to the presence of a low boiling ester of *iso*valerianic acid together with amyl alcohol, although the odour of the crude oil bore no particular resemblance to its other more important constituents.

Altogether, 1,310 lbs. weight of leaves and terminal branchlets were distilled, the average yield of oil being 0.45%, varying from 0.28% to 0.66%, according either to the condition of the leaves upon arrival or to the time of year when collected.*

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* See reference on page 36, this Journal, Vol. LIX (1925) *re* oils from Tasmanian plants.

The principal constituents which have so far been identified were found to be, *d*-limonene (10-20%), a new cyclic ketone, $C_{13}H_{20}O$, about 50-60%, called Zierone, together with sesquiterpene, sesquiterpene alcohol, amyl alcohol ? and a low boiling *iso*valerianic acid ester, unidentified phenolic bodies, a paraffin melting at 56°, and formic acid.

EXPERIMENTAL.

From Herrick, North-East Tasmania, 1,310 lbs. weight of leaves and terminal branchlets, cut as for commercial purposes, yielded on distillation with steam, crude oils possessing the chemical and physical characters as shown in table:—

Date.	Weight of Leaves	Locality	Yield of oil.	$d\frac{15°}{15}$	$\alpha_D^{20°}$	$n_D^{20°}$	Solubility in 80% alcohol by wght.	Ester No. 1½ hrs. Hot	Ester No. after Acetylation
14/2/1924	250 lbs.	Herrick, N.E.Tasmania	0.4%	0.9613	− 54.5°	1.5083	0.8 vol	29.4	68.0
27/8/1924	536 lbs.	do.	0.42%	0.9465	− 39.0°	1.5015	1.1 „	52.8	71.6
26/2/1925	422 lbs	do.	0.28%	0.9693	− 64.8°	1.5148	0.8 „	50.9	70.4
14/10/1925	102 lbs.	do.	0.66%	0.9704	− 66.4°	1.5106	0.8 „	31.0	50.8

On distillation of the crude oils, at 10 mm., the following average results were obtained, according to the respective quantities of terpene and ketone present in the particular lot of oil examined, as indicated by the optical activity:—

Fraction.	Quantity.	$d\frac{15}{15}$	α_D^{20}	n_D^{20}
60 – 63° at 10mm	10 to 20%	0.851	+86° to +90°	1.4670 to 1.4680
63 – 135° ...	4 to 16%	...	...	...
135 – 145° ...	50 to 70%	0.956 to 0.975	− 94° to − 97°	1.5150

Determination of low boiling Ester.—Four hundred and fifty c.c. of crude oil (27/8/24) were distilled at 10 mm. and the portion (146 c.c.) boiling below 100° was collected. On further distillation this was resolved into the following fractions:—

Fraction,	Quantity.	Ester No.
60 – 70° (10 mm.)	101 c.c.	33.7
70 – 105° do.	17 c.c.	40.9
Residue	27 c.c.	11.3

The first and second fractions were mixed together and treated with 50% resorcin solution in order to remove the ester present. The resorcin solution on steam distillation returned only 5 c.c. of liquid. On examination this gave the following results:—
B.pt. (768 mm.) 165 – 175°, $d\frac{15}{15}$ 0.8538, α_D^{20} + 10.1°, n_D^{20} 1.4252

This liquid was saponified by means of aqueous potassium hydroxide solution and when the reaction was completed it was subjected to distillation. The aqueous liquid was acidified with dilute sulphuric acid and the volatile acid removed by steam distillation. The acid liquor was neutralised with ammonia solution and the silver salt prepared therefrom; 0.0370 g. silver salt on ignition yielded 0.0194 g. silver = 52.4%.

The silver salt of valerianic acid requires 51.68% Ag.

The liquid obtained from the distillate was contaminated with small quantities of terpenes and consequently could not be definitely identified. The alcohol in combination with the *iso*valerianic acid appeared to be of the amyl series. Many attempts were made to prepare derivatives, even fresh consignments of oil being obtained specially for the purpose, but they gave negative results.

Determination of Limonene.—The first fractions of the crude oil distilling below 63° at 10 mm. after washing with 50% resorcin solution as indicated above, were repeatedly fractionated over metallic sodium, when over 90%, boiling at 60-63° at 10 mm., was obtained. Even after this treatment the pronounced amylic odour was still present.

On further distillation at 763 to 768 mm. over metallic sodium the first portion distilling below 175° still retained the amylic odour and induced coughing. The main distillates of boiling point 175-177° (763 mm.) possessed the following constants:—

$d\frac{15}{15}$ 0.8464 – 0 8475, $\alpha_D^{20°}$ +82° to +99°, $n_D^{20°}$ 1.4716 to 1.4722.

The terpene when dissolved in four times its volume of glacial acetic acid in the presence of moisture and treated with bromine at 20° yielded a copious precipitate of limonene tetrabromide. On recrystallisation from ethyl acetate, the crystals melted at 104-105°.

Determination of Ketone.—The fractions of the various consignments distilling at 135-145° at 10 mm. and which constituted the greater portion of the crude oils (about 50-70%) were subjected to repeated fractional distillation, but on account of the sesquiterpene and sesquiterpene alcohol present, it was impossible to separate the principal constituents in anything like a condition of purity. Even when concentrated to a small fraction of boiling point 140-143° at 10 mm., the optical rotation did not exceed – 102.8°. It was found best, therefore, to treat the high boiling fractions with semicarbazide hydrochloride and sodium acetate in ethyl alcohol solution and allow the mixture to stand at room temperature for about a week. After that period, the semicarbazone of the ketone had separated out to the bottom of the vessel as a white crystalline solid. It was separated by filtration on a Buchner funnel, washed with a small quantity of ethyl alcohol and dried on a porous plate. The semicarbazone was readily purified by solution in boiling methyl alcohol from which solvent it separated very completely on cooling. The ketone was regenerated from it by treatment with dilute sulphuric acid in the presence of steam. On distillation at 10 m., the ketone was obtained as a pale yellow, somewhat viscous liquid, with a pleasant odour of fresh cedarwood, inclined to be camphoraceous.

As the mean of six different preparations, it was found to possess the following chemical and physical characters:—

Boiling point	142.5 – 144° at 10 mm.
Specific gravity, $\frac{15}{15}$, ..	0.9752
Optical rotation	– 141.2°
Refractive index, 20° ..	1.5140 – 1.5144
Molecular refraction	59.53 (Calc. 59.24)

The formula appears to be $C_{13}H_{20}O$, as indicated by the following combustion and molecular weight results:—

(1) 0.1161 g. gave 0.3468 g. CO_2 and 0.1024 g. H_2O; C = 81.46%, H = 9.8%

(2) 0.1046 g. gave 0.3096 g. CO_2 and 0.0970 g. H_2O; C = 80.72%, H = 10.28%

(3) 0.0966 g. gave 0.2883 g. CO_2 and 0.0894 g. H_2O; C = 81.39%, H = 10.28%

(4) 0.1047 g. gave 0.3112 g. CO_2 and 0.0974 g. H_2O; C = 81.06%, H = 10.05%

$C_{13}H_{20}O$ requires C = 81.25%, H = 10.04%

Molecular Weight Determinations.—A molecular weight determination by the Landsberger boiling point method, using acetone as solvent, gave the following result:—1.1474 g. in 21 c.c. acetone elevated the boiling point 0.6°; M. Wt. = 200.

A determination by the cryoscopic method, using benzene, resulted as follows:—0.3320 g. in 10 g. benzene lowered the freezing point of the solvent 0.81°; M. Wt. = 204. $C_{13}H_{20}O$ requires 192.

The ketone appears to be of a cyclic character and to belong to the Irone-Ionone series. It could not be induced to enter into combination with sodium bisulphite or neutral sodium sulphite solutions, neither did it yield a solid oxime when treated with hydroxylamine or form a solid bromide when treated with bromine in various organic solvents at from −10° to −20°.

The following two crystalline derivatives have been prepared:—

Semicarbazone $C_{14}H_{23}N_3O$.—As stated above, the ketone readily combines with semicarbazide to form a semicarbozone, very sparingly soluble in methyl alcohol. On repeated recrystallisation it was found to melt at 180-181°; 0.5250 g. in 10 c.c. $CHCl_3$ gave a reading of −7.2°, $[\alpha]_D^{20°} = -137°$.

The following results were obtained on combustion:—

(1) 0.1034 g. gave 0.2544 g. CO_2 and 0.0854 g. H_2O; C = 67.10%, H = 9.1%

(2) 0.1002 g. gave 0.2467 g. CO_2 and 0.0822 g. H_2O; C = 67.15%, H = 9.1%

$C_{14}H_{23}N_3O$ requires C = 67.47%, H = 9.23%

Phenylhydrazone.—This crystalline derivative was prepared by mixing together 10 c.c. ketone, 20 c.c. glacial acetic acid and 6 c.c. phenylhydrazine, warming for 10 minutes on water bath and when cold allowing to stand over night in the ice chest. The mixture was found next day to have solidified to a mass of radiating crystals. On repeated recrystallisation from ethyl alcohol the derivative was obtained in the form of plates, varying from a cream to a primrose yellow colour, melting with decomposition at 107-108°; 0.5652 g. in 10 c.c. $CHCl_3$ gave a reading of −15.8°, $[\alpha]^{20°} = -279.5°$.

The name of Zierone is suggested for this interesting ketone. Further work treating of its oxidation and reduction products will be carried out as the opportunity presents itself.

Determination of Sesquiterpene, etc.—The filtrate and alcoholic washings from the ketone semicarbazone were poured into water and the resinous gummy mass thus obtained subjected to steam distillation. Working in this manner with the specimen of oil (26/2/25) 27 c.c. of crude oil free from ketone were obtained. It was treated with alcoholic potash solution to remove the ester present and then distilled over metallic sodium at 10 mm. Finally 16 c.c. of pale yellow coloured oil were obtained possessing the following characters:—
B pt. (10mm.) 128 – 132°, $d\frac{15}{15}$ 0 9308, α_D^{20} +20.2°, n_D^{20} 1.5055.
It failed to yield a solid hydrochloride or any other crystalline derivative characteristic of sesquiterpenes. It gave the usual striking colour reactions with bromine in acetic acid and sulphuric acid in acetic anhydride solutions.

Examinations of various lots of the crude oils pointed to the presence of a high boiling alcohol accompanying the sesquiterpene, which was related to the latter or to the ketone. It could not, however, be isolated.

Determination of Combined Acids.—The saponification liquor resulting from the treatment of the sesquiterpene fraction, as described above, was acidulated with dilute sulphuric acid and steam distilled. The volatile acid was neutralised with ammonia solution and the silver salt prepared; 0.1568 g. gave on ignition 0.0810 g. silver = 51.66%. The silver salt of *iso*valerianic acid requires 51.68% Ag.

Three hundred c.c. of crude oil (26/2/25) were saponified with alcoholic potash solution and the acids separated therefrom by acidulation with dilute sulphuric acid and subsequent steam distillation. The total volatile acids thus obtained were neutralised with ammonia solution and the silver salts prepared. They gave the following results on ignition:—

Acids soluble in water.—1st fraction: 0.1376 g. silver salt yielded 0.0702 g. Ag. = 51.01% Ag. 2nd fraction: 0.1629 g. silver salt yielded 0.0832 g. Ag. = 51.07% Ag.
The silver salt of *iso*valerianic acid requires 51.68% silver.

Oily Acid.—0.1095 g. silver salt yielded 0.0429 g. Ag = 39.18% Ag.

The silver salt of capric acid requires 38.71% Ag.

Determination of free Acid and Phenolic Bodies.—100 c.c. crude oil (27/8/24) on treatment with 8% sodium hydroxide solution gave 0.48 g. crude phenolic body of refractive index, 20°, 1.5201. It gave a greenish-brown colouration with ferric chloride in alcoholic solution, but could not be identified. Similarly, 300 c.c. crude oil (26/2/25) yielded 0.29 g. crude phenol. In the course of its isolation a small quantity of free acid was separated, which from its colour reactions and general chemical deportment towards silver and mercury salts pointed strongly to its identity with formic acid.

Determination of Paraffin.—From the high boiling residues a very small quantity of a paraffin was isolated, which on recrystallisation from ethyl alcohol melted at 56°.

In conclusion, my best thanks are due to the Conservator of Forests, Hobart, and the members of his staff, for the very great interest evinced in the investigation, and for the invaluable assistance in arranging for the excellent supplies of material furnished; to Mr. F. R. Morrison, A.A.C.I., F.C.S., Assistant Economic Chemist, for his usual valuable assistance in these investigations.

THE FIXED OIL OF THE KIDNEY FAT OF THE EMU (*Dromaius novæ-hollandiæ*).

By F. R. MORRISON, A.A.C.I., F.C.S.,
Assistant Economic Chemist, Technological Museum, Sydney.

(*Read before the Royal Society of New South Wales, August 4, 1926.*)

The oil which forms the subject of this investigation was obtained from the fatty tissue surrounding the kidneys of the Emu (*Dromaius novæ-hollandiæ*), the large, flightless, herbivorous bird peculiar to the Australian continent. The oil was kindly supplied, free of cost, by Mr. G. Warby, of Mungindi, New South Wales, who prepared the oil by heating the fatty tissue in a vessel before the fire, whereby the oil was separated from the membrane substance.*

As received, the oil was yellow in colour, and had an odour somewhat resembling that of mutton fat. It had the consistency of soft butter during the cold weather owing to the presence of a stearoptene; during the summer months, however, most of the stearoptene was dissolved and the oil became clear and limpid. The oil was found to consist of the glycerides of oleic, linolenic, palmitic and

* Subsequent to the writing of this paper, Mr. G. A. Warby kindly furnished the following information:—

"I should think a full-grown Emu would be about 200 lbs. and the weight of the kidney fat I would estimate at about 8 to 10 lbs. The amount of oil I sent you was not the total yield but only a small portion. I should think the yield from the kidney would be about 2 quarts, and from a whole Emu about 3 to 4 gallons.

These numbers are only approximate, as I have never weighed them, but if at any time I can get a good Emu I will try and get all the particulars for you."

stearic acids. The occurrence of linolenic acid is of interest, this acid being rarely found in animal oils and fats.

The oil possessed the following physical and chemical characteristics:—

M.pt.	30 – 31°
d^{30}_{30}	0.915
n^{20}_{D}	1.4700
Acid value	1.7
Saponification value	195.2
Iodine value (Wijs. 2 hours) ...	95.5
Unsaponifiable	0.2%

Mixed fatty acids.—The mixed fatty acids were prepared from the crude oil in the usual manner by saponification with alcoholic potassium hydroxide, and liberation of the fatty acid by means of sulphuric acid, 95% of mixed acids being obtained, which when cooled consisted of an almost white, crystalline mass, having the following characteristics:—

M.pt.	41°
d^{40}_{15}	0.885
n^{40}_{D}	1.4530
Iodine value (Wijs. 2 hours) ...	97.0
Neutralisation value	202.2
Mean molecular weight	277

"Solid" and "Liquid" Acids.—A quantitive determination of the "solid" and "liquid" acids using the modified method of Gusserow and Varrentrapp (Lewkowitsch 1921, **1**, 556) gave the following result:—"solid" acid, 40%, and "liquid" acid 60%.

Larger quantities of the respective acids were obtained by the lead salt-ether method of Tortelli and Ruggeri (L'Orosi, April 1900) described by Lewkowitsch (1921, **1**, 560), 27 g. of "liquid" acid and 22 g. "solid" acid being obtained from 50 g. of mixed fatty acids.

Liquid acid.—The liquid acid consisted of a light brown oil possessing the following characteristics:—

d^{15}_{15}	0.914
n^{20}_{D}	1.4663
α_D	±0°
Iodine value (Wijs. 2 hours) ...	124.5
Neutralisation number	197
Mean molecular weight	285

Insoluble Bromides of Liquid Acids.—A quantity (5 g.) of the liquid acids was dissolved in 50 c.c. of pure dry ether cooled to $-20°$ and the solution saturated with bromine; the insoluble bromide thus produced, after standing at the above temperature for twelve hours, was filtered off, washed with cooled ether and dried, 1.5 g. being obtained equal to 11% of linolenic acid. The bromide, after crystallising from acetic acid, melted at 181°, which melting point did not alter when the sample was mixed with an authentic sample of linolenic hexabromide; 0.6290 g. gave 0.2941 g. Ag Br., Br. = 61.2%. Linolenic hexabromide requires Br. = 63.3%.

The ethereal filtrate from the ether insoluble bromide was washed free from excess of bromine by means of sodium thiosulphate solution, and the ether removed. The viscous residue was triturated with petroleum ether (B.pt. below 50°) at $-20°$, but no insoluble bromide was obtained, indicating the absence of linolic acid. The solvent was removed and the bromine content of the liquid bromide determined; 0.2818 g. gave 0.2684 g. Ag Br., Br. = 40.5%. The liquid bromide apparently consists of oleic dibromide (requires Br. = 36.18%) in admixture with a small quantity of linolenic hexabromide.

Oxidation of Liquid Acids.—A quantity (10 g.) of the liquid acids was oxidised in alkaline solution by means of potassium permanganate (Lewkowitsch 1921, **1**, 575). The precipitated manganese dioxide was removed by means of sulphurous acid, and the white precipitate filtered off and dried; 7.3 grams were thus obtained, which on crystallisation from ether, and finally from alcohol as glistening laminæ, melted at 133°. The substance gave the following results on analysis: 0.1124 g. gave 0.2816 g. CO_2, and 0.1158 g. H_2O. C = 68.2%, H = 11.4%; 0.3537 g. required 0.0620 g. KOH for neutralisation, equal to a molecular weight for a mono-basic acid of 319. $C_{18}H_{36}O_4$ requires C = 68.3%, H = 11.4% and has a molecular weight of 316. The acid is, therefore, dihydroxystearic acid resulting from the oxidation of oleic acid.

The aqueous filtrate from the insoluble acid was made slightly alkaline with KOH, the solution concentrated to small bulk, and acidified with dilute sulphuric acid. A small quantity of brown flocculent precipitate was produced, which, after drying and washing with ether, was recrystallised from alcohol, and finally from water. A very small quantity of crystals was thus obtained melting at 203°. Hexahydroxystearic acid, resulting from the oxidation of linolenic acid, melts at this temperature. The liquid acids, therefore, consist of oleic and linolenic acids, the proportion of each, calculated from the iodine value (124.5), being oleic acid 81.3% and linolenic acid 18.7%.

"Solid acids".—The solid acids after recrystallisation from alcohol had a melting point of 57°, and a mean molecular weight of 268. Further recrystallisation failed to alter the characteristics. A quantity (12 grams) of the acids was converted into the methyl esters, and the latter fractionally distilled under reduced pressure, but no definite separation was effected by this means.

Separation of the Acids by means of the Magnesium Salts.—A quantity (12 g.) of the acid was dissolved in 500 c.c. of 95% alcohol, and fractionally precipitated by means of alcoholic magnesium acetate solution. Seven fractions of magnesium salts were thus obtained, which, on decomposition with hydrochloric acid, gave fractions of fatty acids as follow:—

Fraction	Weight (grams)	M.pt. (after recrystallisation)	Mean molecular Weight
1	2.0	66°	280
2	1.7	59°	275
3	1.3	57°	270
4	1.0	60°	268
5	1.5	56°	265
6	1.5	61°	260
7	0.5	62°	258

The first fraction evidently consisted of slightly impure stearic acid, and the last fraction consisted of pure palmitic acid, the intermediate fractions apparently consisting of mixture of these two acids. The tendency of mixtures of these acids to form eutectics is well known, and separation of the individual acids is difficult where large quantities are not available.

Unsaponifiable matter.—The unsaponifiable material extracted from aqueous solution of the saponified oil by means of ether gave the usual colour reactions for cholesterol. The quantity available was not sufficient for further examination.

Stearoptene.—A quantity of the solid stearoptene was separated from the oil by filtration, and the crude substance purified by crystallisation from ether, and finally from acetone. Snow white, microscopic crystals were obtained, possessing the following characteristics:—

M.pt.	61.5°
d_{15}^{15}	0.9912
n_D^{48}	1.4990
Acid value	*nil*
Saponification value	200.2
Iodine value	*nil*

On saponification with KOH and decomposition of the resulting soap with mineral acid, a solid acid of melting point 57°, and mean molecular weight 263, was obtained. The quantity available was insufficient for a separation of the individual acids, but a consideration of the characteristics, as well as those of the stearoptene itself, indicated the stearoptene to be a mixed glyceride of palmitic and stearic acids. According to Lewkowitsch (1921, **1**, 30) β-stearo-α-γ-dipalmitin melts at 60°, and has a saponification value of 201.8.

In conclusion, I have to express my best thanks to Mr. A. R. Penfold, F.A.C.I., F.C.S., Economic Chemist, for his usual valuable advice and assistance in this investigation.

MOUNTAIN LAGOON AND THE KURRAJONG FAULT.

By ALEXA GRADY, B.SC., and H. HOGBIN, B.A.

(Communicated by Associate-Professor Griffith Taylor, D.Sc.)

(Read before the Royal Society of New South Wales, August 4, 1926.)

The area we discuss in this paper is the region to the north of Kurrajong Heights, between Mountain Lagoon and Wheeny Creek, a belt of country in the County of Cook some three and a half miles long by about one mile broad.

The only approach to this area is by way of Bilpin, a settlement eight miles from Kurrajong Heights on the Bell road. From Bilpin a track leads through to Mountain Lagoon, following the top of the ridge which is the main divide between Wheeny and Tootie Creeks. By this, the only practicable route, the Lagoon is fifteen miles from Kurrajong Heights, although in a direct line it is only five or six miles. (See Fig. 1.)

The only previous literature we have come across that deals in any way with this district is Professor David's "An Important Geological Fault at Kurrajong, N.S. Wales," read before the Royal Society of New South Wales on December 3rd, 1902. Of this we have made use in so far as it applies to this region.

We also acknowledge the use of Willan's map of the Sydney District. This we found useful and suggestive, but unreliable both as regards contours and creeks, especially in the immediate neighbourhood of the Lagoon.

Unfortunately we have been able so far only to make a contour map of the northern part of our area. This we hope is more in accord with the facts than any hitherto published.

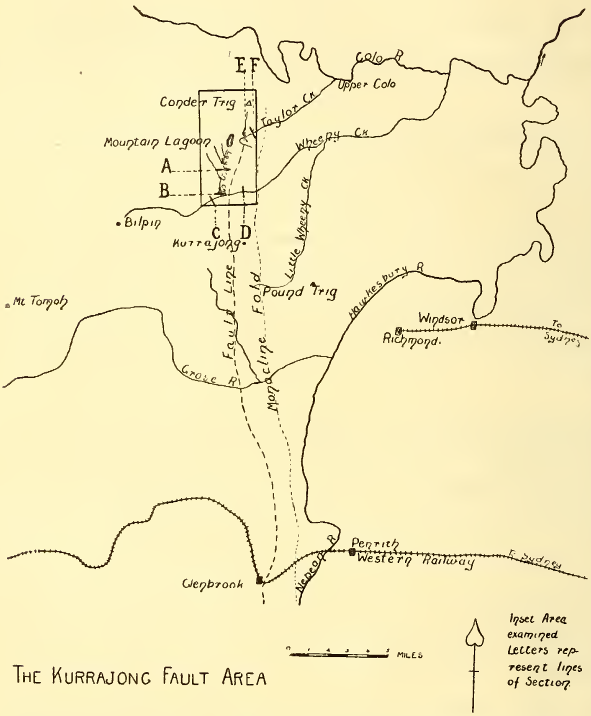

Fig. 1. Plan of the Kurrajong-Fault Area

Where the creeks in the area did not already have names, and most of them had not, we have named them ourselves for convenience of reference. The Lands Department has now adopted these names.

The Monocline and the Kurrajong Fault.—Extending in a north-south direction from Glenbrook to Kurrajong there lies the great monocline fold. At Kurrajong this folding has caused an uplift of over 850 feet, although it is only half that amount at Glenbrook. To the west of the monocline at Glenbrook is a slight downwarp or fold of about 100 feet. Behind Kurrajong there is a well defined fault, with a throw of 450 feet. The fault here and the fold at Glenbrook probably belong to the same movement although their connection has not yet been definitely established. They were probably caused by readjustment after the monoclinal fold, according to Professor David. (See Fig. 1.)

The Colo, the Grose, and the smaller Wheeny Creek were all alike confronted with the fault and were all able to cut their way through it and continue very largely in their old courses, though they were probably all diverted slightly

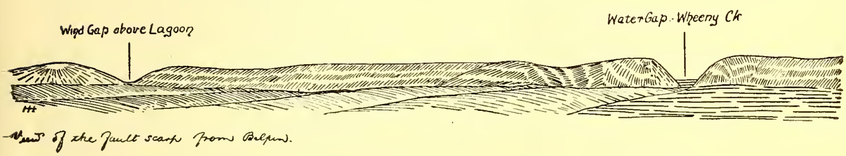

Fig. 2. Panoramic Sketch of Kurrajong Fault.

to the south. (See Fig. 2.) Apparently the faulting took place so slowly that these streams were able to cut a channel right through the upthrust side while the action was going on, for in our cursory examination of Wheeny Creek we could find no evidence of lacustrine deposits indicating a temporary dam, and where the smaller stream was able to continue its flow uninterruptedly, it is unlikely that the larger streams were even dammed up for a time, unless they have changed in volume, which is also unlikely.

It is clear, however, that Mountain Lagoon was caused by the damming up of a small stream, which, before the faulting, flowed straight across into the Colo. This course is occupied now probably by Taylor Creek. For a time, no doubt this old stream was able to keep pace with the faulting for a wind gap has been cut in the fault behind the Lagoon. This wind gap at its lowest point 400 yards from the Lagoon shore is now only eleven feet above the surface of the Lagoon, but this is owing to deepening by

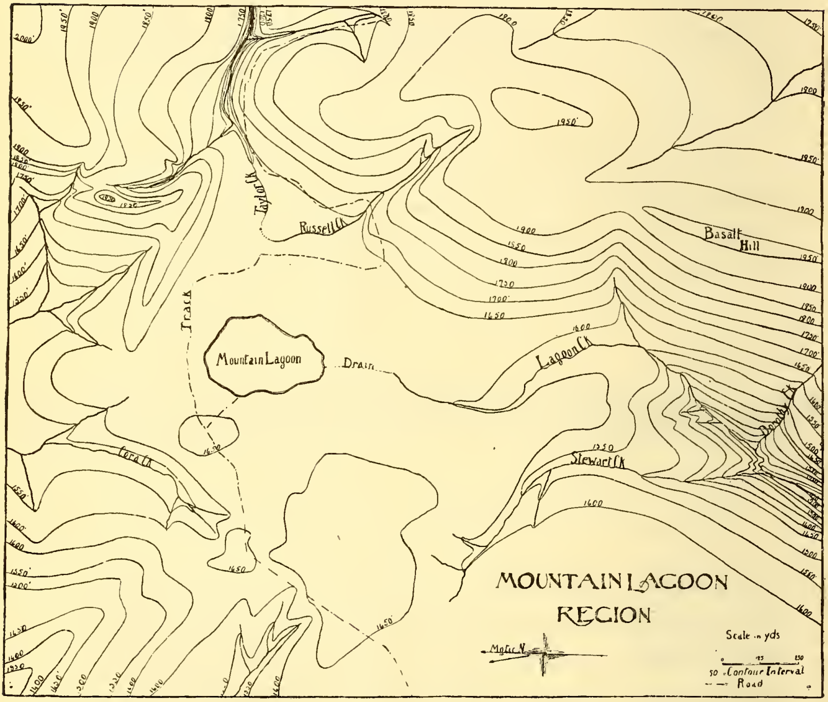

Fig. 3. Contour Map of Area

headward erosion of Taylor Creek. It is improbable that the original wind gap came down as low as this (See Fig. 3.)

The Lagoon Topography.—Mountain Lagoon may be roughly compared with an overturned saucer. The lagoon itself occupies the shallow depression within the rim of the bottom of the saucer. (See Fig. 4.) Its watershed consists of only the narrow rim itself, outside which are streams which besiege it on all sides. Each of these has a very steep grade.

The lagoon is fed by no stream of appreciable size. The longest is a mere soak some 600 yards long, flowing in from the west. We use the term "soak", here and elsewhere, for a short creek-bed normally dry but which carries water after rain.

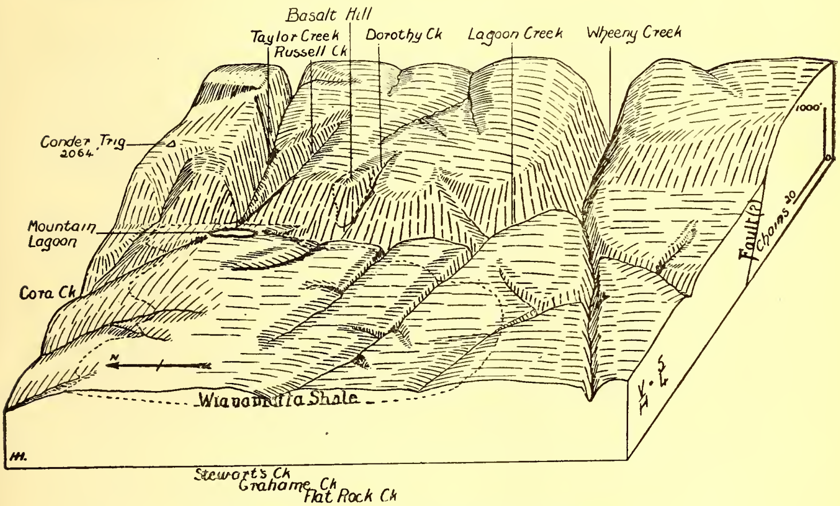

Fig. 4. Block Diagram of Area

In the north one proceeds over a narrow strip of country some 150 yards wide to the top of a divide only 50 feet above the Lagoon. On the far side of this divide are the headwaters of Cora Creek, draining into Tootie Creek and hence into the Colo.

On the south the rim of the bottom of the overturned saucer is even lower. Here the divide is between the Lagoon watershed and Lagoon Creek. Normally the latter does not drain the lagoon, but a few years ago a ditch was cut through the divide to connect the two in order to empty the Lagoon for cultivation purposes. However, nothing was done in that direction and the drain has now become almost filled with silt. Apparently the flow of water from the Lagoon was not sufficient to keep a clear channel, but in course of time the headward erosion of Lagoon Creek must eat back along the ditch and so open the outlet again —this time permanently. As matters are now Lagoon Creek, flowing southward, commences its course some 60 yards to the south of the Lagoon.

The longest slope to the depression is on the west, and down this slope is the soak before mentioned. On this side the divide is over half a mile from the Lagoon. This divide separates the soak waters from those of Stewart's Creek, a tributary of Lagoon Creek.

On the east the saucer analogy is weakest. Here there is a most interesting example of capture. About 150 yards from the Lagoon, running north-south, is the great fault scarp. This scarp is breached by a wind gap right opposite the Lagoon. The divide between it and the headwaters of Taylor Creek lies in the wind gap—400 yards from the Lagoon shore and only 11 feet above it.

Taylor Creek has just captured Russell Creek, which but yesterday, geologically speaking, flowed into the Lagoon. Taylor Creek has eaten back the divide and by doing so has captured Russell Creek, which now, making an angle of about 40°, turns and flows in the opposite direction.

How precarious the position of the Lagoon is can readily be seen. As soon as one of the besieging streams reaches it all traces will be removed in a very short time.

Topography of Surroundings in Detail.—Lagoon Creek for some 500 yards of its course occupies merely a little V-shaped silty trench, five feet deep. This quickly deepens after that and in quite a short distance the creek occupies the bottom of a juvenile gorge some hundreds of feet deep.

Lagoon Creek follows the edge of the fault scarp closely, no doubt because that is a line of weakness, making erosion easier. (See Fig. 5, Section A.)

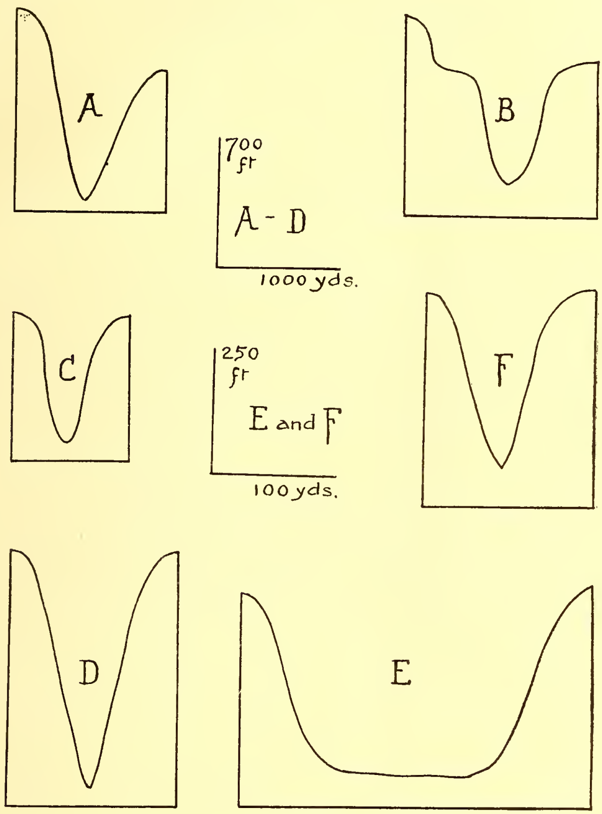

Fig. 5. Cross-Sections (A-E) of Valleys in Area

Just before the junction with Wheeny Creek it takes a turn into the downthrust side of the fault, leaving the scarp. There is here a well-marked shelf on the eastern side of the valley. This shelf is level with the top of the gorge on the western side. Section B (in Fig. 5) shows this shelf.

The reason for this is that the creek is probably following up another line of weakness—a cross fault. The result is that it joins Wheeny Creek with a boat-hook bend.

Dorothy Creek is the only appreciable tributary of Lagoon Creek on the left-hand side. The rest are mere soaks. The reason of this lies in the smallness of the watershed, being confined wholly to the scarp face. Dorothy Creek is the biggest, probably because it has cut its way into the basalt rock of Basalt Hill (see below) and that is easier to erode than the sandstone.

On the right-hand side there are three creeks. Of these the most northerly is Stewart's. The source of this creek is due west of the Lagoon about half to three-quarters of a mile. At its source the level of the creek is much the same as that of the Lagoon, but in its length of only 1500 yards it has a fall of 400 feet.

The two other creeks joining the main creek on this side are Grahame and Flat Rock. Of the three, the last is the longest and has the greatest volume. Both of these creeks flow from the main ridge running from Bilpin to the Lagoon, the main divide between Tootie and Wheeny Creeks. Both Grahame and Flat Rock Creeks are typical juvenile streams with steep grades, falls and gorges.

Wheeny Creek has cut a magnificent gap through the upthrust side of the fault. Just before it reaches the fault it flows through a canyon with walls 500-700 feet high, but where it cuts through the upthrust these are increased by an extra 500 feet. The sections C and D in Fig. 5 give some idea of the difference.

Cora Creek, to the north of the Lagoon, flows into Tootie Creek. It descends even more rapidly than Lagoon Creek, and soon becomes intrenched in a great gorge.

Taylor Creek, on the east, drains straight through to the Colo. As explained above, it probably represents the beheaded stream which formed Mountain Lagoon, when unable to keep pace with the faulting. It, too, flows through a gorge and descends at a steep grade.

When we stand on the divide in the wind gap and look down Taylor Creek we notice that the valley is very wide for such a small stream, even allowing for the captured Russell Creek which flows towards us obliquely and then turns into the main creek. The floor of the valley is here 200 feet wide, but ahead, that is to say downstream, we can see that it narrows. Section (E) is at the wind gap, and section (F) 500 yards below. (See Fig. 5.)

This is very obviously abnormal, and how are we to account for it? Our first theory was that the wide valley represented ordinary erosion by Taylor Creek in the shatter belt caused by the fault. This was strengthened by our noticing that where the valley is wide there is no stratification of the sandstone visible, only huge loosely-sorted boulders forming gigantic talus slopes. Erosion would be, of course, more rapid in a shatter belt.

However, although we do not reject this theory, a second has suggested itself, that the wide valley represents the wind gap cut by the old stream, deepened, as we have said, by the headward erosion of Taylor Creek. The narrow valley below would then represent the normal juvenile valley of Taylor Creek. This does not altogether explain why the outcropping strata are covered in the wide valley while they remain visible in the narrow, so perhaps there is a little of the truth in both theories.

Summary.—The topography of the downthrust side of the fault is a dissected peneplain with a slope towards the east to the great fault scarp. Although the Lagoon occupies a small local depression, it is actually higher than most of the downthrust side of the fault, being one of the few remaining parts of the peneplain as yet undissected.

Geology.

The main geological feature of the area is the Hawkesbury sandstones, the middle series of the local Trias system. In places these are covered by Wianamatta shale beds, but nowhere did we find Narrabeen shales exposed. At Mountain Lagoon there is an outlier of Wianamatta shales. (See Fig. 4.) This is just what we would expect to find at the core of the old peneplain. The shales cease abruptly at the fault scarp on the east. On the north and west we find the shales for a short distance but as the country becomes more dissected they have been worn away. In the south the shales cease abruptly at a small local upwarping of some fifteen feet. This warp is a distinct feature at right angles to the main fault and it is where it crosses them that both Stewart's and Lagoon Creeks enter into their gorges.

On the side of the fault scarp south of the Lagoon there is an exposure of basalt. (See Fig. 4.) We were not able to discover if this was post-faulting or not. However, we noted—

1. that no basalt is exposed at all on the downthrow side;
2. the basalt does not reach the level of the downthrow side;
3. it is not found even as talus in Lagoon Creek;
4. it reaches to within 50 feet of the present top of the fault scarp;
5. it has been weathered into a rich chocolate soil, and there are few exposures of the actual rock.

The boundaries of the basalt and Wianamatta shale are indicated approximately on the block diagram submitted. (Fig. 4.)

Settlement and Economic Effects of the Fault.

At present there are five farms in the district, but only two are being worked. Citrus fruits are grown chiefly. The orchards are located on the Wianamatta shale in the Lagoon area and on the main divide at the Lagoon end. There does not seem much prospect of any greater density in the population, for the best areas have already been taken up, and there only remains a small portion of Wianamatta shale soil. We understand Basalt Hill has been selected, but it is as yet uncleared. The total number of farms in the whole area can never exceed a dozen, so that the construction of a good road is unwarranted unless a tourist route be made, following the present track from Bilpin to Upper Colo. This would make Mountain Lagoon, a place of great geographic and also of scenic interest, much easier of access, but since it is not a place of economic interest it hardly seems likely that such a road will be constructed at present.

THE INTERNAL STRUCTURES OF SOME OF THE PENTAMERIDAE OF NEW SOUTH WALES.

By F. W. Booker, B.Sc.

Geological Survey of New South Wales, Department of Mines, Sydney.

(With Plates V-VIII and seven text figures.)

(*Read before the Royal Society of New South Wales, September 1, 1926.*)

The research, the results of which are embodied in this paper, was instituted primarily to confirm Etheridge's[1] determination of *Pentamerus* (*Barrandella*) *linguifera* var. *wilkinsoni,* from the Barrandella Shales of Hatton's Corner, Yass.

Through the courtesy of Mr. J. Mitchell, I was able to examine specimens of *Barrandella* (*Pentamerella*) *molongenis* Mitchell (sp.), and of *Sieberella glabra* Mitchell. A specimen of *Sieberella galeata* Dalman was obtained from the Dudley Collection in possession of the Department of Mines for comparison with Mr. Mitchell's specimens.

My thanks are due to Mr. W. S. Dun for his kindly supervision and direction of my work, and to Mr. J. Mitchell and Mr. A. J. Shearsby for their help in obtaining material. Miss H. R. Drummond, B.Sc., and Messrs. H. W Hamilton, B.Sc., and C. Barnard, B.Sc., have also allowed me to use material from their collections. An extensive collection of more than 1000 specimens was made in the Yass district.

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[1]Etheridge R., Pentameridae of N.S.W., Records of the Geological Survey of N.S.W., 1892-3, 3, 49.

The Preparation and Examination of Brachiopod Material.—The internal structures of the brachiopods described in this paper were examined by means of thin sections cut serially from the umbo to the anterior margin of the shell. The serial sections were usually 1 mm. or less apart and from them the internal structures of the shell could be reconstructed with great accuracy.

These sections were supplemented by internal casts, natural sections, and sections made by splitting specimens along the median septum in a rock breaker.

A complete photographic record of every specimen was kept.

Genus BARRANDELLA Hall 1893.[2,3]

Synonym, *Clorinda* Barrande, 1879.[4]

Sub-genus BARRANDINA, n. sub-gen.

Plates V. VI. and VIII.

Synonym, *Pentamerus linguifera* var. *wilkinsoni* Eth. Fil. 1892.[5]

Shells sub-globose, usually inflated, and generally wider than long. Their size is variable, but usually small. The umbo of the pedicle valve is large and incurved and much thickened. The umbo of the brachial valve is only slightly thickened. A median sinus is developed on the pedicle valve and a corresponding fold on the brachial valve. The sinus is shallow and bounded by two slightly raised folds, while the fold is impressed by a faint median groove; i.e., the shell is dorsally uniplicate with a tendency to become dorsally biplicate. The sides of the plication are squarish. An area is absent in all cases. The surface of

[2]Report of the New York State Geologist, 1893, 844.
[3]Palaeontology of New York, 1894, 8, 241.
[4]Systéme Silurien, 1879, 5, pls. XXII, XXIV, CXIX, CXXXVIII.
[5]Etheridge, loc. cit.

the valves is ornamented with a few laminae of growth; otherwise the shells are smooth.

The hinge line of the pedicle valve is short and curved with two small, poorly developed, but distinct, teeth. The delthyrium is bounded by a pair of narrow incipient pseudo-deltidial plates. The teeth are supported by a pair of strong dental lamellae, which unite to form a short spondylium, the free extension of which is produced into the cavity of the brachial valve and terminates anteriorly about the centre of the valve. The spondylium is supported at its posterior surface only, by a short but wide septum.

The hinge line of the brachial valve is short and curved, and has two distinct sockets for the reception of the hinge teeth. The sockets are bounded by very short crural plates, supported by slightly longer septa. The septa are divergent and make two distinct lines of union on the surface of the valve.

At the junction of the crural plates and septa a pair of curved, outwardly convex plates are developed. These are attached throughout their entire length to the cruralium, at the junction of the crural plates and septa, either along the median line of the convex side of the plate, or at the edges, being then intercalated between the septa and crural plates. These plates extend beyond the anterior termination of the crural plates and septa for fully one-third of their length and terminate at a point slightly anterior to the end of the spondylium.

A definite series of branching vascular sinuses radiates from the umbonal region.

Type: *Barrandina wilkinsoni,* n. sp.

Locality: Hatton's Corner, Yass.

The sub-genus Barrandina has been erected for the reception of certain Australian Pentameridae, with the fold on the brachial valve and sinus on the pedicle valve, in which the cruralium is modified by the development of an extra plate at the junction of the septa and crural plates. The two species comprising the sub-genus were first described by Etheridge[6] as *Pentamerus linguifera* var. *wilkinsoni*. Subsequent work on the pentameroids of the Yass district has revealed a series of forms paralleling in their structures the Barrandella and Sieberella series of Europe and America, but all characterised by the development of an extra plate in the cruralium.

In view of Hall's comment on the variability of the cruralium in certain of the galeatiform pentameroids, it was deemed inadvisable, at this stage, to give this structure more than sub-generic importance, although it has been found to be very constant throughout a very large series of specimens.

Barrandina wilkinsoni, n. sp.

Plates V., VIII. (No. 1). Numbers 1-5.

Synonym, *Pentamerus linguifera* var. *wilkinsoni* Eth. Fil., 1892.[7]

Shell sub-globose, usually inflated and, as a rule, wider than long. The shells are much larger than those of *Barrandina minor*. The measurements of the largest and smallest specimens examined, and the mean measurements of twelve specimens are:—

	Length	Breadth	Depth
Smallest	20 mm.	21 mm.	16 mm.
Largest	26 mm.	27 mm.	18 mm.
Mean of 12	22 mm.	23 mm.	15 mm.

[6, 7] Etheridge, loc. cit.

The pedicle valve is much thickened and curved in the umbonal region. The umbo is very large and incurved, and often depressed, concealing entirely the delthyrium. A broad shallow sinus with a narrow groove in the median line, and bounded by two low folds, is developed opposite a corresponding fold in the brachial valve. The sinus is concealed by subsequent shell growth until it can only be seen at the anterior margin of the shell, where the front is deflected and produced dorsally, sometimes becoming almost perpendicular to the longer axis of the shell and forming the characteristic "tongue."

"Vascular system possessing two main trunks, arising in the umbonal cavity and shortly bifurcating with a lateral branch proceeding down each flank and central branches on each side of the shallow sinus, each portion again dividing near the front."[8]

The brachial valve is transversely ovate and thin in comparison with the pedicle valve. The beak is highly incurved, but does not enter the opening of the pedicle valve. It is outwardly convex from the umbo until the fold commences to rise, whence it is concave to the anterior margin. The fold is strongly developed and is impressed with a faint median groove, which may be accepted as a tendency to dorsal biplication and which gives the fold a squarish appearance.

The surface of the valves is smooth except for a few concentric laminae of growth.

The hinge line of the pedicle valve is short and curved and provided with two distinct, though not well developed teeth. The delthyrium is large and triangular and modified by a pair of narrow, pseudo-deltidial plates. The teeth are supported by strong, well-developed dental lamellae

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[8]Etheridge, loc. cit.

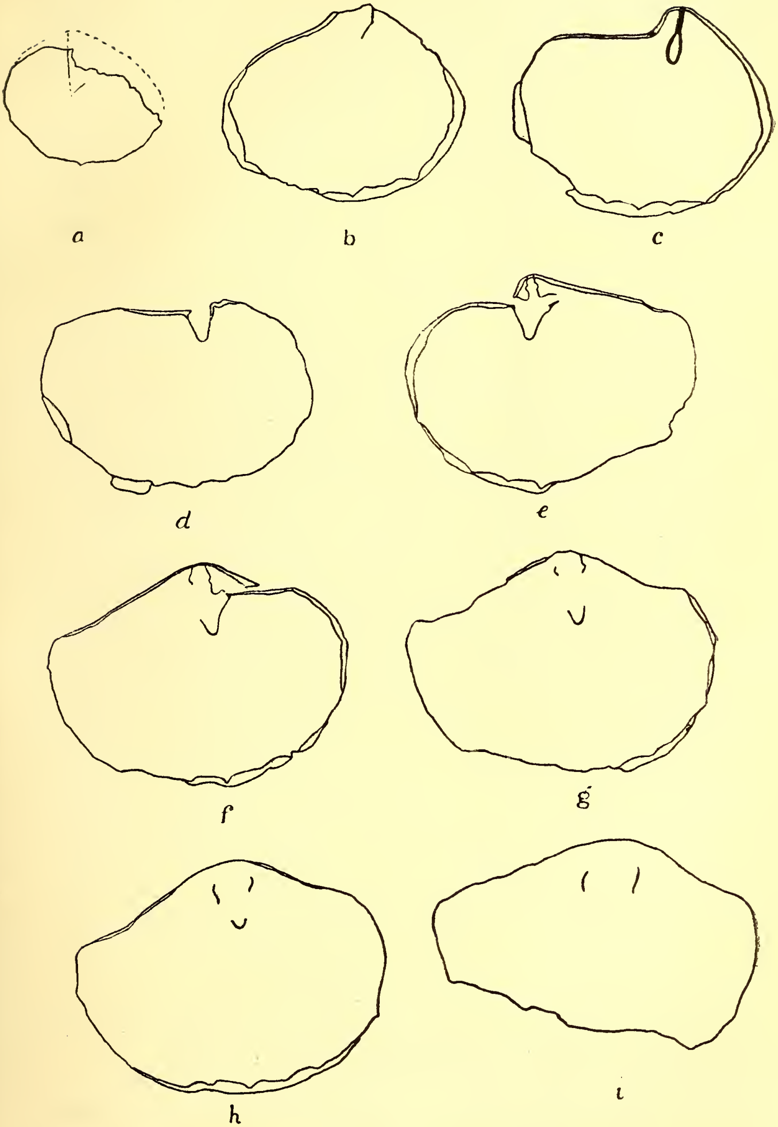

Fig. 1.—*a-i*, nine transverse serial sections of *Barrandina wilkinsoni*, showing septa, spondylium, crural and extra plates. × 1.

which unite to form a short spondylium, the free extension of which is directed forward into the cavity of the brachial valve and terminates anteriorly about the centre of the

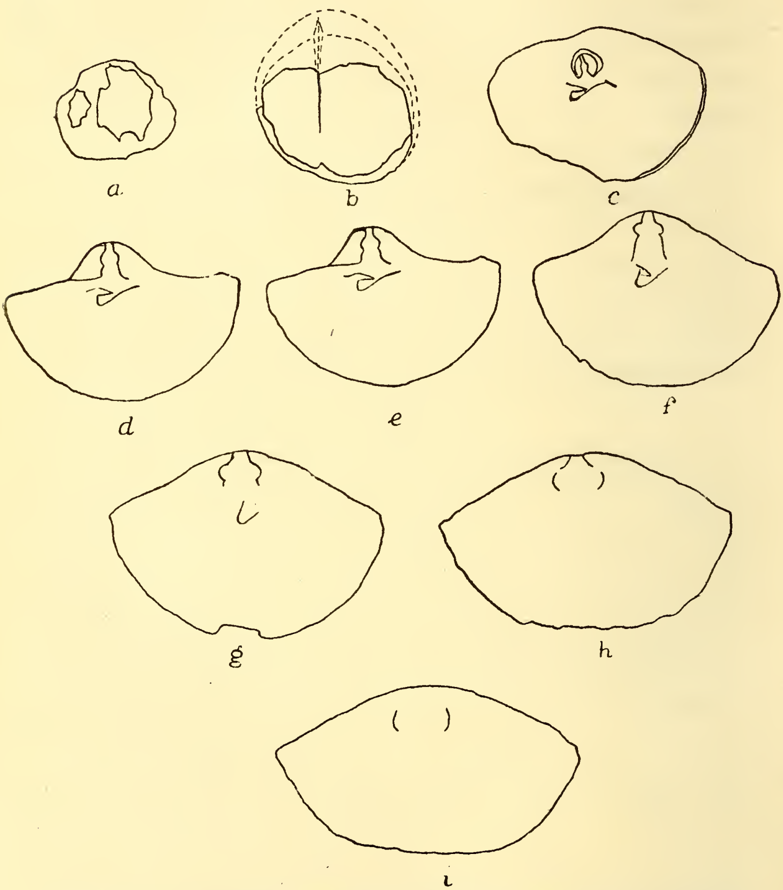

Fig. 2.—*a-i*, nine transverse serial sections of *Barrandina wilkinsoni*, showing septa, spondylium, crural and extra plates. × 1⅓.

valve. The spondylium is supported by a very short septum which extends anteriorly to the point of greatest curvature of the umbo, and which is very wide in comparison with its length, by reason of the great size and depth of the umbo. The spondylium bears a series of muscular markings similar to those seen on the spondylium of *Conchidium knighti* Sow. (sp.) ; a series of longitudinal striae at the bottom of the spondylium representing the adductor scars and a series of transverse markings on the sides being the diductor scars. The septum bears a series of growth striae.

The hinge line of the brachial valve is short and curved with two distinct sockets for the reception of the hinge teeth. The sockets are bounded by very short crural plates, which are outwardly concave. Two convergent septa, slightly longer than the crural plates, are developed. These make two distinct lines of union with the bottom of the valve. The crural plates are not joined directly to the septa, but are separated from them by a pair of additional plates, intercalated between the crural plates and septa. The additional plates are long, curved, and outwardly convex, and are joined to the entire length of the crural plates along the ventral edges, and to the septa, along the dorsal edges. The anterior ends of the additional plates extend beyond the termination of the crural plates and septa for fully one-third of their length and terminate slightly anterior to the end of the spondylium. The septum bears a series of transverse growth striae. The crural plates bear a series of transverse striae, probably of muscular origin, and the additional plates bear a series of similar striae.

Locality and horizon: Barrandella Shales, Hatton's Corner, Yass.

Etheridge's type specimens are, with one exception, referable to this species, which therefore becomes the type of the new sub-genus. The exception is a small specimen from Bowning[9] which I have not been able to examine.

BARRANDINA MINOR, n. sp.

Plate VI., Numbers 1-4, 6, 7. Plate VIII., Number 2.

Synonym, *Pentamerus linguifera* var. *wilkinsoni* Eth. Fil., 1892.[10]

Shell sub-globose, usually inflated, and, as a rule, wider than long. The shells are typically small. The measurements of the smallest and largest examined and the mean measurements of 124 specimens were:—

	Length	Breadth	Depth
Smallest	11 mm.	12.0 mm.	7.5 mm.
Largest	15 mm.	16.5 mm.	11.0 mm.
Mean of 124	13 mm.	13.5 mm.	9.5 mm.

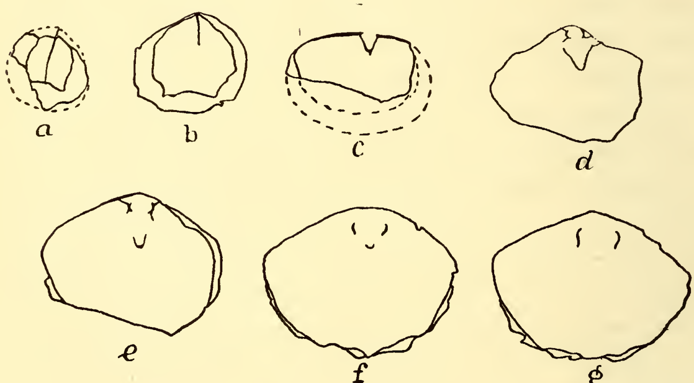

Fig. 3.—*a-g*, seven transverse serial sections of *Barrandina minor*, showing septa, spondylium, crural and extra plates. × $1\frac{1}{3}$.

The internal structures of the pedicle valve are identical with those of *Barrandina wilkinsoni*, but they are developed on a smaller scale, consistent with the smaller size of the shell.

The hinge line of the brachial valve is short, curved and provided with distinct sockets for the reception of the hinge teeth. The sockets are bounded by very short

[9, 10] Etheridge, loc. cit. Plate XI., Fig. 8.

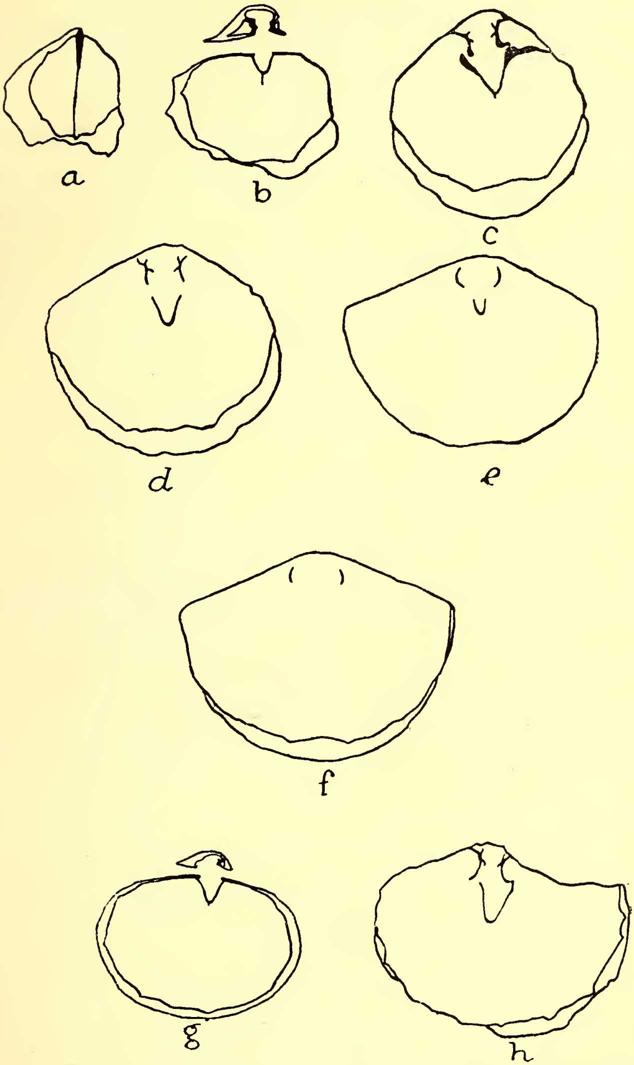

Fig. 4.—*a-f*, six transverse serial sections of *Barrandina minor*, showing septa, spondylium, crural and extra plates. × 1⅓. *g*, section showing thickening of margins of the delthyrium, being equivalent to pseudodeltidial plates. × 1⅓. *h*, section showing the mode of occurrence of the extra plates in this species. × 1⅓.

crural plates, which are outwardly concave. The crural plates are supported by septa slightly longer than themselves. The septa are divergent and make two distinct lines of junction with the valve. At the junction of the septa and crural plates, and on the inner side, a pair of long, curved, outwardly convex plates is developed. These are attached to the whole length of the crural plates and septa, along the median line of the convex side of the plates which are prolonged anteriorly beyond the anterior termination of the septa and crural plates for fully one-third of their length.

Locality and horizon: Barrandella Shales, Hatton's Corner, Yass.

Barrandina wilkinsoni and *B. minor* occur together in the Barrandella Shales of Hatton's Corner, Yass. The adult specimens are readily distinguished specifically by the difference in size, *Barrandina wilkinsoni* being considerably larger than *B. minor.* I have not been able to identify young specimens of either species. It is certain, however, that, of the fifty specimens of *Barrandina minor* which were examined internally, none could possibly have represented the immature stages of *B. wilkinsoni.*

Genus Pentamerella Hall, 1867.[11]

Plate VI., Number 5. Plate VII., Numbers 5 and 6.

Pentamerella molongensis Mitchell (sp.) 1920.[12]

Synonym, *Barrandella molongensis* Mitchell, 1920.[13]

Since Mitchell's description of these specimens, several have been sectioned serially and the internal structures reconstructed.

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[11]Report New York State Geologist, 1893.

[12, 13]Mitchell, Proc. Linn. Soc. N.S.W., 1920, 45, 548.

In the pedicle valve the dental lamellae unite to form a short, curved spondylium which extends only one or two millimetres below the hinge line. It is supported at the extreme posterior end by a rudimentary septum, which does not extend past the highest point of the umbo.

In the brachial valve are two short divergent septa which make two distinct lines of union with the bottom of the valve. These support a pair of short crural plates which unite with the septa on the outer side and slightly below the free edges of the septa.

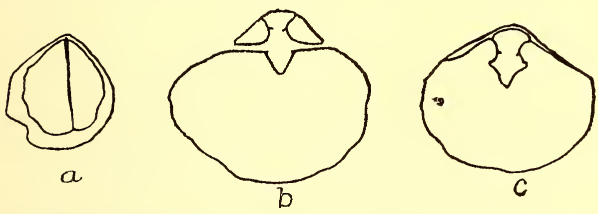

Fig. 5.—*a-c, Pentamerella molongensis* Mitchell (sp.) Three transverse sections showing the form and extent of the internal structures. × 1⅓.

Locality and horizon: The locality given is 8 miles west of Molong, but Mr. Mitchell is very doubtful of the exact locality and it is therefore impossible to refer the specimens to any definite locality or horizon.

The extremely short, rudimentary septum and short spondylium at once remove this species from the genus Barrandella to Pentamerella. In both internal and external characters it agrees most nearly with *Pentamerella fultonensis* Branson (see Plate VII., Number 6) from the Callaway Limestone of Callaway County, Missouri, U.S.A.[14]

Externally *Pentamerella fultonensis* and *P. molongensis* are practically indistinguishable, except perhaps *P. fultonensis* is slightly higher in the umbo and slightly more

[14] Missouri Bureau of Geology and Mines, 1922, 13, 2nd Series, 88, Pl. XVI.

convex in the brachial valve than *P. molongensis.* Internally they agree in the size and degree of development of septum and spondylium. In the brachial valve there are slight differences. In *P. fultonensis* the septa unite as they reach the bottom of the valve, forming only one line of union with the valve. The crural plates unite with the septa along their free margin, while in *P. molongensis* the septa do not unite before reaching the bottom of the valve, and leave two distinct lines of union on the surface of the valve, while the crural plates are joined to the septa on the outer sides and slightly below the free edges.

Genus SIEBERELLA Œhlert, 1887.[15]

A specimen of *Sieberella galeata* Dalman, from Wren's Neck, near Dudley, England, was obtained from the Dudley Collection in the possession of the Mines Department, for sectioning. See Plate VII., Number 4, Plate VIII., Number 4.) The internal characters of this specimen do not agree at all closely with the published figures and descriptions of *Sieberella galeata.* In the pedicle valve of this specimen the septum is short and supports the spondylium at the posterior surface only. The spondylium is about two-thirds the length of the pedicle valve. In the brachial valve are two long, divergent septa. These do not support the crural plates directly, but are separated from them by a pair of long, curved extra plates which are outwardly convex and project for about a quarter of their length beyond the anterior termination of the crural plates and septa.

The specimen had the following external dimensions:—

Length	Breadth	Depth
16 mm.	17 mm.	15 mm.

[15]Fischer's Manuel de Conchyliologie, 1887, p. 1311.

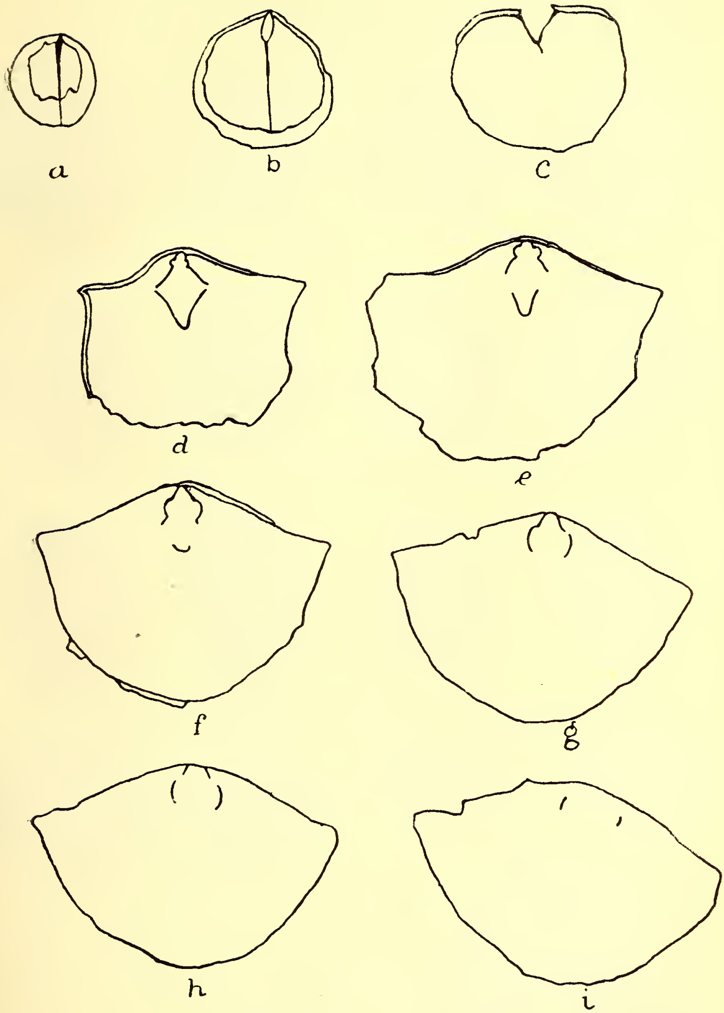

Fig. 6.—*a-i*, nine transverse serial sections of *Sieberella glabra* Mitchell, showing the arrangement of the internal structures and the extra plates. × $1\frac{1}{3}$.

Neither Hall and Clarke[16] nor Davidson[17] mention the occurrence of the extra plate or realise its significance. Davidson's figure of *Sieberella galeata*[18] shows a structure which may represent this extra plate, but if so it does not extend beyond the anterior end of the septum. Davidson also shows a much shorter spondylium and a longer septum than occur in the specimen examined.

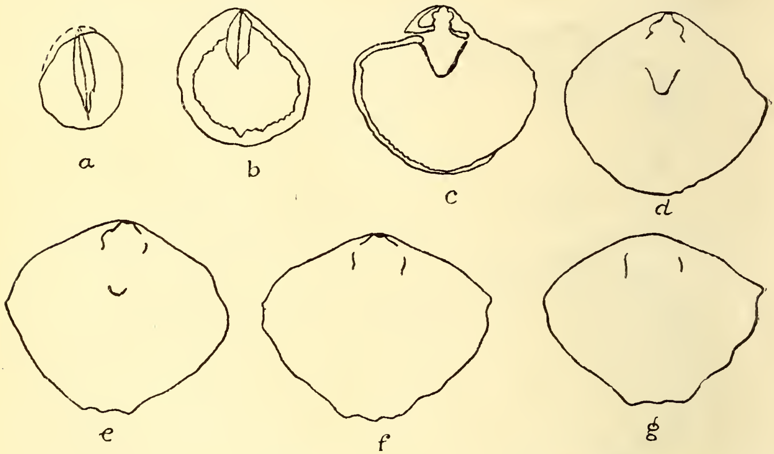

Fig. 7.—*a-g*, seven sections of *Sieberella galeata* Dalman, from Wren's Neck, Dudley, showing extra plates in the cruralium. × 1⅓.

SIEBERELLA GLABRA Mitchell (sp.).[19]

Plate VII., Number 1-3. Plate VIII., Number 3.

A single specimen of this species was sectioned serially. The dental plates unite to form a deep spondylium which extends forward more than half the length of the shell. It is supported for about one-third of its length by a well-developed septum. In the brachial valve two strong but low septa are developed and make two distinct lines of

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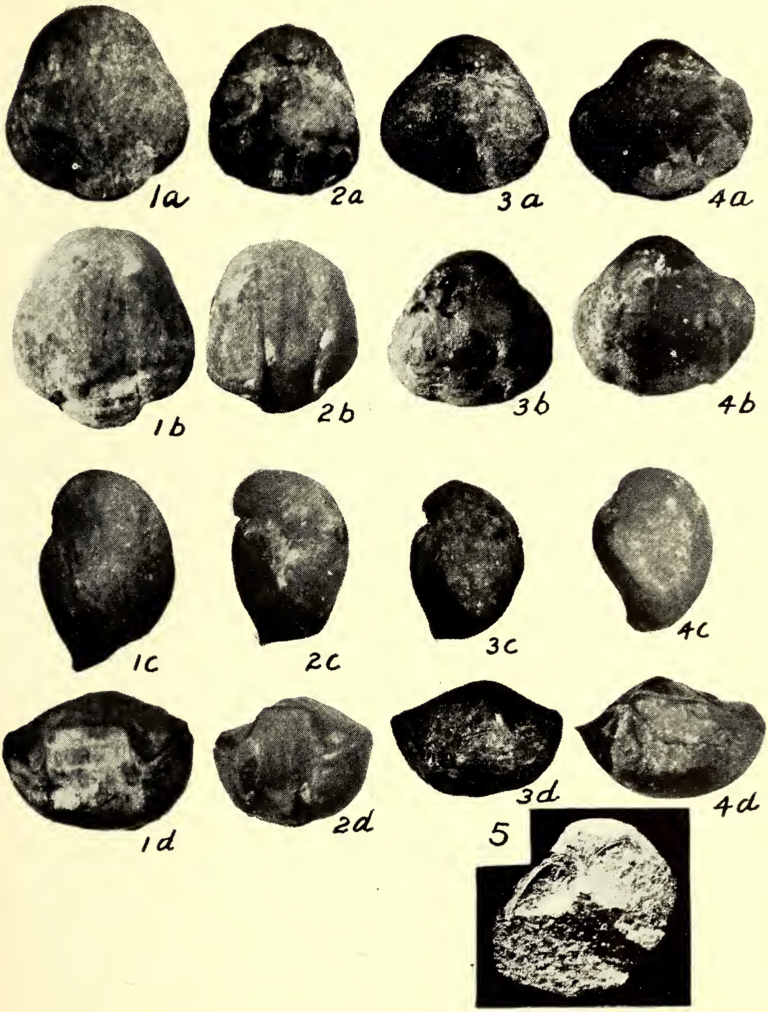
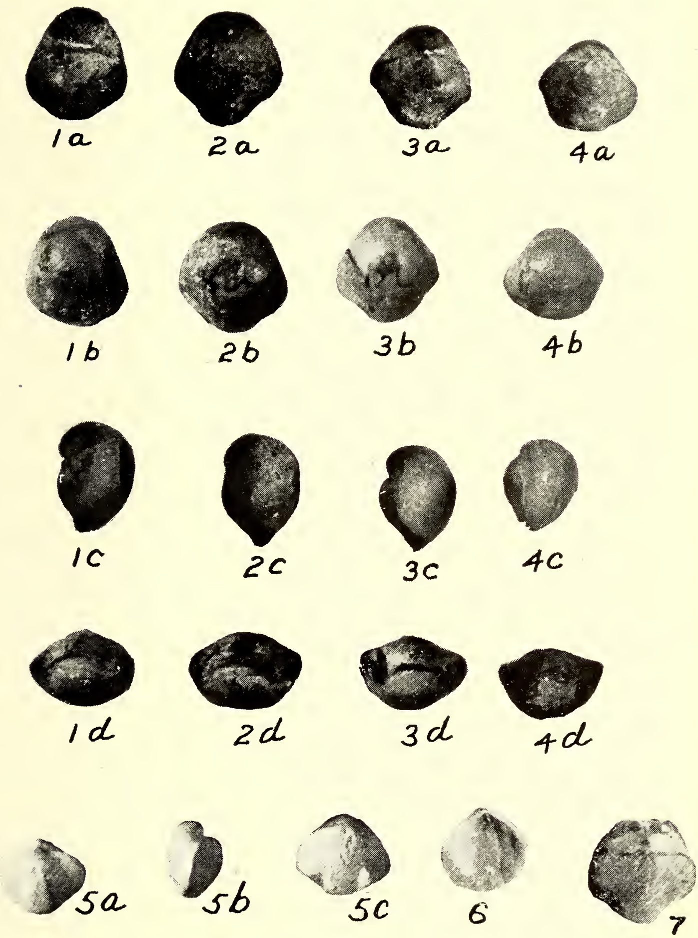
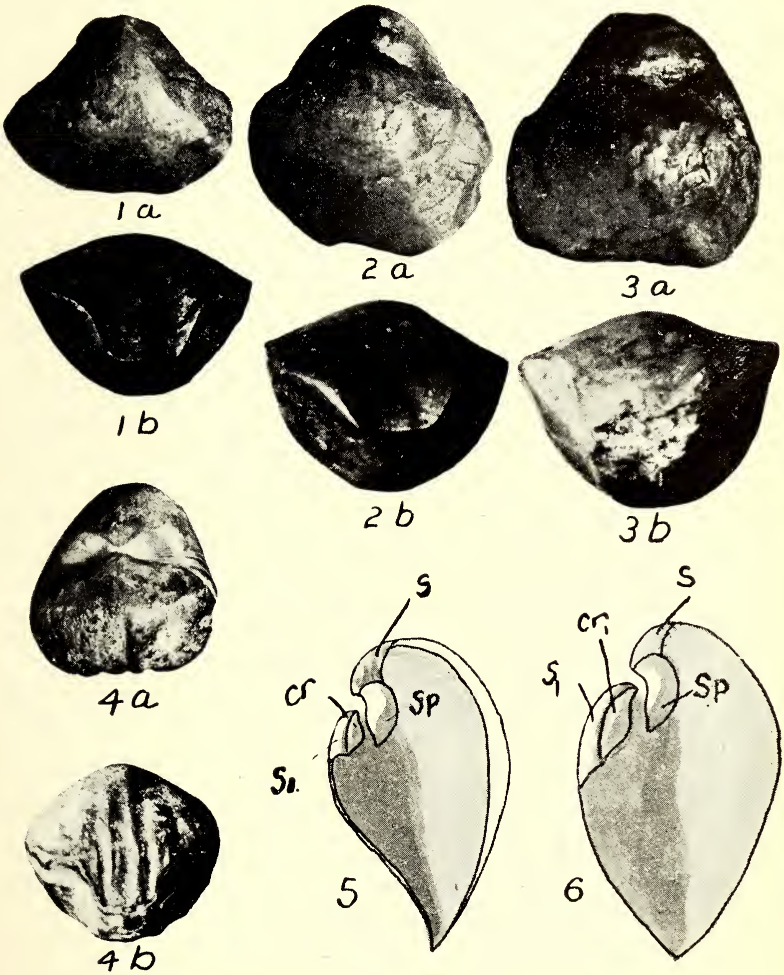
16 Hall and Clarke, Palaeontology of New York, 1894, 8, 246.
17 Davidson, Mon. Brit. Fossil Brachiopoda, 1867, 3, 145.
18 Loc. cit., Plate XV, fig. 23.
19 Mitchell, loc. cit. Pl. XXXI., figs. 13-15.



Barrandina wilkinsoni (sub-gen. et sp. nov.)

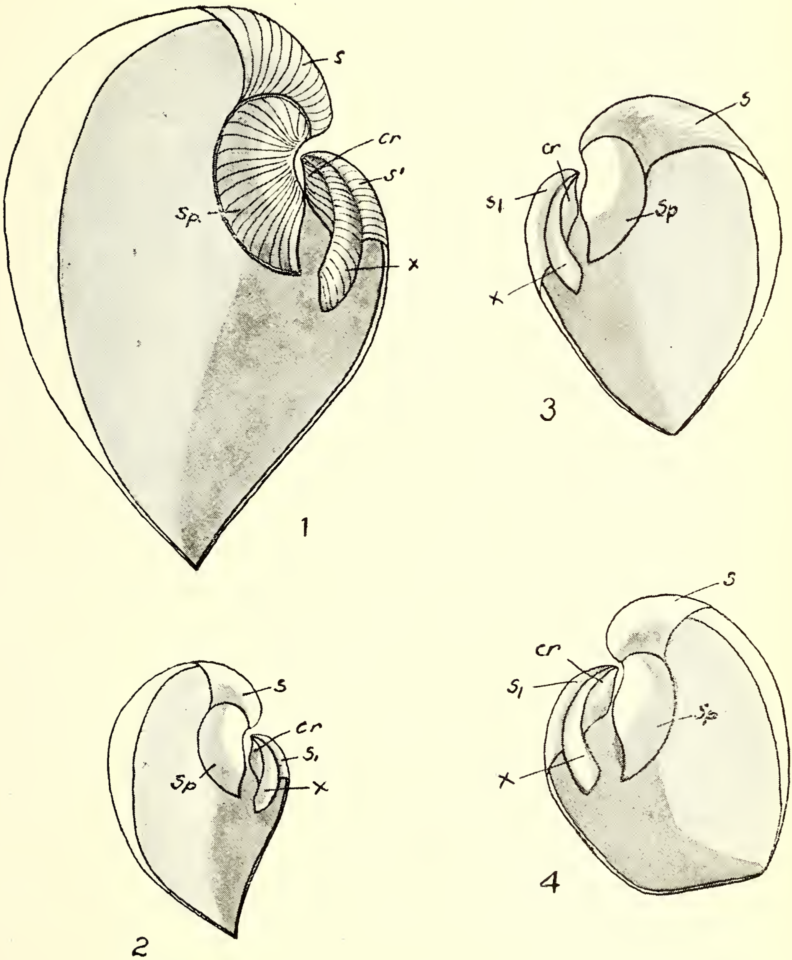


Barrandina minor (sp. nov.)
Pentamerella molongensis Mitchell (sp.)



S. glabra Mitchell. *Sieberella galeata* Dalman

Reconstruction of *Pentamerella fultonensis.*



Reconstruction of *Barrandina wilkinsoni*, *B. minor* and *Sieberella glabra*.

junction with the shell. The crural plates are shorter than the septa and do not rest directly on them but are separated from them by a curved, outwardly convex plate which extends forward for about 2 mm. beyond the anterior termination of the septa.

Mr. Mitchell's species agrees with the published descriptions and figures of *Sieberella galeata* Dalman, in the character of the spondylium and septum, but the septum of *S. glabra* is considerably longer than that of the specimen of *S. galeata* examined. The cruralium of *S. glabra* is identical with that of the specimen of *S. galeata* examined.

DESCRIPTION OF PLATES.

Plate V.

Numbers 1-4. *Barrandina wilkinsoni* (sub-gen. et sp. nov.). × 1.

Number 5. *B. wilkinsoni* Longitudinal section showing septum of pedicle valve, spondylium, one crural plate and the extra plate. × 1.

Plate VI.

Numbers 1-4. *Barrandina minor* (sp. nov.). × 1.

Number 5. *Pentamerella Molongensis* Mitchell (sp.). × 1.

Number 6. *Barrandina minor.* Interior of a pedicle valve, showing vascular sinuses and portion of septum. × 1.

Number 7. An etched specimen of *B. minor* showing septa. × 1.

Plate VII.

Numbers 1-3. *Sieberella glabra* Mitchell. Mr. Mitchell's type specimens. × 1.

Number 4 *Sieberella galeata* Dalman. A specimen from Wren's Neck, Dudley, England. × 1.

Number 5. *Pentamerella molongensis* Mitchell (sp.). A reconstruction of *P. molongensis* showing the internal structures. × 4.

Number 6. A reconstruction of *P. fultonensis* Branson, showing the internal structures. × 4.
S. = septum of pedicle valve. Sp. = spondylium.
SI. = septum of brachial valve. Cr. = crural plate.

Plate VIII.

Number 1. *Barrandina wilkinsoni.* A reconstruction showing the internal structures. × 2.

Number 2. *Barrandina minor.* A reconstruction showing the internal structures. × 2.

Number 3. *Sieberella glabra.* A reconstruction showing the internal structures. × 2.

Number 4. A reconstruction of *Sieberella galeata.* × 2.
S. = septum of pedicle valve. Sp. = spondylium.
SI. = septum of brachial valve. Cr. = crural plate.
× = extra plate.

THE WOOD STRUCTURE OF CERTAIN EUCALYPTS BELONGING CHIEFLY TO THE "ASH" GROUP.

By M. B. Welch, B.Sc., A.I.C.

(With Plates IX.-XII.)

(Read before the Royal Society of New South Wales, Sept. 1, 1926.)

The term "ash" is used in Australia to denote trees belonging to widely different Natural Orders, which have no connection botanically with the European Ash (*Fraxinus*). The chief resemblance is usually one of colour, the majority of the Australian woods being pale coloured, but exceptions such as the Red Ash, *Alphitonia excelsa,* and *Tarrietia argyrodendron,* var., occur. In this paper the wood structure of certain Eucalypts, namely, *Eucalyptus Dalrympleana* J.H.M.; *E. Delegatensis* R.T.B., *E. fastigata* Deane and Maiden; *E. fraxinoides* Deane and Maiden; *E. obliqua* L'Her; *E. oreades* R.T.B. and *E. regnans* F.v.M., some of which possess the vernacular name of "Ash," is described. The reason for the inclusion of several other species, not strictly classed in this group, is that they possess timber closely resembling the "Ashes" and occur in the same districts, so that confusion is likely to arise. The woods are pale coloured, normally of moderate weight and hardness and possess, in general, remarkable strength; they are therefore an important commercial group which must eventually play an important part as a substitute for Oregon as a scantling timber. The species generally occur in large quantities, especially in southern New South Wales, Victoria, and Tasmania; moreover, they regenerate readily and there is no reason why supplies of the timber should not be assured for all time. The trees grow in regions of comparatively high rainfall and often attain an enormous size; in fact, probably the largest trees in Australia belong to this group, forest giants exceeding 300 feet having been measured in the Gippsland district of Victoria.

On account of their increasing commercial importance, it was thought desirable to examine the woods microscopically to see whether any reliable method could be found whereby they could be identified with accuracy.

The group is an exceedingly difficult one, and although those accustomed to handling the timbers might be able to separate the species growing in their districts, it is sometimes doubtful whether their confidence is always justified. When, however, even the locality is doubtful, the problem becomes still more difficult. Botanically, considerable confusion has existed in the past in reference to the systematic position of certain species, and even to-day opinions differ as to whether one species at least is entitled to specific rank. The synonymy and confusion in connection with *E. obliqua, E. regnans, E. Delegatensis* and *E. fastigata* are dealt with rather fully in a paper on the Eucalypts of Tasmania, by Baker and Smith;* other references can be found in the exhaustive work of the late J. H. Maiden.**

As perhaps might have been anticipated, the results have proved rather disappointing from the point of view of identification, on account of the variation found to occur in the wood of the same species, but it was thought advisable to place them on record.

* R. T. Baker and H. G. Smith. A research on the Eucalypts of Tasmania and their Essential Oils. Proc. Roy. Soc. Tasmania, 1912.

** J. H. Maiden. A Critical Revision of the Genus Eucalyptus. Govt. Printer, Sydney.

The following notes apply principally to the microscopic wood structure of the individual species, but a short description is given of the tree and the uses to which the wood is put. Systematic descriptions can be found in Maiden (loc. cit.) or in the Eucalypts and their Essential Oils.† A short account of the anatomy of the woods of *E. Delegatensis, E. oreades* and *E. regnans* is given in the "Hardwoods of Australia";* *E. Dalrympleana*† was described after the publication of that work. The structures of the various species are illustrated by means of photo-micrographs of transverse sections taken with a comparatively low magnification, in order to include as large a field as possible without losing too many details. There is frequently, of course, considerable variation in the appearance of different parts of a transverse section, and it is impossible to do more than show a very small area.

EUCALYPTUS DALRYMPLEANA J. H. Maiden.

Mountain or White Gum.

A large forest tree attaining a height of several hundred feet and 30 feet in girth, found at moderately high elevations in central and southern portions of the dividing range and spurs in New South Wales. The wood is white to pinkish in colour, of moderately open texture, straight-grained and fissile. It is largely used for building construction, e.g., flooring, lining, weatherboards; hoe and light hammer handles, etc. It seasons well when cut from matured trees, but is sometimes inclined to warp and show

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† R. T. Baker and H. G. Smith. A Research on the Eucalypts and their Essential Oils. 2nd Edition, Govt. Printer, Sydney, 1920.

* R. T. Baker. Hardwoods of Australia and their Economics. Govt. Printer, Sydney, 1919.

† J. H. Maiden. Forest Flora of New South Wales, vol. 7, p. 137. Govt. Printer, Sydney, 1920.

collapse. Weight, 40-48 lbs. per cubic foot. Hardness = Moderately hard.

Macroscopical characters.—Pores medium-sized to small, easily visible on end section with the naked eye; usually in short oblique rows; distribution irregular, more crowded in early wood, often absent in late wood. Vessels practically without contents. Soft tissue not apparent. Rays scarcely visible on end or tangential sections without lens; easily visible radially, being slightly darker in colour than the surrounding tissue. Growth rings fairly prominent, due to darker colour of late wood, and more or less complete absence of pores; more pronounced in specimens from Laurel Hill, New South Wales, at an elevation of 4,000 feet, than in specimens from the Blue Mountains.

Microscopical characters.—Pores almost always single, very variable in size, being very small in late wood; single pores usually elliptical; radial diameter, 45-300μ, mean 240μ; tangential diameter, 30-225μ, mean 165μ; vessel segments 200-500μ; walls 4-6μ in thickness; lateral pits narrow, slit-like, border circular or almost so; ray pits irregularly elliptical, simple; end walls transverse or inclined up to 20°; end perforation always simple; end projection up to 90μ in length; tyloses occasionally present but rarely filling whole of cell cavity; number per sq. mm. 1-9. Wood fibres (fibre-tracheids) in radial rows; 750-1350μ in length; average diameter 13μ; lumen often reduced to 1.5μ, walls very variable in thickness 3-5μ; pits narrow, bordered; transitions to narrow irregularly shaped tracheids occur, the latter with numerous bordered or simple pits and measure up to 600μ in length and 20μ in diameter. Wood parenchyma largely developed, chiefly vasicentric, also diffuse, even approaching short irregular metatracheal bands; cells usually devoid of contents, pits elliptical crowded; at times conjugate; cells up to 270μ in length and 35μ in width. Rays uniseriate, 2-18 cells in height; biseriate, or even triseriate, particularly in wood from Laurel Hill district; larger rays up to 450μ in height and 40μ in width; ray cells usually with dark contents more or less filling inner cells; rays becoming heterogeneous, due to increase in size and depth of outer cells; 10-15 per mm. of transverse section.

Burns with a fair percentage of unburnt carbon and a small greyish ash. Alcoholic extract yellow; no evidence of flavone; slight turbidity on adding water; pale blue to blue colouration with ferrous sulphate; medium precipitate with lead acetate.

Eucalyptus Delegatensis R. T. Baker.

Alpine Ash, Mountain Ash, Red Mountain Ash, Victorian Woollybutt, Gum-topped Stringybark, Tasmanian Oak.*

A large forest tree found at high elevations (over 4000 feet) on the southern tablelands of New South Wales, and also in parts of Victoria and Tasmania. This tree yields one of the most valuable light-weight hardwoods in Australia, the wood being remarkably strong and tough for its weight, and it possesses also a high modulus of elasticity. Provided it is cut from mature trees the wood usually seasons well, without evidence of collapse or washboarding, whilst the shrinkage is not excessive. Too rapid seasoning is liable to cause honeycombing, however, and should be avoided. It is usually pale coloured but at times pinkish, moderately open textured, usually straight-grained and fissile, and is used for general building purposes, e.g., flooring, etc., motor body and carriage building, furniture and cabinet work, interior panelling, boat oars, light hammer and hoe handles, spokes, billiard cues, bentwork,

* Of these the name "Alpine Ash" is usually adopted for the timber grown in New South Wales.

casks, etc. Weight, 41-55 lbs. per cubic foot.† Hardness = Moderately hard.

Macroscopical characters..—Pores easily visible with the naked eye on end section, crowded in early wood, occasionally absent in late wood, often in short oblique rows. Soft tissue not apparent. Rays visible on end section, particularly in darker wood, also on radial and tangential faces. Growth rings very pronounced; late wood much darker and denser than early wood.

Microscopical characters.—Pores usually single, rarely in obliquely joined pairs; single pores elliptical in section; very irregularly distributed, due to their complete absence in some specimens in the late wood, this being possibly the nearest approach to a ring-porous timber in the Eucalypts; uneven in size, late wood pores much smaller; radial diameter 105-350μ, mean 250μ; tangential diameter 60-225μ, mean 150μ; vessel segments 300-500μ in length; walls 3-6μ in thickness; lateral pits narrow, slit-like, borders circular to elliptical; ray pits irregularly oval, simple; end perforation always simple; end wall transverse or oblique, up to 45°; end projection up to 200μ in length; tyloses often present in varying amount, at times filling whole of vessel cavity; number per sq. mm. 0-1 in late wood, 7-11 in early wood. Wood fibres variable in size and thickness; 450-1500μ in length; average diameter 15μ; walls 3-4μ in thickness; lumen often reduced to 3μ; pits slit-like bordered; transitions occur to elongated tracheids measuring up to 800μ in length and 30μ in diameter. Wood parenchyma not abundant, principally vasicentric or a little diffuse; cells measuring up to 185μ in length and 26μ in diameter. Rays chiefly uniseriate, 2-16 cells in height; varying in width from a mean of 7μ

† The higher figure was obtained from a Tasmanian specimen. It is exceptionally high; the weight does not usually exceed 48 lbs. per cubic foot.

in late wood to 11μ in early wood; a few rays show the division of a few cells, about the middle, to form narrow biseriate rays; almost homogeneous, but frequently the outer cells become enlarged; the cells usually with small light brownish coloured granular or amorphous bodies; 10-12 per mm. of transverse section.

Burns with a comparatively small percentage of unburnt carbon, smouldering to a small brownish-grey ash. Alcoholic extract yellow in colour; slight trace of flavone in one sample; no turbidity on adding water; blue colouration with ferrous sulphate; slight to medium precipitate with lead acetate; no marked fluorescence.

EUCALYPTUS FASTIGATA Deane and Maiden.
Brown Barrel, Cut-tail, Blackbutt, Stringbark.

A large forest tree found in central and southern parts of the main Dividing Range, extending into Victoria. The wood is pale coloured, moderately open textured, and usually straight-grained. It is a tough, strong wood, possessing a high modulus of rupture and elasticity, usually rather denser than the other members of the group, and is said to be durable in the ground. The principal uses at present appear to be for general building purposes. Weight 41-56 lbs. per cubic foot. Hardness = Moderately hard to hard.

Macroscopical characters.—Pores moderately large to small, easily seen on end section, often with dark contents, usually arranged in short oblique rows, rather more crowded in early wood. Soft tissue not apparent. Rays scarcely visible on end or tangential sections, more pronounced radially but not much darker than the surrounding tissue. Growth rings usually not very prominent. The sapwood is not clearly differentiated, there being little alteration in colour in the heartwood.

Microscopical characters.—Pores usually rather evenly distributed except in late wood, single, rarely in pairs; single pores usually elliptical, variable in size; radial diameter 50-300μ, mean 210μ; tangential diameter 50-210μ, mean 165μ. Vessel segments 200-500μ in length, walls 4-6μ in thickness; lateral pits slit-like, rather crowded, borders circular or almost so; ray pits irregularly oval, simple, end walls transverse or oblique, the angle being as much as 50° in some cases; end perforation always simple, end projection up to 140μ in length; tyloses only present in comparatively few vessels, and not filling whole cavity; number per sq. mm. 1-12. Wood fibres in radial rows; 600-1500μ in length; average diameter 15μ; walls 2-4μ in thickness; lumen often reduced to 3μ; pits narrow, slit-like, bordered; transitions occur from these fibre-tracheids to copiously pitted tracheids which are in close proximity to the vessels, and measure up to 675μ in length and 30μ in diameter. Wood parenchyma fairly abundant, chiefly vasicentric, or diffuse; cells with large simple pits; up to 185μ in length, and 37μ in width. Rays uniseriate or often biseriate; uniseriate rays 2-30 cells in height; biseriate rays up to 400μ in height and 38μ in width; almost homogeneous, though at times the outer cells are enlarged; cells frequently with amorphous or granular brownish contents; 13-15 per mm. of transverse section.

Burns without smouldering, leaving a large amount of unburnt carbon. Alcoholic extract yellow to yellow-brown in colour; no evidence of flavone; clear or a very slight turbidity on adding water; blue to deep blue colouration with ferrous sulphate; heavy precipitate with lead acetate; no marked fluorescence.

A specimen from Rydal, New South Wales, showed very numerous biseriate rays.

Eucalyptus fraxinoides Deane and Maiden.

White Ash, White Mountain Ash.

A tall forest tree found in southern New South Wales at moderately high elevations, valuable forests occurring on the Main Dividing Range east of Cooma. The wood is very pale coloured, moderately open in texture, usually straight-grained and fissile, and is used for general building purposes, cabinet work, staves, etc., whilst its high strength-weight-factor makes it a suitable timber for certain aeroplane parts. Weight, 41-45 lbs. per cubic foot. Hardness = Moderately hard.

Macroscopical characters.—Pores medium-sized to small, easily visible on end section with naked eye, usually in oblique or even radial rows, especially in late wood; crowded in early wood; often with brownish contents. Soft tissue not apparent. Rays not or scarcely visible on end section without lens, easily visible on a radial section, being rather darker than the surrounding tissue. Growth rings fairly prominent on end section, the late wood being denser and darker in colour.

Microscopical characters.—Pores usually single, rarely in pairs, fairly evenly distributed, usually elliptical; radial diameter 45-300μ; mean 240μ tangential diameter 30-210μ, mean 165μ; vessel segments 180-525μ in length; walls 4-6μ in thickness; lateral pits narrow, slit-like in irregular longitudinal rows, borders usually elliptical; ray pits irregularly elliptical or almost circular; end perforation always simple; end wall transverse or almost so; end projection up to 120μ in length; tyloses often present but usually only partially filling cavity; number per sq. mm., 6-12. Wood fibres moderately thick-walled, in radial rows, rather irregular in size and shape; length 750-1400μ, the average length being greater than in most species; average diameter 15μ; lumen often reduced to 2μ; pits slit-like, bordered;

gradations occur to narrow tracheids measuring up to 700μ in length and 35μ in diameter, with numerous elliptical bordered pits in contact with vessels; fibres often with dark contents extending for a short distance in the lumen. Wood parenchyma not abundant, vasicentric or very little diffuse; cells up to 185μ in length and 30μ in width, with numerous crowded elliptical simple pits approaching a conjugate nature; usually without contents. Rays almost exclusively uniseriate, rarely biseriate, and even then the biseriate portion is not more than one cell in height; uniseriate rays almost homogeneous, narrow, not exceeding 11μ in width, average 6μ; 2-22 cells in height; walls moderately thick; cells usually with rounded irregular brownish contents; 7-12 per mm. of transverse section.

Burns with a small percentage of unburnt carbon, smouldering to a small ash. Alcoholic extract pale to yellow in colour; no evidence of flavone; very slight turbidity on adding water; pale blue to blue colouration with ferrous sulphate; slight to medium precipitate with lead acetate; no marked fluorescence.

Eucalyptus obliqua L'Heritier.

Stringybark, Messmate, Tasmanian Oak.

A large forest tree reaching a height of 250 feet and a girth of 35 feet, found principally in Victoria and Tasmania, in New South Wales along parts of the Dividing Range, and extending into South Australia. The wood is pale coloured, almost white to light brown, moderately open textured, usually straight-grained and fissile. It is used for general building purposes, furniture and cabinet work, piles, railway sleepers, poles, etc. The wood is tough and strong and tests showed great stiffness, the modulus of elasticity exceeding 3,000,000 lbs. per sq in. Weight, 46-56 lbs. per cubic foot.* Hardness = Moderately hard to hard.

Macroscopical characters.—Pores medium-sized to large, easily visible on end section; often arranged in oblique or even tangential rows, especially in late wood; crowded in early wood. Soft tissue not apparent. Rays not or scarcely visible on end or tangential section, readily seen on radial face. Growth rings fairly well defined, due to uneven pore development.

Microscopical characters.—Pores usually single, but occasionally in pairs, very variable in size and shape, elliptical to almost circular; radial diameter 60-390μ, mean 270μ; tangential diameter 45-300μ, mean 225μ; vessel segments 180-525μ in length; walls 3-4μ in thickness; lateral pits slit-like, borders usually circular or elliptical; ray pits irregularly elliptical; end perforation always simple; end walls usually oblique, up to 30°, but occasionally transverse; end projection measuring up to 150μ in length. A few vessel segments often with dark granular contents which usually only fringe the cavity; tyloses often present, but rarely filling whole of cell; number per sq. mm. 4-10. Wood fibres in radial rows, irregular in shape, particularly in early wood; 675-1500μ in length, average diameter 19μ; walls 3-4μ; lumen reduced to 3μ in late wood; pits slit-like, border usually circular. Gradations occur to irregularly shaped tracheids with numerous bordered pits; up to 800μ in length and 40μ in diameter. Wood parenchyma abundant, principally vasicentric, a little diffuse; a few cells with dark granular contents, but usually empty; up to 200μ in length and 22μ in diameter. Rays numerous, uniseriate or frequently biseriate; uniseriate rays 2-17 cells in height; ray cells wide, up to

* A range of 48-66 lbs per cubic foot is given in the 2nd Edition of Tasmanian Forests, Timber Products and Sawmilling Industry. Govt. Printer, Tasmania, 1910.

40μ, average 22μ; biseriate rays up to 40μ in width; 9-13 per mm. of transverse section.

Burns without smouldering, with a very large amount of unburnt carbon, but pale-coloured specimens from Mt. Wellington, Tasmania, and from the Victorian Forestry Commission, smouldered to a greyish-brown ash. Alcoholic extract pale to deep yellow-brown; no definite evidence of flavones; no turbidity on adding water; blue to deep blue with ferrous sulphate; slight to heavy precipitate with lead acetate; no marked fluorescence.

Eucalyptus oreades R. T. Baker.*

Smooth-barked Mountain Ash.

A tall tree found at moderately high elevations on the Main Dividing Range and spurs, from central New South Wales to southern Queensland. The wood is pale coloured, moderately open in texture, straight-grained and fissile. It is occasionally marred by the development of ''gum-veins,'' but this fault occurs in practically every Eucalypt to a greater or lesser extent. The wood is used for general building purposes, joinery and cabinet work, casks, carriage work, billiard cues, etc. Weight, 41-46 lbs. per cubic foot. Hardness = Moderately hard.

Macroscopical characters.—Pores medium-sized to small, easily visible on end section, usually in short oblique rows, especially in late wood, scarcely crowded in early wood. Soft tissue not apparent. Rays scarcely visible on end or tangential sections without lens; easily visible on radial surface, being slightly darker than the surrounding tissue. Growth rings fairly well-defined, due to darker colour of late wood, and reduction in number of pores. There is no sharp differentiation between sapwood and heartwood, but the latter is somewhat darker in colour.

* This is *E. altior*, (Deane and Maiden) Maiden. Critical Revision of Genus Eucalyptus, 1922, 6, 272.

Microscopical characters.—Pores comparatively evenly distributed, almost always single, rarely in pairs; single pores usually elliptical, variable in size; radial diameter 55-300μ, mean 210μ; tangential diameter 40-225μ, mean 165μ; vessel segments 120-525μ in length; walls 4-6μ in thickness; lateral pits narrow, slit-like, borders circular or almost so, distribution in irregular rows corresponding with the position of adjoining tracheids; ray pits irregularly elliptical; end perforation always simple; end walls transverse or nearly so; end projection up to 150μ in length; tyloses not common, and where present, only partially filling cavity; number per sq. mm., 5-12. Wood fibres in radial rows, fairly regular in size, exceptionally long, measuring up to 1650μ in length; average diameter 16μ; walls 2-4μ in thickness; lumen often reduced to 4μ; pits slit-like, bordered. Gradations occur to narrow, elongated tracheids with numerous pits, measuring up to 1000μ in length and 30μ in width. Wood parenchyma not abundant, chiefly vasicentric or a little diffuse; pitting crowded; elliptical; cells measure up to 185μ in length and 20μ in diameter. Rays almost entirely uniseriate, 2-20 cells in height, narrow, average width 15μ; almost homogeneous, the outer cells being usually without contents; a few rays showing division of one or two cells.

Burns with a little grey ash, and small percentage of unburnt carbon. Alcoholic extract pale coloured; no evidence of flavones; pale blue to blue colouration with ferrous sulphate; slight precipitate with lead acetate; no turbidity on adding water; no marked fluorescence.

Eucalyptus regnans F.v.Mueller.

Mountain Ash, Tasmanian Oak, Swamp Gum, Giant Gum, White Gum, Blackbutt.

A large forest tree often attaining an enormous size, found in south-eastern Victoria and Tasmania. The wood is pale-coloured, moderately open textured, usually straight-grained and fissile, and is used for general building purposes, interior joinery and cabinet work, coach and carriage building, etc. It often possesses remarkable stiffness, specimens tested giving a mean modulus of elasticity of over 3,000,000 lbs. per sq. in. Weight, 37-46 lbs. per cubic foot.† Hardness = Moderately hard to hard.

Macroscopical characters.—Pores medium-sized, easily seen with the naked eye on end section, usually single but often distributed in oblique rows, especially in late wood. Soft tissue not apparent. Rays faint on end and tangential sections without lens, easily visible on radial surface. Growth rings fairly well-defined by the crowding of pores in early wood, and their more or less complete absence in late wood.

Microscopical characters.—Pores almost entirely single, though sometimes approaching each other closely; single pores more or less elliptical; radial diameter 75-330μ, mean 240μ; tangential diameter 45-260μ, mean 180μ.* Vessel segments 300-600μ in length; walls 3μ in thickness; lateral pits small, slit-like, arranged in irregular longitudinal rows, borders circular; ray pits larger, more or less oval; end perforation simple; end wall transverse or obliquely inclined up to 20°; end projection up to 150μ in length; tyloses rare but occasionally present in a few cells; vessels usually without contents; number per sq. mm., 4-10. Wood fibres arranged in radial rows, often compressed radially;

† 48-54 lbs. per cubic ft., according to Tasmanian Forestry, 2nd Edition.

* Sections of a small tree of *E. regnans* from Mt. Wellington, Tasmania (fig. 7) gave an average radial diameter of 150μ and a tangential diameter of 120μ. This reduction in size of the pores is usual in the wood of small trees, and care should be taken therefore that the specimens for microscopical examination are not taken from near the heart or from immature timber, e.g., branches, saplings, etc.

550-1200μ in length;* average diameter 15μ; walls 3-4μ in thickness; lumen often reduced to 3μ; pits small, slit-like, borders circular. Gradations occur to copiously pitted tracheids, irregular in shape and measuring up to 600μ in length and 50μ in diameter. Fibres occasionally contain dark contents which only extend for a short distance in the lumen. Wood parenchyma not abundant, principally vasicentric, a few cells diffuse; cells measure up to 110μ in length and 22μ in diameter, usually without contents. Rays almost entirely uniseriate, 2-19 cells in height; end walls usually oblique; almost homogeneous, though outer cells deeper; dark granular contents often present; 9-11 per mm. of transverse section.

Burns with small ash and medium amount of unburnt carbon. Alcoholic extract pale to yellow; no evidence of flavone; very slight turbidity on adding water; blue colouration with ferrous sulphate; moderate precipitate with lead acetate; no marked fluorescence.

Summary.

The pores are typically arranged in short, more or less oblique, rows, more crowded and larger in the early wood. They are particularly variable in size in *E. obliqua* and to a lesser extent in *E. Dalrympleana.* The irregular or zonal distribution reaches a maximum in *E. Delegatensis,* whilst in *E. oreades* and *E. fraxinoides* they are comparatively evenly distributed. The maximum radial diameter of the pores in the specimens examined was found in *E. obliqua,* the measurement being 390μ; this species has also the greatest average pore size. The minimum mean radial diameter of 210μ was observed in *E. oreades* and *E. fastigata.* The vessel segments are fairly uniform, the limits being 120μ (minimum) in *E. oreades* and 600μ (maximum) in *E. regnans.* Any measurements must be regarded with

* Mt. Wellington specimen up to 1400μ.

caution, since, as pointed out under *E. regnans,* considerable variation can occur in the one species, and even in the one tree; they should only be regarded as an indication of the size. The vessel pitting is usually not crowded, the bordered vessel-tracheid pits being arranged in undulating longitudinal rows, corresponding to the position of the tracheids. The end projection is always simple, whilst the end walls vary from transverse to oblique, a maximum inclination of 50° to the horizontal being observed in *E. fastigata;* the inclination is too variable to be of much value for diagnosis. Tyloses were found to be more or less common in *E. fraxinoides, E. Delegatensis, E. obliqua,* and *E. Dalrympleana,* and comparatively rare in *E. fastigata, E. oreades* and *E. regnans.* The pore distribution reached a maximum of 12 per sq. mm. in *E. fastigata, E. fraxinoides,* and *E. oreades,* in the early wood.

As in other Eucalyptus woods so far examined,* the wood fibres possess definitely bordered pits and therefore approach the condition of fibre-tracheids. Irregularly-shaped tracheids, often blunt-ended, and not necessarily fusiform, occur in close proximity to the vessels, and between this type and the wood fibres are connecting links in the shape of prosenchymatous cells, thinner walled than the latter but with more numerous bordered pits which are simple in contact with the ray cells.

Wood parenchyma is principally vasicentric, although in *E. obliqua* and *E. Dalrympleana,* where it is particularly abundant, it approaches a metatracheal condition. Parenchyma is fairly abundant in *E. fastigata,* and is developed to a lesser extent in *E. Delegatensis, E. fraxinoides, E. oreades* and *E. regnans.* This feature might prove of some

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* Welch M.B. Notes on the Structure of some Eucalyptus Woods. Journ. Roy. Soc. N.S.W., 1924, 58, 169.

Welch M.B. The Identification of the principal Ironbarks and allied Woods. Journ. Roy. Soc. N.S.W., 1925, 59, 329.

diagnostic value, as it appeared to be fairly constant in the material examined. The cells are often much elongated, especially at the end of a row, and at times become conjugate; pits are numerous.

The rays are typically uniseriate but biseriate rays occur frequently in *E. Dalrympleana* and *E. obliqua, E. fastigata,* and to a lesser extent in *E. Delegatensis* and *E. fraxinoides;* triseriate rays were observed in *E. Dalrympleana,* to a small extent; uniseriate rays, with very few exceptions, were found in *E. oreades* and *E. regnans.* The usual range of vertical depth of the uniseriate rays is from 2-20 cells, but in *E. fastigata* rays were measured up to 30 cells in height. Particularly narrow rays were found in *E. oreades* and *E. fraxinoides,* the average width being only 8μ; a specimen of *E. regnans* from Mt. Wellington (young tree) showed an average width of 12μ, whilst mature wood from Victoria of the same species gave a mean of 8μ. The variation in width of one ray in the early and late wood has been indicated under *E. Delegatensis.* The relative development of uniseriate and biseriate rays was found to vary considerably in *E. fastigata,* from different localities, but was otherwise fairly constant. Similarly, in *E. Dalrympleana* triseriate rays were more numerous and biseriate rays much more strongly developed in wood from the Laurel Hill district, than from the Blue Mountains. The simple ray pits are occasionally in a single row, but more frequently appear to be biseriate.

The colour of the alcoholic extract and its behaviour with various reagents is largely due to what are apparently tannins or their products. The variation in the depth of colour of the extract is chiefly governed by the original colour of the wood. Burning the shavings, though of undoubted value in the separation of some woods, did not give very conclusive results, considerable variation being observed in *E. obliqua,* in which darker coloured wood burnt "black," whilst pale-coloured wood smouldered to an ash.

Growth rings are usually very prominent in *E. Delegatensis* and are least pronounced in *E. fastigata;* the definition seems to vary to some extent in the majority of the specimens examined.

The colour of the woods of *E. obliqua* and *E. fastigata* varies from very pale to light brown; *E. Dalrympleana* is often quite pink, at times almost white, a similar variation occurring also in *E. Delegatensis,* though the latter does not reach the same depth of colour as *E. Dalrympleana. E. fraxinoides,* in the material so far examined, was almost white; *E. regnans* and *E. oreades* are also usually pale-coloured.

The heartwood is seldom clearly defined, although in those specimens in which this part becomes brownish or pink, the sapwood can be more easily differentiated. In the more rapidly grown trees the sapwood is often over an inch in width, and since it is always liable to destruction by the Powder Post beetle (*Lyctus brunneus*), it should be rejected, unless specially treated with some preventive.

The weight of the woods varies considerably, and therefore a range is given, but it is not claimed that these are the outside limits; they only represent the maximum and minimum figures obtained from specimens in the Technological Museum. The results sometimes given, in which lbs. per cubic foot are expressed to several places of decimals, can only apply to the particular sample measured, and may be nowhere near the average weight. The figures are for air-seasoned wood, with about 12% moisture on the dry weight.

The descriptions under "hardness" are roughly comparative, and are obtained by measuring the indentation made by a falling weight; the method is described in the "Hardwoods of Australia" (loc. cit.).

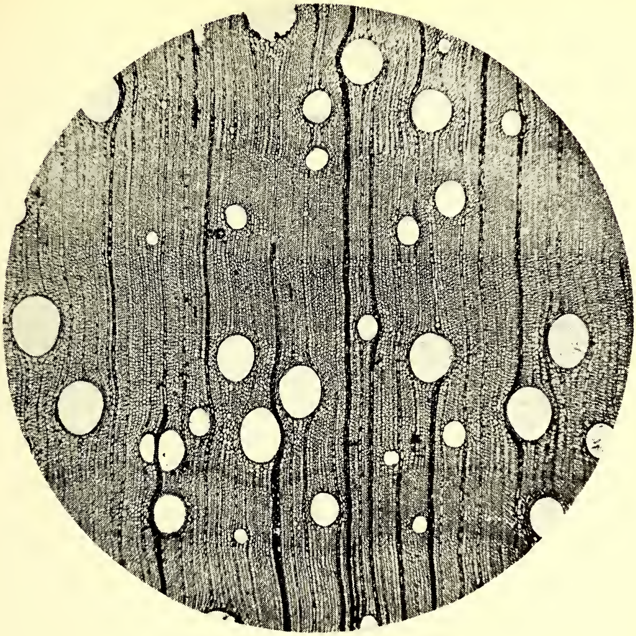

Fig 1.

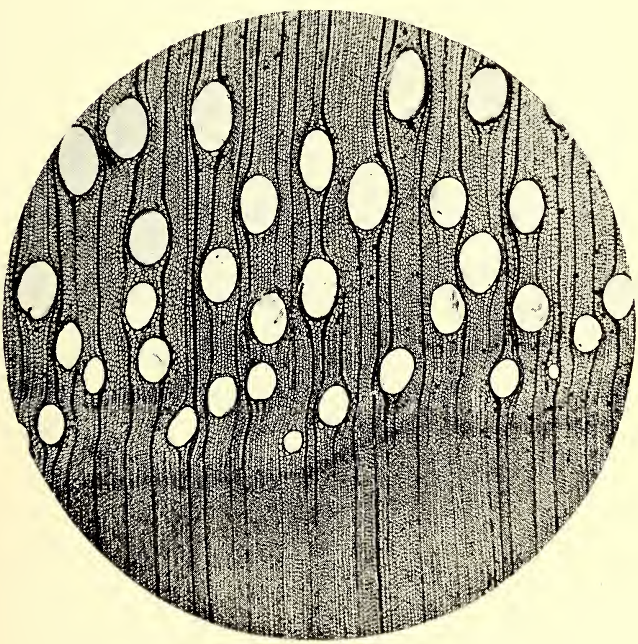

Fig. 2.

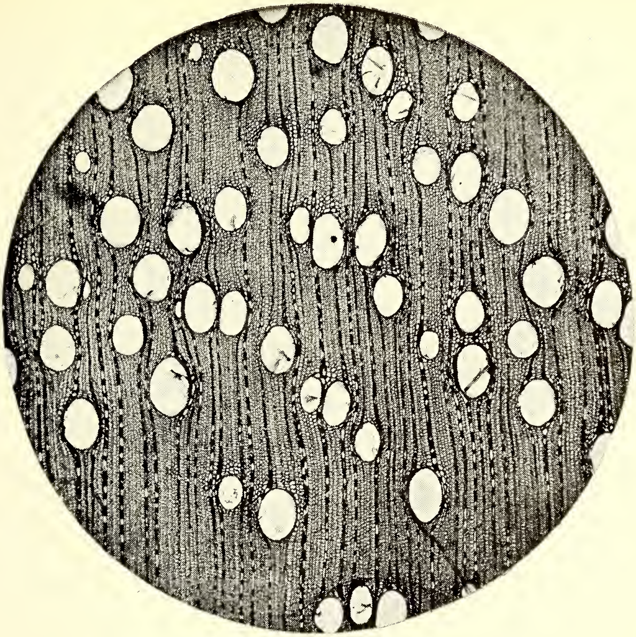

Fig. 3.

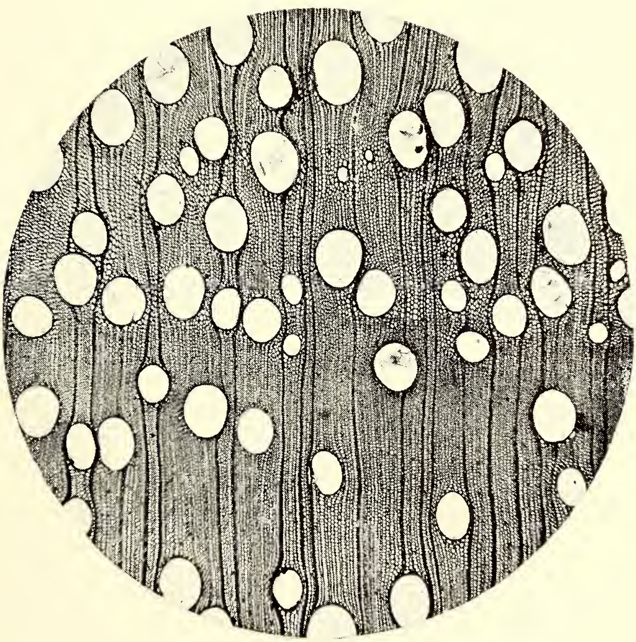

Fig. 4.

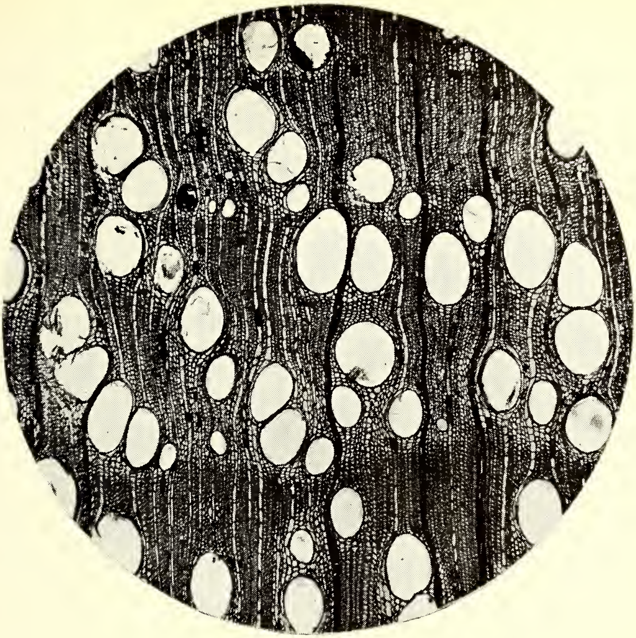

Fig. 5.

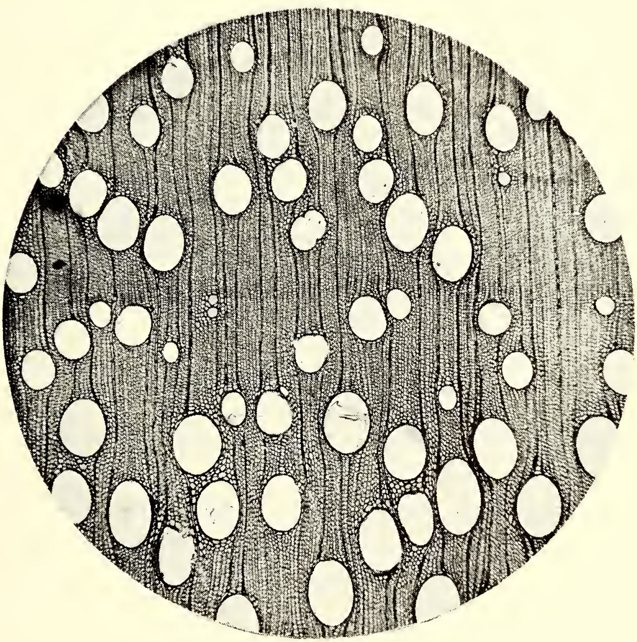

Fig. 6.

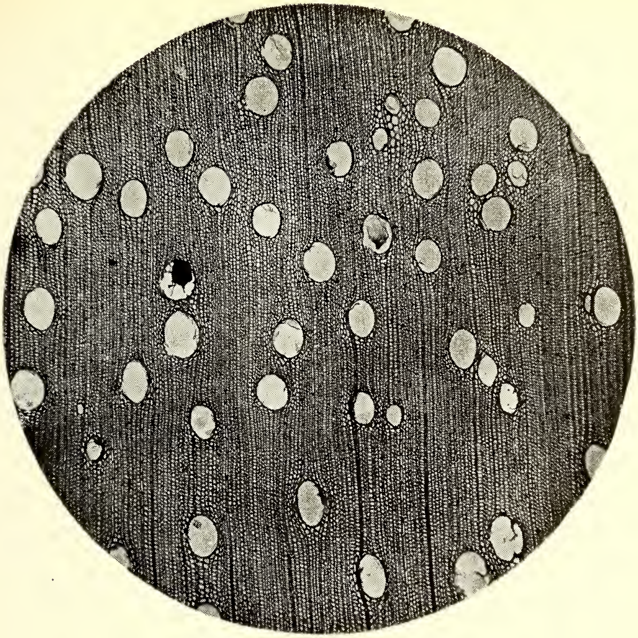

Fig. 7.

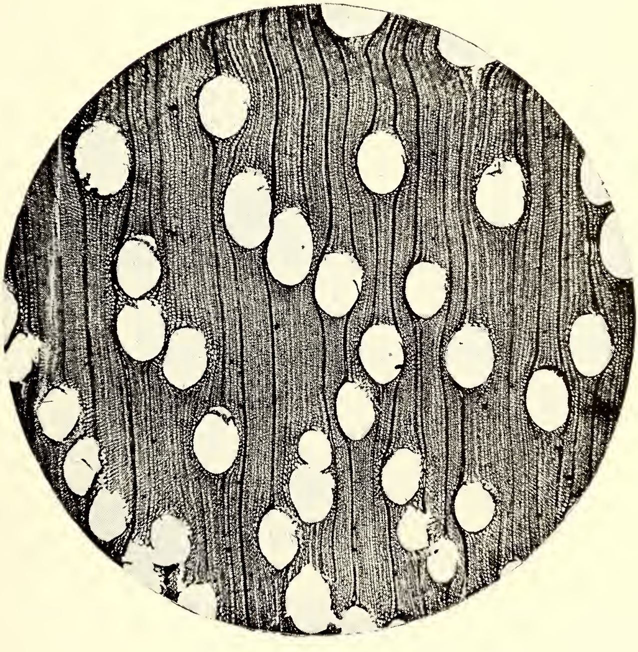

Fig. 8.

One of the principal faults in the woods of this group, apart from "gum-veins," which seem to occur chiefly as the result of injury to the cambium, is the presence of concealed checks or cracks, especially in *E. Delegatensis*, *E. obliqua* and *E. regnans*. Although these are frequently caused by case-hardening, due to faulty seasoning bringing about a condition of great internal stress, with the result that "honeycombing" occurs; yet it seems doubtful whether seasoning is always responsible. It might perhaps be possible that collapse occurs during the life of the tree.

In conclusion I wish to express my thanks to Messrs. D. Cannon and F. Shambler, of the Museum Staff, for their assistance in many ways.

The Technological Museum,
Sydney.

EXPLANATION OF PLATES.

Plate IX.

E. Dalrympleana J.H.M., transverse section of wood showing considerable variation in size of the pores, which are usually single. The comparatively large amount of wood parenchyma, principally vasicentric, is characteristic. The broad biseriate or even triseriate rays are prominent. Fig. 1 × 30.

E. Delegatensis R.T.B., transverse section of wood at junction of early and late wood. The absence of pores in the denser late wood is usually characteristic of this species. Tyloses are present in many of the vessels of the early wood, which are seen to be clearly separated, though appearing as oblique rows when viewed macroscopically. The reduction in width of the rays in the late wood is clearly shown. There is no great development of wood parenchyma. Fig. 2 × 30.

Plate X.

E. fastigata H.D. and J.H.M., transverse section of wood showing comparatively even distribution of pores, in many of which can be seen tyloses. The wood parenchyma is abundant and chiefly vasicentric. The rather regular alternating dark and light patches in the rays are due to the crowding of the contents towards the ends of the cells. Fig. 3 × 30.

E. fraxinoides H.D. and J.H.M., transverse section of wood at junction of early and late wood, the difference in thickness of the fibres being very marked. The pores are crowded and fairly evenly distributed, though smaller in the late wood; tyloses is present in several of the cells. There is comparatively little wood parenchyma. Fig. 4 × 30.

Plate XI.

E. obliqua L'Her., transverse section of wood showing extremely variable size and shape of pores, several of which contain tyloses, and also dark phlobaphene-like masses. The most striking feature is the very great development of the wood parenchyma, especially in the vicinity of the vessels. Fig. 5 × 30.

E. oreades R.T.B., transverse section of wood showing comparatively even distribution of pores, and the comparatively indefinite demarcation of the growth rings, which however are actually rather more pronounced than is indicated by the figure. Tyloses occur in several of the vessels. The wood parenchyma is almost entirely vasicentric, whilst the rays are narrow. Fig. 6 × 30.

Plate XII.

E. regnans F.v.M., transverse section of wood from a young tree from Mt. Wellington, Tasmania, showing even arrangement of comparatively small pores. There is a slight reduction in pore size in the late wood. Fig. 7 × 30.

E. regnans F.v.M., transverse section of wood of mature tree with same magnification as Fig. 7, showing the considerable variation in pore size. The arrangement of the pores in more or less oblique rows is typical of most Eucalypts. Wood parenchyma is not abundant, being confined practically to the vasicentric condition. Fig. 8 × 30.

THE GERMICIDAL VALUES OF SOME AUSTRALIAN ESSENTIAL OILS AND THEIR PURE CONSTITUENTS,

TOGETHER WITH THOSE FOR SOME ESSENTIAL OIL COMPONENTS, AND SYNTHETIC SUBSTANCES.

PART IV.

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(Read before the Royal Society of New South Wales, Oct. 6, 1926.)

The following tables represent a further series of results obtained in the determination of the Rideal-Walker coefficients of essential oil constituents, isolates and synthetics. For previous investigations see this Journal: 1923, **57,** 211; 1924, **58,** 117; and 1925, **59,** 346.

The present paper treats mainly of a series of aliphatic aldehydes and alcohols, C_8–C_{12} series, which have become of much importance in perfumery in recent years.

We are indebted to Messrs. Polak and Schwarz, Ltd., Zaandam, Holland, who kindly donated an exhibit of these interesting substances to the Sydney Technological Museum. In view of the great difficulty of preparing and purifying these bodies on the laboratory scale, small quantities were taken from this exhibit and further purified for the express purpose of determining the Rideal-Walker coefficients.

The results are of interest in view of the influence this particular group of substances may have upon theoretical considerations which no doubt will receive attention when large numbers of such determinations are available for review.

The high coefficients obtained with the C_8–C_9 aldehydes and alcohols respectively are noteworthy.

It will be observed that the dispersion of the various substances examined, varies according to the medium used, some being more highly dispersed in alcohol than in rosin-soap solution, and *vice versa,* the difference in the case of C_9 aldehyde being in the neighbourhood of 142% greater in the alcoholic solution. We would direct attention to the fact that with substances dispersed in ethyl alcohol, the germicidal effect of the dispersion medium itself must be taken into account with substances yielding a low coefficient. With those bodies giving coefficients over 4, the alcohol value is negligible. This increase with alcohol dispersed substances has been noticed since the commencement of our investigations, and we avail ourselves of the present opportunity to bring it under notice.

A glance at the tables will show that the alcohols appear to be more evenly dispersed than the aldehydes, irrespective of the nature of the dispersion medium.

One of us (A.R.P.) is engaged in an investigation of the alcohols present in the West Australian Sandalwood Oil, and it was thought advisable to determine its Rideal-Walker coefficient as well as that of the East Indian Oil for purposes of comparison. The results, however, confirm our previous experience that sesquiterpene alcohols in general possess comparatively poor germicidal properties.

Experimental.

The Rideal-Walker tests were carried out as described in previous papers (this Journal 1922, **56**, 219), standard suspension of 1% of the oils and various bodies examined being prepared in $7\frac{1}{2}\%$ rosin-soap solution. The great majority of the synthetics examined were also prepared in ethyl alcohol solution in order to determine any variation in the degree of relative dispersion.

Table "A."—*Crude Essential Oils.*

Crude oil.	Constants. $d\frac{15°}{15}$; $\alpha_D^{20°}$; $n_D^{20°}$	R.W. Coefficient.	Principal active constituents.
Fusanus spicatus (W.A. Sandalwood oil.)	d 0.9693 α −8.35° n 1.5055 Ester No. 13.36 Ester No. after acetylation 207.0	1.5	Sesquiterpene alcohols
Santalum album (East Indian Sandalwood oil.)	d 0.9786 α − 17.5° n 1.5063 Ester No. 19.21 Ester No. after acetylation 208.5	1.5	Sesquiterpene alcohols
Zieria macrophylla	d 0.9704 α − 66.4° n 1.5106	2.2	Zierone

Table "B."—*Essential Oil Constituents and Synthetic Substances.*

Constituent.	Nature.	Source.	Constants. $d\frac{15°}{15}$; $\alpha_D^{20°}$; $n_D^{20°}$	Coefficient. (* = ethyl alcohol solution.)
Zierone	ketone	*Zieria macrophylla*	B.pt. $142\frac{1}{2}$-144° (10mm.) d 0.9752 α −141.2° n 1.5142	 2 3.5*
Isomenthol	alcohol	Reduction of piperitone	M.pt. 81-82° α +23.5°	20 24 (acetone)
Phloraceto-phenone-di-methyl-ether	phenol ether (ketone)	*Geijera sp.* (at present unpublished).	M.pt. 82-83°	10 (in both acetone and ethyl alcohol)
Hydrocinnamic aldehyde	aldehyde	Museum stock. (Polak & Schwarz Ltd.)	B.pt. 105-108° (10mm.) d 1.0255 α ±0° n 1.5230	 7 5.3*
Hydroxy-citronellal	do.	do.	B.pt. 125-127° (5mm.) d 0.9300 α +9° n 1.4499	 6 4*

Constituent.	Nature.	Source.	Constants. $d\frac{15°}{15}$; α^{20}_{D} ; n^{20}_{D}	Coefficient (* = ethyl alcohol solution)
C_8 aldehyde	do.	do.	B.pt. 73-74° (10mm.) *d* 0.8397 *a* ±0 *n* 1.4256	 16 22*
C_9 aldehyde	do.	do.	B.pt. 86-88° (10mm.) *d* 0.8384 *a* ±0 *n* 1.4298	 9.5 23*
C_{10} aldehyde	do.	do.	B.pt. 95-103° (10mm.) *d* 0.8538 *a* ±0 *n* 1.4355	 7 9.25*
C_{11} aldehyde	do.	do.	B.pt. 109-115° (5mm.) d 0.8624 *a* ±0 *n* 1.4520	 6 5.25*
C_{12} (methyl nonyl acetic) aldehyde	do.	do.	B.pt. 108-111° (5mm.) *d* 0.8345 *a* ±0 *n* 1.4382	 1 3.5*
C_{12} (laurinic) aldehyde	do.	do.	M.pt. 24-25° B.pt. 110-114° (4mm.) *d* 0.8317 *a* ±0° *n* 1.4412	 3 5*
C_8 alcohol	alcohol	Museum stock (Polak & Schwarz).	B.pt 85° (5mm) *d* 0.8294 *a* ±0 *n* 1.4289	 25 26*
C_9 alcohol	alcohol	do.	B.pt. 97-99 (5mm.) *d* 0.8377 *a* ±0 *n* 1.4348	 13 19*
C_{10} alcohol	alcohol	do.	B.pt. 108-110 (5mm.) *d* 0.8337 *a* ±0 *n* 1.4365	 5 6.25*
C_{11} alcohol	alcohol	do.	B.pt. 124½-126 (5mm.) *d* 0.8453 *a* ±0 *n* 1.4500	 4.5 5.75*
C_{12} alcohol	alcohol	do.	M.pt. 22.23° B.pt. 131-133° (5mm.) *d* 0.8300 *a* ±0 *n* 1.4420	 2.75 3.5*

DESCRIPTIONS OF FIFTEEN NEW ACACIAS

AND NOTES ON SEVERAL OTHER SPECIES.

By the late J. H. Maiden, I.S.O., F.R.S., F.L.S.
and
W. F. Blakely,
Assistant Botanist, National Herbarium, Sydney,

With Plates XIII.-XVIII.

(Read before the Royal Society of New South Wales, Nov. 3, 1926.)

Pungentes (Plurinerves).

Acacia Carnei Maiden.*

Plate XIII.

Pods not previously described. They are sessile, oblong, or tapering somewhat abruptly at both ends, coriaceous, valves rather thick, pubescent, and more or less corky, 4-5 cm. long, up to 1 cm. broad. Seeds ovate, longitudinal or slightly oblique. Funicle yellow, carnose, rather thick, much dilated at the point of attachment, and slightly so over the seed. Silverton, Broken Hill, A. Morris, No. 406.

The following are some additional notes relative to size, habit and range:—

"A shrub about 10 feet high growing near water-courses (dry except when rain falls)," Broken Hill, A. Morris, No. 80; "Small tree, phyllodes round but when dry 4-angled," A. Morris, No. 188; "6-12 or 15 feet high, branches at right angles to the trunk. *A. Carnei* is a very deceptive type. It is very similar in general appearance to a stiff *Hakea*, say, *H. leucoptera*. At times considered to be the

* This Journal, 1915, 49, 470.

Hakea. It is common in gregarious groupings on sand hills and ridges scattered sporadically over the district. I have watched it for two years and have only seen flowers during the last three months.'' Pinnacles-Balaclava Road, Broken Hill, E. C. Andrews, April 21, 1920.

UNINERVES (Brevifoliae).

ACACIA ANCEPS DC. var ANGUSTIFOLIA Benth. in B.Fl. 1864, **2**, 355.

''Branches rather less angular. Phyllodia from narrow-obovate to linear-oblong, 1 to 2 in. long, occasionally with a prominent gland above the middle. Peduncles under ½in. long. S. Coast, R. Brown; towards Spencer's Gulf, Warburton. This variety has sometimes almost the phyllodia of *A. notabilis,* but the peduncles are always simple.''

The prominent gland referred to by Bentham is also a conspicuous character in *A. Bancrofti;* sometimes it occurs in *A. pycnantha* and *A. amoena.*

Brown's specimen is in the National Herbarium, Sydney, and is labelled as follows, in Brown's handwriting:—''Mimosa. Near the Shores of Bay No. III, South Coast, 1802, R. Brown, No. 4352.'' Other specimens are:—Fowler's Bay (Dr. R. S. Rogers, September, 1907); Near Elliston (Walter Gill, April, 1921). Some of the phyllodia are small and linear and very dissimilar from those of *A. anceps.* We invite the attention of local botanists to this variety, as we are of the opinion that it is specifically distinct from *A. anceps.*

ACACIA CENTRINERVIA, n. sp.

Plate XIII.

Frutex pyramidalis, 1-3 ft. altus; ramis verticalibus, teretibus, resinosis, dense pilosis; stipulis obscuris; phyllodiis resinosis, linearibus, lanceolatis, uninerviis, marginibus nervis similibus, 1.5-2.5 cm. longis, 2.5 mm. latis; glandula parva basi; pedunculis filiformibus, pilosis, phyllodiis brevioribus; capitulis globosis 15-20 floris; floribus 5-meris; sepalis spathulatis; petalis liberis, magnis, glabris, sepalis duplo longioribus; ovario glabro; legumine non viso.

Briefly described in this Journal, 1915, **44**, 497, under *A. lineata* A. Cunn., Group I.

A pyramidal-shaped shrub, 1-3 feet high, with terete, vertical, resinous, closely pilose branches. Stipules obscure. Phyllodia resinous, linear-lanceolate, with a straight or slightly curved point, and a more or less prominent central nerve, and nerve-like margins, 1.5-2.5 cm. long, 2.5 mm. broad, gland small, marginal, inserted a little above the petiole. Peduncles filiform, pilose, shorter than the phyllodia, usually subtended by a small, navicular bract, bearing globular heads of about twenty 5-merous flowers. Sepals shortly united at the base, spathulate, concave, hairy. Petals free, rather large, glabrous, keeled, more than twice the length of the sepals. Ovary glabrous. Pod not seen.

Branches perpendicular, giving one the impression of a young White Pine (*Callitris*), Parkes, N.S.W. (J. L. Boorman, October, 1906). The type. Inglewood, Queensland (C. J. Smith, per C. T. White, October, 1922); Eummundi (Bailey) (which we have not seen). Then we have a cultivated specimen with the following note attached "Grown in New York under the name of *A. heterophylla*. It is not a strong grower and must be trimmed to keep it in shape. I have never seen it over four feet (in greenhouse culture), but it is a good pot plant and blooms very freely during February and March at 40 to 50 deg. F." (H. J. Rumsey).

Very close to *A. lineata*, from which it is readily distinguished by the linear-lanceolate straight phyllodes with the mid-vein central, and the gland some distance from the base, also in the larger flowers and different shaped calyx.

Uninerves (Angustifoliae).

Acacia Victoriae Benth.

Mitch. Trop. Aust. 1848, 333; *A. sentis* F. Muell. *Journn. Linn.* Soc. 1854, 3, 128. J. M. Black in Fl. S.A. 1924 Pt 2, 277 shows that Bentham's name has priority over *A. sentis* F. Muell.

It is found in all the States of the mainland and has an extensive range in New South Wales, extending from Hay to Broken Hill in the south, to the Paroo River in the west, and then northward to Collarenebri.

Uninerves (Racemosae).

Acacia Betchei, n.sp.

Plate XIII.

Frutex gracilis glaber, 10-12 ft. altus; ramulis paulo angulatis; phyllodiis tenuibus, linearibus, rectis vel paulo falcatis, uninerviis, 8-9 cm. longis, 2mm. latis; racemis simplicibus, glabris, gracilibus, phyllodiis brevioribus; capitulis globosis, 20-25 floris; floribus plerumque 5-meris; sepalis spathulatis, crassis, ciliatis; petalis liberis, laevibus, lato-lanceolatis, ovario laevi; legumine plano, lente dehiscente, stipitato 9-11 cm. longo, 7 mm. lato; seminibus nigris, ovoideo-oblongis; funiculo clavato, semine breviore.

A slender, glabrous shrub, 10 or 12 feet high, with a stem diameter of 1-3 inches. Branchlets glaucous, slightly angular when young. Phyllodia rather thin, linear, somewhat glaucous, more or less falcate, straight or slightly falcate, with a short weak point, tapering gradually towards the base, mostly about 8 cm. long and about 2mm. wide in the upper or wider half, with some secondary inconspicuous spreading veins, dotted all over with fine dots, with a rather obscure marginal gland about a quarter of the way up. Racemes simple, rather slender, not exceeding the phyllodia, the rachis and peduncles glabrous. Flower-heads, globular, small, pale yellow, about 22 in the head, usually 5-merous. Bracts capitate. Sepals broadly spathulate, though sometimes with a truncate appearance owing to their being more or less adnate, about half as long as the corolla, hairy at the tips. Petals smooth, broadly lanceolate, uninerved. Ovary smooth. Pod tough, almost woody, tardily dehiscent along the suture, nearly flat, straight or nearly so, stipitate, with a long, filiform stipes, about 10 cm. long and 7 mm. broad. Seeds black, shining, elongated ovoid-oblong, longitudinal; funicle short and filiform, with the last fold appressed and thickened from the middle upwards into a club-shaped aril obliquely embracing the seed.

Type, Wallangarra, N.S.W., (E. Betche, December, 1891, in flower); pod and seed described from same locality, (J. L. Boorman, January, 1918). Torrington, on acid granite, 10-12 feet high (R. H. Cambage, No. 1622, flowers and empty pods, July, 1907); Reddish brown stems (R. H. Cambage, No. 1622A, unripe pods, September 29, 1907); Torrington, on stony ridges (J. L. Boorman, flowers and pods, January, 1911; seedlings and unripe pods, October, 1911); Bismuth, near Deepwater, Torrington. In January, 1916, J. L. Boorman collected seedling plants, flowers and pods. "A rather tall, weak-growing plant, with long, narrow, grass-like leaves, glandular at the edges. It flowers and seeds at the same time." Flowers and pods with ripe seeds (J. L. Boorman, January, 1918).

Named in honour of the late Ernst Betche, Chief Botanical Assistant, Botanic Gardens, Sydney.

Affinities:—With *A. neriifolia*. *A. Betchei* is a smaller and glabrous shrub, with reddish stems and narrower phyllodes, also smaller and paler racemes.

With *A. adunca*. Both species have narrow phyllodes and moderately large, smooth pods; the flowers of *A.*

Betchei are smaller and paler than those of *A. adunca*, and the pod is also smaller.

With *A. linifolia*. The general appearance of both shrubs is somewhat similar, but *A. Betchei* is more glaucous, has longer phyllodes, brighter flowers, and broader pods.

Acacia McNuttiana, n. sp.

Plate XVI.

Frutex glaber, pumilus; ramulis valde angulatis; phyllodiis rectis vel curvatis, tenuibus cum mucrone parvo innocuo, basin versus angustatis, 10-14 cm. longis, 3 mm. latis, uninerviis; racemis simplicibus, phyllodiis brevioribus; rachisibus et pedunculis paulo tomentosis; capitulis globosis, ca. 11-floris; calyce turbinato, truncato, crasso, breviter lobato, piloso; petalis pilosis, 5-6 meris, liberis, incurvatis, duplo calycis longitudinem aequantibus; ovario glabro, leguminibus non visis.

A dwarf, glabrous, densely foliaged shrub, with very angular branchlets. Phyllodia straight, or curved by means of one or more glandular angles, thin, with a small innocuous point, narrowed slightly towards the base, 10-14 cm. long, about 3 mm. broad, uninerved, with a few secondary inconspicuous spreading veins; dotted all over with microscopic dots, with one to three distant marginal glands. Racemes simple, shorter than the phyllodia, the rachis and peduncles slightly tomentose. Flower-heads globular, of moderate size, about 11 in the head. Bracts capitate, ciliate. Calyx turbinate, sinuolate, and more or less ribbed, densely hairy. Petals besprinkled with short hairs chiefly along the keels, 5-6-merous, thick, free, incurved, more than twice the length of the calyx. Ovary smooth. Pod not seen.

Range:—Bismuth, near Deepwater (A. McNutt, in flower, small phyllodes, D9; large phyllodes, D8, August, 1913). The type. A shrub 3-4 feet high on acid granite, Torrington (R. H. Cambage, No. 1638, July 10, 1904, in flower).

Allied to *A. Betchei* and *A. adunca,* but differing from both in shape of the phyllodes and in the flowers. It is also a much smaller shrub than its congeners.

ACACIA LINEARIFOLIA A. Cunn. (Herb).

(A. ADUNCA Maiden—but not of Cunningham.)

"Forest Flora of N.S.W." Part XLVI., p. 116, Plate 173, figs. B, C, H, J, are all from Mt. Danger, J. L. Boorman.

We have not seen Cunningham's description of *A. linearifolia,* but we believe it is in his MSS. As already stated, l.c., p. 115, portion of the type of *A. linearifolia* was received from Kew, labelled "115 *A. crassiuscula* Wendl. (*A. linearifolia* A. Cunn.), Blue Mountains, December 84/1825, New South Wales, A. Cunningham." The locality is evidently a mistake, as we know of no such Acacia occurring on the Blue Mountains.

Specimens from Gungal, Mt. Dangar, J. L. Boorman, match Cunningham's type, and are fully described and figured as stated above, and therefore no further description is necessary except that under Range, attention may be drawn to the size and habit of the plant, and also to the petals being slightly hairy.

Range:—The Rock, Corowa (G. Wiburd); The Rock, near Wagga, "The trunk resembles *A. doratoxylon.* The tree is about 20 feet high and about 6-9 inches in diameter. It is very much given to reversion shoots" (Bishop J. W. Dwyer, September, 1922); Mudgee-Cassilis Road, 35 miles from Mudgee (Sabina Helms No. 646); "A tree 50 feet high, 18 inches in diameter; grows on low-lying ground on ridges adjacent to mountains, Springfield, near Gulgong (A. Isbister March, 1920); near Dunedoo "Known as Stringybark Wattle; grows to a good height, and over 2 feet in diameter" (Andrew Murphy, September, 1916);

Mount Dangar, Gungal, "A tall shrub 8-20 feet high" (J. L. Boorman, December, 1904).

Acacia adunca A. Cunn.

In Part XLVI, after some preliminary remarks concerning plants referred to *A. crassiusula,* at pp. 115-117 of my "Forest Flora of New South Wales" I have set out what I consider this species is, and at Plate 173 have figured the type.

The type came from "the broken country investing Mount Dangar on the west branch of the Hunter River, Aug. 1827." I have not certainly obtained it from the Mount, but see p. 117.

I have only obtained it from no great distance from the New South Wales-Queensland border, viz., *New South Wales*-Wallangarra (formerly Jennings), in fruit (J.H.M. and J. L. Boorman, December, 1903); in flower (J.L.B., July, 1904); in fruit (J.L.B., November, 1904). *Queensland*—Stanthorpe; in flower (J.L.B., July, 1904); in fruit (J.L.B., November, 1904). All the above were referred to *A. accola* Maiden and Betche.

The following figures on Plate 173 are referable to *A. adunca*-A. B, D, E, F, G, K, L, M, all from Stanthorpe, Queensland, J. L. Boorman, July, November, 1904, except A, which is portion of the type.

Acacia accola Maiden and Betche.

In *Proc. Linn. Soc., N.S.W.,* 1906, **31**, 734 the late Mr. Betche and I described the above species, and it is figured on the *A. adunca* plate already referred to. It seems to me that it is *not* sufficiently different from *A. adunca.*

The Wallangarra and Stanthorpe specimens have been already referred to; those from Mt. Dangar, J. L. Boorman, are referable to *A. linearifolia* A. Cunn. See notes under *A. adunca*.

ACACIA Forsythi, n.sp.

Plate XIV.

Frutex parvus glaber, ramis acute angulatis, rubidis; phyllodiis lineari-oblongis vel lineari-falcatis, uninerviis, 6-9 cm. latis, marginibus nervis similibus; racemis glabris, 5-10 floris, phylodiis brevioribus; pedunculis elongatis, capitula globosa 25-30 flora gerentibus; calyce angusto-turbinato profunde 5-lobato, apice hirsuto, petala glabra, partim conjuncta, uninervia ca. dimidio aequante; ovario glabro; legumine non viso.

A small, glabrous shrub with acutely angular, reddish branches. Phyllodia linear-oblong to linear-falcate, narrowed towards the base, and usually tapering, though somewhat abruptly, into a short curved point, uninerved, with moderately distinct lateral veins, and reddish, nerve-like margins, 6-9 cm. long, 3-5 mm. broad. Gland small, prominent, close to the base. Racemes glabrous, 5-10 flowered, shorter than the phyllodia. Peduncles elongated, bearing globular heads of 25-30 flowers. Calyx attenuate, turbinate, deeply 5-lobed, hirsute at the top, about half the length of the glabrous, partly united uninerved petals. Bracts truncate, clavate. Ovary glabrous. Pod not seen.

Warrumbungle Ranges, between Coolah and Blackville, New South Wales (W. Forsyth, October, 1901). The type.

Named in honour of the late William Forsyth, for many years the respected Superintendent of the Centennial Park, Sydney.

Near *A. Murrumboensis, A. neriifolia* and *A. adunca* in general appearance, but differing in botanical characters. The inflorescence is somewhat similar to that of the above species as regards size and richness of colour, but the peduncles are quite smooth, and the phyllodia and gland are also distinct.

Acacia Murrumboensis, n. sp.

Plate XV.

Frutex parvus glaber; ramis paulo angulatis, pruinoso-purpurascentibus; phyllodiis lineari-oblongis abrupte uncinatis, uninerviis, 6-10 cm. longis, 2-3 mm. latis; racemis glabris, phyllodiis brevioribus; floribus 8-10 in capitulo, paulo hirsutis; calyce turbinato, crasso; petalis 5, liberis, concavis, minute ciliatis, calycis tubum duplo excedentibus; ovario glabro; leguminibus non visis.

A small, glabrous shrub with slightly angular sub-glaucous reddish branches. Phyllodia linear-oblong, abruptly uncinate, narrowed into a very short wrinkled petiole, prominently uninerved and with faint marginal nerves, lateral veins obscure, or only present in the vicinity of the prominent marginal gland which usually occupies the lower half of the phyllodia, 6-10 cm. long, 2-3 mm. broad. Racemes glabrous, shorter than the phyllodia, of 5-10 heads. Flowers 8-10 in the head, besprinkled with short weak hairs. Buds somewhat globular-turbinate. Calyx turbinate, with short, thick, hairy lobes. Petals 5, free, hairy, concave, minutely ciliate, more than twice the length of the calyx. Bracts capitate, ciliate. Ovary glabrous. Pods not seen.

Murrumbo, Goulburn River, New South Wales (R. T. Baker, September, 1895). The type.

Closely allied to *A. Forsythi* in appearance and in the phyllodes, but the latter character is more penninerved in *A. Forsythi,* while the gland of *A. Murrumboensis* is nearly central, that of *A. Forsythi* close to the base. This species has the hairy flowers of *A. neriifolia,* but is very dissimilar in the phyllodes.

Acacia caesiella, n. sp.

Plate XIV.

Frutex patens paulo glaucus 6-20 ft. altus; ramulis angulatis sericeis, pubescentibus; phyllodiis angusto-linearibus, paulo falcatis, uncinatis, 7-9 cm. longis, 5-6 mm. latis; racemis aliquando phyllodiis longioribus; capitulis globosis 12-16 floris; calyce turbinato, sinuolato, minute piloso; petalis 5 liberis, firmis, in alabastro paulo striatis, glabris, calycem vix duplo superantibus; ovario pruinoso, legumine plano vel fere, recto, 6-8 cm. longo, 9-10 mm. lato; seminibus longitudinalibus; funiculo primum filiformi deinde in arillum pileiformem super seminis apicem incrassato.

A small, spreading, slightly glaucous shrub or small tree, 6-20 feet high, attractively floriferous; branchlets angular, silky-hoary, but eventually glabrous with age. Phyllodia minutely silky-pubescent, rather thin, glaucous, narrow linear to linear-falcate, with a slightly hooked point, 7-9 cm. long, 5-6 mm. broad, uninerved, with a few lateral veins scarcely visible, except with the aid of a lens. Gland minute, on the margin a short distance from the base. Racemes sometimes exceeding the phyllodia. Buds nearly spherical, 12-16 in the head; rachis sprinkled with short silky hairs. Bracts capitate to spathulate, silky-hairy. Calyx turbinate, slightly more than half as long as the petals, readily splitting to the base, besprinkled all over with short hairs. Petals 5, free firm, slightly striate in bud, faintly keeled, glabrous. Ovary hairy. Pods of a waxy lustre, straight or nearly so, 6-8 cm. long, 9-10 mm. broad, the valves prominently and longitudinally embossed with the seeds, slightly reticulate and with thickened margins. Seeds longitudinally arranged in the centre of the pod. Funicle filiform for about half its length, then thickened into a fleshy pileiform aril over the top of the seed.

Range:—Confined to New South Wales so far as we know at present. "A spreading shrub or small tree, 15-20 feet high, very attractive flowers," Burrinjuck (E. C. Andrews, per R. H. Cambage, August, 1922; pods were collected in the following December by J. W. Campbell for Mr. Andrews); Cox Creek, Rylstone (W. Dunn, No. 11, December, 1922, in pod); Camboon, 7 miles N. of Rylstone

(R. T. Baker, October, 1893); "Small shrubs attaining a height of 4-5 feet, stems thin, unbranched at the base, but forming umbrella-like heads. The plants throw up numerous thin growths from a Mallee-like rootstock. Fairly common in one place only in the district, covering an area of an acre or more. Leaves and young shoots silvery-hairy. The whole plant has a soft texture and is conspicuous from all the other plants in the neighbourhood by reason of its soft and silvery appearance," Capertee, (J. L. Boorman, September and December, 1915). The type. "Small glaucous shrubs 3-9 feet high, usually growing in dense masses on light granite soil," about one mile north of Marrangaroo Railway Station (W. F. Blakely and Dr. E. C. Chisholm, May, 1922, in bud; later on in September flowers were collected by Dr. Chisholm).

Affinities:—(1) With *A. Clunies-Rossiae* Maiden, but differing in the longer vestiture, which is more or less hirsute, in the longer and narrower phyllodes, different shaped gland, turbinate calyx and in the tomentose ovary. A comparison of the gland of these two species is interesting. In *A. Clunies-Rossiae* the gland is pouch-like, extending well below the marginal nerve, and sometimes touching the midrib, causing a lunate-like break in the marginal nerve. The gland of *A. caesiella* is very small, like a raised speck on the marginal nerve and not, or rarely, extending below the nerve. It is also closer to the base of the phyllode than the gland of *A. Clunies-Rossiae.*

(2) With *A. Hamiltoniana* Maiden, which it approaches very closely. The chief points of difference lie in the glaucousness, vestiture, less rigid phyllodia, venation, and slightly narrower pods, with the seeds placed longitudinally, and not more or less oblique as in *A. Hamiltoniana.* The phyllodia of the latter is usually very hard, thick and rigid, and when dry is brownish in color.

ACACIA CONFLUENS, n. sp.

Plate XVI.

Frutex magnus glaber; phyllodiis petiolatis, angusto-lanceolatis, acuminatis uninerviis 10-14 cm. longis, 5-10 mm. latis; racemis solitariis vel germinis, capitulis 6-12, magnis, globosis, ca. 40-floris; calyce turbinato, breviter 5-lobato, ciliato; petalis 5, liberis, glabris, angusto-lanceolatis, calycis longitudinem fere duplo excedentibus; ovario glabro; legumine recto vel curvato, marginibus incrassatis, 10-24 cm. longis, 1 cm. latis; funiculo gracili semen plica duplo fere incingente.

A medium-sized, glabrous shrub; branchlets more or less angular. Phyllodia petiolate, narrow to falcate lanceolate, or gradually tapering into a long, acuminate curved point, smooth, slightly scurfy when old, uninerved, which is usually closer to the lower margin and sometimes confluent with it for a short distance at the base, lateral veins more or less penninerved, 10-14 cm. long, 5-10 mm. broad. Gland small, depressed, inserted close to the wrinkled petiole. Racemes axillary, spreading, 1 to 2 springing from the same axis, glabrous, with long spreading peduncles, the lower ones developing much earlier than the upper ones, bearing large globular heads of about 40 flowers. Calyx turbinate, 5-ribbed, the short thick lobes ciliate. Petals 5-6, glabrous, partly united at the base, faintly 1-nerved, nearly twice the length of the long calyx. Bracts short, peltate, ciliate. Pods glabrous, coriaceous, straight or curved, with slightly thickened margins, more or less constricted between the seeds, 10-25 cm. long, 1 cm. broad. Seeds dark brown to black, compressed, broadly ovate to somewhat orbicular, a few more or less flask-shaped, longitudinally arranged. Funicle slender, slightly dilated into a double fold and completely encircling the seed, the basal portion thickened into a white, pyriform aril.

"Wyrilda" of the Mount Lyndhurst blacks, by whom the seeds are eaten." Mount Lyndhurst, South Australia (Max Koch, No. 48). The type.

Near *A. rhetinodes* in the phyllodia and pods. The former appears to be more acuminate than those of *A. rhetinodes,* and the pods are considerably longer and broader, while the seeds and funicle are also different. There is a slight difference in the calyx; that of *A. confluens* is more prominently ribbed and more deeply lobed. *A. microbotrya* has a somewhat similar pod, but there are marked differences in the seed and funicle, also in the phyllodia and flowers.

Acacia Gillii, n. sp.

(*A. pycnantha* Benth. var. (?) *angustifolia* Benth. B.Fl. **2**, 365; *A. retinodes* Schl. var. *Gillii* Maiden, *Trans. Roy. Soc.* S.A., 1908, **32**, 275; *A. rhetinodes* Schl. var. *angustifolia* (Benth.) J. M. Black, Fl. S.A., 1924, Pt. 2, 277.

I had looked upon *A. Gillii* as an environmental form of *A. rhetinodes,* but after careful examination of the specimens, and consultation with other botanists, I have come to the conclusion that they are distinct species.

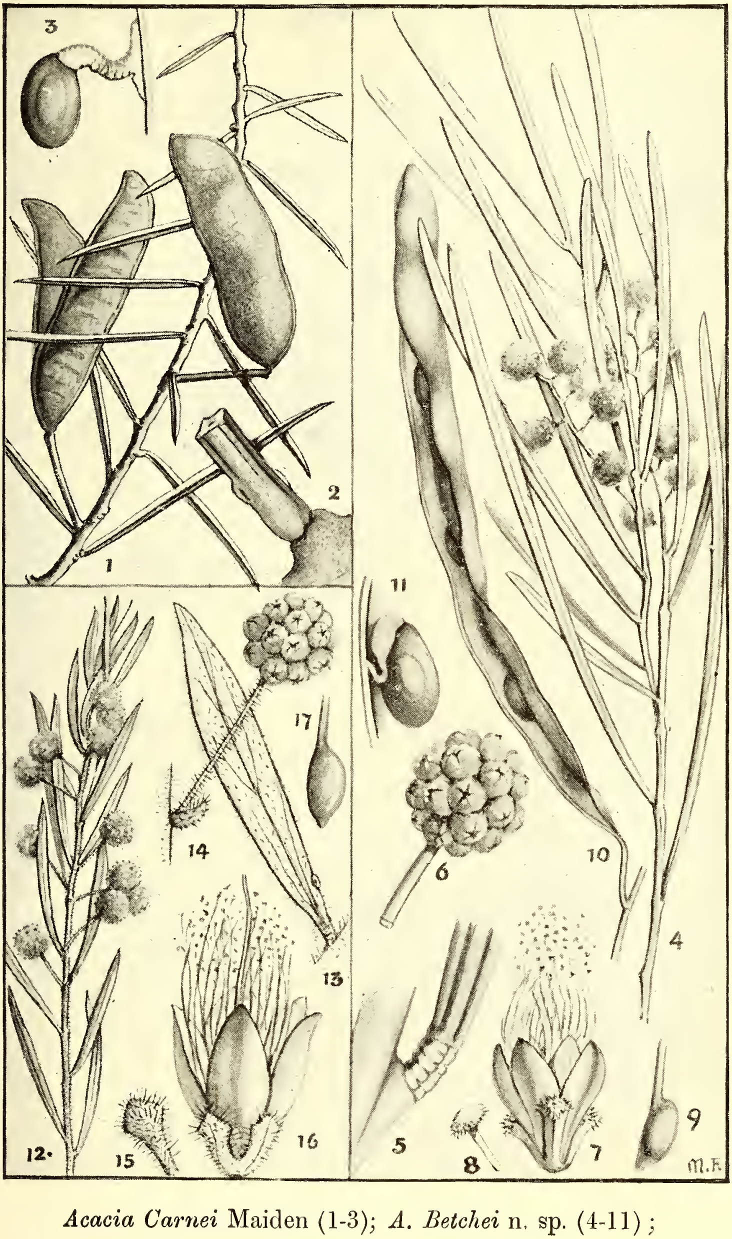
A. Gillii is readily distinguished from *A. rhetinodes* by its dwarf. zig-zag habit, in the more rigid phyllodia, and in the flower-heads being usually solitary, and larger calyx and more woody pods.

It is common throughout the Port Lincoln and Marble Range districts, South Australia.

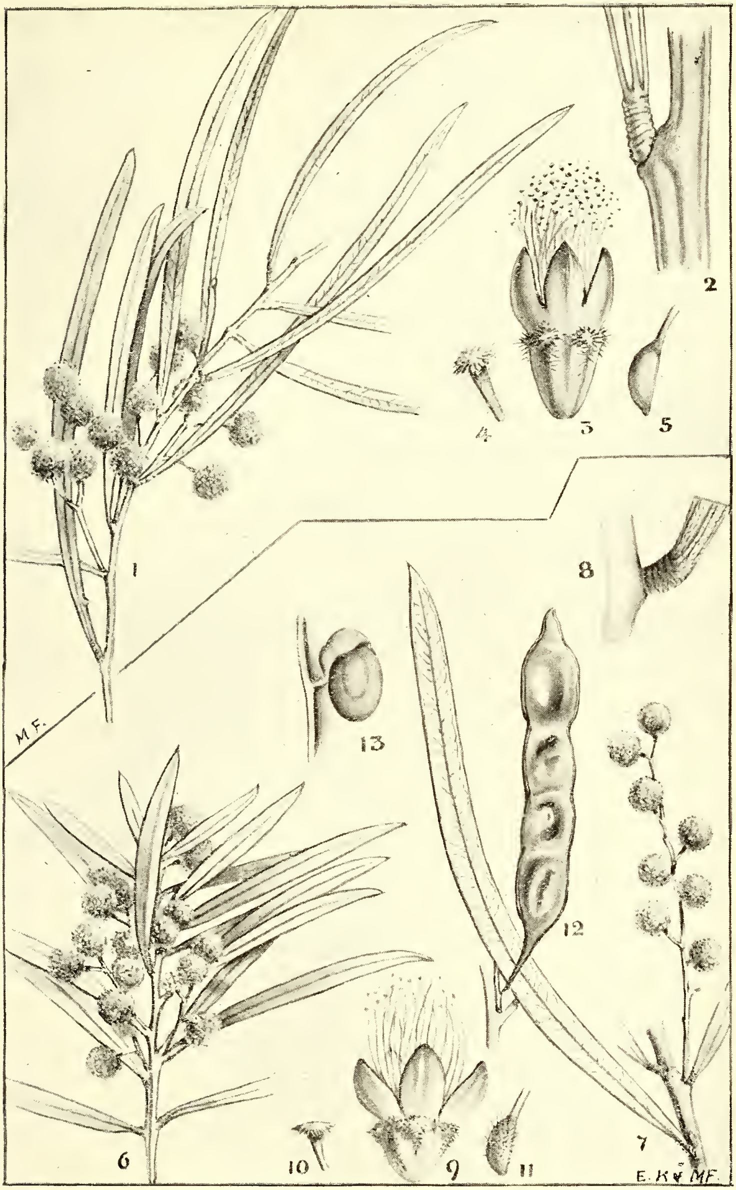
Acacia Walteri, n. sp.

Plate XV.

Frutex glaber, ramulis acute angulatis; phyllodiis oblongo-spathulatis, obtusis vel obliquo-mucronatis, tenuibus, penninerviis, uno nervo valido longitudinali, 5-7 cm. longis, 5-10 mm. latis; racemis glabris, phyllodiis brevioribus; capitulis 16-20 floris; calyce turbinato, paulo angulato, crasso, hirsuto, breviter et acute lobato; petalis ca. duplo aequilongo; ovario dense hirsuto; legumine non viso.



Acacia Carnei Maiden (1-3); *A. Betchei* n. sp. (4-11); *A. centrinervia* n. sp. (12-17).



Acacia Forsythi n. sp. (1-5); *A. caesiella* n. sp. (6-13).

A glabrous shrub several feet high, with acutely angular, reddish-brown branchlets, but soon becoming terete, and usually marked with the decurrent lines of the angles. Phyllodia oblong-spathulate, obtuse, or obliquely mucronate, thin, uninerved, which is nearest the upper margin, and with a prominent reddish lateral nerve at the base of the conspicuous lower gland, penninerved on both sides, 5-7 cm. long, 5-10 mm. broad; glands 1-3, marginal, the lowest the largest and the most constant, with a wide orifice, inserted about 1.5 cm. from the base, causing a marginal break in the phyllode, and usually terminating one or two distinct short lateral nerves. Racemes glabrous, shorter than the phyllodia, the rachis angular, bracteole at the base of each peduncle; heads globular, of about 20 flowers. Calyx turbinate, sinuolate, the lobes acute, slightly angular and more or less hirsute. Petals 5, free, glabrous, rather firm, acute, incurved, with a faint keel, barely twice the length of the calyx. Bracts stipitate-triangular, ciliate. Ovary densely hairy. Pod not seen.

Buffalo Mountains, Victoria (Chas. Walter, October, 1902). The type.

In general appearance this species resembles *A. prominens*, but differs in the longer and flatter phyllodes, different shaped calyx, bracts, and densely pubescent ovary. It is also very close to *A. oreophila*, but differs in the broader phyllodes, more numerous glands, and in the shape of the floral bracts.

Acacia oreophila, n. sp.

Plate XV.

Frutex glaber ramulis acute angulatis; phyllodiis lineari-oblongis vel lineari-lanceolatis, crassis, aliquando oblique mucronatis, obscuris, uninerviis, marginibus nervis similibus, 3-5 cm. longis, 3-7 mm. latis; racemis glabris, rache paulo flexuosa phyllodiis longiore; floribus 10-15 in capitulo, sulphureis; calyce hirsuto, turbinato, paulo angulato, lobis brevibus, crassis, obtusis; petalis 5, liberis, glabris, carinatis, calycis longitudinem ca. duplo aequantibus; ovario hirsuto; legumine non viso.

A glabrous shrub with acutely angular branchlets. Phyllodia linear-oblong to linear-lanceolate, often obliquely mucronate, thick, dull, uninerved, with nerve-like margins, faintly penninerved and more or less rugose, 3-5 cm. long, 3-7 mm. broad. Gland marginal, prominent, a short distance from the base. Racemes glabrous, the rachis somewhat flexuose; peduncles bract opposed, bearing small globular heads of 10-14 bright yellow flowers. Calyx turbinate, more or less angular, hirsute, with short, thick, obtuse broadish lobes. Petals 5, free, glabrous, keeled, about twice the length of the calyx. Bracts stipitate, spathulate, ciliate. Ovary densely hirsute. Pod not seen.

Buffalo Mountains, Victoria (Charles Walter, October, 1902). The type.

Near *A. prominens* A. Cunn. in the phyllodes, shape of the gland, and in the racemes. The gland of *A. prominens* is nearly in the centre of the phyllode, while in *A. oreophila* it is close to the base. The flowers of the former are also more glabrous, while the ovary is quite smooth. *A. prominens* is a large glaucous shrub confined to a limited area on the coast between Camden and Newcastle. From herbarium specimens *A. oreophila* does not appear to be glaucous.

The dry phyllodes of *A. oreophila* are not unlike some of the small forms of *A. suaveolens,* but the inflorescence is quite distinct from that species.

Acacia oreades, n. sp.

Plate XVII.

Frutex parvus 18-24 in. altus; ramis teretibus, pruinosis, pubescentibus; phyllodiis rigidis subverticalibus, angusto-lanceolatis, breviter petiolatis, crassis, uninerviis, in mucronem brevem et rigidum angustatis, 10-17 mm. longis, 3-5 mm. latis; racemis pruinosis, phyllodiis longioribus; floribus ca. 8 in capitulo; calyce cupulari, minimo, paulo angulato ciliato; petalis 5, liberis, paulo obtusis, leniter striatis, calycem longitudine plus duplo excedentibus; ovario glabro; legumine stipitato, oblongo, 2.5-3 cm, longo, 8-9 mm. lato; seminibus longitudinaliter despositis vel leniter oblique orbicularibus; funiculo filiformi in arillum brevem super seminis apicem dilatatum.

A dwarf shrub, 18-24 inches high. Branches terete, hoary-pubescent. Phyllodia almost vertical, narrow-lanceolate, shortly petiolate, thick, uninerved, with strong, nerve-like margins, the nerve usually closer to the upper margin, lateral veins obscure, usually terminating in a short stiff mucro, 10-17 mm. long, 3-5 mm. broad; gland small, marginal, inserted a short distance from the base. Racemes minutely hoary, of 5-10 shortly pedunculate globose heads, of about 8 flowers. Calyx cupular, sinuolate, very small, thick, somewhat angular, ciliate along the angles and margin. Petals 5, free, somewhat obtuse, narrowed into the base, more or less striate when dry, and with a strong central nerve on both sides, more than twice the length of the calyx. Ovary glabrous. Pod stipitate, oblong, constricted between the seeds, 2.5-3 cm. long, 8-9 mm. broad; valves thinly coriaceous; seeds placed longitudinally or slightly obliquely, black, broadly ovate to almost orbicular, about 4 mm. long and nearly as broad. Funicle filiform for about half its length, then forming a clavate aril over the end of the seed.

Clarence to Wolgan, New South Wales (R. H. Cambage, No. 1559, August, 1906; H. Deane, same locality, in pod, December, 1906); recorded in the "Forest Flora of N.S.W.," Part XLIV, p. 84 as *A. buxifolia*.

Near *A. buxifolia*, from which it differs in the minutely hoary branches, slightly different phyllodia, more hairy calyx and much smaller pods, with the seeds arranged more or less obliquely. The seeds are also more orbicular.

ACACIA KYBEANENSIS, n. sp.

Plate XVII.

Frutex densus 6-8 ft. altus; ramulis teretibus, pruinosis; stipulis parvis, persistentibus; phyllodiis paulo hirsutis vel glabris, angusto-lanceolatis, curvatis, in mucrone longo terminantibus, uninerviis, 2-2.5 cm. longis, 4-6 mm. latis; racemis minute pruinosis, phyllodia excedentibus; floribus 7-10 in capitulo; calyce cupulari, sinuolato, ciliato; petalis 5, liberis, paulo striatis carinatis calycem longitudine plus duplo excedentibus; ovario glabro; lemumine non viso.

A dense shrub 6-8 feet high. Branches terete, hoary tomentose. Stipules small, somewhat scarious, hairy persistent. Phyllodia slightly hairy when young, glabrous when old, narrow-lanceolate, flat, thin, slightly undulate, terminating in a short, straight or curved point, penninerved, with one prominent longitudinal nerve which is nearly central, 2-2.5 cm. long, 4-6 mm. broad, bearing on the upper margin and a little below the centre a small, prominent gland which causes a slight depression or bend in the margin. Racemes minutely hoary-tomentose, longer than the phyllodia; peduncles rather stout, bearing globular heads of 7-10 flowers. Buds globular or nearly so. Calyx cupular, slightly angular, thick, sinuolate, ciliate. Petals 5, free, somewhat obtuse, narrowed into the base, more or less striate when dry, and with a strong central nerve or keel, more than twice the length of the calyx. Bracts capitate, ciliate. Ovary glabrous. Pod not seen.

''Dense bushes 6-8 feet high,'' in valley, head of Tuross River, Kybean (R. H. Cambage, No. 2000, November 4, 1908). The type.

Near *A. oreades,* with which it has been confused, and from which it is readily distinguished by the thin lanceolate, almost acuminate phyllodia, with the gland more distant from the base, in the small, somewhat scarious, hairy stipules, smaller and thicker calyx with its oblique rows of fine hairs and slightly larger petals. It also appears to be a much larger shrub than *A. oreades.*

ACACIA SEMIBINERVIA, n. sp.

Plate XVII.

Frutex glaber, ramis acute angulatis; phyllodiis pallidis vel paulo glaucis, lanceolatis, acuminatis, semi-binerviis, plus minus penninerviis, 1.5-2 cm. longis, 5-7 mm. latis; racemis glabris, phyllodiis longioribus 4-7 flores gerentibus, capitulis parvis globosis 7-10 floris; calyce cupulari, sinuolato, glabro; petalis lanceolatis, acutissimis, plus duplo calycem longitudine aequantibus; ovario glabro; legumine non viso.

A glabrous shrub: branchlets acutely angular. Phyllodia pale or slightly glaucous, lanceolate, acuminate, semi-binerved, strongly penninerved, the second nerve on the gland side of the phyllodia joins the margin about three-quarters of the way up, and in no case does it extend to the apex, 1.5-2 cm. long, 5-7 mm. broad in the middle, marginal nerve conspicuous, gland a short distance from the base, large and swollen with a prominent orifice. Racemes glabrous, longer than the phyllodia, bearing 4-7 flowers; heads globular, 7-10 flowered. Calyx broadly cupular, sinuolate, glabrous. Petals lanceolate, very acute, slightly keeled, more than twice the length of the calyx. Bracts shortly clavate, truncate, ciliate. Ovary glabrous. Pod not seen.

This species was raised from seed by a Mr. F. Drissel, Barling Cottage, Trant Road, Tunbridge Wells, England, and flowered 20th March (year not stated), and was sent to J. Smith, Esq., Royal Botanic Gardens, Kew, England, for identification. Its source of origin is unknown to us, but it seems to be closely allied to *A. pravissima* and *A. cultriformis,* and differs from both in the somewhat bi-nerved phyllodia, and in the structure of the flowers. It is probably a Victorian or New South Wales species.

PLURINERVES (Oligoneura).

ACACIA PTYCHOCLADA, n. sp.

Plate XVIII.

(*A. elongata* Sieb. var. *angustifolia* Maiden and Betche; "Wattles and Wattle Barks," 1906, p. 73.)

Frutex parvus paludosus, 2-5 ft. altus; ramulis hirsutis acute angulatis; ramis teretibus, striatis, hirsutis; phyllodiis linearibus, elongatis, planatis vel semi-teretibus, leviter hispidis et pungentibus, distincte 3-nerviis, marginibus nervis similibus, 7-11 cm. longis 1 mm. diametro; pedunculis dense hispidis; capitulis magnis, globosis vel ovoideis; floribus numerosis, sulphureis; sepalis linearibus, spathulatis, hirsutis; petalis 5, liberis, glabris, crassis, leviter carinatis, sepalis duplo longioribus; ovario hirsuto; legumine lineari-oblongo, stipitato, 4-5 cm. longo, 5 mm. lato; seminibus longitudinalibus, late ovatis; funiculo filiformi, flexuoso vel prope seminis basin bis vel ter irregulariter plicato.

A small, slender, swamp-loving shrub, 2-5 feet high, with acutely angular, hirsute branchlets. Branches terete, somewhat ribbed or prominently and coarsely striate, hirsute. Phyllodia linear, subulate, elongated, flat to semi-terete, slightly hispid, and more or less hirsute when young, terminating in a straight or slightly uncinate, almost pungent point, prominently trinerved, with strong, nerve-like margins, 7-11 cm. long, about 1 mm. broad. Peduncles densely hispid, with short brownish hairs, bearing large globular or ovoid heads of about 30-35 5-merous, pale-yellow flowers. Sepals shortly united at the base, linear-spathulate, hirsute. Petals 5, free, glabrous, rather thick, with a faint central nerve, fully twice the length of the calyx. Bracts spoon-shaped, densely ciliate. Ovary hirsute. Pods linear-oblong, stipitate, slightly constricted between the seeds, 4-5 cm. long, 5 mm. broad; seeds longitudinal, broadly ovate, with a conspicuous areola on both sides. Funicle filiform, flexuose, or forming two or three irregular folds a short distance from the base of the seed.

Range:—Confined to the Blue Mountains, New South Wales, from the following localities:—Woodford (J. H. Maiden, January, 1899). The type. (R. H. Cambage, No. 4009, December 6, 1913); Lawson (W. M. Carne); Leura (W. M. Carne, F. R. Smith, A. A. Hamilton); Blackheath (J. H. Maiden, April, 1899).

Differing from *A. elongata* mainly in the narrower and more pungent phyllodes, paler flowers, and in the shorter and narrower pods.

ACACIA ELONGATA Sieb. var. DILATATA, n. var.

Plate XVIII.

Phyllodia glabrous, linear, flat, thin, gradually expanded upwards, and dilated at the apex and mucronate, with 4 conspicuous longitudinal nerves 10-12 cm. long, 4-7 mm. broad at the top. See Plate XVIII., fig. 8a.

National Park, N.S.W., M. Bell, August, 1896.

JULIFLORAE (Stenophyllae).

ACACIA GRACILIFOLIA, n. sp.

Plate XVIII.

Frutex gracilis, glaber; ramulis acute angulatis, resinosis; phyllodiis filiformibus; teretibus, flexuosis, alte sulcatis, 5-7 cm. longis, 1 mm. diametro; spicis pedunculatis, ovoideis; calyce turbinato, leviter lobato, dense tomentoso; petalis 4, liberis, glabris, calyce vix duplo longioribus; legumine lineari, stipitato, undulato, inter semina incincto, 5-7 cm. longo, 2 mm. lato; funiculo filiformi, super semen semel vel duplo irregulariter plicato.

A slender, glabrous, somewhat resinous shrub; branchlets flexuose, acutely angular, striate with resinous lines. Phyllodia filiform, terete, straight or flexuose, with an oblique apex, deeply canaliculate, 5-7 cm. long, about 1 mm. in diameter; glands usually two, slightly raised. Spikes pedunculate, ovoid to nearly globular. Flowers small, calyx turbinate, shortly and obtusely lobed, covered in a woolly tomentum. Petals 4, free, glabrous, slightly keeled, scarcely twice the length of the calyx. Bracts spoon-shaped, ciliate, resinous. Ovary hoary. Pod linear, stipitate, undulate, contracted between the seeds, 5-7 cm. long, 2 mm. broad, valves coriaceous, more or less resinous, somewhat carnose over the brown, oblong, longitudinally placed seeds. Funicle filiform, forming one or two short, irregular folds a short distance from the end of the seed.

Flinders Range, South Australia (W. Gill, 1900). The type.

A. gracilifolia seems to be more closely allied to *A. Hynesiana* than to any other species known to us, particularly in the flexuose, resinous branchlets and in the terete phyllodes. The latter character, however, is straighter than that of *A. Hynesiana,* and the pod is quite different. At one time *A. gracilifolia* was referred to *A. juncifolia,* which it resembles in the phyllodes, but the inflorescence and pods are very dissimilar.

BIPINNATAE (Botryocephalae).

ACACIA MOLLIFOLIA, n. sp.

(*A. decurrens* Willd. var. *lanigera* Maiden in "Wattles and Wattle Barks," 1906, p. 41; "Forest Flora of N.S.W.," Part XXIII, p. 60, Plate 88, figs. O-R.)

Frutex parvus vel arbor parva dense pilosa; ramulis fere tertibus, pinnis 4-10 paribus; foliolis 20-36 paribus, linearibus, acutis, molliter pilosis, 5-7 mm. longis, 1-1.5 mm. latis; racemis pinnis longioribus; 4-6 cm. longis, pedunculis longiusculis, robustis, velutinis; capitulis globosis 20-30 floris; calyce turbinato, lobis brevibus, dense pilosis, petalis 5 liberis, hirsutis, crassis, marginibus hyalinis, calyce duplo longioribus; ovario tomentoso; legumine stipitato, lineari, dense inter semina incincto, 9-13 cm. longo, 4-6 mm. lato; seminibus longitudinalibus.

A small tree or tall shrub characterised by every part of it—old and young leaflets, rachises and twigs and pods being densely covered with white or brown indument. Branchlets almost terete, velvety. Pinnae usually in 4-10 pairs, with a pair of deciduous, lanceolate stipules at the base of each pinnae in the early stages, and with an almost obscure gland at the base of each pair of pinnae; rachis velvety, 4-8 cm. long, terminating in a long, soft point. Leaflets in 20-36 pairs, linear, acute, softly hairy, up to 7 mm. long, about 1½ mm. broad. Racemes velvety, exceeding the pinnae, 4-6 cm. long; peduncles rather long, stout, velvety, bearing globular heads of 20-30 flowers, subtended by a small, acute, almost glabrous, concave bract. Calyx turbinate, with short, thick, densely pilose lobes, otherwise glabrous. Petals 5, free, hirsute, narrow, rather thick, with hyaline margins fully twice the length of the calyx; ovary densely tomentose. Pods stipitate linear, densely velvety, nearly straight, constricted between the seeds, but not seen in a fully developed state, 9-13 cm. long, 4-6 mm. broad. Seeds longitudinal.

The variety name is already occupied, and therefore cannot be used.

This species appears to be confined to New South Wales, and has been collected from the following localities:—"A very common Acacia, about 12 feet high, growing all over the hills at high elevations; stems branched, 3-6 inches in diameter," Harvey Ranges, near Peak Hill (J. L. Boorman, November, 1905). The type. Parkes Water Supply (J. H. Maiden, August, 1897); Gloucester Buckets (E. Betche, January, 1882; J. H. Maiden, September, 1892).

It is a very handsome species, and worthy of cultivation for ornamental purposes.

Near *A. dealbata* Link, but readily distinguished from it by its coarser leaflets, and in being densely velvety in all its parts, including the pods, which are considerably longer and narrower than those of *A. dealbata.*

We wish to express our indebtedness to Dr. Darnell-Smith, Director of the Botanic Gardens, Sydney, for many courtesies in connection with the preparation of this paper, and to Miss Margaret Flockton and Miss Ethel King for the illustrations.

EXPLANATION OF PLATES.

Plate xiii.

Acacia Carnei Maiden.

1, twig with pods, natural size; 2, lower portion of phyllode to show basal gland and attachment to branch; 3, seed and funicle.

Acacia Betchei, n. sp.

4, flowering twig, natural size; 5, base of phyllode; 6, head of flowers; 7, flower; 8, bract; 9, ovary; 10, pod, natural size; 11, seed and funicle.

Acacia centrinervia, n. sp.

12, flowering twig, natural size; 13, phyllode showing venation and gland; 14, head of flower and basal bract; 15, floral bract; 16, flower; 17, ovary.

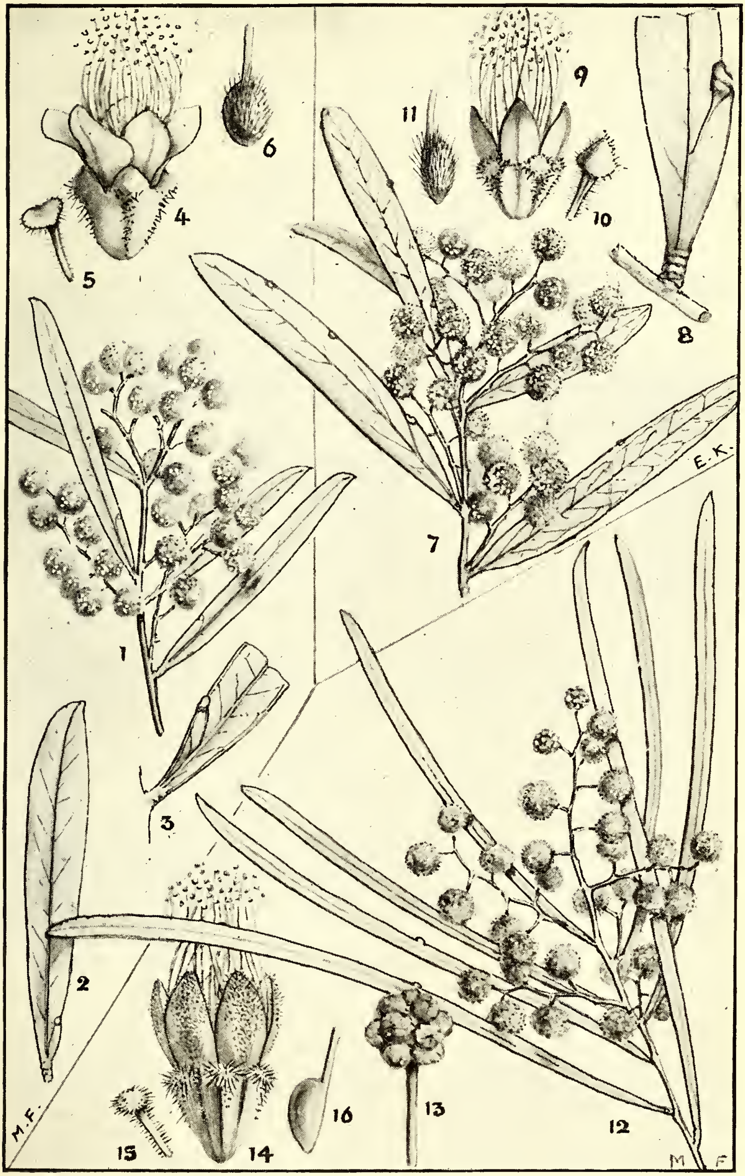
Plate xiv.

Acacia Forsythi, n. sp.

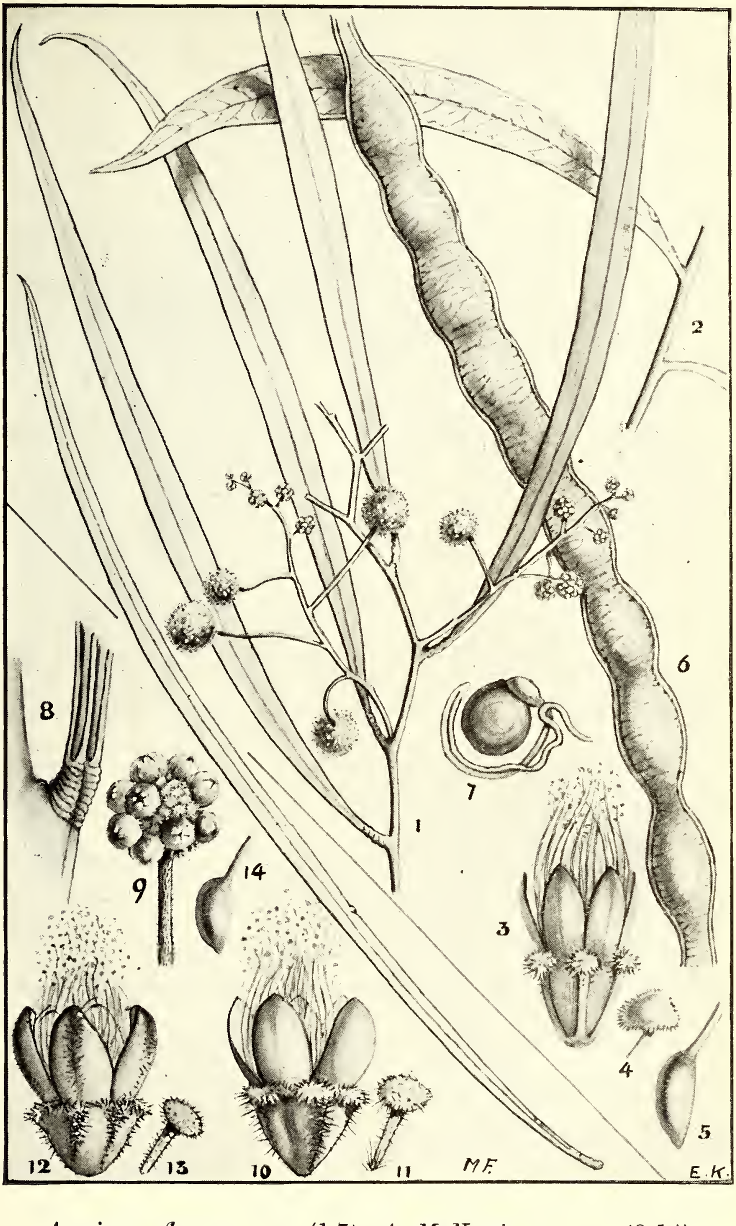
1, flowering twig, natural size; 2, base of phyllode to show the attachment; 3, flower; 4, bract; 5, ovary.

Acacia caesiella, n. sp.

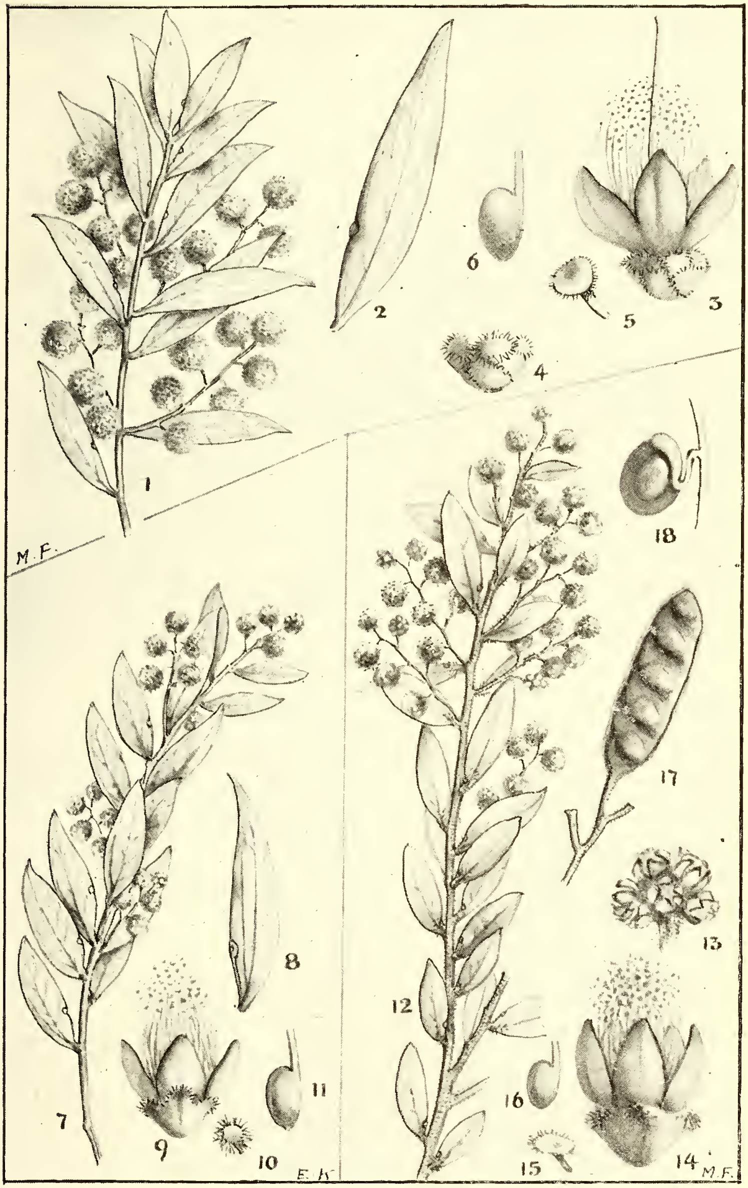
6, flowering twig, natural size; 7, flowering twig with longer raceme and phyllode than 6, natural size; 8, base of phyllode showing vestiture and attachment; 9, flower; 10, bract; 11, ovary; 12, pod, natural size; 13, seed and funicle.



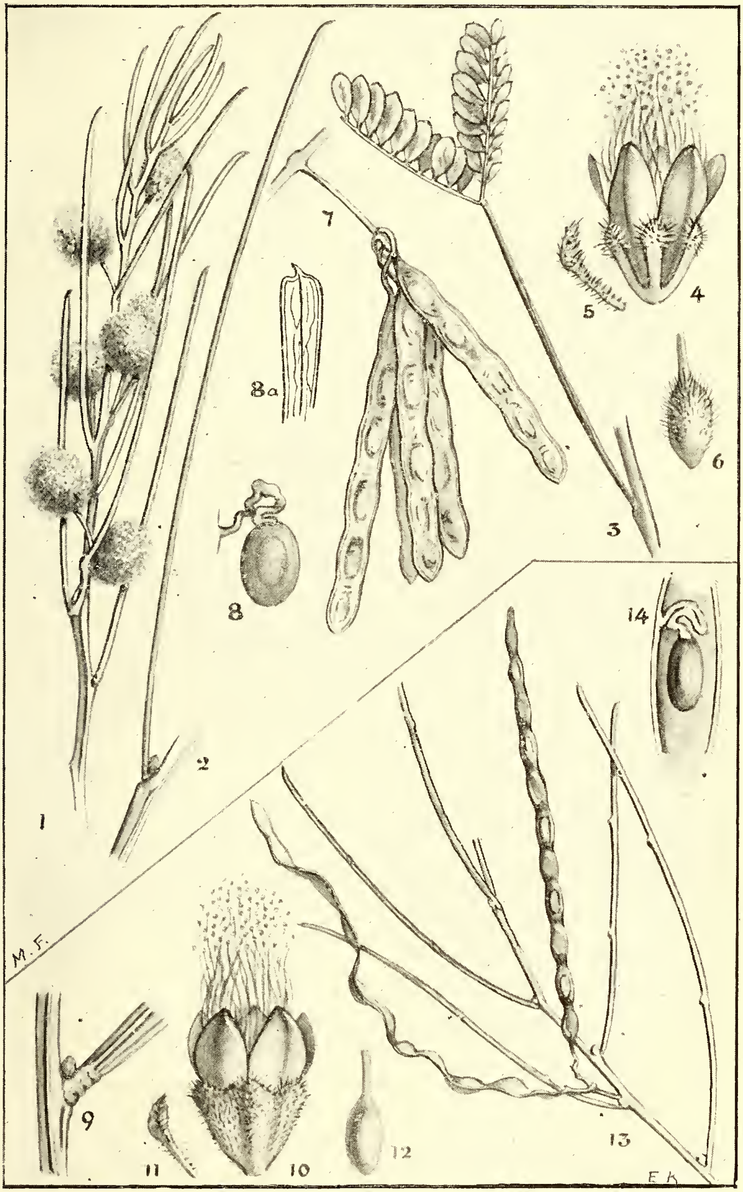
Acacia oreophila n. sp. (1-6); *A. Walteri* n. sp (7-11);
A. Murrumboensis n. sp. (12-16).



Acacia confluens n. s.p. (1-7); *A. McNuttiana* n. sp. (8-14)



Acacia Kydeanensis n. sp. (1-6); *A. semibinervia* n. sp. (7-11); *A. oreades* n. sp. (12-18).



Acacia ptychoclada n. sp. (1-8); *A. elongata* Sieb. var. *dilatata* n. var. (8a); *A. gracilifolia* n. sp. (9-14).

Plate XV.

Acacia oreophila, n. sp.

1, flowering twig, natural size; 2, phyllode to show basal gland; 3, base of phyllode; 4, flower; 5, bract, 6; ovary.

Acacia Walteri, n. sp.

7, flowering twig, natural size; 8, base of phyllode to show the large gland above and below the marginal nerve; 9, flower; 10, bract; 11, ovary.

Acacia Murrumboensis, n. sp.

12, flowering twig, natural size; 13, head of flowers; 14, flower; 15, bract; 16, ovary.

Plate XVI.

Acacia confluens, n. sp.

1, flowering twig, natural size; 2, phyllode to show basal gland; 3, flower; 4, bract; 5, ovary; 6, pod, natural size; 7, seed and funicle.

Acacia McNuttiana, n. sp.

8, phyllode, natural size; 8a, base of phyllode to show the attachment and venation; 9, head of flowers; 10, flower with glabrous petals; 11, bract; 12, flower with hirsute petals; 13, bract; 14, ovary.

Plate XVII.

Acacia Kybeanensis, n. sp.

1, flowering twig, natural size; 2, phyllode to show the gland; 3, flower; 4, calyx; 5, bract; 6, ovary.

Acacia semibinervia, n. sp.

7, flowering twig, natural size; 8, phyllode to show the gland and the venation; 9, flower; 10, bract; 11, ovary.

Acacia oreades, n. sp.

12, flowering twig, natural size; 13, head of flowers; 14, flower; 15, bract; 16, ovary; 17, pod, natural size; 18, seed and funicle.

PLATE XVIII.

Acacia ptychoclada, n. sp.

1, flowering branch, natural size; 2, phyllode, natural size; 3, pinnae, natural size; 4, flower; 5, bract; 6, ovary; 7, pods, natural size; 8, seed and funicle.

Acacia elongata Sieb. var. *dilatata*, n. var.

8a, top of phyllode, natural size, to show venation and expanded upper portion.

Acacia gracilifolia, n. sp.

9, base of phyllode to show venation and attachment; 10, flower; 11, bract; 12, ovary; 13, twig with pods, natural size; 14, seed and funicle.

THE SOLUTION VOLUME OF A SOLUTE IN LIQUID MIXTURES.

By G. J. Burrows, B.Sc.

(Read before the Royal Society of New South Wales, Nov. 3, 1926.)

The volume of a solute in liquids other than water has been investigated by various authors and the results indicate that in general the "solution volume of a solute" is a function of the compressibility of the solvent (Tyrer, J.C.S. 1910, **97**, 2620). In a previous paper (This Journ. 1919, **53**, 74) the author published figures for the solution volumes of certain amides in water, alcohol, and water-alcohol mixtures. It was shown that the volume in alcohol was less than in water, whereas the volume in water-alcohol mixtures was greater than in either of the separate liquids. It was found that, in a series of such mixtures, the values of the "specific solution volume" passed through a maximum for a particular mixture, not actually the mixture that had suffered the maximum contraction in its preparation. Thus it was found that the specific solution volume of acetamide in dilute solution at 30° was 0.945 in water, 0.932 in alcohol, but 0.954 in a mixture containing 36.62 per cent. of alcohol by volume, a value agreeing very closely with that of the pure liquid acetamide at this temperature, 0.956. This result indicates that the addition of acetamide causes no further decrease in volume in the case of this mixture, and, in the case of formamide in such solvents an increase in volume was actually observed.

Such a result seemed to indicate that the "specific solution volume of the solute" actually depended on the contraction that had already taken place in the preparation of the solvent mixture, or more generally on the compressibility of the solvent. It was considered that in such mixtures there was a maximum contraction that could be suffered by the liquid components, i.e., alcohol-water, and the apparent solution volume of a third component (i.e., the solute) would depend on the amount of contraction that had already taken place.

In the case of mixtures such as benzene-acetone or benzene-alcohol which are formed with only a small change in volume, a solute has a specific solution volume intermediate between those in the separate liquids.

This work has since been extended, and the following results have been obtained for the solution volumes of urea and acetamide in water-methyl alcohol and water-acetone mixtures respectively. The densities were determined at 25° in the usual way with a pyknometer of about 20 c.c. capacity. In the following tables, d_0 is the density of the solvent, A is the number of grams of solute dissolved in 100 grams of solvent, d_1 the density of the solution, and v_s the specific solution volume of the solute calculated from the equation:

$$v_s = \left(\frac{100 + A}{d_1} - \frac{100}{d_0}\right) \div A$$

Table 1.

	A	d_1	v_s
Urea in methyl alcohol ($d_0 = 0.78702$),			
	4.4444	0.80407	0.637
	8.6286	0.81938	0.639
Urea in water ($d_0 = 0.99707$),			
	5.0484	1.00980	0.738
	7.3010	1.01520	0.740
Urea in water-methyl alcohol ($d_0 = 0.89752$),			
	6.5366	0.91628	0.743
	9.6849	0.92460	0.745

The solvent in this case was prepared by mixing 57.90 g. of methyl alcohol with 44.11 g. of water, the total volume corresponding to these masses being 117.81 c.c. The volume after mixing, calculated from the density, was found to be 113.66 c.c., which corresponds to a specific contraction of 0.0352 c.c. per c.c. of the original mixture.

Table 2.

	A	d_1	v_s
Acetamide in acetone ($d_0 = 0.78555$),			
	5.7772	0.79868	0.890
	8.3455	0.80403	0.893
	16.7101	0.81974	0.902
Acetamide in water ($d_0 = 0.99707$),			
	7.0164	1.00134	0.938
	8.5573	1.00225	0.937
Acetamide in water-acetone ($d_0 = 0.88641$),			
	8.6620	0.89884	0.940
	10.9589	0.90166	0.941
	18.8201	0.91048	0.943

The water-acetone mixture was prepared from 313.75 g. of acetone and 183.83 g. of water, corresponding to a total volume of 583.77 c.c. As the volume after mixing was 561.34 c.c., the specific contraction was 0.0384 c.c. per c.c. of the original.

It will be seen that in these mixtures the specific solution volume of the solute is greater than in either of the separate liquids. A marked contraction in volume accompanies the formation of each of these mixtures and it is considered that the results indicate that the contraction which takes place on the addition of the solute depends on the amount of condensation in volume that the particular solvent has previously undergone. The apparent solution volume of a solute therefore depends on the extent to which the solvent can be further compressed, i.e., the compressibility of the solvent medium. It thus appears that there is a limit to the amount of contraction that any such solvent can undergo, and in cases where such a limit has already been reached by the admixture of two liquids, the addition of a third substance, as solute, should have no further effect on the volume. In such a mixture a solute should dissolve without any apparent change in volume, i.e., the value for v_s for a normal solute in such a mixture should be the same as for the solute in the liquid state.

The investigation was further extended to include solutions of one liquid in mixtures of two others. In these cases the actual specific contractions in volume were also calculated. It will be noticed that whereas the values of v_s for any particular solvent vary regularly with the concentration of the solute, the actual specific contractions pass through a maximum value for solutions in the separate solvents. This apparently contradictory result has already been shown by the author to be due to the equation used for calculating the specific solution volumes (loc. cit.).

As regards the solution of a third liquid in a mixture of two others, it will be seen that in these cases also, the specific contractions Δ_1 (for solute in solvent) pass through a maximum value, whereas the total specific contractions Δ_2 (i.e., the total contraction divided by the total volume of the three components) decrease regularly with the amount of solute added. This is no doubt due to the fact that in both the cases considered, the contraction observed during the formation of the mixed solvent is much greater than the further contraction resulting from the addition of a small amount of the third component (i.e., the solute).

Table 3.

A	d_1	v_s	Δ_1
Methyl alcohol in acetone ($d_0 = 0.78555$).			
18.1443	0.78855	1.24144	0.00352
114.361	0.79095	1.25670	0.00582
323.466	0.78977	1.26409	0.00393
Methyl alcohol in water ($d_0 = 0.99707$).			
17.2200	0.97258	1.17486	0.00874
46.6290	0.94571	1.17420	0.02459
701.994	0.82220	1.24663	0.01639

A	d_1	v_s	Δ_1	Δ_2
Methyl alcohol in water-acetone ($d_0 = 0.88641$).				
11.5127	0.87825	1.2297	0.00372	0.0378
31.2140	0.86648	1.2373	0.00689	0.0354
95.9851	0.84256	1.2481	0.00923	0.0277
229.165	0.82117	1.2569	0.00779	0.0187
396.557	0.80999	1.2614	0.00590	0.0130

The solvent used in this case was the same as that described under Table 2.

Table 4.

A	d_1	v_s	Δ_1
Pyridine in water. The density of the pyridine was 0.97705.			
13.3143	0.99987	0.97902	0.0000456
60.8770	1.00274	0.98795	0.009725
181.734	1.00232	0.99480	0.01620
405.488	0.99674	1.00336	0.01471
Pyridine in acetone.			
15.0860	0.80747	1.0094	0.00146
116.450	0.88106	1.0165	0.00331

A	d_1	v_s	Δ_1	Δ_2
Pyridine in water-acetone ($d_0 = 0.88641$).				
23.6881	0.90352	1.0166	0.00119	0.0284
75.2675	0.92509	1.0183	0.00205	0.0218
103.613	0.93241	1.0194	0.00194	0.0192
433.811	0.95935	1.0226	0.000683	0.0075

It will be noticed that in the case of methyl alcohol-acetone and pyridine-water the values of d_1 pass through a maximum value for a particular solution. This result is due to the fact that in each case the two components have very similar densities. In cases where there is a marked difference between the densities of the two components, no maximum is observable in the density of a solution formed by dissolving a third substance in a mixture of these two, although a maximum is found if one calculates the specific contractions. In such cases departure of the density curve from a straight line has the same significance as a variation in change of volume passing through a maximum value.

Many properties of alcohol-water or acetone-water mixtures pass through a maximum (or minimum) value corresponding to a certain (variable) composition. This result, or rather, this distinction from results observed in the case of other properties or other binary mixtures is mainly one of degree. If there is any variation of a property with composition in any system of two components, a maximum or minimum value of that property will always be manifested in a property composition diagram, provided that the actual difference between the components(with respect to the particular property) is sufficiently small (i.e., provided the observed deviation of the curve from a straight line is greater than the difference between the components). In other words all such property-composition curves are of the same type provided they show any variation from a straight line—a minimum or maximum point may have a mathematical significance but such a curve differs only in degree from one not passing through a maximum provided the latter is not a straight line.

Such variations in property with composition may be considered by distributing the observed variation between the two components. If on a property-composition diagram, the tangent at any point be drawn, then the intercepts on the ordinate axis will give the partial magnitudes of the property with reference to each of the components. For instance, if we take the densities of mixtures of methyl alcohol and acetone given in Table 3, and calculate from A and d_1 the percentage composition and specific volume of the mixture respectively, we obtain the following results:—

Composition, % methyl alcohol by weight.	Specific volume of mixture.
0	1.27593
15.36	1.26815
53.36	1.26430
76.40	1.26619
100.0	1.27062

The values of the specific volume pass through a maximum value at a point corresponding to 44% methyl alcohol by weight, at which composition the partial volumes of the two components are equal. Such a curve is in reality the resultant of two curves (a) that of the partial volume of methyl alcohol increasing from 0 to 1.27062 and (b) that of acetone decreasing from 1.27593 to 0.

In the same way for the pyridine-water mixtures one obtains the following results:—

Composition, % pyridine.	Specific volume of mixture.
0	1.0029
11.75	1.00013
37.85	0.99727
64.5	0.99769
80.2	1.00327
100.0	1.02349

In this case the partial volume of pyridine increases from 0 to 1.02349, the partial volume of water decreasing at the same time from 1.0029 to 0. The partial molar volumes are equal in the case of a mixture containing about 50% pyridine.

In the case of methyl alcohol-water mixtures the following results are obtained:—

Composition, % methyl alcohol.	Specific volume.
0	1.00294
14.7	1.0284
31.8	1.05741
87.5	1.21625
100.0	1.27062

This curve differs only in degree from the preceding examples. Here the partial volume of methyl alcohol increases from 0 to 1.27062 at the same time as the partial volume of water decreases from 1.00294 to 0. In this case no minimum is apparent owing to the fact that the maximum divergence from a straight line curve is less than the difference between the specific volumes of water and methyl alcohol.

The above results are not capable of interpretation on the assumption that volume change is merely the outcome of closer packing, resulting from the admixture of molecules of different sizes (cf. Holmes, J.C.S., 1913, **103,** 2147). Thus if we consider the three liquids, water, methyl alcohol and acetone, the molecular radii of which (according to Holmes) are in ratio, 1, 1.31, 1.6 respectively, the contraction resulting from the admixture of methyl alcohol and water should be approximately the same as that resulting from the admixture of acetone and methyl alcohol, whereas in reality the former is 6 or 7 times as great as the latter. Furthermore, if we consider the effect of the addition of a third substance to a binary mixture of two liquids, we are faced with an equally anomalous result. Thus the particular water-acetone mixture used in Tables 3 and 4, contains the liquids in the ratio of one molecule of the latter to slightly less than two of the former. This mixture contains less acetone than the mixture of maximum contraction (according to Holmes), although more than the mixture of maximum specific contraction as calculated in terms of both components. Of the liquids chosen as solutes, methyl alcohol has a smaller molecular volume than acetone, whilst pyridine has a slightly greater volume. Yet in both cases the addition of the solute causes further contraction. Assuming that the solution of one liquid in another is simply a process of admixture of molecules of two different sizes, one would expect the addition of methyl alcohol to the particular water-acetone mixture used above, to cause a change in volume in the opposite direction to that caused by the addition of pyridine. Such, however, is not the case.

Nor can these results be explained in terms of compressibility of the solvent. As already stated, the figures obtained indicate that in a binary mixture A-B, there is apparently some relationship between the total contraction that that mixture can undergo as the result of varying the relative amounts of A and B on the one hand, and the sum of the contractions resulting from mixing a certain amount of A with a certain amount of B, together with the contraction that results from the addition of a third substance C to this particular mixture. If, however, we regard the relative solution volumes of the same solute in a series of mixtures, as an indication of the order and sense of volume change, we are faced with results incompatible with the view that such changes are determined entirely by compressibility. For instance, the solution volume of a solute in water is generally greater than in methyl alcohol or acetone, a result which suggests that these two liquids are more compressible than water. It is found, however, that the contraction resulting from mixing acetone (or methyl alcohol) with water is much greater than that resulting from the mixing of methyl alcohol with acetone.

It is thus evident, that in binary or ternary mixtures in which one component is water, volume change cannot be regarded as a purely physical (or mechanical) result. Nor can the results obtained in this work be attributed to a general change in molecular complexity resulting from the mixing of different species. It has already been shown (This Journ., 1925, **59**, 225) that the volume changes resulting from the solution of any associated solute in any associated solvent is very different from that resulting from the solution of a non-associated solute in either a non-associated or associated solvent. As far as we know, water resembles the alcohols and acetone as regards its molecular complexity, all of these liquids being associated to about the same extent. So that if we regard the process of solution of one in the other as tending to decrease the degree of complexity in conformity with the equations:

$$(H_2O)_n + (CH_3OH)_n = n(H_2O) + n(CH_3OH)$$

$$(H_2O)_n + (CH_3COCH_3)_n = n(H_2O) + n(CH_3COCH_3)$$

We should also expect

$$(CH_3OH)_n + (CH_3COCH_3)_n = n(CH_3OH) + n(CH_3COCH_3),$$

i.e., we would expect each of the above to be accompanied by the same specific volume change, which is not the case. A consideration of the reverse process, i.e., the building up of complex from simple molecules leads to the same conclusion, since in all cases this process will merely be the result of the tendency of oxygen to pass into the tetravalent condition, or rather to exert a co-ordination valency of three, a property which appears to be equally well developed by the oxygen atoms in water, the lower alcohols and acetone. Hence the author considers that the abnormality of water in such mixtures is related to some other property, and at the present time dielectric constant and molecular refractivity are being considered in this connection.

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THE PREPARATION OF CERTAIN IODO-BISMUTHITES.

By E. M. Bartholomew, B.Sc., and G. J. Burrows, B.Sc.

(*Read before the Royal Society of New South Wales, Nov. 3, 1926.*)

Many complex chloro-bismuth salts have been described, a complete bibliography being given by Gütbier and Müller (Zeit. Anorg. Chem. 1923, **128**, 137). These authors described the preparation of various chloro-bismuthites of organic bases such as aniline, dimethyl aniline, pyridine, etc. In all of these cases the compounds described may be regarded as various types of derivatives of bismuth trichloride such as:

$R_4[BiCl_5]_2$ e.g. $[PhNMe_2H]_4\,[BiCl_5]_2$
$R_3[Bi_2Cl_9]$ e.g. $[MeNH_3]_3\,[Bi_2Cl_9]$
$R_3[BiCl_6]$ e.g. $[Me_2NH_2]_3\,[BiCl_6]$

All of the above are derivatives of trivalent bismuth in which the co-ordination valency of the metal is six. In addition to these, compounds of the type $R[BiI_4]$ or $R[BiCl_4]$ are well known, in which the co-ordination valency of bismuth is four.

Gütbier and Haussmann (Zeit. Anorg. Chem. 1923, **128**, 153) have described antimony compounds of the type $R[SbCl_6]$ which are derived from antimony pentachloride. Bismuth differs from its congeners in the fifth group of the periodic table in that its pentoxide is unstable and that its acidic properties are extremely feeble; hence its inability to form a pentachloride. Nevertheless it seemed feasible to expect that the complex derivatives of the hypothetical $BiCl_5$ or BiI_5 could be obtained, just as ferro- and ferri-cyanides are obtainable although the simple cyanides of iron are unknown. Experiments were therefore carried out in which bismuth chloride and the calculated quantity of the hydrochloride of a base were treated with chlorine, both in aqueous and hydrochloric acid solution, in the hope that the compound $R[BiCl_4]$ at first formed would be oxidised to $R[BiCl_6]$, but without success. In this way various derivatives of bismuth chloride were isolated, but these all conformed to the previously described types of chloro-bismuthites of Gütbier and Müller, e.g., $Py_3[BiCl_6]$, $[PhNMe_2H]_4[BiCl_5]_2$, etc.

In view of this failure to prepare chlorobismuthates (corresponding to $H[BiCl_6]$), attempts were then made to prepare iodobismuthates by treating bismuth iodide and an organic base with iodine in hydriodic acid solution. In every case, however, the compound isolated was found to be a derivative of the triiodide. These compounds are readily obtained from bismuth iodide and the base in hydriodic acid solution and may be recrystallised from hot concentrated hydrochloric acid.

Experimental.

Anilinium hexa-iodobismuthite $[PhNH_3]_3[BiI_6]$.

Calculated amounts of aniline and bismuth iodide were mixed in a beaker with a slight excess of hydriodic acid. An orange-coloured paste was thus obtained and this gradually dried to a powder, readily soluble in hot concentrated hydrochloric acid, from which it crystallised in yellow needles. These were dried over sodium hydroxide in a desiccator in the dark.

Found:—Bi, 16.96; I, 60.75 per cent.

$[C_6H_5NH_3]_3[BiI_6]$ requires Bi, 16.61; I, 60.80 per cent.

Pyridinium hexa-iodobismuthite $[C_5H_5NH]_3[BiI_6]$.

This compound was prepared in a similar manner to the preceding; it crystallised from concentrated hydrochloric acid in scarlet needles.

Found:—Bi, 17.5; I, 62.4 per cent.

$[C_5H_5NH]_3[BiI_6]$ requires Bi, 17.2; I, 62.9 per cent.

Dimethyl anilinium hexa-iodobismuthite
$[PhNMe_2H]_3[BiI_6]$.

Prepared in an analogous manner to the above, this compound crystallised from hydrochloric acid in dark red plates.

Found:—Bi, 16.04; I, 57.07 per cent.

$[C_6H_5N(CH_3)_2H]$ $[BiI_6]$ requires Bi, 15.8; I, 57.0 per cent.

Phenyl dimethyl arsonium tetra-iodobismuthite
$[PhAsMe_2H]$ $[BiI_4]$.

In this case the arsine and bismuth iodide were taken in the proportions to give the hexa-iodo compound and treated with excess of hydriodic acid. The reaction was slow and the mixture was heated for some time; it gave a scarlet-coloured compound which was soluble with difficulty in hot concentrated hydrochloric acid. It crystallised in fine scarlet plates which on analysis proved to be the tetra-iodobismuthite.

Found: Bi, 23.2; I, 56.7 per cent.

$[C_6H_5(CH_3)_2AsH]$ $[BiI_4]$ requires Bi, 23.1; I, 56.4 per cent.

p-*Toluidinium hexa-iodobismuthite* $[C_6H_4CH_3NH_3]_3[BiI_6]$.

This compound, obtained from the base and bismuth iodide in hydriodic acid solution, readily crystallised from hydrochloric acid in yellow plates.

Found:—Bi, 16.1; I, 58.8 per cent.

$[C_6H_4CH_3NH_3]_3[BiI_6]$ requires Bi, 16.1; I, 58.2 per cent.

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NOTE ON THE SALINITY OF THE WATER OF THE GULF OF CARPENTARIA.

By G. J. Burrows, B.Sc.

(Read before the Royal Society of New South Wales, Nov. 3, 1926.)

This short investigation was carried out in 1911 at the suggestion of Dr. W. G. Woolnough, to whom the author is indebted for the samples of water. The latter were collected at various positions by Professor Gilruth whilst crossing the Gulf in August, 1911, with a view to ascertaining what evidence there was of dilution of the water of the Gulf by water from the artesian basin. For this purpose the chlorine content of each of the samples was determined and the results are given in the accompanying table and are also shown in the chart.

Position. Longitude.	Latitude.	Chlorine content (grams per litre.)
136.4	14.8	19.10
136.8	14.8	19.34
137.3	14.65	19.34
137.65	14.30	19.55
138.05	13.97	19.70
138.55	13.54	19.54
138.80	13.25	19.60
139.20	12.90	19.60
139.60	12.60	19.58
140.00	12.28	19.34
140.33	12.00	19.14
140.65	11.75	19.05
141.10	11.40	20.00
141.48	11.00	19.32

The salt content of sea water varies slightly, but as a rule it is greater near the equator than in localities more remote, and of course it is influenced by the discharge of fresh water rivers. A sample of sea water, collected off the coast of Sydney at the time these Gulf samples were examined, was found to contain 20.22 parts of chlorine per litre. A specimen from a latitude of 13 would therefore have as its normal content a value not less than 20.22. The results given in the table therefore indicate a definite dilution of sea water by water containing little or no salt. No doubt this effect is partly attributable to the discharge into the Gulf of certain small rivers such as the Roper, Flinders and Mitchell.

At the same time it does not seem possible to explain the dilution entirely in this way, and it is considered that these low chlorine values of the water of the Gulf are due to the discharge into it of water from the artesian basin.

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THE GEOLOGY OF THE GOSFORTH DISTRICT, N.S.W.

PART I.—GENERAL GEOLOGY.

By W. R. Browne, D.Sc.,
Assistant Professor of Geology, University of Sydney.

(With Plates XIX.-XXI.)

(Read before the Royal Society of New South Wales, Nov. 3, 1926.)

INTRODUCTION.

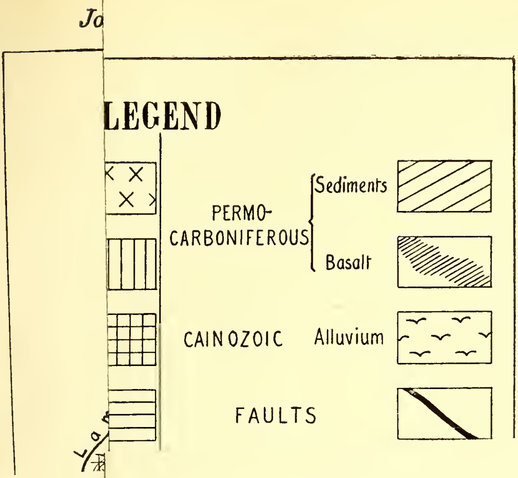
After the important discovery in 1914 by Professor Sir Edgeworth David of glacial beds of Carboniferous age near the village of Seaham, in the Maitland district, the Carboniferous system in this State acquired a new interest, and field-work was undertaken in various places, particularly in the Seaham-Paterson-Clarencetown district, where the sequence was studied chiefly by Mr. C. A. Süssmilch, the results being published in 1919.[1] At the suggestion of Prof. David, work was commenced by me in the neighbourhood of the village of Gosforth, about eight miles from West Maitland, early in 1915, but for various reasons it could not be continued, except spasmodically, until comparatively recently.

Sufficient data have now been accumulated to make possible a fairly detailed account of the geology of a moderately large area, although there are quite a number of matters still obscure.

The broad features of the stratigraphy are largely a repetition of those described by Süssmilch, and later by Osborne,[2] for the so-called type-area, but the departures from the type-sequence are, it is considered, of sufficient interest to merit description, while the tectonic and physiographic features call for some notice. Furthermore, a great part of the area dealt with is within easy reach of West Maitland, and affords the geological visitor a good opportunity for a rapid inspection of some of the main features of the Kuttung division of the Carboniferous system, so that the publication of a map and sections, with descriptive details, seems desirable, the petrography being reserved for a later publication.

The delay in the completion of the survey has really facilitated the work by enabling me to take advantage of the work of Süssmilch and Osborne, which has, of course, been of considerable service in the elucidation of the stratigraphical sequence, complicated as it is by major and minor faulting.

To Professor Sir Edgeworth David I am much indebted for my first introduction to a very fascinating district and for much first-hand acquaintance with the details of the geology of other Carboniferous areas, as well as for continued interest in the work. During the field-investigations I was laid under many obligations for assistance of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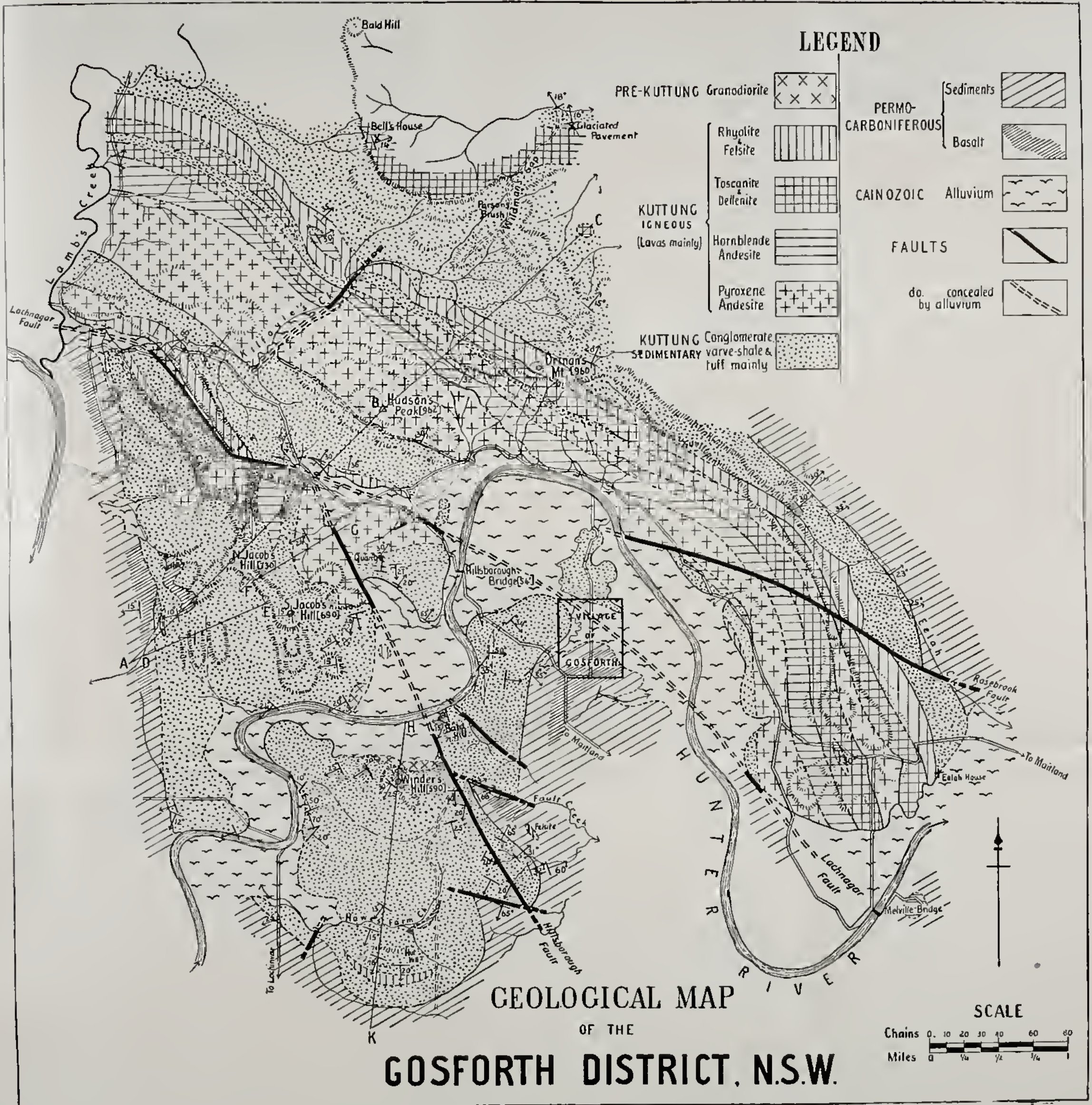


GEOLOGICAL MAP OF THE GOSFORTH DISTRICT, N.S.W.

various kinds, which is here gratefully acknowledged. Much help in surveying and examining the geology was given by senior University students at different times, and I was fortunate on more than one occasion in having the invaluable help of my colleague, Mr. G. D. Osborne, B.Sc., whose wide knowledge of the Kuttung rocks was particularly useful. Mr. W. S. Dun has kindly supplied palaeontological information, and it is on his determinations that the junction-line between Carboniferous and Permo-Carboniferous rocks has been drawn.

The actual field-operations were to a large extent made possible by the warm-hearted and generous hospitality of Mr. and Mrs. E. Cant and family, of Hillsborough, and of Mr. and Mrs. A. McDonald, "Craignair," Gosforth, while other residents of the area showed a kindly interest in the work, and were ever ready to help in any way possible.

An endeavour has been made to see that the details of the map are as accurate as possible, but the discontinuity of outcrops has made the boundaries difficult to draw in places. The available topographical maps of the three parishes concerned were found to be unreliable in matters of detail, but it is hoped that the map here presented is reasonably accurate, alike in the main topographical and geological features.

The area examined, about seven miles by six, comprises portions of the parishes of Wolfingham, Gosforth, and Middlehope. The limits have been determined on the west, south, and east by the upper boundary of the Kuttung rocks, but elsewhere a more or less arbitrary intra-Kuttung limit has had to be set. The work, indeed, centres mainly round the Carboniferous core of what is known as the Lochinvar anticline or dome, an important tectonic feature, which was early known to New South

Wales geologists. It was first mapped, and its economic significance demonstrated by Professor David,[3] and the present study has been built on the foundation of his work, and represents to a great extent the result of a somewhat more detailed examination of the central portions of the structure.

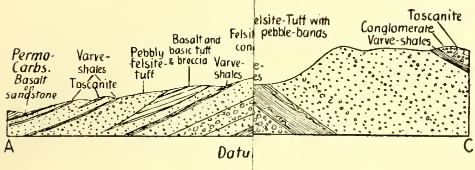
STRATIGRAPHICAL AND REGIONAL GEOLOGY.

CARBONIFEROUS.

Two main divisions of the Carboniferous rocks of this State have been recognised—the lower or Burindi series, of marine origin, and the upper or Kuttung series, entirely terrestrial in character. No representatives of the Burindi series have been found in the Gosforth district.

For the type-area the rocks of the Kuttung series have been divided by Osborne[2] as follows, in ascending order:—(1) The basal stage, comprising the Wallarobba conglomerates and tuffs of Süssmilch, (2) the volcanic stage, equivalent to Süssmilch's Martin's Creek beds, and (3) the glacial stage, comprising all the strata above the volcanic stage. These subdivisions, although, as it happens, not altogether happily named, correspond to real changes in the sequence of deposition. While volcanic activity is indicated right through the series, the lava-flows are almost entirely confined to the volcanic stage, and the lithology of the interbedded conglomerates is different from that of the beds of the basal stage. Further, the glacial stage contains all the glacial and aqueo-glacial deposits found in the type-area, and its massive basal conglomerate marks a distinct change from the conditions obtaining in the volcanic stage.

This grouping of the strata does not hold in its entirety in the area now being described, but for purposes of comparison it will be applied as far as possible. It


Permo-
Carbs.
Basalt on sandstone
Varve-
shales
Toscanite
Pebbly
felsite-
tuff
Basalt and
basic tuff
& breccia
Varve-
shales
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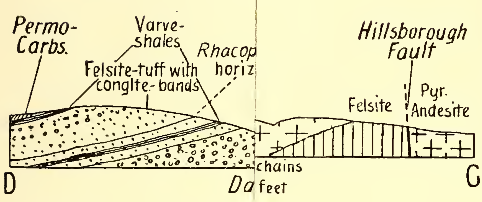
con
elsite-Tuff with
pebble-bands
Toscanite
Conglomerate
Varve-shales
A
Datu
C


Permo-
Carbs.
Varve-
shales
Felsite-tuff with
conglte-bands
Rhacop
horiz
Hillsborough
Fault
Felsite
Pyr.
Andesite
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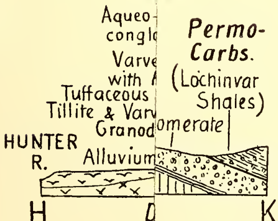
Aqueo-
congl
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Tuffaceous
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omerate
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Carbs.
(Lochinvar
Shales)
HUNTER
R.
Alluvium
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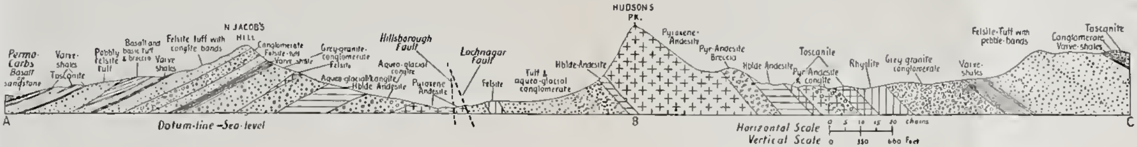


Fig. 1.

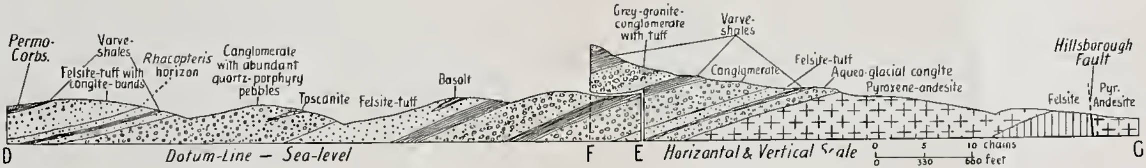


Fig. 2.

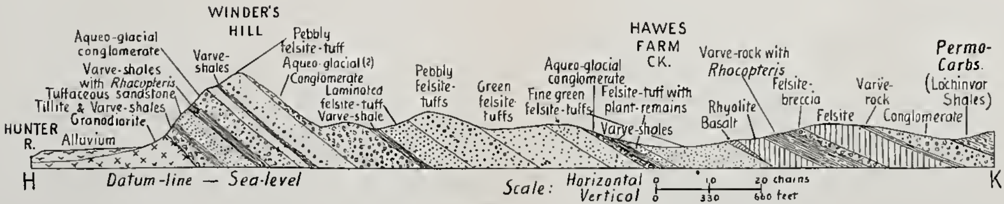


Fig. 3.

will be more convenient, however, to consider the Carboniferous geology by regional units; these may be arranged as follows:—

the Drinan's Mount Division,
the Winder's Hill Division,
the Jacob's Hills Division, and
the Hillsborough Division.

The Drinan's Mount Division.

This is a great unit, extending in a gentle curve convex to the north-east, between Eelah and Lamb's Valley, but the series is prolonged for another seven or eight miles to the west, being terminated abruptly by the meridional Elderslee Fault. This unit is bounded on the south and west by a heavy fault, which has been styled the Lachnagar Fault by Prof. David, and as the average dip of the strata is north-easterly the lower portion, stratigraphically speaking, is truncated by this fault.

(1) Volcanic Stage.

The principal feature of this division is the great series of lavas, extending in an unbroken curve from Eelah to Lamb's Valley, wonderfully uniform in total thickness and in the sequence of flows. An exceedingly fine section through this volcanic series is got by ascending Hudson's Peak from the south or south-west, and then descending to a saddle or col and ascending the spur leading to the top of Drinan's Mount. Other sections, showing substantially the same sequence, but not so striking, may be obtained by ascending anywhere the ridge extending from Drinan's Mount to Eelah, while, for those who dislike climbing, excellent road-sections are found at what is known as "The Gap," near Eelah, and along Lamb's Valley, which cuts almost directly across the strike, exposing the entire sequence from the Lachnagar fault northwards for about a couple of miles to the bridge over

Lamb's Creek. The general succession is included in Plate XX, Fig. 1.

This region is a particularly good one in which to study the volcanic flows, since for the most part the succession of lavas is uninterrupted by interbedded tuffs and conglomerates, as is the case elsewhere. A section has been measured between Hudson's Peak and Drinan's Mount, the details of which are approximately as follow, in descending order:—

	Feet
Rhyolite (including about 10 feet of dacitic pitchstone)	230
Toscanite and dellenite	560
Pyroxene-andesite and conglomerate	360
Toscanite and dellenite*	175
Hornblende-andesite and glass	360
Pyroxene-andesite breccia	215
Pyroxene-andesite	1110
Pyroxene-andesite glass	90
Hornblende-andesite	60
Hornblende-andesite glass	40
	3200

This section probably gives the maximum aggregate thickness.

Individual flows vary in thickness when traced along the strike, and in places may vanish altogether. The lower hornblende-andesite, for example, disappears north of Hudson's Peak and at Eelah, and the top toscanite, which is so prominent at Eelah and at Drinan's Mount, thins out and disappears between these two points for a short distance, and also to the north of Drinan's Mount,

* These two types are often closely associated on the same horizon, and cannot be differentiated in hand-specimen, while even in thin section, owing to albitization of the original plagioclase, distinction is difficult and sometimes impossible. Elsewhere in this paper the rock-name "toscanite" is used to indicate flows some phases of which may be dellenitic.

making again north of Kilfoyle's Creek, and forming quite a wide outcrop in Lamb's Valley.

While the general succession of flows is constant, occasional small flows are found out of place, as it were; examples are the lens of hornblende-andesite near the Eelah Gap, the abruptly lenticular mass of pyroxene-andesite pitchstone at the entrance to Lamb's Valley, and the small mass of hornblende-andesite and pitchstone forming a little knoll in among the topmost rhyolite flow north of Kilfoyle's Creek. The small outcrop of biotite-dacite pitchstone in the topmost rhyolite near the summit of Drinan's Mount, appears to be the only one of its kind in the area.

Of all these units the most impressive is the lower pyroxene-andesite, because of its thickness and its physiographic prominence, which is all the more marked because the lava is underlain by easily eroded tuff and conglomerate, making for the formation of a dip-scarp. The line of the pyroxene-andesite ridge can be traced with some interruptions from the parish of Stanhope, south-easterly as far as Hudson's Peak, where the lava attains a thickness of 1200 feet, and where it shows a rude prismatic jointing. About Rosebrook the relief is very much less marked, possibly through the flow, or succession of flows, being thinner, but the andesite rises again to form the more westerly of the twin low bare hills just south of the road through the Eelah Gap, only, however, to sink once more and disappear beneath the river-alluvium. The rock is markedly porphyritic, and occurs in both lithoidal and glassy phases, which are apparently quite distinct, though frequently found together, as at Hudson's Peak, the glassy phase being generally the subordinate type.

Through the low col or saddle east of Hudson's Peak there runs an outcrop of andesitic breccia, and somewhat similar outcrops are seen at the forking of the roads at Rosebrook and in the col between the two low bare hills at Eelah. The breccia always occurs at or near the top of the pyroxene-andesite, and this fact, along with the thickness (over 200 feet in the first outcrop), suggests that it is a volcanic rather than a fault-breccia.

A band of hard fine-grained tuff is seen on the Eelah road, about a mile S.E. of Hudson's Peak, near Mr. Dooley's house, evidently interbedded with the pyroxene-andesite.

The upper flow of pyroxene-andesite is not usually so thick as the lower. On the Hudson's Peak-Drinan's Mount section it is much finer-grained than the other, and is intimately associated with a bed of conglomerate. About a mile north of the Peak an exposure in a creek-bed shows the andesite and conglomerate to have been apparently contemporaneous; the pebbles, though mostly of pink granite, are in places composed of the andesite, which elsewhere forms a matrix to the granite pebbles, though this matrix is usually a biotite-bearing felspathic tuff. North of Kilfoyle's Creek the flow gradually thins, so that on the Lamb's Valley road-section it has no great thickness at all. South-east from Drinan's Mount the andesite, with its attendant conglomerate, persists for some distance, then the latter dies out, and the andesite is at first underlain, and eventually almost superseded by an andesitic pitchstone, which carries on right to Eelah, forming a prominent ridge there. Siliceous thermal waters have converted the pitchstone in places on this ridge into green and white chalcedony, and veins of the same material ramify through the rock.

Of the toscanites the lower horizon, though comparatively thin, is wonderfully persistent, and has never been found missing from any section examined. This rock, when unweathered, has a characteristic blue-grey colour, with abundant phenocrysts of quartz, felspar, and biotite. The upper horizon is by no means so persistent, and in some places disappears completely. The greatest thickness of this upper horizon is perhaps at Drinan's Mount, and here it is evidently composed of a number of flows of aspect and composition slightly different among themselves. The lowest flow when fresh has a grey colour weathering to khaki-brown, the upper ones being brownish-red, buff, or lavender, while the proportion and nature of the phenocrysts vary, the grey and brown phases being very rich in biotite, and showing very little felspar and quartz, while the other phases are rich in both.

The hornblende-andesite is found on two main horizons, the lower of which is not very thick nor very persistent, while the higher is quite important and continuous right through; a thin flow of pitchstone in very many places underlies the stony phase. This rock is identical with that called the Martin's Creek type by Süssmilch and Osborne, and in this area it has almost invariably been found to contain a small proportion of quartz among the phenocrysts. The rock has a very characteristic appearance; it is usually quite a bright blue colour when fresh, changing on decomposition to a brownish-grey, and is often recognisable by its tendency to platy parting, which causes it to break into slabs or flags from two to five inches thick. In places, as at Eelah, owing to hydrothermal changes, the aspect of the rock changes somewhat, and its recognition is less easy. The pitchstone, though often closely associated with the stony phase, differs from it mineralogically in containing notable proportions of biotite and hypersthene, in addition to hornblende, among the phenocrysts.

Along the Eelah road, just after it passes from the parish of Wolfingham to Middlehope, there is what appears to be an irregular dyke-intrusion through the hornblende-andesite, the only one of its kind yet encountered. Thin sections show it to belong to the hornblende-andesite group.

The rhyolite or porphyritic felsite at the top of the volcanic series clearly represents more than one flow, as it changes character a good deal from place to place. On Drinan's Mount the only conspicuous phenocrysts are of biotite set in a buff or pink groundmass, containing numerous inclusions and occasional patches of chalcedony. At Eelah one phase contains small phenocrysts of quartz, but there is another on top of it from which megascopic quartz is absent. North of Drinan's Mount the rock is often found to have conspicuous phenocrysts of white felspar in a pink or reddish groundmass, but elsewhere little biotite crystals are the most important porphyritic constituents.

In a few places there appear to be traces of a thin flow of toscanite on top of this felsite.

On the whole, the series just described is wonderfully compact, with a remarkable uniformity of type-variation from top to bottom. It evidently corresponds with the Martin's Creek beds of Süssmilch and the Volcanic Stage of Osborne. But whereas these observers find no lava-flow stratigraphically below the hornblende-andesite, which rests directly on the Wallarobba tuffs and conglomerates, at Hudson's Peak the hornblende-andesite, as may be seen in the section, is underlain by 1250 feet of biotite-rich tuff and tuffaceous conglomerate containing abundant pebbles of pink granite, felsite, and other hard rocks, on a few of which glacial striae have been observed. Small flows of felsite and of pyroxene-andesite are interbedded with the underlying conglomerates, and the lowest exposed member of the sequence is a porphyritic felsite underlain in places by thin flows of pyroxene-andesite and pitchstone. Immediately to the west of this runs the Lachnagar fault, which causes the rest of the series to be concealed from view.

This lowest flow of felsite, which varies in facies from place to place, and shows well-marked flow-planes dipping steeply in an easterly direction, can be traced from the parish of Stanhope, where it forms an east-and-west ridge; about ¾-mile east of the Maryvale turn-off it makes a rather sharp turn to the south, crossing the road and continuing a little east of south for about a mile, when its outcrop stops suddenly, the ridge being carried on to the south by a toscanite dipping to the west. This sudden break is evidently due to the Lachnagar fault, which has been running more or less parallel to the felsite, but here makes a sharp turn to the east, cutting off the felsite, which is never with certainty picked up again.

The conglomerate and tuff immediately underlying the Hudson's Peak hornblende-andesite can be picked up at intervals along the strike towards Eelah, as at the village of Gosforth, where they are represented by abundant pebbles, mostly of pink granite with some grey granite. Conglomerates are likewise seen at Rosebrook, near Mr. Campbell's house, and along the road as far as Mr. Magnus Campbell's, beyond which they die out, but farther south fine felspathic grey tuffs appear under the pyroxene-andesite. At Mr. Magnus Campbell's a traverse from the road westwards towards the river shows a small thickness, possibly about 100 feet, of conglomerate, underlain by a rather decomposed porphyritic felsite, under which is hornblende-andesite pitchstone. The felsite may possibly be on the same horizon as that outcropping at the mouth of Lamb's Valley, and if this be so the overlying conglomerate and tuff have thinned out very considerably.

The lithology of all the conglomerates mentioned above is exactly similar to that of those occuring at higher levels, showing that we are here not dealing with the basal stage of the Kuttung series. The whole thickness of strata, therefore, in the Hudson's Peak section from the base of the hornblende-andesite westwards to the Lachnagar Fault, probably of the order of 2300 feet, is to be added to the volcanic stage, the total exposed thickness of which here is of the order of 5500 feet.

(2) Glacial Stage.

Turning again to the topmost flow of the volcanic stage at Drinan's Mount, we find it overlain by a series of sediments belonging to Osborne's Glacial Stage. The very flat dip of these in places strongly suggests an angular unconformity with the underlying volcanic rocks, this feature being very marked at the back of Drinan's Mount, as viewed from the north.

A very interesting series of variations is seen in the strata when traced north from Eelah. At the back of Eelah House, where the whole series emerges from the alluvium covering it to the south, the rhyolite is overlain by a band of conglomerate not more than 100 feet thick, containing rounded pebbles of granite, gneissic granite, aplite, and quartzite up to nine inches in diameter; in the blue-grey matrix are embedded numbers of small angular and subangular rock-fragments, giving the rock in part the aspect of a tillite.

Following up the valley of the creek (which I have called Eelah Creek) draining the country east of the Rosebrook ridge, we find the conglomerate thickening considerably. The basal parts consist of very large toscanite boulders, some upwards of six feet in diameter, and well-rounded for the most part, embedded in a matrix which is similar in appearance to the enclosed boulders, and which is, in fact, a toscanite; overlying this volcanic conglomerate is another conglomerate characterised by abundance of smaller pebbles, averaging about ten inches across, mostly of the hard pink granite or aplite which is such a constant constituent of most of the Kuttung conglomerates.

These conglomerates, which may be regarded as the basal beds of the glacial stage, can be followed, resting directly on top of the volcanic rocks, from Eelah House for about 2½ miles in a north-westerly direction at the back of the Rosebrook ridge; then they give place apparently to tuff and varve-rock, which continue in contact with the volcanic rocks as far as the culminating point of the ridge—Drinan's Mount. In the creek just north of this point the rhyolite underlies a very hard tillitic rock, containing small pebbles and angular fragments of felsite and grey granite, or more precisely granodiorite, and containing a few grey granite boulders, one of which, an exceptionally fresh granodiorite, would appear to have been upwards of ten feet across originally. The granite boulders quickly become very numerous, and the horizon, which is about 150 feet thick a little north of Drinan's Mount, continues to the north-west as a conglomerate composed essentially or dominantly of uniformly well-rounded boulders of grey granite, averaging perhaps 15 inches in diameter, often rather gneissic and generally very decomposed. So abundant and close-packed are these boulders that the disintegration of the rock gives rise in places to a coarse sandy soil, closely resembling that formed by granite.

This horizon (which also contains a goodly proportion of pink aplite and quartzite pebbles) can be found outcropping at intervals in the creek-beds following a general north-westerly direction from Drinan's Mount, and thickens to possibly as much as 300 feet where the track ascends

Wildman's Gap. On the road along Lamb's Valley it appears just a little south of the bridge over Lamb's Creek. At this bridge, and for about a mile upstream, a magnificent outcrop of the conglomerate, characterised by unstratified and unsorted boulders up to four feet across, may be studied, both in plan and in section. Here it has a flat dip, and probably has quite a considerable width of outcrop, but the bridge forms the northern limit to the present survey. About a mile east of the bridge the junction between conglomerate and felsite swings away to the south-east, and in a tributary to Lamb's Creek boulders of felsite up to ten feet in diameter appear in the conglomerate near its base, evidently rifted off from the underlying lava-flow.

This conglomerate is one of the most striking formations in the area examined; it is practically unique as regards its lithology, and the great abundance and the size of the granite boulders enable it to be identified without difficulty. The absence of definite stratification, the presence of occasional abnormally large boulders, the subangular shape of some of the harder pebbles, and the merging of the conglomerate into a tillite, suggest ice-action, and this view is strengthened by the occurrence of varve-shales immediately on top of the conglomerate. The associated strata are of freshwater origin, and the conglomerate may have been laid down on the floor and round the margin of a very large freshwater lake filling a depression excavated in part in rhyolite, with ice-capped granite highlands some distance away.

At all events this horizon marks a definite change in conditions, and in this division at least ushers in what must be regarded as a new phase in the sedimentation. It is evidently the equivalent of the coarse conglomerate described by Osborne as occurring at the base of the glacial stage in the Paterson-Clarencetown area.

The details of the sequence in the glacial stage vary from place to place. At Eelah House the conglomerate is overlain by a variable thickness of varve-rock which marks the top of the stage. Further north, between this varve-rock and the conglomerate there are local occurrences of tillite, pebbly mudstone and tuff. About half-a-mile south of the northern boundary of portion 26, parish of Middlehope, the series, which is here about 400 feet thick, and has never exceeded 500 feet, begins to increase rapidly in thickness as the result of the incoming of fine and coarse acid tuffs, pebbly in places, which more than compensates for the thinning and local extinction of the conglomerates. At the same time a series of varve-shales makes its appearance resting directly on the volcanic series, and between the top varve-shales and the Permo-Carboniferous Lochinvar Shales are bouldery mudstones, weathering easily to a very dark brown clayey soil.

The upper part of the glacial stage swings off in a north-easterly direction sympathetically with the Permo-Carboniferous basin in the parish of Houghton, and has not been further studied.

At the back of Drinan's Mount the following section through the lower portion of the glacial stage has been measured:—

	Feet
Conglomerate	2
Varve-shales	220
Tuff with a little conglomerate	220
Varve-shales with *Aneimites*	70
Tillite, passing northwards into grey granite conglomerate	150
	662

The divide to the north of Drinan's Mount is composed mostly of the tuff and overlying varve-shales, on top of which are in places a few feet of conglomerate capped occasionally by small patches of toscanite.

On ascending the plateau at Wildman's Gap by the bridle track from the valley we pass over conglomerate and then tuff for the first 450 feet; at the top of the first ascent is a small and thin outcrop of toscanite. A fairly level walk of about 400 yards over tuff, followed by another abrupt rise of 80 or 100 feet over coarse conglomerate, brings us to the top of the plateau, the varve-shales that separate the tuff and conglomerate further south having disappeared. About 150 yards along the track from the edge of the plateau we reach the overlying toscanite, which is thin here, but thickens considerably to the north-east and north-west, disappearing rapidly to the south. It is on this toscanite about a mile to the north-east that the striated pavement occurs, discovered by G. D. Osborne in 1921.[4] The outcrop forms the edge of the plateau from the head of Parson's Brush, at least as far as Mr. Bell's house, where the mass is over 100 feet thick, and the toscanite is constantly underlain by the coarse conglomerate, but details of the strata between this horizon and the base of the stage are difficult to obtain owing to cliff-talus and alluvium. Along the Wildman's Gap section, the thickness of the glacial stage up to the base of the toscanite (corresponding with the Mt. Johnstone beds of Süssmilch) is not less than 1700 feet, an increase of over 1000 feet compared with that of the same beds a mile to the south-east, at Drinan's Mount.

The toscanite, which has been shown by Osborne to be identical with the Paterson toscanite, is overlain variously by varve-shales, tillite, mudstones, and conglomerate, towards some of which its relations are doubtful. In the bed of Webber's Creek, for example, the overlying mudstone is hardened, and appears as though intimately penetrated by stringers of toscanite. Just over the brow of the plateau at Bell's house there are hardened varve-shales apparently underlain and overlain by the igneous rock, and on the valley slope just to the east, conglomerates are interbedded with the toscanite. These features suggest the possibility that the toscanite is a sill-intrusion, but if so the overlying sediments must have been eroded off before the advent of the ice which produced the striated pavement, and deposited the tillite on top of it. It may be that the toscanite represents a series of subaqueous flows, which assumed in part an intrusive relationship towards the varve-clays and the pebble-and-mud deposits accumulating on the floor of a Kuttung lake or inland sea.

The geology of the plateau is at present being investigated by Mr. G. D. Osborne.

The Winder's Hill Division.

Under this heading is included an area bounded on the north by the winding Hunter River, and extending southward to within a mile of the village of Lochinvar.

The Kuttung rocks of this division consist entirely of beds which are the faulted equivalents of the tuffs and aqueo-glacial rocks resting upon the volcanic series of the Drinan's Mount Division.

From the village of Gosforth the beds swing round in a wide sweep to the south and south-west, towards Lochinvar, and then to the north-west and north, dipping outwards all the way and forming the southern portion of the lower or Carboniferous part of the Lochinvar dome, the lowest outcropping beds in the division being found on the northern scarp of Winder's Hill.

A section showing the sequence from Winder's Hill towards Lochinvar was published in the paper by Süssmilch and David, which requires some modification in the light of a fuller examination of the rocks. The revised section along the line HK (Plate XX, Fig. 3), which was measured in a direction of S. 7° W. from Winder's Hill, probably gives the most complete sequence and the maximum thickness of the beds, for some of the horizons become much thinner and others die out completely or are cut off by faults when traced along the strike; the direction of section is also approximately that of the longer axis of the dome.

The series rests on an old surface of granodiorite, and there is reason to believe, as will be shown hereafter, that the lowest horizons correspond in stratigraphical position approximately with the tillite at the back of Drinan's Mount, which merges into the grey-granite conglomerate, so that the section as shown gives the complete sequence from top to bottom of the glacial stage for this particular division.

The granodiorite outcrops are of very limited extent, being confined mainly to the lower part of the northern face of Winder's Hill; a few very decomposed remnants also occur on the opposite side of the river and along the eastern boundary of portion 72, parish of Wolfingham. This granodiorite evidently represents part of an old land-surface over which the Kuttung glaciers moved, for at Winder's Hill it is immediately overlain by tillite containing angular fragments, large and small, of the granodiorite. The tillite passes upwards into dark-red varve-shales, which exhibit contemporaneous contortions and, in places, the worm-tracks that are a characteristic feature of the similar rocks at Seaham. Traced upwards the shales become coarser in texture, and pass into flaggy, tuffaceous sandstones, on which in turn rest fine varve-like shales containing *Aneimites*.

Altogether seven horizons of varve-rock have been noted in this section, but the lateral extent of some of them has not been determined. The topmost horizon, however, is quite persistent, and can be traced round most of the area, forming the stratum next below the Lochinvar shales; a lower horizon, that which outcrops on the face of what may be called Hut Hill, south of the dam on Hawes Farm, is associated with very plentiful and well-preserved impressions of *Aneimites ovata,* and the varve-rock proper grades down into what appears to be a very fine-grained, white, cherty tuff.

Of the various conglomerate horizons shown on the section, at least two have been proved of aqueo-glacial origin by the occurrence in them of ice-scratched pebbles, and it is probable that all have had the same origin. The pebbles are, as a rule, well-rounded, and are composed largely of hard, red aplitic granite, quartzite, etc., and also in the higher horizons of quartz-porphyry or rhyolite, and occasionally of pink felsite. The matrix appears to be tuffaceous in most cases, and, indeed, the conglomerates in many instances, by diminution in the size and number of pebbles, pass into pebbly tuffs. Underlying the topmost varve-rocks at the village of Gosforth, and outcropping half-way up the hill on the road to the Hillsborough Bridge, is a very hard and tough dark bluish-grey rock, occasionally pebbly, which has all the appearance of a tillite. Traces of this same horizon may be seen as the strike of the beds is followed round to the south, but it does not persist for any great distance.

About three-quarters of a mile south of the Windermere crossing, on the road to Lochinvar, there is a good section of the topmost varve-shales overlain by a tuffaceous conglomerate, which continues to the east and south-east, thinning out and apparently disappearing on the south-eastern face of Hut Hill; this then locally replaces the varve-shales as the topmost Kuttung horizon.

Volcanic ejecta, mostly fragmental, make up about 1300 feet of the total thickness of 4000 feet of strata measured along the line of section, and tuffaceous rocks form a very important part of the glacial stage in this division. Starting in the bend of the river north-west of Winder's Hill the main belt of tuff sweeps round to the south-east in a great crescent, attaining its greatest thickness where the section-line intersects it, and thinning as it swings round again to the east, where it is cut off by the Hillsborough fault. Further north it is well seen on the northern face of Bald Hill, whence it continues northwards along the steep river-bank almost as far as the Hillsborough Bridge.

The tuffs are always rhyolitic in character, and are composed for the most part of angular fragments of white or green felsite and quartz, the grainsize varying considerably. The finer tuffs may be thinly bedded, but the coarser ones are generally massive, as between Hillsborough Bridge and Bald Hill. These coarser types have the bedding indicated by occasional pebbly bands, and pass locally into breccias. A very beautiful felsite-breccia with fragments up to half-an-inch in diameter is exposed near the top of Hut Hill, while on the eastern slope of the same hill along a north-and-south fence, there is to be seen another dark red tuff-breccia or conglomerate, containing rounded and angular fragments of felsite up to an inch in diameter, with chips of glassy quartz in the matrix.

Much of the tuff in the crescentic outcrop south of Winder's Hill has a characteristic light blue-green colour, and some of it is quite aphanitic in hand-specimens, the microscope revealing it as a very acid, devitrified pumiceous tuff.

There are a few massive igneous rocks among the strata in this division, apparently not wholly effusive; the section southwards from Winder's Hill includes three occurrences. The lowest is a dark, brownish-green aphanitic rock, slightly amygdaloidal, which may be observed in a couple of places on the northern face of Hut Hill and elsewhere, the outcrops being as a rule of but slight extent. This appears to be an albitized basalt, and though it may be of the nature of a contemporaneous flow, a rude prismatic structure in the overlying tuff at the dam north of Hut Hill suggests the contact-effect of a sill.

A small outcrop of rhyolite, very rich in inclusions, appears on the northern face of Hut Hill, and at a higher horizon, immediately under the topmost varve-shales, is a pink felsite which is of much greater extent, being traceable at intervals from a little west of the Windermere-Lochinvar road (where it emerges from a cover of high-level alluvium) across the southern face of Hut Hill to the southern branch of Hawes Farm Creek. The effusive character of this felsite is proved by the association with it, west of the Windermere-Lochinvar road, of a pyroclastic phase.

Along the river between Bald Hill and Hillsborough Bridge, a number of felsites are encountered; one, a dyke prismatically jointed in places, cuts southward diagonally along the river-bank, emerging on to the top of it, and continuing as far as Fault Creek, where it is cut off by a fault. The appearance of this dyke suggests that it has been injected in a vertical position while the strata were still horizontal, and has been tilted during the subsequent folding. Further north is what appears to be a sill or thin laccolite of white fluidal felsite a little over half-a-mile long. Among the tuffs near the river-level between Hillsborough Bridge and the Bald Hill is a flow or intrusion of highly jointed felsite. Another small felsitic intrusion is found east of the Hillsborough-West Maitland Road, a little way north of the Gosforth turn-off, the invaded sediments including the bluish-green tillitic rock immediately under the topmost varve-shales. There is nothing to indicate whether these intrusions are of Kuttung or Permo-Carboniferous age.

Rhacopteris (*Aneimites*) has been found in this division in quite a number of places, either in a kind of light-coloured shale, or in a fine tuff. In the former case the pinnules and fronds, together with what appear to be stems of the plant, and sometimes calamite-like stems as well, often form close-packed masses in the shale, which is easily and thinly cleavable, each new fracture exposing more of the fossils. In other cases where the plant occurs in tuff, fine but coarser than the shale, well-preserved individual pinnules or isolated fronds may be found. Two horizons have been noted on the road just south of Hillsborough Bridge; these same horizons have been found east of the road in Mr. Robert Vile's paddock (portion 44), and may be traced among the coarser tuff along the river bank upstream, one horizon on the very crest of the bank, the other about 40 feet down. These are possibly to be correlated with the occurrence on Hut Hill, and another a little north of Hawes Farm Creek, the former outcrop, which is associated with varve-shales, yielding particularly fine specimens. A third horizon is just under the conglomerates on the northern face of Winder's Hill, the matrix being again a varve-like or cherty shale.

It will be seen from an examination of the section that this plant ranges practically from the bottom to very near the top of the series in this division, and that it is found in close association with the aqueo-glacial sediments.

The Jacob's Hills Division.

The strata comprised in this division form the northerly continuation of those just described, but show such distinctive characters that they are best treated separately. The division extends from the Hunter at Winder's Hill in a N.N.W. direction as far as the Lachnagar Fault, at the Lamb's Valley-Hillsborough road. The western boundary lies just eastward of the Dalwood Bridge road, and is determined by the base of the Permo-Carboniferous system, while the eastern limit is in part the Lachnagar fault, in part the Hillsborough fault.

A fairly good, though interrupted, section through the sequence at the southern end of the division can be obtained by going along the river-bank upstream from the eastern boundary-fence of portion 72, parish of Wolfingham, for about three-quarters of a mile, and then continuing in a direction a bit north of west up a little tributary creek. Rotten granodiorite may be detected a little way east of the fence, succeeded by mudstone or tillite and then by dark red varve-shales which outcrop at the fence, dipping about W.S.W. These are overlain by about 300 feet of felsite-tuff, and these in turn by conglomerates, of which a splendid section may be seen forming in places a low cliff rising abruptly from the river. These are not less than 400 feet in thickness, and are probably best regarded as the equivalents of the upper conglomerates outcropping on the southern face of Winder's Hill. The pebbles, which are very badly sorted, and range up to and over 18 inches in diameter, include pink and grey granites, quartz-porphyries, felsite, quartzite, and a hard acid tuff. The matrix is composed of red tuff or arkose, notably rich in biotite, and occasional thin layers of the same material serve to indicate the direction of dip.

The conglomerates are succeeded upwards by about 100 feet of tuffs with a few thin layers of dark-red varve-shale showing contemporaneous contortions; the outcrops, probably of felsite-tuff, are here obscured by alluvium, and save for a little bedded tuff nothing more is to be seen for about 500 yards until an outcrop of conglomerate is encountered in the bed of the tributary creek. The pebbles of the lower part are badly sorted, but the small uniform size and marked rounding of the pebbles in the horizon as a whole place it in marked contrast with the conglomerate on the river-bank. Above this fine-grained conglomerate is another somewhat coarser one, characterised by abundance of well-rounded red-brown quartz-porphyry or rhyolite pebbles, on top of which occur more felsite-tuff and tuff-breccia, sometimes pebbly, sometimes fine-grained, and containing impressions of *Aneimites* and indeterminate plant-remains. The topmost recognisable horizon, of varve-shales, completes a thickness of something like 1800 feet of sediment measured from the top of the granodiorite, as compared with the maximum of 4000 feet in the Winder's Hill division.

The impersistence, both in thickness and in lithological facies, of the different members of this series when followed along the strike is very characteristic of the rock-units in the Jacob's Hills division, as is probably to be expected in deposits largely of aqueo-glacial origin, but in a general way it appears that conglomerate increases to the north, as compared with tuff and varve-shale.

The coarse conglomerate outcropping on the river-bank appears again at the top of South Jacob's Hill, containing occasional large boulders of grey granite, thence on account of the land-contours, the outcrop trends N.W., and then back to N.E., passing east of the summit of North Jacob's Hill, and swinging round to the north. The grey granite boulders are much more prominent here, and are very noticeable in the outcrops along the course of Thermos Creek. In places well-rounded toscanite boulders become prominent, and the conglomerate gets mixed up in rather perplexing fashion with some flows of toscanite, recalling the somewhat similar occurrence in Eelah Creek at the back of the Rosebrook ridge. Further north the outcrops are obscured, but what is probably the same conglomerate outcrops in Thermos Creek, near its mouth, not far south of where the whole series is cut off by the Lachnagar fault.

The distinctive lithology of this conglomerate suggests very strongly its correlation with the grey-granite conglomerate resting on the top of the volcanic series in the Drinan's Mount division, although here it does not appear to have any marked stratigraphical significance.

If now we return to the original starting-point, and follow the eastern fence of por. 72 northwards from the river for about three-quarters of a mile, the granodiorite will again be observed, but with a dark porphyritic felsite resting on it and separating it from the overlying varve-shales.

An instructive section is that along the line DEFG (Plate XX, Fig. 2). Here the felsite (which is cut off to the east by the Hillsborough fault) is overlain by pyroxene-andesite, which has a glassy phase at the top. Between the andesite and the lowest varve-shales a wedge of aqueo-glacial conglomerate has come in, and there is a thickness of about 400 feet of tuff, conglomerate and varve-shales between the base of the grey-granite conglomerate and the top of the andesite. Here, as elsewhere, there is not an abrupt change but a gradual passage from tuff to conglomerate.

In this section, involving about 1500 feet of strata, no less than five horizons of varve-rock are seen, and it is possible that others are obscured by soil and talus. That immediately overlying the grey-granite conglomerate is about 110 feet thick, but thins out to the north, west, and south. The most imposing individual horizon shown is that of the conglomerate rich in quartz-porphyry pebbles, which is here upwards of 300 feet thick. Two thin layers of toscanite, of slight extent, are met with on this section, one in among the quartz-porphyry conglomerate, and another near the top of the series. The latter is probably a flow, but the former may be a sill, as there is not far away a small circular outcrop of similar toscanite in among the conglomerate and obviously intrusive.

Further north than the section-line FG there are, in addition to the pyroxene-andesite, flows of hornblende-andesite and pitchstone and of pink porphyritic felsite, on the last of which the grey-granite conglomerate rests (see Fig. 1). So far as can be observed these flows are separated by bands of conglomerate, but the relatively feeble drainage at the eastern foot of the Jacob's Hill ridge has resulted in the formation of long, gentle, soil-covered slopes, so that horizons of tuff and of varve-shale, if present, would be difficult of detection.

On the ridge and dip-slope about half-a-mile north of North Jacob's Hill, and on a higher horizon on North Jacob's Hill itself, are flows of toscanite. The former are those noted above as being intimately associated with the grey-granite conglomerate, and indeed the conglomerate can in one place be traced into the toscanite, as if sandwiched in between flows. Elsewhere on the dip-slope conglomerate and lava are intimately associated, and there are places in which boulders of toscanite and granite appear to be embedded, close-packed, in a matrix of toscanite. What is the precise significance of this state of affairs it is hard to say, but it would appear that sedimentation and volcanic activity were proceeding synchronously, flows of toscanite being poured out at intervals and engulfing or covering the boulders in course of deposition round the margin of a large lake. The toscanite is similar to those occurring in the volcanic stage, and to the Paterson toscanite, but cannot be definitely correlated with any one of them so far as stratigraphical position is concerned.

An interesting feature brought out in the section ABC is the existence of a layer of basalt and basic breccia and tuff not far below the top of the Kuttung series. This appears as a lenticular mass with a north-south extension of half-a-mile about 25 chains to the west of North Jacob's Hill. It is evidently conformable with the Kuttung sediments, and has the appearance of being contemporaneous with them. On a ridge about half-a-mile west of South Jacob's Hill a small outcrop of basalt has been observed not very far above the horizon of the grey-granite conglomerate, but whether this is an intrusion or a contemporaneous flow I cannot tell.

The felsite-tuffs which are so prominent in the Winder's Hill division continue north across the river, and form an important part of the rocks of the Jacob's Hills division. One horizon immediately overlies the lowest varve-shales and outcrops strongly for some distance north of the river, but gradually thins, and is replaced by conglomerate to the north. There is also a good thickness of felsite-tuff, both fine and coarse, above the grey-granite conglomerate horizon interbedded with conglomerate and varve-shale, and extending right to the top of the series.

From about three-quarters of a mile north of North Jacob's Hill most of the lower part of the series is cut off by the Lachnagar Fault to the east, and the upper part, that above the grey-granite conglomerate, thins considerably, being not more than 300 feet thick, whereas along the Hunter it exceeds 1000 feet. In this northern part also tuff and varve-shales are very subordinate, and the series is made up largely of conglomerate, with a couple of lava-flows, the lower being a dark chocolate-red felsite, containing many inclusions, and the other a thin northerly extension of the toscanite in Thermos Creek.

Above this flow the conglomerate is very rich in quartz-porphyry pebbles, some up to three feet in diameter, as in the quarry across the road from ''Maryvale'' homestead. This appears to be a continuation of the quartz-porphyry conglomerate noted on the section along the river-bank, which attains a considerable thickness along the line of section DE, thins out under the basic lava and tuff, and makes again, extending at ''Maryvale'' almost to the base of the topmost varve-shales.

Reasons have been given for correlating the grey-granite conglomerate of this division with the similar horizon marking the base of the glacial stage in the Drinan's Mount division, and from certain indications it would appear most reasonable likewise to correlate it with the thick conglomerate on the southern face of Winder's Hill. If this is so, there are some 400 feet of strata exposed in the Jacob's Hills division, and about 600 feet in the Winder's Hill division, which are below the base of the so-called glacial stage. These strata are to a very large extent aqueo-glacial and glacial in character, and they emphasise, in conjunction with the scratched pebbles in the Hudson's Peak conglomerate, the fact that glacial action commenced much earlier in the Kuttung period that has hitherto been supposed, and that for this area, at least, the distinction between glacial and volcanic stages has no real meaning.

The Hillsborough Division.

This is of very small extent, but is described separately on account of the difficulty of assigning its strata to their proper stratigraphical position. It is a roughly triangular area, bounded on the south and east by the Hunter River, on the west by the Hillsborough Fault, and on the north and north-east by the road from Hillsborough Bridge towards Lamb's Valley. There would appear to be three principal units in this division:—(1) A low ridge of felsite-tuff and conglomerate lying south and south-west of Mr. Robert Vile's house, with a general north-easterly dip, and underlain by a thin flow or sill of pyroxene-andesite; (2) a rather more conspicuous ridge of varve-shale running almost east and west at the back of Mr. B. Cant's residence towards Mr. R. Vile's; and (3) between this ridge and the road an area of pyroxene-andesite with a little felsite.

The dips of tuff and varve-shale are so conflicting, owing to minor faults, and the outcrops of the different units so obscured in places by soil and creek-alluvium, that it has been found impossible satisfactorily to interpret their relations to each other and to the rocks of the other divisions. The felsite-tuff is exactly similar to that on the opposite bank of the Hunter, and may be a continuation of it, though the dip-directions are slightly out of harmony. Most of the dips on the varve-shale ridge are to the south and south-east, but in many places the rocks are on edge, and elsewhere they are inclined in directions between north and east. On the northern side of the ridge they pass in places into tuff and conglomerate, which, in turn, give place to pyroxene-andesite.

For the most part no dips are obtainable on the pyroxene-andesite, but the general slope of the country formed by it is between north and east, and in a creek along the eastern boundary-fence of portion 71, about 120 yards south from the road, there is rotten andesite exposed, which gives the impression of a north-easterly dip.

While the varve-shales and tuff most probably belong to the top part of the Kuttung sequence, it is difficult to place the andesite; possibly it has been brought against the varve-shales by faulting, and it may be the equivalent of the andesite and felsite of the Jacob's Hills division, but on the eastern side of the dome, for the Hillsborough Fault just here must cut through pretty close to the axis of the dome.

About a quarter of a mile west of Mr. B. Cant's house is a road-metal quarry in the varve-shales, giving a good exposure. The characteristic paired laminae are very well exhibited, the colours alternating between chocolate-red and light grey-pink, and there is much contemporaneous contortion, the disturbance being confined to certain well-marked horizons. A few isolated pebbles have been noted, evidently having been dumped in the glacial clays, and traces of plant-fossils, including species of *Aneimites* and *Cardiopteris,* have been found in the quarry and on the ridge above it. A thickness of about 10 feet of sediment is exposed in this quarry, and in another one a short distance away.

Nowhere else in the district is there such an excellent spot for studying the varve-shales, and it is, therefore, the more to be regretted that the precise horizon of their occurrence here cannot be stated with any pretence of certainty.

Summary of Carboniferous Geology.

Of the Carboniferous succession only the Kuttung portion is developed, and of this the basal stage is missing. The strata are much faulted, the chief dislocation being the Lachnagar Fault. On the northern side of this there are exposed strata belonging to Osborne's glacial and volcanic stages; the base of the latter is not seen, but a thickness of over 5000 feet is exposed, consisting mainly of acid and intermediate lavas, with a preponderance of tuff and conglomerate, in part aqueo-glacial, in the lower portions. The so-called glacial stage is very thin near Eelah, but thickens considerably to the north; it consists mostly of tuff and aqueo-glacial deposits, with a little tillite, and has a well-marked basal conglomerate, which appears to rest unconformably on the rocks of the volcanic stage. A mass of toscanite, the equivalent of Osborne's Paterson toscanite, appears in part of the area, and in one place bears on its surface glacial striations.

In the Winder's Hill division, resting on a floor of grano-diorite, there are 4000 feet of strata, including much felsite-tuff, two horizons of tillite, and several of varve-rock and aqueo-glacial conglomerate.

The strata continue across the river into the Jacob's Hills division with decreasing thickness, and are cut off to the north by the Lachnagar Fault. Sections across this division disclose the existence of several varve-shale and aqueo-glacial conglomerate horizons, as well as much felsite-tuff, and a number of lava-flows.

The Hillsborough division contains outcrops of felsite-tuffs, varve-shale, and pyroxene-andesite; but, owing to faulting and other causes, the relations of the various units are indeterminate.

The succession of the strata differs in many respects from that recognised by Osborne in the Paterson-Clarence-town area, and the divisions proposed by him are not entirely applicable here.

PERMO-CARBONIFEROUS.

No detailed examination of the Permo-Carboniferous rocks was made beyond what was incidental to the determination of the upper limit of the Kuttung succession, but as some new facts came to light during the progress of the survey a short description will not be out of place.

In a paper by W. S. Dun and myself,[5] reasons were given for considering the Lochinvar shales as the basal horizon of the Permo-Carboniferous system for the area now being described. This formation has been described by Prof. Sir Edgeworth David[3], and some additional notes have been given in the paper mentioned above, so that little need be added here.

These dark-red shales form a remarkably persistent horizon, and have proved extremely useful as a datum-bed for mapping purposes, inasmuch as owing to their easily-eroded character they occur in depressions between the underlying hard Kuttung rocks and the overlying plant-bearing sandstones. Only in a few places do the shales fail entirely; one of these is along the road south from Windermere crossing, where the topmost Kuttung horizon, a fairly heavy conglomerate, is overlain directly by the Permo-Carboniferous plant-bearing sandstone. The boundary is here on top of a hill, in itself a sufficient indication of the absence of the Lochinvar shales.

Along the western margin of the Jacob's Hills division the Lochinvar shales are apparently thinning, for they do not make recognisable outcrops, though the characteristic soil produced by their weathering is present; indeed, this western boundary had to be mapped to a large extent on the fragmentary evidence of the presence of the topmost Kuttung varve-shales and the Lochinvar shale soil. In the creek north of "Maryvale," the plant-bearing sandstone appears to be resting directly on top of the Kuttung tuffs, owing either to strike-faulting or, more probably, to overlapping of the sandstone over the Lochinvar shales and the topmost Kuttung beds.

The Lochinvar shales make good outcrops along Eelah Creek, and have been traced as far as the northern boundary of portion 26, parish of Middlehope, at which point they are still outcropping strongly.

The included pebbles, often striated, which are such a characteristic feature of this formation, particularly in the Winder's Hill division, are usually small, but occasionally boulders of diorite, gabbro, etc., up to a couple of feet in diameter, are seen. An interesting find, made by Dr. A. A. Pain, was that of a boulder of Devonian quartzite, containing impressions of *Rhynchonella pleurodon* in the shales near Gosforth village.

The so-called plant-bearing sandstone, which is really, in part at least, an acid tuff, and in places pebbly, lies immediately on top of the Lochinvar shales. Professor David noted the occurrence in it of impressions of indeterminable plant-stems, and it has been shown to contain marine fossils in its upper portions. The sandstone occasionally takes on a peculiar mottled appearance, which serves to distinguish it when the characteristic plant-stems are missing.

A small flow or sill of buff-coloured felsite occurs in the sandstone in portion 53, Parish of Gosforth.

Next above the sandstone comes a flow of basalt, sometimes solid, but frequently amygdaloidal, the vesicles being filled with analcite, natrolite, calcite, and chalcedony. This outcrops strongly at the village of Gosforth, sweeps round to the south, forming a belt of rich dark soil, crosses the river, and continues north as far as the Lachnagar Fault. Mr. K. J. F. Branch, B.Sc., has drawn my attention to the fact that just north of "Maryvale" Homestead, there are two flows, separated by a small thickness of fossiliferous conglomerate. For the most part this basalt occurs immediately on top of the plant-bearing sandstone, but on the western margin of Jacob's Hills division it appears, in places, to overlap both the sandstone and the Lochinvar shales, and even the topmost of the Kuttung strata. In addition, a little south of the northern boundary of portion 72, Par. Wolfingham, there is some evidence that basalt has broken through the topmost varve-rock, which is hardened and brecciated and underlain by basalt.

Not far beneath this is the lens of basalt and breccia referred to above as being probably contemporaneous in the Kuttung strata.

Reference has been made to other basalts both in the Jacob's Hills and in the Winder's Hill divisions, among the Kuttung strata, and it would appear that the great outpourings of basic lava of Permo-Carboniferous times were heralded by outflows on a small scale in late Kuttung times, and that during the extrusion of the Permo-Carboniferous submarine flows, sills were injected among the Carboniferous rocks through which the volcanic pipes or feeders were being drilled.

Near Gosforth village, and further south, the basalt is overlain by calcareous shales and a little fossiliferous limestone, the resulting dark clayey soil containing abundance of calcareous nodules. The basalt is missing from the Permo-Carboniferous section east of Rosebrook ridge. Indeed, the sequence here differs in certain respects from that found elsewhere; it would appear that the plant-bearing sandstone is very thin, and that associated with it is a hard, cherty rock, weathering to a buff-coloured crust, above which are greenish, ripple-marked shales. There is no sign of basalt here until a much higher stratigraphical level is reached, although a small neck of basalt on top of the Rosebrook ridge may have been a feeder for a Permo-Carboniferous flow.

A cursory inspection of the strata to the east of Eelah makes it pretty certain that the Permo-Carboniferous sequence there, right up to the Upper Marine series, would repay investigation, which it is hoped to carry out at some future date.

Relations of Permo-Carboniferous and Carboniferous Strata.

These are to some extent discussed in the paper by W. S. Dun and myself already referred to, and the conclusion is reached that no local discrepancies in the dips of Permo-Carboniferous and Kuttung strata exist more than can be found within the Kuttung succession itself. It is pointed out, however, that the transition from terrestrial to marine sedimentation, and the violent life-break, indicate marked changes in the relations of sea and land at the close of the Carboniferous period.

These conclusions were based principally on observations made from the village of Gosforth south towards Lochinvar, but, as mentioned above, to the west of Jacob's Hills it would appear that there is overlapping of the lowest Permo-Carboniferous strata on each other, and both the plant-bearing sandstones and the basalt probably transgress in places the topmost of the Kuttung strata.

PLEISTOCENE AND RECENT.

There is a big break in the sequence of the strata represented in the Gosforth area. Following the depression of the region at the close of Kuttung times, it is practically certain that Permo-Carboniferous sediments were deposited, if not during the whole period, at all events till Upper Marine times, but these rocks have all been eroded.

Whether or not the Triassic sandstones which form the southern wall of the Hunter Valley ever extended as far north as Gosforth it is not possible to say. It is curious that, with the single exceptiton of the small outlier reported by J. E. Carne[10] from Mount Temi, near Ardglen, no outcrops of Triassic rocks are known to exist to the north of the lower Hunter Valley or the east of the Wingen-Elderslee Fault; if any were ever deposited on what are now the highlands north and east of Gosforth they were probably wiped out during the Tertiary peneplanation following on the elevation produced by the faulting.

Tertiary sedimentation is likewise unrepresented, as far as is known, and the only Cainozoic deposits belong to Pleistocene and Recent times. Apart from sedentary soils and present-day flood plain deposits, these may be divided into:—

(a) high-level river-gravels and other alluvium, and
(b) cemented rubble.

(a) The high-level alluvium is well exhibited as terraces along the Hunter River and its tributaries, particularly fine developments being observable in the bends of the river both upstream and downstream from the Hillsborough Bridge. On the left bank of the river, about three-quarters of a mile upstream from the bridge, four of these terraces are well shown at approximate heights of 120, 75, 55, and 35 feet, respectively, above the river, which is here about 50 feet above sea-level. On either side of the bridge there are three very distinct terraces at 55, 35, and 20 feet above the river, the lowest one being subject to occasional flooding. A series of terraces is also well seen immediately north of the village of Gosforth. The highest deposit, about 120 feet above the river, occurs 50 chains along the road north of Mr. A. McDonald's house; it is here, as elsewhere in the area, of fine gravel mainly, but contains abundant larger pebbles of red jasper and silicified wood, as well as of black chert, quartzite, "grey-billy," etc. The red jasperoid rocks have numerous peculiar circular or sub-circular cuts or grooves on the surface. It is notable that most of the pebbles are of rock-types quite foreign to the locality, a fact which serves to distinguish them from the pebbles of the Kuttung conglomerate close by.

This gravel-deposit rests on Kuttung strata, which surround it on all sides, so that it is isolated from the lower terraces of fine alluvium at heights of about 80 and 40 feet, respectively, above the river.

The alluvium as exposed in road-cuttings is not noticeably stratified, and chemical alteration has produced a kind of nodular structure in places, the soil being thickly studded with little ferruginous pellets.

These alluvial terraces, with the present-day flood-plains, constitute most of the cultivated land in the district, vines, citrus, and other types of fruit, lucerne, and maize being grown. Narrow belts of gravel are found amid the finer sandy and loamy soils, indicating the positions of former river-channels. The terraces are regarded as having been formed during the Pleistocene period, from the occurrence of *Nototherium* remains in similar deposits further up the river at Elderslee, as recorded by Prof. David.[3a]

(b) A curious deposit of post-Tertiary age is found sporadically distributed throughout the area. This consists of pebbles or angular rock-fragments, creek-gravel, and surface-rubble generally, the whole cemented into a more or less compact mass, usually of a dirty-grey colour. Occasionally the matrix may be quite free from large fragments. The cementation of lava-fragments into a breccia, or of pebbles weathered out of the Kuttung conglomerate into a more or less level-bedded formation, resting unconformably on the underlying rocks, is apt to cause perplexity, but the matrix does not ring under the hammer, a blow from which generally serves to disclose the true nature of the rock. In hand-specimen the matrix is rather light and somewhat porous, with a tendency to crumble when pressed between the fingers, and appears to be a mixture of gritty and clayey material.

No definite law controlling the occurrence of this deposit has been discovered; it has been found on slopes and in valleys, between the soil and the solid rock, or outcropping at the surface where the soil has been removed, and it has generally been observed in the neighbourhood of felsites, felsitic tuffs, toscanites, and varve-shales.

This formation would seem to have much in common with the "hardened grey mudstone" described by Prof. David as overlying the Permo-Carboniferous strata in the Hunter Valley[3b]. G. D. Osborne has given a clear and concise account of its occurrence in the Paterson-Clarencetown area, and I have observed it in other areas of Kuttung rocks, as in the neighbourhood of Cranky Corner, and on the north-eastern flank of Mt. Bright, near Pokolbin.

It appears possible from the mode of occurrence that the cementing material of the rock is of the nature of a chemical deposit, due in the first instance to the leaching of siliceous rocks, like the felsites, etc., by ground-water, and subsequent deposition, either through chemical reactions or by evaporation of the solvent. A chemical examination, kindly undertaken by Mr. H. P. White, of the Geological Survey Laboratory, revealed the absence of any alumina soluble in caustic soda solution, but it was noticeable that a quantity of silica was dissolved by the alkali. The cementing material is, therefore, not bauxitic, but there seems the possibility that it may be partly of silica in a soluble, perhaps colloidal, form. It likewise seems probable that the deposit was formed under the soil-layer during the present cycle of erosion, as it is found on the present-day valley-floors and valley-slopes, sometimes on quite steep slopes. True, it is being in places eroded by the present-day small streams, but these are cutting into their own alluvium, here as elsewhere in the State, as a result of deforestation and cultivation, and are most likely now eroding where they were aggrading their channels before the advent of the white settler.

STRUCTURAL GEOLOGY.

Folding.

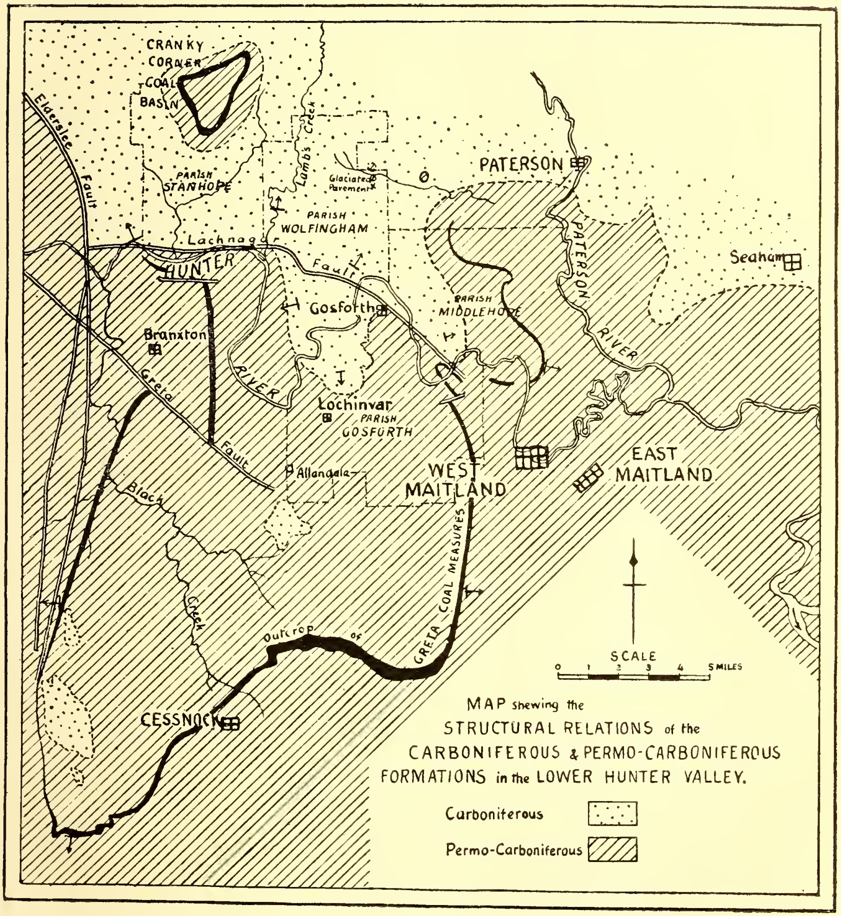
The geological structure, of which the region under discussion contains the central part, is variously known as the Lochinvar anticline and the Lochinvar dome, and it will be well to try and settle the question as to which is the correct designation, especially since the use of the term "dome" appears to have caused the structure to be regarded by some folks as a possible reservoir for rock-oil.

A consideration of the known facts leads to the conclusion that the present structure was originally a dome of somewhat irregular shape and of considerable size, but that as a result of very heavy faulting and subsequent erosion the domal character has been obscured, and may even be considered to have disappeared altogether.

The predominant factor in the modification of the original structure has been the Lachnagar overthrust or reversed fault described below, some impression of the magnitude of which can be gained from a comparison of the curvature shown by the strata in the Drinan's Mount division with that of the corresponding strata in the Winder's Hill division. Relatively to the latter area the former has been raised considerably by the fault, and erosion has laid bare in it the lower strata, wiping out thousands of feet of Kuttung, and probably of Permo-Carboniferous sediments, of which latter indeed only a few outliers remain.

It is difficult to visualise the exact state of affairs existing before the dome was faulted, but a study of the small-scale map (Plate XXI) throws some light on the matter. If we consider the northern area, it will be noticed that the Kuttung rocks close to the fault-plane dip radially outwards, from Eelah round almost as far as Elderslee. A basin of Permo-Carboniferous rocks, the Cranky Corner basin, lies in a tectonic depression of the Kuttung rocks west of Lamb's Valley. The work of G. D. Osborne has revealed the existence of another basin or dimple, in the plateau east of Lamb's Valley, in which occur small outliers of Permo-Carboniferous rocks, and Lamb's Creek has eroded its valley along the axis of a subsidiary anticlinal structure pitching to the north, which has resulted, in part at least, from the existence of the two basins. Running northwards to the west of Paterson is a gulf, as it were, of Permo-Carboniferous rocks, and it is beyond reasonable doubt that the Upper and Lower Marine Permo-Carboniferous series were originally continuous, though much thinned, from the Paterson "gulf" across to Cranky Corner and beyond; the Greta coal-measures were probably not continuous, as they are overlapped by the Upper Marine series south-west of Paterson.

If now we try to restore the strata on the northern side of the Lachnagar Fault as they would have appeared after faulting, but without erosion, we shall get a portion of a dome, the cover consisting of Permo-Carboniferous rocks, and the borders of the structure rudely goffered or wrinkled. If we go still further, and in imagination push



MAP shewing the STRUCTURAL RELATIONS of the CARBONIFEROUS & PERMO-CARBONIFEROUS FORMATIONS in the LOWER HUNTER VALLEY.

this northern area down into the position it occupied before the faulting, and restore the eroded Permo-Carboniferous cover over the area south of the fault, the result will be a dome, very unsymmetrical it is true, rather elongated, and bulging considerably at the northern end, but a dome neverthelesss.

As things are at present the continuity of the Permo-Carboniferous sediments is completely broken by erosion to the north, and for the main portion of them, those lying south of the Lachnagar Fault, the structure is probably best described as a pitching anticline, but for the Carboniferous rocks, seeing that outward dips are found to nearly every point of the compass, it is perhaps permissible to refer to the structure as a faulted dome.

The apex or apical line of the dome is probably somewhere about Hillsborough, but the Hillsborough Fault has apparently cut through the centre, and has made exact determinations impossible.

Owing to ignorance of the tectonic structure of the Carboniferous strata north of Lamb's Valley, I cannot say whether this dome was an isolated structure or whether it represented the southern end of an anticline with undulating ridge.

No evidence as to the geological age of the folding is available in the Gosforth area, but Professor David considers it to have been initiated at the close of Upper Marine times, and to have been consummated before the deposition of the Triassic sediments.[3c, 3d]

Faulting.

As seems to be the usual rule wherever the Kuttung series has been studied, the strata in the Gosforth district have been much dislocated by faulting, of which there are numerous evidences, although, owing to the presence of much alluvium and soil, and the difficulty of detecting dislocations where stratigraphically different but lithologically similar horizons are concerned, the details of the faulting are in many cases obscure.

The most important fault is that which has been termed the Lachnagar Fault by Professor David; this cuts obliquely across the area surveyed, striking east-west at Lamb's Valley, but curving to the south-east sympathetically with a marked outcrop of felsite, which appears to be practically at the base, so far as it is revealed, of the Hudson's Peak volcanic succession.

It would be natural to expect the fault to continue its easterly direction rather than make this abrupt bend, but the strike of the felsite outcrop, the continuity of which is beyond doubt, swings round sharply from east to south-east, and there is no possibility of the fault cutting across it at the bend. For about a mile the fault follows the western side of the felsite, then it suddenly changes its direction again to a more easterly one, probably passing along the creek near the junction of the Hillsborough and Eelah roads, and crossing the river a bit downstream from the Hillsborough Bridge. Its exact position just here is largely conjectural, but it can be placed within comparatively narrow limits in the Parish of Gosforth, where the topmost beds of the Kuttung are brought against what is pretty evidently the continuation of the conglomerates outcropping along the base of Hudson's Peak. Across the river again, in the parish of Middlehope, between Rosebrook and the Melville Bridge, Lower Marine strata are found on one side of the road, and pyroxene-andesite on the other side, only a few yards away.

The course of the fault beyond this point is somewhat of a mystery; it probably crosses the river again somewhere about the Melville Bridge, for just up from this on the south side of the river there is a small outcrop of volcanic rock in a quarry, discovered by Professor David, and shown on the map accompanying his memoir, which is a continuation of that which disappears under alluvium on the opposite side of the river at Eelah. This small outcrop appears to be surrounded by Permo-Carboniferous strata on all sides, and the fault evidently passes close to the western side of the quarry: thereafter it gets into Permo-Carboniferous country and is lost. Prof. David's map indicates beyond this point considerable minor faulting, but no considerable dislocations along the line of the Lachnagar fault. A "hairpin" syncline is shown near the fault at Eelah, and a bit further to the south-east, indicated by the outcrops of the Greta coal-measures and the Muree rock; it is perhaps not altogether unreasonable to regard the northern limb of this syncline, which is on the downthrow side, as having been due to local updragging, by the overthrust fault, of strata dipping towards the fault-plane. If this interpretation is correct then the fault can be continued past the Melville bridge, and may die out and be buried under an extensive sheet of alluvium which lies in its course, since there is no appearance of it in the Tomago coal-measures lying beyond.

This is the master-fault of the area, and it must have a very considerable throw; an estimate based on a section through Gosforth village and the Rosebrook ridge, the Lochinvar shales being used as a datum-horizon, puts the throw here at about 5000 feet, but such an estimate is really little more than a guess owing to the irregularities in thickness of the strata, and the very great amount of hypothetical restoration of the series necessitated by the extensive erosion. As pointed out above, this fault makes the determination of the original geological structure very difficult, but it is only fair to add that by way of compensation it has revealed excellent sections through the volcanic series which would otherwise have been hidden.

Of the minor faults the most important, the Hillsborough fault, runs along the valley to the east of South Jacob's Hill, its presence being indicated by a fault-breccia, and by the fact that west-dipping volcanic rocks of the Jacob's Hill section are in close proximity to discordantly dipping varve-shales and felsite-tuffs. This fault, which, if normal, throws to the E.N.E., is probably the same which on the south bank of the river causes the evident dislocation between Winder's Hill and the Bald Hill (the beds of the latter having a dip which would carry them into the Winder's Hill granodiorite), and which further to the south-east brings the east-dipping topmost beds of the glacial stage against the Winder's Hill strata, lower in the same stage, and with a strong southerly component of dip.

The northern end of this fault is buried under alluvium, but the mapping suggests that it continues at least as far as the Lachnagar fault, by which it may be cut off.

Another important minor fault is that shown along Kilfoyle's Creek, north of Hudson's Peak. This is admirably revealed in the course of a traverse up the creek, the displacement of the lava-flows on either side being very striking. Unfortunately the extensions of this fault have hitherto baffled investigation; to the north-east the outcrops are buried under alluvium and wash from the hills, and to the south-west, although it is evident that the fault has an appreciable throw, it has been impossible to trace it farther than the road. Indeed, the whole position about this spot is very obscure; the marked divergence in strike between the basal felsite and the Hudson's Peak lavas and the sudden disappearance of the Kilfoyle's Creek fault, both call for some explanation, which it is not possible at present to give.

It is pretty certain that a fault cuts obliquely across the Rosebrook ridge in the parish of Middlehope. Along Eelah Creek, a little east and north of the north-east corner of portion 27, there is a marked off-setting of the Lochinvar shales, the conglomerates and varve-shales comprising the glacial stage, and the topmost flow of the volcanic stage. Dislocation can also be observed on top of the ridge, and although the fault has not been traced down the western slope, near Mr. Campbell's house, on the road and between it and the river are conglomerates which when traced northwards disappear abruptly against the pyroxene-andesite. This is explicable on the view that the fault cuts through here, but the rest of its course is lost in alluvium. The throw of this fault is possibly not very great.

Very clear evidence of dislocation is seen in a creek flowing through portion 56, parish of Gosforth, about half a mile east of Winder's Hill, where the Permo-Carboniferous beds have been displaced some 700 yards by a fault striking E.S.E. The fault has provided a direction of easy erosion, but has not been traced with certainty beyond the head of the creek. The throw, if we assume the fault to be normal, is to the south, but marked jointing in the strata near the fault-plane shows a dip of about 70° in a direction N. 33° E., suggesting steep overthrusting from the north.

About a mile to the south of this the strata are again dislocated by a fault, likewise apparently throwing to the south, which has caused a marked relative displacement of the southern end of the dome towards the west. This fault has not been traced westward for any distance.

On the north-eastern side of the Bald Hill, which lies to the N.E. of Winder's Hill, is a deep gully along which the strata are notably disturbed, and in places are almost on end; the discordance of dips in the neighbourhood and the discontinuity of outcrops, indicate a fault, which may be a branch of the Hillsborough fault.

It is not certain whether Lamb's Valley owes its existence to a fault; certainly there is some suggestion of displacement of outcrops on either side of the valley along the Stanhope road, and Mr. K. J. F. Branch has drawn my attention to very heavy sub-vertical jointing in the andesite outcropping in the creek about a mile up from this road, but no definite evidence of faulting has been found.

As remarked above the varve-shales in and about the quarry on Mr. Cant's property exhibit minor dislocations, which may be subsidiary to more important faulting, but as to the existence of this no definite evidence is forthcoming.

In regard to the nature of much of the faulting, whether it is of normal or overthrust type, there are no positive indications, but the Lachnagar fault is probably best regarded as an overthrust, chiefly because of the difficulty of explaining otherwise the close juxtaposition of strata on opposite sides of the fault which are dipping in very different directions, and are at very different horizons in the Kuttung sequence. About a mile north of North Jacob's Hill, for example, there are immediately to the west of the fault strata about the horizon of the grey granite conglomerate dipping to the west. Just across the fault-plane is the felsite dipping steeply to the east, which is the lowest exposed member of the Hudson's Peak volcanic sequence, and probably over 5000 feet stratigraphically below the conglomerate. If an attempt is made to draw a section in a direction at right angles to the fault-plane here, restoration of the dome is impossible except on the assumption that the fault has been an overthrust from the east towards the west. The increasing steepness of dip close to the fault-plane on its northern and eastern sides also suggests overthrusting; the hornblende-andesite on the western side of Hudson's Peak has a dip of 30°, but the felsite near the junction of the Eelah and Hillsborough roads dips at angles up to about 60°, and the inclination of the felsite north of North Jacob's Hill is equally steep.

Now, if the fault was a normal one the south-west would be the downthrow side, and owing to down-dragging the north-easterly dip on the other side of the fault near the fault-plane so far from steepening should actually flatten; in overthrusting, on the contrary, steepening might be expected to occur.

It should be mentioned that this conclusion as to the nature of the Lachnagar fault, is in harmony with the views of Sir Edgeworth David, the officers of the Geological Survey, and G. D. Osborne, in regard to what is probably part of the same fault-system near Singleton and Muswellbrook. For reasons stated below, I had been disposed to regard the fault as probably normal, but a study of the geological map, followed by an attempt to draw structural sections, convinced me that normal faulting would not account for the facts in this particular locality.

It would appear at first sight, from the nature of the resulting displacements, that the Kilfoyle's Creek fault is normal, throwing to the north-west, but at one place along the creek close to where the fault-plane must be, jointing was observed dipping E. 30° S. at about 30°: further, there is evidence of a dragging movement in the curvature of the outcrops on either side of the fault-plane: it is probable then that there is an important horizontal component in the faulting, which may in that case have been the result either of upthrust from the south-east or of downthrow towards the south-east, combined with a horizontal south-westerly movement (relatively speaking) on the north-western side. Similar evidence of horizontal dragging is seen along the Rosebrook fault near the top of the Rosebrook ridge, where the sense of the movement has been westerly for the rocks to the north as compared with those to the south of the fault. Indeed if, as seems possible, these two faults were developed as subsidiary to the major Lachnagar overthrust, the principal movement along both of them may well have been horizontal.

That the Hillsborough fault is of the normal type is indicated by the fact that on its eastern or downthrow side to the east of Winder's Hill the strata abutting on the fault-plane dip in their original direction but at a much increased angle: this is what would be expected from the dragging of the strata down along the fault-plane on the downthrow side of a normal fault.

The throw of this fault is probably considerable, possibly of the order of 1000 feet.

Age of the Faulting.

All the faults have affected both Kuttung and Lower Marine Permo-Carboniferous rocks, and have dislocated strata already folded: if the folding commenced during late Permo-Carboniferous times then an upper limit is put to the age of the faulting. Physiographic considerations suggest strongly that the faulting took place before the Kosciusko uplift[6] of late Tertiary times, inasmuch as there would seem to have been already in existence, at the time of that great epeirogenetic movement, a peneplain carved indifferently out of the Carboniferous rocks and the Triassic rocks lying to the south of them: in other words there had been time, between the faulting and the uplift, for the production of a uniform level on both sides of the fault-planes.

These are wide time-limits, but they are the best that can be got from a consideration of the local geology: it is impossible even to tell whether all the faulting belongs to the same diastrophic period. Quite possibly the normal faults, like the Hillsborough and the cross-faults developed during and in connection with the folding. Professor David was of the opinion that most of the faults affecting the Permo-Carboniferous strata of the Lower Hunter Valley were pre-Triassic,[3d] a view which received support from Osborne's examination of the crustal shortening in the region.[7] As mentioned above, the mapping of the Hillsborough fault suggests that it is cut off to the north by the Lachnagar overthrust, which, as will be shown, is possibly of much later date.

The indications of horizontal movement of strata along the Kilfoyle's Creek and Rosebrook faults suggest that they may have been produced as the result of the differential movement westward of adjacent blocks during the Lachnagar faulting. In order to get evidence as to the geological age of the latter fault it is necessary to travel far beyond the confines of the Gosforth district.

In the small-scale map (Plate XXI) the fault is shown sweeping round in a wide curve from Eelah beyond Lamb's Valley to near Elderslee and ending against the Elderslee fault. This represents Sir Edgeworth David's original view, but he has since, in conversation, put forward the suggestion that the Lachnagar fault swings round, near the Elderslee Bridge, from a westerly to a northerly direction, so that the Elderslee fault north of the river is really a continuation of the Lachnagar fault.

The presence of a great fault bringing Carboniferous and Permo-Carboniferous strata into contact near Muswellbrook was noted by Carne and Morrison, of the Geological

Survey, in 1914,[8] and in the same year Professor David suggested, with hesitation, its continuity with the Elderslee fault.[8a] In a paper by myself[9] this fault was shown to extend northward beyond Wingen, and reasons were given for believing it to be of Tertiary age. Since that paper was written I have had the opportunity, under the guidance of Messrs. Morrison and Kenny, of the Geological Survey, of making a hurried examination of the section at Murrurundi, about 13 miles north of Wingen, which shows that the Wingen fault extends as far north as this point, where it passes along the valley of the Page River. Further, the position of the basal conglomerates of the Triassic Hawkesbury series at Murrurundi suggests very strongly that the faulting post-dated their deposition, and if Carne's record of Triassic rocks on the slopes of Mt. Temi,[10] well to the east of the Wingen fault, is correct, then there is no doubt whatever of its post-Triassic age.

The tentative correlation of the Wingen and Elderslee fault-systems would appear to be confirmed by the work of the Geological Survey and of Mr. G. D. Osborne now in progress, so that one may with a certain degree of confidence assign the Lachnagar fault to post-Triassic and probably to Tertiary times. Except in so far as it may be a much later expression of the same thrust from the east, the fault is thus quite unconnected with the folding of the strata, which, as Professor David has shown,[3d] was complete before the deposition of the Hawkesbury Series.

At Parkville, Wingen and Murrurundi my isolated observations led me to the belief that the fault was probably a normal one, and hence I was rather disposed to regard the Lachnagar fault as being of the same type. However, for reasons already given, it seems evident that such is not the case.

PALAEOGEOGRAPHY AND GEOLOGICAL HISTORY.

Owing to the absence of any considerable exposure of basement rocks it is impossible entirely to reconstruct the physical geography of this region as it appeared in Kuttung times. The only pre-Kuttung formation revealed in the district, and indeed for a great many miles around, is the granodiorite outcropping at the base of Winder's Hill and at a few spots across the river. Of its exact geological age we know nothing, but it formed part of the land-mass over which the Kuttung lavas were outpoured and on which were laid down the glacial and aqueo-glacial deposits from the Kuttung ice-sheets.

Part, at least, of this region was dry land at the time when the Burindi sea covered much of the country beyond Seaham and Clarencetown, and it is indeed possible that the granodiorite was laid bare by subaërial erosion during Burindi times. In this connection it is interesting to recall that similar remnants of an old granodiorite floor underlie the Kuttung lavas of Mount Bright, near Pokolbin, 16 miles away to the south-west.[3, 11]

For some reason the part of the old land-surface near Winder's Hill remained uncovered by lavas and other deposits, and it was not until near the time of commencement of the so-called glacial stage that the granodiorite began to disappear under volcanic, glacial, and aqueo-glacial deposits. It may have been that this particular part was of too high relief to be buried earlier, or that what had been highlands at the beginning had been gradually depressed or eroded, or again that the Winder's Hill area was beyond the geographical limits of the volcanic activity during the extrusion of the lavas and tuffs of the volcanic stage.

No actual foci of eruption have been discovered, but the absence of lava at Winder's Hill and the relative insignificance of the flows in the Jacobs' Hills division make it probable that the centres of most prolific and sustained volcanic activity were away to the east and north, possibly outside the confines of the area being considered. Of course there is abundance of pyroclastic material, and some of this is so coarse as to indicate the proximity of volcanoes; still, much of the tuff bears evidence of sub-aqueous deposition, and may have come originally from a distance.

It is evident that glacial action and volcanic activity were synchronous, and much of the volcanic ash was certainly borne along by the glacial streams and deposited with true aqueo-glacial material, while occasionally lava-flows were poured out over the aqueo-glacial accumulations: doubtless, too, showers of volcanic ash and dust fell into the lakes in which the varve-clays were being deposited, for we find tuff and varve-rock closely associated.

The region was the scene of the advance and retreat of ice-sheets, and evidences of the passage of land-ice occur in a number of places. In the vicinity of the village of Gosforth there are the tillite resting on the granodiorite at Winder's Hill and the bluish tillite outcropping on the Maitland road less than a mile south-east from the Hillsborough Bridge: this latter is close to the top of the glacial stage and immediately under the topmost varve-shales. On the other side of the Lochnagar fault is the tillite at the back of Drinan's Mount, probably slightly higher than the Winder's Hill horizon; then, much further up in the sequence, is the striated pavement on the plateau, with its thin veneer of tillite, and lastly down along Eelah Creek and near Eelah House just under the topmost varve-shales are deposits of tillite which are possibly to be correlated with the similarly placed occurrences at Gosforth and with that of the plateau.

Thus there are evidences of at least two transgressions of land-ice during the currency of the glacial conditions.

Retreat of glaciers is indicated by the aqueo-glacial conglomerates, representing probably outwash-gravels, and by the varve-shales resulting from deposition in lakes at a distance from the ice-front. Where, therefore, varve-rock is superimposed on conglomerate, we have two successive phases in the retreat; where varve-rock or conglomerate occurs without underlying tillite, the indications are of a re-advance of the ice-sheet, but not quite to the spot marked by the outcrops, and its subsequent retreat. Events of this kind are denoted by the numerous separate horizons of varve-shale shown in the Winder's Hill-Lochinvar section and in sections across the Jacob's Hills division.

An interesting but difficult problem is that of the direction from which the ice came. Evidence in regard to such matters is usually derived: (a) from the grooving in the ice-striated pavements, and (b) from the boulders contained in the glacial and aqueo-glacial deposits. The only striated pavement available in the present instance is the small patch on the plateau, the scratches on which indicate that the land-ice was moving in a direction N. 15° W., but the value of this observation is limited, since it is not confirmed by other similar observations elsewhere; it implies merely that the ice-sheet which moved over the toscanite was going in the direction stated at this one particular spot.

The evidence of the boulders in the tillites and conglomerates is equally inconclusive. The granite of the pebbles is similar to that composing the base of Winder's Hill and to that at Mt. Bright, and the pink aplite is doubtless comagmatic with it, but this only indicates a former wide extension of the granodiorite highlands in some direction unknown. No rock-mass closely resembling the quartz-porphyry of the pebbles is known: it is an orthoclase-bearing rock, and different in appearance and constitution from any of the known Kuttung lavas. The felsites, and the few andesites that have been found among the pebbles, may well have been of local derivation, and the quartzites may have come from anywhere. The only significant feature, apparently, about the conglomerates is the persistence of granitic pebbles in them through a very big vertical range, indicating that the ice was coming from the same gathering-ground most of the time. The highlands which formed this gathering-ground were most probably situated to the south or south-east or south-west; at all events they are not likely to have been to the north or north-east, since in those directions for a long distance there must have extended the sediments originally deposited in the Burindi sea, at this time, it is true, converted into dry land, but of low relief and itself in process of being buried beneath Kuttung deposits. The highlands must have had considerable elevation in the first instance, or else must have been stable or rising whilst the Gosforth of Kuttung times was slowly sinking: their superior elevation was maintained during the deposition of more than 7000 feet of strata, or, to put it another way, they stood, at the end of Kuttung times, at a height of more than 7000 feet above what had been the early Kuttung land-surface.

During the piling up of the thousands of feet of volcanic and glacial material slow subsidence was taking place, and some of the lakes formed were of considerable extent and permanence, as may be inferred from the thickness of some of the lake-deposits and the continuity of outcrop of others, as well as from the presence of considerable plant-material. The sinking was greatest along a north-and-south axis, and accordingly for the glacial stage we find the greatest thickness of water-laid sediment, including tuff, from Winder's Hill southward, and in the Drinan's Mount division a thickening of the strata of the glacial stage from Eelah northward. The sagging at the close of the volcanic stage was so pronounced as to produce an unconformity in places between the rocks of the glacial stage and the lavas on which they were laid.

After the close of the Kuttung period the sinking continued, but with the abatement of volcanic activity and the retreat of the glaciers causing a diminution in the rate of sedimentation, the terrestrial eventually gave place to marine conditions.* The principal sagging was still along a sub-meridional axis, as indicated by the fact that the Lochinvar shales, when traced from their most southerly exposure to the north-east and north-west, are found to be overlapped by later sediments. As was to be expected, this axis of greatest depression became later on the axis of greatest elevation when the folding of the region began in late Permo-Carboniferous times, and what had been the Lochinvar basin became the Lochinvar dome.

Volcanic action continued right up to the end of the Kuttung period; during the later stages the ejected material was mostly fragmental, the only important flow being that of the toscanite on the plateau, although to the west and south a number of minor flows occurred. Even after the Kuttung strata were buried beneath the sea, volcanic activity was maintained, for acid tuffs and basalt flows are found among the earliest of the marine deposits.

During the Permo-Carboniferous period the slow and gradual sinking of the area was interrupted for a time by elevation during the deposition of the Greta coal-

* It may be also that the transgression of the sea was due in part to melting of the ice-sheets and the consequent rise in sea-level following on a general amelioration of climate.

measures, which, as mentioned above, are overlapped near Paterson, but with this exception there was a general movement of subsidence until the close of Upper Marine sedimentation. Then a marked change in the local tectonic conditions took place, the gradual subsidence being succeeded by the folding of the strata into a great irregular dome. It seems probable that there was no deposition of Upper coal-measures here and that the area existed as highland country suffering erosion and supplying material for the sediments of the Newcastle coal-measures and later on possibly for the Triassic sandstones of the Narrabeen and Hawkesbury stages.

In Tertiary times came the great overthrusting movement of the Lachnagar fault and the erosion of the upthrust side, the faulting movement being so gradual and erosion so effective that the close of the Tertiary period saw the whole surface reduced to a peneplain level.

The subsequent geological history is really that of the present physiography, and is dealt with below.

PHYSIOGRAPHY.

In order to get this region in its proper physiographic setting one must go a long way off. From the top of a hill about three miles along the road from Branxton to the Elderslee Bridge, one can see in the distance, over to the east, the Jacob's Hills, Hudson's Peak, and the long scarp that extends north from Eelah to Drinan's Mount and thence in a general N.N.W. direction to Lamb's Valley. The eye then travels along the rampart of hills rising abruptly almost from the water's edge to the north of the Hunter, forming Durham Peak and other eminences which really constitute the dissected southern edge of an elevated area extending westward from Lamb's Valley, and bounded to the west by the low ridges of which Brooks'

Mount forms the highest point. A further examination reveals that all this country is a great plateau, rising to 1530 feet above sea-level at Mount Tangorin, and to a maximum of about 1100 feet on the bare hill north of Bell's farm, in which Lamb's Valley and the broad Hunter Valley, here some 15 miles wide, have been cut, and that the elevations of Hudson's Peak, Winder's Hill and the Jacob's Hills are remnants which, while composed of more resistant rocks than the softer Permo-Carboniferous sediments of the lowlands, have, through faulting or the presence of weaker strata, yielded to the forces of erosion and been partially or wholly isolated from the highlands. The original peneplain, before elevation into a plateau and dissection, was probably continuous with the Hawkesbury sandstone country of the Broken Back Range and other highlands to the south and south-west, but since its elevation with a tilt to the east and south, presumably during the Kosciusko uplift at the close of Tertiary time, erosion has been extremely active. As pointed out by Taylor,[12] the rapid excavation of the broad Hunter Valley, which here might almost be considered a peneplain, has been favoured by the weak and unresistant nature of the Permo-Carboniferous sediments of which the valley is composed, while even among the harder Carboniferous rocks, weaker strata have been discovered and old fault-planes sought out, so that the dissection for the most part is quite advanced. Where, however, the tributary creeks head up among the harder rocks, they show the characteristics of youth, with steep gradients and even hanging valleys and intermittent waterfalls.

The edge of the plateau, from the eastern side of Lamb's Valley to some distance south of Drinan's Mount, forms the watershed between the basins of the Hunter and Paterson Rivers, and the tributaries of the latter have cut almost right back to the edge of the scarp, erosion being aided by the general easterly dip of the strata, so that here the divide is very sharply marked indeed.

The general course of the Lower Hunter River is characterised by much meandering, such as one would expect in a mature or old stream, but the details of its windings are not always amenable to interpretation. To the north of Branxton it is flowing east, its course evidently determined by the hard Kuttung lavas and conglomerates on its left bank, which have been brought against the soft Permo-Carboniferous strata by the Lachnagar fault. From the point of entry of Lamb's Creek the river turns south, almost along the junction between the Permo-Carboniferous and Kuttung strata, both dipping west. Doubtless the meridional strike of the Ravensfield sandstone further south has helped to confine the river to a more or less southerly course. Further downstream the river curves to the south-east, but instead of continuing across the low country in a general easterly direction, it suddenly, about 1½ miles west of Lochinvar, swings round to the north-east, leaves the soft Permo-Carboniferous rocks and takes a tortuous course across the hard Kuttung tuffs and conglomerates (see Plate XXI). This transgression is particularly noticeable where the river passes between Winder's Hill and South Jacob's Hill, which rise about 530 feet and 630 feet respectively above it. Sweeping round to the north in sympathy with the curving strike of the rocks, the river is brought up against the hard Kuttung lavas forming Hudson's Peak and the Rosebrook ridge and is diverted southwards, its course here being related once again to some extent to the Lachnagar fault and possibly to the Rosebrook fault as well. Except for a short distance near Eelah House, where it has cut across the strike, the river does not again come into contact with Carboniferous rocks during its course to the sea.

This peculiar behaviour of the Hunter is obviously in part related to differences in the erosional resistance of the strata through which its present course lies, which did not operate during some previous stage of the river's history. Having regard to the late mature or senile nature of the valley both upstream and downstream, that part of the river between the Windermere Crossing and Hillsborough Bridge must be looked upon as a rather mature entrenched meander, and this suggests the course of evolution possibly followed by the river as a whole. At or near the close of the Tertiary Era the old Tertiary peneplain was uplifted with a tilt towards the south and east, and to a height, in the region under consideration, of about 300 feet. Prolonged crustal stability enabled a consequent or rejuvenated Hunter River to erode rapidly through the soft Permo-Carboniferous strata a broad valley, which may have been comparable in width with that of the present day. At this time the present Jacob's Hills and Winder's Hill were beneath the floor of that valley, being covered by the softer top layers of Kuttung rocks, and even possibly by the basal Permo-Carboniferous strata. At all events the river in its meanderings over its valley-floor followed substantially its present serpentine course, but among stratigraphically higher rocks. Although at this time the differences in hardness of the rocks had not revealed themselves, the level valley-floor was really underlain by a very heterogeneous series of strata, partly of soft Permo-Carboniferous shales, sandstones, etc., partly of hard Kuttung conglomerates, tuffs and lavas, and the present river may therefore in some degree be regarded as a superimposed stream.

A further uplift of over 500 feet caused the meandering stream to become entrenched, but whereas elsewhere it was soon able to bring its new valley to a state of maturity, in the Gosforth region its downward cutting exposed the hard Kuttung rocks below, the erosion of which could not keep pace with that of the softer rocks elsewhere.

Nevertheless, mature dissection of the Kuttung rocks was accomplished, and fairly extensive flood-plains were accumulated during Pleistocene times.

A series of subsequent small uplifts again entrenched the river, as indicated by the alluvial terraces, relics of the former flood-plains, which are found up to a maximum elevation of 120 feet above the present stream-level. The first of these minor uplifts was probably the greatest, causing the river to cut down through its gravelly alluvium and into bed-rock once more: much silt was thereafter accumulated, which during subsequent small uplifts was cut into successive terraces by the river, and these are now being very slowly dissected by gullies.

Consideration of the fact that at Gosforth the Hunter has become entrenched against the northern wall of its valley, and has been a fixture in its present course while cutting through a vertical distance of over 600 feet, prompts the reflection that the great expanse of what is known as the Hunter valley—some 16 or 18 miles wide—between Hudson's Peak and the Broken Back Range, has been cut down to its present level, not by the Hunter itself but by its minor tributaries, such as Black Creek, Swamp Creek and others. However much the main stream may have wandered elsewhere over its broad valley-floor before the uplift which entrenched it, once it started to cut down into the harder Carboniferous rocks about Gosforth and Hillsborough, its wanderings were over so far as that part of its course was concerned, and the flat country to the south, which is now 400 or 500 feet below Winder's Hill and Jacob's Hills, must owe its inferior elevation to the activity of the smaller tributary-streams which intersect it.

Of the local tributaries to the Hunter a number have their courses across the strike of the hard volcanic rocks. The most important of these is Lamb's Creek, flowing south in a valley which is broad and typically mature where it is carved out of the tuffs and conglomerates of the glacial stage, but contracts very considerably downstream where the creek encounters the harder lavas of the volcanic stage. Indeed from a distance the outlet of the valley to the south appears to be blocked by hills and the open valley seems to swing round to the south-east, but this is really the valley of a subsequent tributary which has sought out the junction between volcanic and glacial stages and as a result joins the parent stream with a marked boat-hook bend.

Lamb's Creek is a very obvious misfit, and must formerly have been quite an imposing stream before a dwindling rainfall caused it to shrink to its present insignificant proportions. The cross-section of the valley above the bridge is very strikingly U-shaped, this being due to the presence of the layer of hard toscanite and conglomerate capping the plateau, underlain by the softer strata of the lower part of the glacial stage.

Another locally-important tributary of the Hunter is Kilfoyle's Creek, which, draining the country west and north of Drinan's Mount, cuts obliquely across the volcanic rocks and, emerging from them to the north of Hudson's Peak, flows westward parallel to the road, being joined on the way by a number of small subsequent tributaries from the south, and finally enters Lamb's Creek near its junction with the Hunter.

The course of Kilfoyle's Creek is very evidently determined partly by the Kilfoyle's Creek fault, and partly too, near its mouth, by the Lachnagar fault, which is responsible for the curious boat-hook bend or barbed junction which the creek makes with the Hunter: the courses of the creek and the Hunter River are practically collinear, the one flowing from the east, the other from the west.

Whether Lamb's Creek flows along a line of weakness I cannot say with certainty; if its course has not been determined by a fault, then it probably illustrates the tendency for maximum river-erosion to take place along the crest of an anticline.

The two creeks just mentioned have in places ceased from vertical cutting and have aggraded their valley-floors with fine-textured, fertile alluvium.

Among the smaller streams there are numerous examples of adjustment to geological structures. Generally the course of the stream lies along a relatively soft horizon: Eelah Creek is a case in point, marking as it does the junction between Kuttung beds and Lochinvar shale. But fault-planes have likewise been eroded into creek-beds, and it is quite possible that some of the little steeply-graded gullies which cut through the lavas may mark the courses of small faults or joint-planes.

The dissection of the succession of dipping beds of varying hardness by an abundance of small subsequent streams has resulted in the formation of many dip-ridges or cuestas and valley-divides. Hudson's Peak and the Jacob's Hills ridge are typical of the former, while of the latter the low saddle between Hudson's Peak and Drinan's Mount and the depression behind Drinan's Mount are only two out of very many examples.

Very fine views displaying the broad features of the physiography are to be seen from the various eminences in the district. From Hudson's Peak and South Jacob's

Hill, for example, to the north-west one may note the high Kuttung hills of the Stanhope area, truncated by the Lachnagar fault, and giving abruptly on to the plain eroded by the Hunter right up to the fault-plane. In contrast to this, from an eminence behind Drinan's Mount one may look over to the east towards Seaham and observe that the Kuttung highlands are lower than at Drinan's, emphasising the eastward tilt of the land, and that the slope by which they merge into the broad valley is a gentle one, being due not to any dislocation, but to the southerly pitch of the folded Kuttung strata carrying them under the Permo-Carboniferous sediments in which the river-valley has been cut.

The most casual inspection and the most detailed examination of the physiography of this region alike impress one with the very close dependence of surface-features on geological structures, and it would be difficult indeed to find an area where this great truth is more strikingly and convincingly demonstrated.

One minor but interesting physiographic feature calls for mention. At Gosforth itself and along the Maitland road may be seen a number of elongated lagoons, more or less permanent, some 20 or 25 feet above the river-level: these sheets of water occur in the flat alluviated lower portions of creek-valleys, and are separated effectually from the river by alluvial barriers breached in places by outlet gullies. It is considered that these lagoons have been formed by the creeks gradually damming themselves in the course of time. These have their greatest flow, indeed practically their only flow, during flood-rains, which is just the time when the river is highest, and so the current of the tributary creek is slackened and deposition of the transported silt occurs, well back from the normal river-channel. Thus a silt-bank is gradually built up, which forms a dam to the creek, the base-level of erosion of which is to all intents the flood-level of the river. The silt-bank deposited during a high flood would be breached by the creek during a subsequent flood of smaller dimensions.

Another minor phenomenon of frequent occurrence is that of a type of sub-surface drainage. On the gentle slopes near creeks there are to be seen holes, up to about a foot in diameter, opening into underground tunnels which lead down towards the creek-beds. In times of heavy rain these tunnels are water-channels and at the lower end of them sometimes the water may be seen spouting through a small vertical aperture owing to the hydraulic pressure behind it.

These tunnels are excavated in the subsoil, between the solid rock underneath and the soil on top, and when erosion has enlarged them sufficiently the roof collapses and an ordinary open gully ensues.

Aurousseau[13] has described a very similar phenomenon occurring along the Darling Range in Western Australia, and he attributes it to cracks forming during the hot, dry summer in the subsoil but not in the soil. During the wet season these cracks form channels for the water and are gradually enlarged into tunnels.

The same explanation very possibly applies in the present case, but it seems not unlikely that the tunnels may also commence in rabbit-burrows and in the holes left by rotting tree-roots. The whole phenomenon is ultimately related to the existence of a stiff fine-grained compact soil overlying a much less compacted subsoil, with the solid rock, the downward limit of percolation, not more than a couple of feet or so beneath.

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NOTE ON THE OCCURRENCE OF TRIPLETS AMONG MULTIPLE BIRTHS.

By Sir George H. Knibbs, C.M.G., M.I.I. de Stat., Hon. F.R.S.S., Hon. M.A.S.A., Hon. M.S.S. Hung., etc.

(Read before the Royal Society of New South Wales, Nov. 3, 1926.)

In the Journal of this Society I gave an analysis of Multiple Births (this Journ. 1925, **59**, 128) and in this the solution for triplets was founded on the assumption, therein indicated, that triplets were never produced from a single ovum. Professor Corrado Gini, of the University of Rome, writing to me 20th August, 1926, says:—

> "A mon avis l'analyse que vous faites à pages 133 et 136 n'est pas exacte. Le défaut provient du fait que vous admettre que les accouchements triples peuvent provenir seulement de deux ou de trois œufs. Au contraire il est bien certain qu'il y a aussi des accouchements triples qui proviennent d'un œuf seulement. Cela, malheureusement, empêche de suivre la methode, d'ailleurs extrêmement ingénieuse, que vous avez adopté."

The question being of interest and importance, I submitted my reasons for the assumption to Professor W. E. Agar, F.R.S., of the University of Melbourne. From him I learn that the division into multiple embryos is now known to take place at a comparatively late stage of development, and is not a case of the separating of the 2, 4, 8, etc., cells of the first few divisions as was once believed and as I had assumed. When a single ovum has developed as far as the blastocyst stage, the flat plate of cells, normally giving rise to a single embryo, produces a number radiating from the centre. Thus there appears to be no valid reason for assuming that a like process does not occur in the human being, i.e., one similar to the case with the armadillo, one species of which regularly gives birth at one time to 6-9 young, all of the same sex and all enclosed in one chorion. The finding of several fœtuses in one chorion, however, is not in itself decisive, Prof. Agar points out, since it is sometimes found, for example as in the case of cattle, that two chorions may fuse. With cattle, twins are usually enclosed in a common chorion, for though the chorions start separately, they fuse later.

Taking the same data for triplets as given on page 132 of the paper quoted, we have the following cases:—

MMM	MMF	MFF	FFF	Total
343	390	395	361	1489

We have immediately masculinity over all:—

	− 0.0132 or 1 in 75.7
MMM and FFF	− 0.0256 or 1 in 39.1
MMF and MFF	− 0.0021 or 1 in 471.0

Treating the masculinities as possibly differing in the several cases, and adopting the principles of solution indicated in my former paper, we have, by simple enumeration, for the several cases the following results, assuming only that the masculinity is symmetrically distributed:—

Ova	Cases	M M M	M M F	M F F	F F F
1	2z	$z(1+\mu)$	——	——	$z(1-\mu)$
2	4y	$y(1+\nu)$	$y(1+\kappa)$	$y(1-\kappa)$	$y(1-\nu)$
3	8x	$x(1+\lambda)$	$3x(1+\xi)$	$3x(1-\xi)$	$x(1-\lambda)$

Thus the unknowns are x, y, and z, and κ, λ, μ, ν, and ξ; the totals being from one ovum, 2z cases; from two ova, 4y cases; and from three ova, 8x cases. Distributed according to the sex-numbers these are:—

$$(1) \ldots\ldots \text{MMM} = x+y+z+x\lambda+y\nu+z\mu = A$$
$$(2) \ldots\ldots \text{MMF} = 3x+y \quad +3x\xi+y\kappa \quad = B$$
$$(3) \ldots\ldots \text{MFF} = 3x+y \quad -3x\xi-y\kappa \quad = C$$
$$(4) \ldots\ldots \text{FFF} = x+y+z-x\lambda-y\nu-z\mu = D$$

the values of the data in the case under review being A = 343; B = 390; C = 395; D = 361. The symmetry of the expressions is consistent with their legitimacy. From these, taking (1) and (4), and then (2) and (3), one sees that

$$(5) \quad \text{Triovular cases} = 8x = 4z + 2(B + C) - 2(A + D)$$
$$(6) \quad \text{Diovular cases} = 4y = -6z + 3(A + D) - (B + C)$$
$$(7) \quad \text{Uniovular cases} = 2z = -8x - 4y + A + B + C + D;$$

from which, however, no solutions are possible for the values of x, y and z, since the equations are not independent.

If we assume that $\lambda = \mu = \nu$, which the table for 1, 2 and 3 ova indicates as extremely probable, then from (1) and (4) we have

$$(8) \ldots\ldots \mu = \tfrac{1}{2}(A - D)/(x + y + z).$$

Again, if we assume that $\kappa = \xi$ we have similarly from (2) and (3),

$$(9) \ldots\ldots \kappa = \tfrac{1}{2}(B - C)/(3x + y).$$

Further, if it could properly be assumed that $\kappa = \mu$, then it would follow from (8) and (9) that

$$(10) \ldots\ldots (A - D)/(x + y + z) = (B - C)/(3x + y).$$

It has to be noted, however, that these assumptions are invalidated by the figures themselves. Thus, assuming that $\lambda = \mu = \nu$ and also that $\kappa = \xi$, we have from (1) and (4) by division, and from (2) and (3) by division, respectively,

$$(11) \ldots\ldots \mu = (A - D)/(A + D);$$

in the example $-18 \div 704 = -0.0256$

(12) .... $\kappa = (B - C)/(B + C)$;

in the example $-5 \div 785 = -0.0064$

If these values for μ and κ be adopted as probable, we still cannot find the values of x, y, and z, though their sum is 352.0, and that of 3x and y is 392.5, which gives

(13) .... $2x - z = 40.5$, and $2y + 3z = 663.5$.

This is, of course, the same as (5). If we assign an arbitrary value to z, then the values of x and y are determinable, *but not otherwise.*

It would appear therefore that practically an analysis of the case of triplets into uniovular, diovular and triovular cases is impossible: *it must be a matter of observation.*

It is not without interest to assign values to z, and then to note the consequence. The following table illustrates it.

Value of z		0	½	1.....	10....	87.5....	100....	200..
3 ova	8x	162	164	166....	202...	512	562....	962..
2 ova	4y	1327	1324	1321...	1267...	802	727....	127..
1 ovum	2z	0	1	2.....	20...	175	200....	400..

The case for $z = 0$ was that given in the former paper, see p. 136. The masculinities μ and κ will both be minus, viz., λ, μ, or $\nu = -0.0256$ and κ or $\xi = -0.0127$, and this would apply whatever value was assigned to z.

To return to (10) based upon the assumption that $\kappa = \mu$: we should then have from (8) and (9),

(14) .... $z = 9.8x + 2.6y$.

By substituting this value in the sum of (1) and (4), and also in the sum of (2) and (3) the two equations give $y = 200.25$ or $4y = 801$. This would fit in the preceding table with $z = 87.5$, that is with the assumption that, in say 175 cases in 1489, triplets were formed from a single ovum. There is, I submit, however, no sufficient reason to regard it as probable.

If we find the mean value of $(1+\mu)/(1-\mu)$ from (1) and (2) taken with (3) and (4), it is 0.9696; that is to say $\mu = -0.0154$. Eliminating the masculinity term from (1) and (4), we get

$$A' = 348.36;\ B' = 396.10;\ C' = 389.00;\ D' = 355.50;$$

the accented letters denoting the values of A to D so corrected. A′ should then be equal to D′, and B′ equal to C′. The above figures give a numerical idea of how far the assumption is from being a satisfactory one. If it be admissible at all, A′ and D′ may be taken as 351.94 and B′ and C′ as 392.56, the total being 1489 as before. Then we have

$$x + y + z = 351.94 \text{ and } 3x + y = 392.56$$
$$2y + 3z = 663.26 \text{ and } 2x - z = 40.62.$$

The preceding table, based upon assumed values of z, would then become as follows:—

Value of z	0	0.5	1	10	87.5
3 ova	162.48	164.48	166.48	.....202.48	....512.48
2 ova	1326.52	1323.52	1320.52	....1266.52	....801.52
1 ovum	0	1	2	20	175

These results, if expressed to the nearest whole number, are the same as before, and the values for z = 87.5 (to the nearest unit) are the same. Nevertheless they do not, I think, afford any sufficient warrant for believing that as many as 175 cases of triplets are produced from a single ovum in a total of 1489.

It is worthy of remark that the femininity is very high in these cases of triplets.

THE GEOLOGY OF THE FLINDERS RANGE, SOUTH AUSTRALIA.

IN THE NEIGHBOURHOOD OF WOOLTANA STATION.

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(With Plate XXII.)

(Read before the Royal Society of New South Wales, Dec. 1, 1926.)

Wooltana Station is situated at the foot of the imposing eastern escarpment of the Flinders Range, in Latitude 30⅓ degrees South, Longtitude 139½ degrees East. For some distance to the south, and for over forty miles to the north, the range has an almost precipitous face, strikingly linear in direction, and running about N.N.E. and S.S.W. Along the foot of the range there runs a narrow shelf of foothills, composed, in part at least, of a high level terrace formed during a former high-water period in the history of the ancestral lake dwarfed, descendants of which are now represented by the shallow salt "lakes", of which Lakes Frome and Callabonna are the nearest. The origin and structure of this terrace feature will be considered in detail in a later communication.

Wooltana Homestead is situated on this shelf, and looks out eastwards over extensive salt-bush plains falling very gradually and uniformly to the shores of Lake Frome, 20 miles distant.

The continuity of the escarpment is unbroken for a distance of 40 miles to the north, where, at Moolawatana Station, it suddenly breaks off as the result of profound disturbance of the geological structure. Twelve miles south of Wooltana, in the neighbourhood of Balcanoona Station, the continuity of the scarp is interrupted by a deep embayment, which, for convenience, may be referred to as the Balcanoona Embayment. This stretches westwards for about six miles to the mouth of Italowie Gorge, a most imposing scenic feature, whence the drainage of a large mountainous area to the west issues through a narrow defile.

In the immediate neighbourhood of Wooltana the range, for a distance of several miles is actually a steep, narrow rampart of hills, rising to heights of upwards of 1000 feet above the plains to the east. This rampart may be termed the Nepouie Rampart, from the name of the extremely sharp peak which is its most conspicuous feature. Behind this rampart, and extending for at least 15 miles from north to south, and for at least three or four miles from east to west, is a low, comparatively smooth valley which may be referred to as the Mulyallina Valley. As will be seen later, the Nepouie Rampart is due to the very strong development of the Sturtian Glacial Beds, while the Mulyallina Valley has been caused by a wide extension of very weak, friable argillaceous rocks belonging to the Tapley's Hill Slates, and to the overlying Brighton Beds. Such a combination of land forms is not at all common in the Flinders Range, which is essentially a well-dissected uplifted peneplain.

The linear escarpment of the eastern side of the Flinders Range is undoubtedly due to a very heavy fault throwing in the direction of the lacustrine trough to the east. The almost equally striking feature caused by the western escarpment of the Nepouie Rampart is entirely due to differential weathering.

The chief elements in the geological structure of the area may be summarised as follows:—

Lacustrine saliferous loams	Recent.
Older lacustrine, fluviatile and aeolian deposits	Probably Pleistocene.
Silicified Hill—cappings (very limited in distribution)	Winton Beds (Miocene?)
Moolawatana Glacials (?)	Upper Cretaceous.

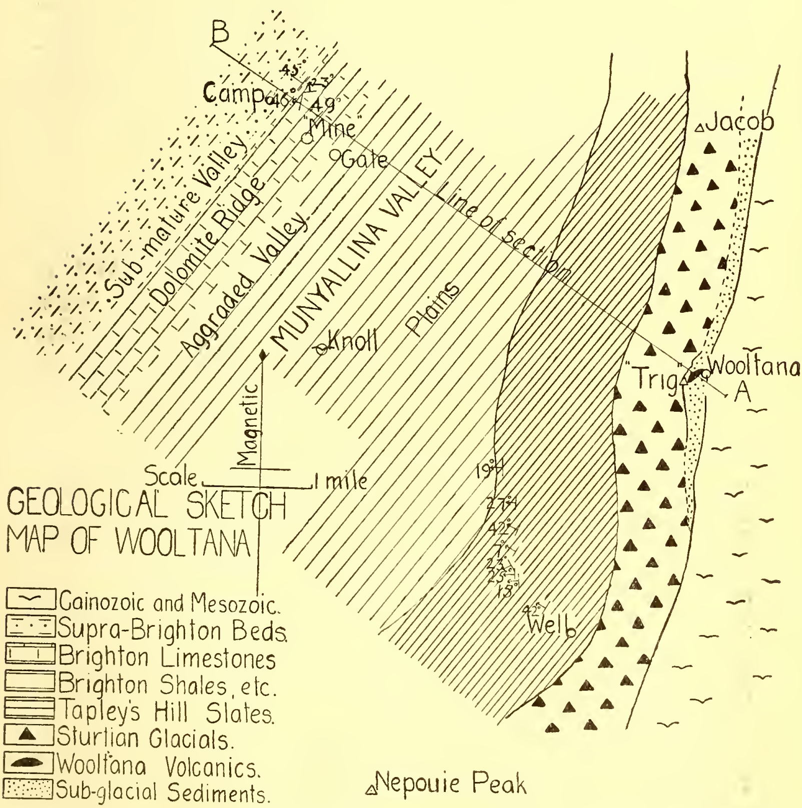

Figure 1.—General geological sketch map of part of the Flinders Ranges, South Australia, in the neighbourhood of Wooltana Station.

Brighton Beds (shales, dolomites and (?) desert beds)	Proterozoic.
Tapley's Hill Slates	
Sturtian Glacial Beds	
Volcanic Series	
Sub-glacial Sediments	

The Archaeozoic gneisses and schists with their copper and radium deposits, which are very strongly developed a very short distance to the north, and which constitute almost the whole of the north-eastern portion of the range, are not met with in the actual area considered. Mount Painter, the chief centre of the radium mining, is only some 16 miles north of Wooltana.

Sub-Glacial Sediments.

The oldest rocks seen are not at the actual base of the Proterozoic Group, but disappear beneath the lacustrine beds of the foothills and plains. No doubt the basal beds, resting upon the crystalline schists of the Archaeozoic formation will be found later between Wooltana and Mount Painter.

The lowest rocks in the sequence, within the limits investigated, are those occurring near the mouth of a deep gully about 600 yards north of the Homestead. At this point there is a steep bank showing a regular succession of sediments, dipping in a westerly direction at about 20 degrees. They consist of sandy calcareous beds with thin purplish sandstones and shales. The sandstones are beautifully ripple-marked.

Following the section up the gully the higher beds are found to be gently folded. Whilst most of the dips are in a general westerly direction, inclinations to the east of as much as 15 degrees are encountered.

Interbedded amongst the clastic sediments, and becoming progressively more and more abundant in the upper parts of the section, are bands of cream-coloured to white, dense to crystalline dolomite. These dolomites attain their maximum development in the gully to the north of that referred to above, at a point about 1300 yards N.W. by W. of the Homestead. It is probable that they become even more strongly marked still further to the north.

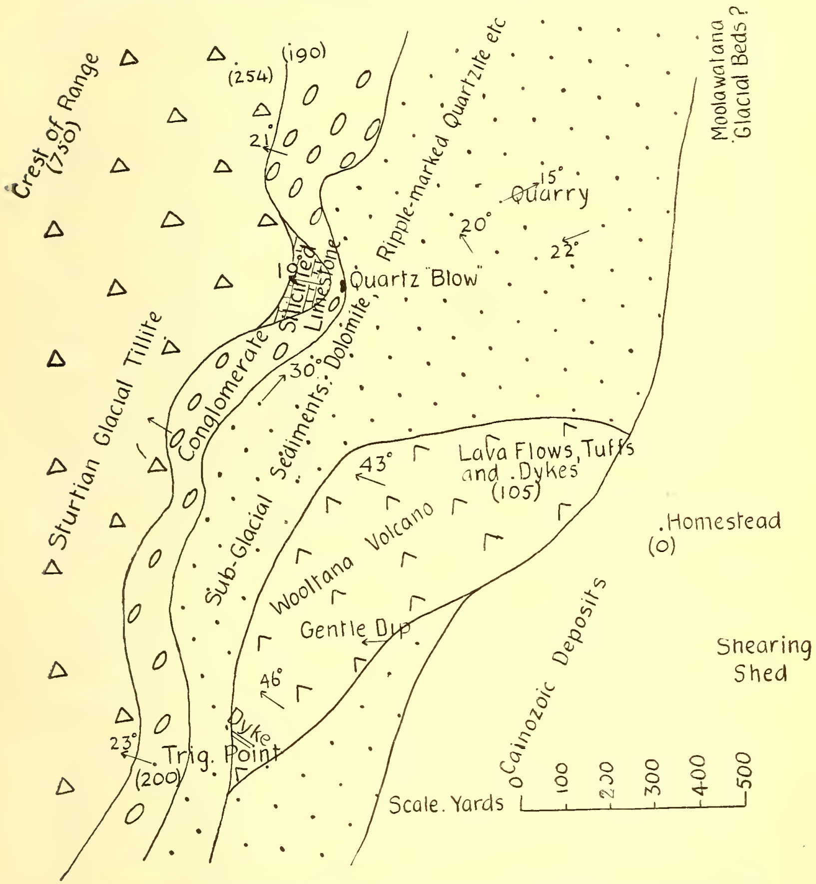

Figure 2.—Detailed map showing the distribution of geological features in the immediate neighbourhood of Wooltana Homestead, Flinders Ranges, South Australia. Numbers in brackets, thus (750), indicate heights, in feet, above the homestead.

Another very solid outcrop of similar dolomite occurs immediately to the south of the Homestead. Between these two points the continuity of the sub-glacial sediments is interrupted by the intercalation of the volcanic series (described below). While this vulcanicity may account for the great irregularity in the development of the dolomites, there is a very strong suggestion that, independent of such interference, the latter formed small isolated reef patches upon a shallow sandy bottom.

At a point 900 yards N.W. of the Homestead there is a spur capped by intensely hard conglomerate a few feet thick, overlain conformably by thin argillaceous limestones which are separated by thin bands of ripple-marked sandy shales. Both conglomerate and limestone are strongly silicified. In the limestone the action is not uniform; but spreads irregularly from numerous centres. In comparison with the glacial conglomerate (see below) this conglomerate possesses very highly distinctive characters. It is very strongly indurated, and, in fracturing, it breaks indifferently across matrix and pebbles. The latter include a large number of red jasper fragments, but there is a very conspicuous absence of quartz porphyries of the Gawler Range type.

At the locality under consideration, this conglomerate, with its associated limestones and shales, immediately underlies the Sturtian Glacial Beds. Further to the north similar conglomerates are much more strongly developed, and are separated from the glacial beds by a thickness of not less than 200 to 300 feet of dolomite (see above). This rapid variation in the thickness and disposition of individual beds produces a complicated lenticular structure, demanding far more detailed field investigation for its complete elucidation than I was in a position to carry out. It is obvious that conditions of deposition were in a state of rapid flux, and that the geographical environment was markedly unstable.

Just below the conglomerate there is a very curious quartz intrusion. This is not a regular reef, but is in the form of an isolated knot of reef-quartz associated with carbonates. Its ground plan is like a figure 8, the long axis, about 60 feet lying north and south. The shorter diameter is about 18 feet. Around the main mass are several small

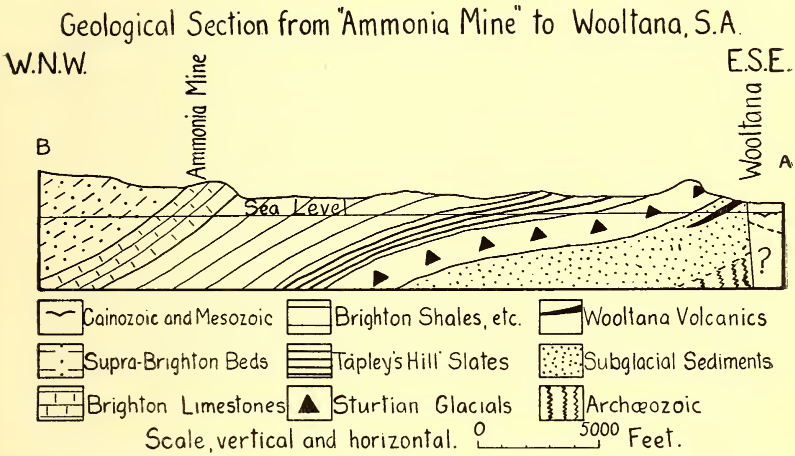

Figure 3.—Geological section across the escarpment of the Flinders Ranges, at Wooltana, South Australia.

satellites of similar material. From the marked similarity in mineral composition between this and the central portion of the dyke described below it is almost certain that this knot of quartz was produced during a late stage of the volcanic activity.

Immediately to the west of the Homestead, the lower beds of the sub-glacial series are replaced by lavas and tuffs; but, as the eruption waned in intensity, normal sedimentation was resumed, and the tuffaceous strata, immediately underlying the Sturtian Glacials, exhibit local development of dolomites.

Volcanic Series.

Volcanic rocks so old as Proterozoic are not very common in Australia, and when the structure is clearly that of a small local centre of eruption the feature possesses particular interest.

The volcanic rocks occupy an elliptical area, approximately 1200 yards long by 400 yards wide, immediately behind (west of) the Homestead. The lateral measurement given is somewhat arbitrary, since the gradation from volcanic deposits to normal marine sediments is very gradual. The long axis of the exposure trends about E.N.E. and W.S.W. It is completely surrounded by sediments of the sub-glacial stage except on the east, where the latter are thinly covered by the lake-terrace material. In the gullies bounding the spur upon which the Homestead stands the sub-glacial sediments are clearly visible.

Three hundred and fifty yards W.N.W. of the house there is a conspicuous rocky knoll composed of lavas and tuffs, intersected by a complex of dykes. The general aspect of the lavas under the microscope is spilitic; but they are considerably altered. One, casually examined in hand-specimen, appears to be an amygdaloidal rock, with steam holes filled with stilbite. (Plate XXII, Fig. 1.) Under the microscope, however, the ''amygdules'' are found to be actually xenoliths of orthoclase and quartz, fragments of a fairly coarse-textured orthoclase pegmatite. These xenoliths are very strongly corroded by the magma, deeply embayed, and surrounded by dense and dark-coloured reaction rims.

The declivity to the west of the knoll is formed of purplish tuffaceous beds, with occasional bombs (?).

Similar purple tuffs are met with to the south-west of the knoll. They are mostly fine in texture, dip gently and uniformly in a westerly direction, and contain scattered boulders of rock, similar in general characteristics to the lavas of the volcano occurring *in situ*. The fine textured rocks are certainly tuffs; and some, at least, of the boulders are strongly suggestive of volcanic bombs. The possibility of some of them being glacially rafted erratics must be borne in mind.

Interstratified with the fine tuffs are bands of coarser lapilli. Towards the south, lapilli and ash become more and more interstratified with thin dolomite bands, until, at a point some 450 yards south-west of the Homestead, we meet with massive reefs of this material, building up the bulk of the hill at this point.

Seven hundred and fifty yards W.S.W. of the Homestead the tuffaceous shales, with scattered rounded boulders up to eight inches in diameter, rest upon a very coarse conglomerate, which, in turn, is underlain by the dolomitic marine sediments. Here, the volcanic rocks dip in a northwesterly direction at low angles, and contain bands of heavy, fine-grained material, strongly epidotised.

Eight hundred yards from the house, on a bearing of 245° (magnetic), there is a very interesting section. At this point is seen the sudden termination of an amygdaloidal lava flow. It seems certain that this was a submarine flow, on account of its very confused interbedding with the associated tuffs, and the very strong suggestion of pillow structure which it exhibits. The spilitic aspect of the rock under the microscope bears this out. The "pillows" are finer in texture towards their peripheries and coarser towards their centres, and are internally fractured in radial directions.

Still further to the south-west, about 1000 yards from the Homestead, and 200 yards east of the Trigonometrical Survey Point, beds of vesicular melaphyre, associated with incoherent greyish tuffs containing vesicular bombs, dip at moderate angles towards the north-west. This series is traversed by a nearly vertical dyke, some ten feet wide, of dark amygdaloidal melaphyre, with chloritic amygdules. The central core of this dyke is occupied by a sheeted vein of calcite and quartz, containing abundant copper carbonate and micaceous haematite (compare the quartz knot described above, page 289).

Passing upwards, the character of the rock alters somewhat rapidly. While still notably tuffaceous, the proportion of material of volcanic origin decreases, and that of ordinary sediment increases, until, at the Trig. Station, the formation consists of very massive flesh-coloured to chocolate-brown tuffaceous cherts. These are superficially stained, sometimes very strongly, with black manganese oxide, and contain sporadic, well-rounded pebbles of pinkish quartzite up to six inches diameter.

In the neighbourhood of the Trig. Station there is no recurrence of dolomite formation between the top of the volcanic phase and the base of the glacial beds, such as occurs a little further towards the north. The investigation could not be carried further south than the Trig. Station on this side of the range, so that the southern limits of the volcano cannot be drawn with certainty.

From the above description it will appear that the volcanic action was merely an episode in the deposition of the sub-glacial sediments. Downwards, upwards and laterally the fragmental volcanic material grades into the normal sediment; the gradation, as we might expect, being much more insensible upwards than downwards. None of the facts recorded are incompatible with the supposition that the eruption was mainly submarine, or at all events, subaqueous. Locally it interrupted the growth of the dolomite reefs; but these probably continued to form freely away from the actual centre of eruption. Reef building conditions continued to exist throughout the whole of the volcanic period, and re-asserted themselves whenever and wherever the opportunity presented itself. Taken in conjunction with the evidences of shallow water conditions amongst the sediments, the occurrence of strong conglomerates associated with the tuffs to the south-west of the Homestead suggests occasional and local emergence of the sea bottom and parts of the volcanic cone above sea level.

Sturtian Glacial Beds.

Much of the most conspicuous and outstanding geological feature of the area is the enormous development of the Sturtian Glacial Beds. These rocks form the main backbone of the Nepouie Rampart, and of the main portion of the range for some distance to the north.

Within the area affected by the volcano it is very difficult to ascertain at exactly what horizon the glaciation commenced. Scattered boulders of large size are quite frequent throughout a considerable thickness of beds; but it would take much more prolonged and exhaustive examination than I was in a position to give before it would be possible to distinguish with certainty which of these are glacial erratics, and which are volcanic bombs.

Throughout the whole of what have been called above the "sub-glacial sediments," occasional intensely rounded pebbles like cricket balls, about 3 inches in diameter, scattered through the finer sediment, indicate some rather abnormal means of transportation. The pebbles must have been "rafted" in, and not simply brought by ordinary water currents. Owing to the great age of the formation, floating timber is excluded as a possible means of transport. Since ice was undoubtedly active at a somewhat later stage, it seems not unreasonable to invoke its aid in explaining the presence of such erratic boulders.

Immediately above the conglomerate 900 yards northwest of the Homestead (see above, page 288), the results of ice-rafting on a considerable scale are clearly discernible. A little to the north, embedded in a dense grey quartzite, there are the remains of an enormous erratic of white vitreous quartzite. While it is now much shattered by insolation, it must originally have measured not less than 9 feet in diameter. The grey quartzite, which is extremely local in development, rests upon a thin breccia composed of siliceous limestone. On the hill immediately to the south (where the silicified conglomerate and limestone are typically developed), this breccia bed is strongly in evidence, and is followed by a sandstone in which quartzite erratics up to 3 feet 6 inches long are abundant. With these quartzite fragments a piece of porphyry 8 inches in diameter of the Gawler Range type was found. As has been pointed out above, this highly characteristic rock type is conspicuous by its absence from the subjacent siliceous conglomerate.

Whatever may be the origin of the sporadic "cricket ball" boulders in the lower sediments, this brecciated bed may be taken to mark the onset of the intense phase of the Sturtian glaciation at this point. In this earliest stage the deposits seem to have been produced by floating ice; but the main body of the Sturtian Glacials were certainly due to land ice. Apparently the water remained somewhat deeper in the neighbourhood of the Trig. Station, further to the south, for the passage from the tuffaceous sediments, with occasional boulders, to the normal boulder clay is much more gradual at that point; and there does not seem to be any development of the siliceous conglomerate and limestone, nor of the breccia.

Once fairly inaugurated, the glaciation became very intense, and thoroughly typical boulder clay was built up to a thickness of not less than 600 feet. The main range exhibits a precipitous face of this height, in which the enormous erratics, embedded in the familiar type of matrix can readily be seen with the naked eye, even from considerable distances.

No systematic census of rock types represented amongst the erratics could be attempted. Much the most abundant material is quartzite, followed by granites, gneisses and schists, and by very frequent examples of the handsome quartz porphyries of the Gawler Range type. The largest erratic actually measured was the white quartzite boulder (9 feet diameter) referred to above; but others of still larger dimensions can be seen in the cliff face.

The great majority of the erratics are well rounded and waterworn. Even many of these, however, show very distinct faceting. Such individuals were probably originally well striated, but have had all traces of the scratching worn off by subsequent fluviatile action. There are very numerous exceptions to the rule of perfect rounding, and perfectly angular boulders are met with frequently. So very decidedly glacial is the general aspect of the formation that quite a considerable time was spent in searching for definitely striated stones. This search was amply rewarded, and many beautiful examples were picked up, notably on a steep spur about 900 yards W.N.W. of the Homestead. (Plate XXII, Fig. 2.)

The groundmass (Plate XXII, Fig. 3) is a highly typical glacial tillite of reddish-chocolate colour, in which fine-grained rock-flour is intimately mingled with angular chips of the most diverse rock types.

No competent geologist could feel a moment's hesitation in insisting most emphatically upon the glacial origin of the formation.

No very accurate estimate of the thickness of the Sturtian Glacials at Wooltana is yet possible. The detailed mapping was limited to the immediate vicinity of the Homestead, and to that of the "Ammonia Mine" to the west of the Mulyallina Valley. The intervening areas were traversed several times rather rapidly, and fully detailed measurements were not taken. The vertical thickness of the beds, as seen in the precipitous faces of the range just behind the Homestead, is about 600 feet, and the formation certainly continues some distance towards the valley to the west.

The track to the "Ammonia Mine" traverses the Nepouie Rampart along the actual bed of Mulyallina Creek, which emerges from the Valley through a deep, narrow gorge. At the mouth of the gorge the Sturtian Glacials are covered by creek deposits and lacustrine beds, so that there is a hiatus, of unknown dimensions, in the section at this point. The beds dip upstream at angles of 20 degrees, or a little more, and are seen for a third of a mile (cyclometer reading), so that their vertical thickness is not less than 500 feet. It therefore appears that the total thickness of the glacial beds may approximate to 1000 feet.

Tapley's Hill Slates.

As in the type section near Adelaide, the beds of the next succeeding stage are finely laminated, cleaved "varve" rocks, the Tapley's Hill Slates. In their lowest portion they are rather calcareous and cherty. Being much cleaved

Fig. 1.

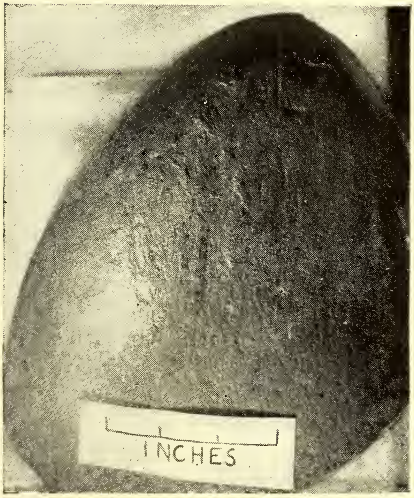

Fig. 2.

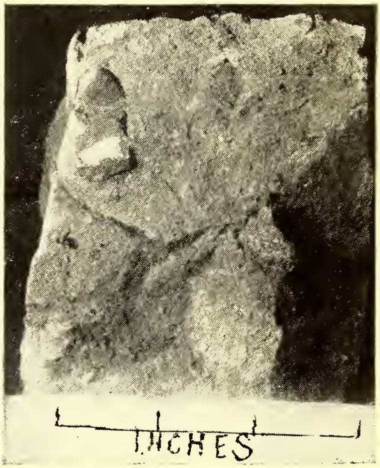

Fig. 3.

in directions transverse to the planes of bedding, which, however, still constitute lines of weakness, these rocks disintegrate readily. This is responsible for the rapid widening of the valley up-stream. On the whole, the rocks of this stage dip in a general westerly direction at moderate angles. An estimate, only roughly approximate, of their thickness, shows it to be about 1000 feet.

The passage of the Tapley's Hill Slates to the overlying calcareous series is extremely gradual, and no sharp line of demarcation can be drawn. In the upper part of the Tapley's Hill Stage, very thin, but remarkably persistent, bands of fine textured dolomite put in an appearance. On the treeless, and almost bare, plains of the Mulyallina Valley these calcareous bands, even when less than an inch wide, can be traced for long distances. They become increasingly numerous and individually thicker until they become the dominant lithological element.

Brighton Shales and Limestones.

The line between the Tapley's Hill and the Brighton Stages can be drawn, tentatively, at the point where the limestones alter from thin bands to thick beds, with a corresponding increase in the relief of the land surface. Many of the thicker bands are very argillaceous; in fact, there are all possible gradations between dolomitic limestones and shales. The argillaceous bands are flaggy, and yield excellent slabs for building purposes. The more purely argillaceous rocks have a strong tendency towards redness, many of them being brilliantly coloured.

On the whole, the rocks of this stage are very little disturbed. Minor faults and folds occur, and are seen in plan, with diagrammatic clearness, on the bare surfaces of the valley floor. The average dip is towards the west at low angles.

The Mulyallina Valley is some 3 to 4 miles wide from east to west by 12 to 15 miles long from north to south. On the western side it is enclosed by high rugged hills of dolomite occurring in thick beds. Immediately below these in the geological sequence are *extremely* friable shales, the weathering of which has produced a very mature valley feature along the western side of the main depression. So completely have these shales been removed as a rule, that heavy alluviation of the valley has occurred along this line.

From stratigraphical and lithological considerations there is no doubt that the massive dolomites are the equivalents of the Brighton Limestones of the Adelaide area. Their total thickness is about 1500 feet. Within recent and sub-recent times large solution caverns have been opened in them, and have been tenanted by bats, marsupials and other animals.

Purple Slate Series (?)

The reef-building conditions suggested by the development of the massive dolomites, gave place somewhat suddenly to the renewed deposition of mechanically formed sediments. There is, however, no suggestion of unconformity. The sediments consist largely of arenaceous material, and show abundant evidence of deposition in extremely shallow water; if, indeed, they are not of sub-aerial origin. All the thicker bands of quartzite and sandstone are current-bedded, and ripple-marks and sun-cracks are beautifully preserved. Variations in the texture of the materials are extremely rapid, and large numbers of disrupted shale particles are embedded in the sandstones. With some hesitation the author suggests that these features, taken in conjunction with the prevalent red colour of the rocks, indicate deposition in an arid basin. Much study of desert conditions may, however, have made him too prone to assign formations to such action. It is pertinent, however, to call attention to the very striking similarity exhibited by these rocks to those of the Keuper and Bunter of England, to the Upper Devonian Red Beds of New South Wales and Victoria, and the Hawkesbury System of New South Wales. Another formation comparable, in many respects, is that which builds up the Stirling Range in Western Australia.

The author was unable to extend his investigations into the very rugged country to the west of the "Ammonia Mine." Cliff faces in this direction can be seen to be built up of very uniformly bedded, and rather thinly laminated argillaceous and arenacous material, the predominating colour of which is grey. Some miles further to the west lies Illinawortina "Pound," one of those curious, completely enclosed depressions of which there are several in the Flinders Range.

Nothing is known to the author of the geological structure of the northern part of the Mulyallina Valley. The conspicuous peak of Mount Painter can be seen at no great distance in this direction; so that the Archaeozoic formations, with their radium and copper minerals, must approach the northern end of the valley fairly closely.

In the south, the valley is cut off from the Balcanoona Embayment by a belt of rugged hills which preclude all hope of finding an easy exit for the products of the valley in this direction. These hills are composed very largely of dolomite in thick beds, which, while somewhat folded on a small scale, are approximately horizontal as a whole. These can be seen very plainly from the Copley-Balcanoona Road, and are exposed in high cliff faces in the gorge of the creek just above Balcanoona Homestead. These dolomites are obviously directly continuous with those of the "Ammonia Mine," and are therefore referable to the Brighton Stage.

Cretaceous Glacial Beds.

The eastern foothills of the Flinders Range, where, if anywhere, one would expect to find evidence of Cretaceous Glaciation, could not be extensively examined on this occasion. At a point about half a mile north of Wooltana Homestead there is, somewhat about the level of the house, a boulder strewn terrace upon which the abundance, the size, the distribution and the constitution of the rock fragments are strongly reminiscent of those at Moolawatana, where the glacial origin of the formation is clear. Boulders up to 3 feet in diameter occur in profusion, and include rock types in great variety. Many of these are distinctly of local origin, including large fragments of the highly characteristic siliceous conglomerate of the sub-glacial beds. Most of the types represented are those which contribute most liberally towards the formation of the Sturtian Glacials immediately to the west. In absence of evidence as to the occurrence of definite tillite, or of associated silicified tree trunks (as at Moolawatana), and in view of the situation of the terrace with respect to the drainage lines of the locality, and most particularly in view of the close proximity of the Sturtian Glacials (wanting at Moolawatana), correlation with the Moolawatana Glacial bed cannot be insisted upon. Further search may reveal the missing evidences, particularly the tillite.

The possibility must be borne in mind that the gravel terrace may represent a beach deposit formed at the period of highest level of the lakes. This last suggestion is not incompatible with the somewhat meagre aneroid levelling which has been carried out to connect the relative heights of Moolawatana and Wooltana.

Winton Beds.

The thin siliceous capping of Winton Beds, so widely distributed throughout Australia, which constituted the original "Desert Sandstone" of Daintree, and which is very conspicuous over the Mesozoic rocks 40 miles to the north-north-east, has not been extensively noted in the area under consideration. As pointed out above, the foothill zone, in which they should occur, has received very little attention. Some of the flat-topped hills about three miles north of Wooltana, appear from the road to possess such cappings.

One very remarkable isolated outcrop was encountered almost at the centre of the Mulyallina Valley. It occurs in the form of a small knoll capped by vitreous quartzite, heavily stained and impregnated with manganese for the most part. From its mode of occurrence it is evident that this small outcrop is an outlier, the remnant of a once continuous bed which originally covered at least the southern half of the valley.

Beyond the hill barrier to the south, throughout the whole of the Balcanoona Embayment, and thence to Wertaloona, the Winton Beds are strongly developed. They will be considered at a later date, when the author hopes to issue a comprehensive description of the geology of the whole area.

Late Cainozoic Deposits.

These include lacustrine beach gravels, saliferous lacustrine loams, river terraces and cave deposits. Those of the first three types are negligible within the area considered; but some account of the cave deposits may be given.

Quite numerous caves are known in the area, but most of them are of small dimensions. The only one examined on this occasion was that being opened up as a source of manurial material, and locally known as the "Ammonia Mine." This occurs near the head of a small gully in the massive dolomites of the Brighton Stage. It consists of two main chambers united by a narrow opening. The upper chamber, estimated as 60 feet long, by 40 feet wide, and 60 feet deep, is open to the daylight. It contains a few coarse stalactite and stalagmite formations. Quite considerable quantities of liquefied wallaby dung are present. This material is widespread in the caves of Australia, and is constantly being mistaken by prospectors for bitumen.

At the south-eastern corner of the upper cave, a joint crack has been somewhat enlarged by solution, and leads downwards into a second chamber, the dimensions of which are 80 feet by 105 feet, and some 30 feet high. This cave is completely dark, and contains much more abundant "formations," though none of them are of striking beauty. Close to the entrance there is a very considerable heap of bat guano, in a dry condition, containing numerous mummified remains of a large bat. Such bats are totally unknown in the district now. The floor of the cave is covered by a considerable thickness of pulverulent material with admixed dolomite boulders of large size. The underlying parts of this dusty material contain very few soluble constituents; but are covered by a crust of fibrous ammonium chloride some 6 inches in maximum thickness. In this crust the ammonium salt is fairly pure. Its nitrogenous portion has certainly been derived from the organic deposits, while the chlorine probably comes from the saline ground waters of the arid region. The relative inaccessibility of the cave militates against the successful commercial exploitation of these otherwise useful nitrogenous deposits.

Summary of Conclusions.

The rocks of the Flinders Range in the immediate vicinity of Wooltana Homestead are referable, almost exclusively, to the Adelaide Series. The base of the series is not seen within the area examined. Its lowest members are argillaceous and arenaceous sediments deposited in shallow water, and passing upwards into pure dolomites of considerable thickness.

A fact of extreme interest is the intercalation of a "pocket edition" of a volcano during the stage. The eruption was almost certainly a submarine one, and is one of the earliest of which we have definite information in Australia.

Local emergence of the sea bottom above sea level occurred towards the end of this stage.

A very intense phase of Sturtian glaciation followed, the deposits of very typical boulder clay and tillite being not less than 600 feet thick, and more probably, about 1000 feet thick. Striated erratics are comparatively abundant, though the boulders suffered considerably from fluviatile action before final deposition.

Tapley's Hill Slates of the well-known "varve" aspect succeed the boulder clays, and pass upwards, by insensible gradations, into the equivalents of the Brighton Slates and Limestones of the Adelaide area. Very thick and massive dolomite reefs close this stage.

The dolomite-forming period was followed by a recurrence of shallow water, or, more probably, subaerial accumulation. The existence of an arid climate during the period is suggested.

It is not certain that either the Upper Cretaceous Glacials of Moolawatana, or the Lower Tertiary Winton Beds are represented; but possible occurrences of both are noted.

Very interesting caves in the Brighton Limestones contain relatively extensive guano deposits of animal origin, and crusts of quite pure ammonium chloride have been developed in association with the organic matter.

DESCRIPTION OF PLATE XXII.

Rock Specimens from Wooltana, South Australia.

Fig. 1.—Pseudo-amygdaloidal spilitic lava. The light-coloured patches are corroded xenoliths of orthoclase pegmatite.

Fig. 2.—Glaciated boulder from the Sturtian Tillite of Wooltana.

Fig. 3.—Groundmass of the Sturtian Tillite of Wooltana.

THE MICROPHONE AS A DETECTOR OF SMALL VIBRATIONS.

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(With Plates XXIII.-XXIV.)

(Read before the Royal Society of New South Wales, Dec. 1, 1926.)

During the war a large number of "detectors" were employed, to investigate the nature and extent of enemy activity. These may be divided into two groups: (a) Stethoscopes, (b) Microphones, so far as the appreciation of mechanical earth disturbances is concerned. Besides these were electrical "detectors" for earth currents, and hot wire microphones for the detection and location of hostile artillery.

A brief investigation of the stethoscope has been given by the late Professor Pollock.†

This present investigation deals with the detection of vibrations by means of microphones, so that the microphone may be used to examine the nature of earth disturbances either existing naturally, or artificially produced.

The microphones employed, being military instruments, may not be described in detail. But the principles involved being identical, namely a variation in pressure between a carbon plate and carbon granules or balls due to the movement of the system whilst an inertia mass remains at rest relative to it, they may be compared by means of the diagrams herewith.

† The Stethoscope, with Reference to a Function of the Auricle. J. A. Pollock, Journ. Roy. Soc. of N.S.W., 1920, 54, 187.

Diagram I shows the Télégéphone, a French instrument. It would appear to be aperiodic, the soft felt washer resting against the carbon plate assisting this. The inertia mass is the mercury behind the mica plate; the carbon granules lie loosely in their carbon container, which is mounted on a light brass strip, permitting small movements of the inertia system. This was found to be the most consistent and satisfactory type of instrument.

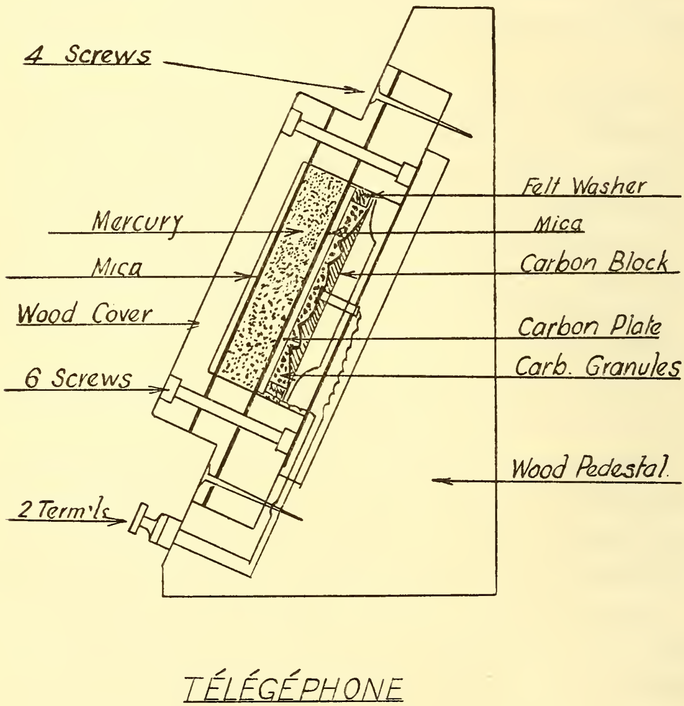
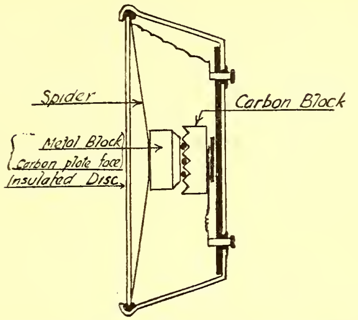


Diagram I.

Diagram II is the Siemens Capsule microphone; it is not aperiodic, the period being that of the brass inertia mass (carrying the carbon plate) attached to its four spring clips.



SIEMEN'S CAPSULE MICROPHONE

Diagram II.

Diagram III is the Western-Electric Detector, a torpedo in brass and aluminium casting carrying a self-adjusting microphone system inside. It is not aperiodic, the period being that of the mass attached to the long brass strip. A very sensitive type, but is not consistent, and given to variable current transmission through the microphone, even without intentional variation in pressure.

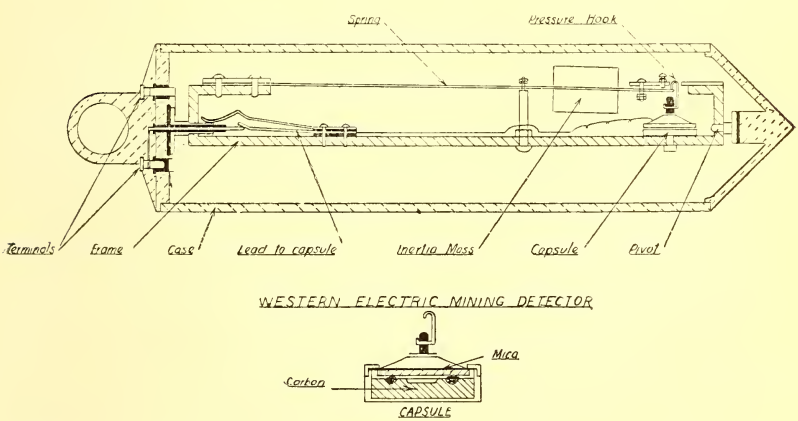


Diagram III.

Diagram IV is the seismomicrophone (French Military Type). This would not appear to be aperiodic, as the rubber rings supporting the brass inertia mass will have a high period, and this will not be highly damped. Experimentally, this is found to be a good instrument, at any rate for the detection of oscillations of low frequency (less than 40 per second).

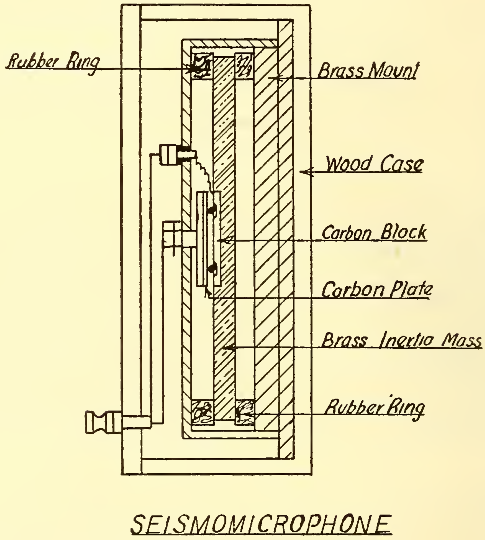


Diagram IV.

The variations in current through the microphone circuit when a potential was applied across it, were recorded by an Einthoven string galvanometer, and cinematograph with the interrupter removed. The microphones were disturbed by (a) jarring the material on which they stood (e.g., dropping weights on the ground, tapping the table); (b) impressing on the tables on which they stood simple harmonic motions of different frequencies; (c) tapping the microphones lightly to represent a horizontal or a vertical component.

Two methods of coupling the Einthoven and the microphone circuit were employed—a Wheatstone network, and a transformer. The Wheatstone network was not found to be convenient, as with some microphones (such as the Western-Electric) the zero position of the galvanometer thread had to be re-established for each reading. Consequently the work was all carried out with transformers, occasional check readings being taken by the other method to see that the type of curve, and the amplitude relationship, was being correctly interpreted.

Both air and iron core transformers were used for comparison. To study the effect of the natural period of the Einthoven string, or to use it as an aperiodic recorder, observations were made both with the primary and with the secondary of the transformers in the microphone circuit, so that the thread might be in series with a big resistance (the secondary), or practically short circuited through the primary. The thread originally employed was a silvered glass. This was discarded in favour of silver, of resistance approximately 60 ohms, and length 7 inches.

When either the primary or the secondary were in the microphone circuit, the same potential drop across the microphone and variable resistance was established by varying the number of cells in the circuit. The potential was always well below that to produce "singing" or "frying" in the microphone.

If the string of the galvanometer be disturbed by a single impulse, such as produced by (a) touching the string carrier, (b) making or breaking an electric circuit including the string, and the system is aperiodic, the thread should record precisely this effect. If there is too great a resistance in its circuit, it will oscillate; if it is too highly damped, it is insensitive. Errors were made in the earlier work of making the resistance in the Einthoven circuit so small that although the natural fundamental period of the string was not apparent, the record was confused by its overtones.

A phonic wheel shows on the film bars corresponding to 1-40th second interval.

The system then involves (a) the disturbance, (b) the microphone, (c) the transformer (if employed), (d) the Einthoven galvanometer.

Examination of Einthoven with Transformer.

This was examined with (i) loose thread, (ii) tight thread, associated with both air and iron core transformers, and in all cases with firstly the secondary and then the primary in series with the Einthoven.

The first tests were of simple make and break in a circuit in the secondary of the transformer by means of a tapping key. It was found necessary to add up to 500 ohms to the Einthoven circuit, otherwise it was over damped, and overtone oscillations were set up in it.

Film I. shows a typical make, break, followed by rapid make and break, by tapping key. (Air core.)

The transformer equation here is $L\frac{di}{dt}+Ri=0.$

The solution being $i=C\ e^{-\frac{R}{L}t.}$

The constant C is found from the condition that when $t=0,\ i=\frac{M}{L}I.$

Hence $i=\frac{M}{L}I\ e^{-\frac{R}{L}t.}$

This gives us the value of the current in the secondary at any instant after the "break" in the primary.

This would be represented by the curve in diagram V, theoretically.

With film I. and diagram V. we may compare film II., the difference here being that the iron core transformer is employed. Here the time length OQ is greater, M not being so nearly equal to L.

(The small fluctuations are undesired local effects, which with big magnifications it was difficult to completely shield.)

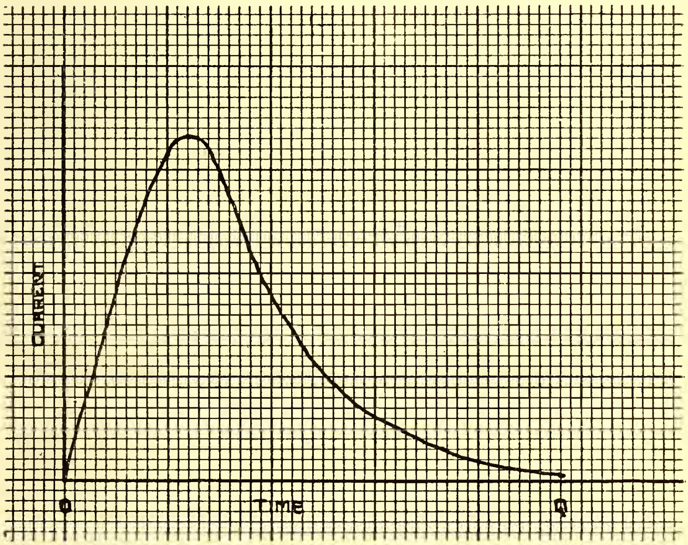


Diagram V.

It was now desired to check whether the microphones would record variations in energy, or amplitude. Naturally, as we are dealing with an inertia mass we will record acceleration, so, dimensionally, the apparatus should give deflections proportional to amplitudes impressed.

This was examined both for impressed simple harmonic motions and for impressed impulses.

In the former case, tuning forks of various frequencies were attached to the microphones, or to tables on which the microphones rested, the shadow of a bristle on the prong of the fork being cast on to the moving film alongside the shadow of the string, so that the fork amplitude and string amplitude might be compared. A portion of a typical film is illustrated. (Film III.)

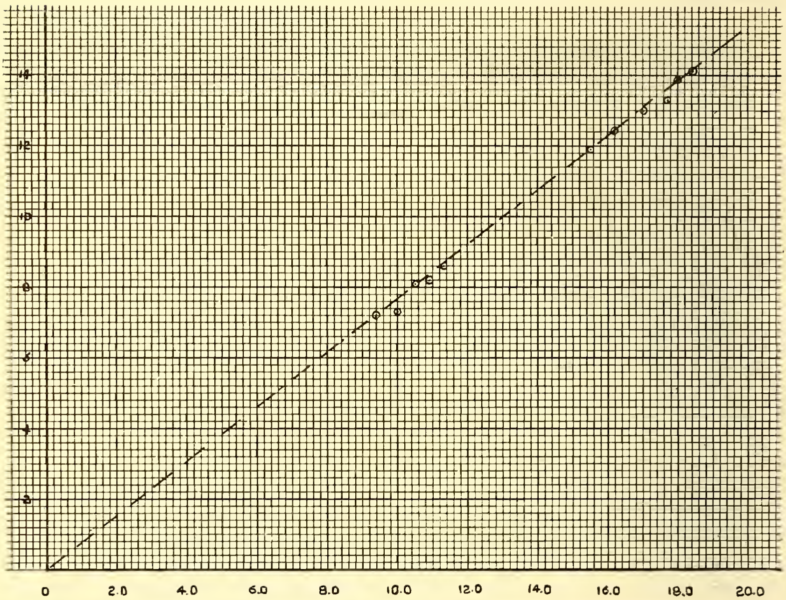
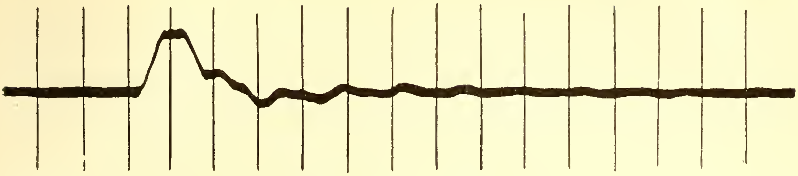
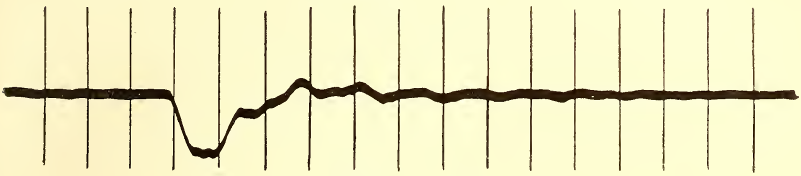


Diagram VI.

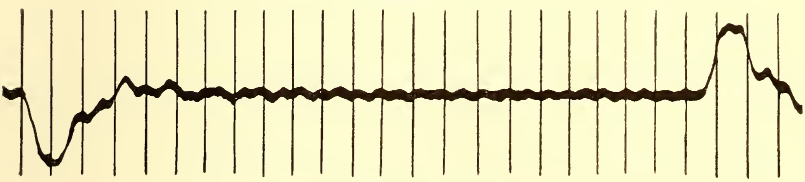
Diagram VI shows the relationship between the amplitude of the fork movement and the amplitude of the string movement, for the gradually diminishing values. To save film, in some cases the beginning of the movement was recorded, in others the end, and in others the film was stopped and started at intervals so as to get a reading throughout. Once the microphone has been set in forced vibration the amplitude of the string movement is pro-



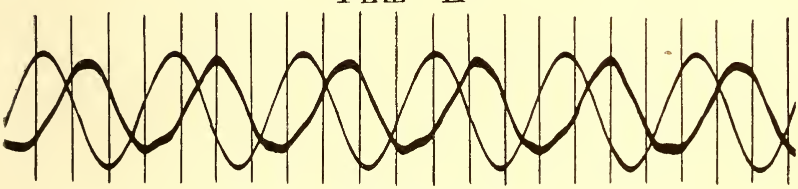
Film I[a]



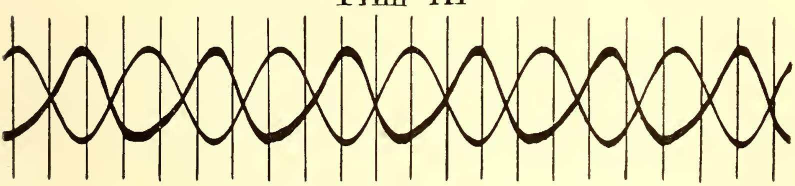
Film I[b]



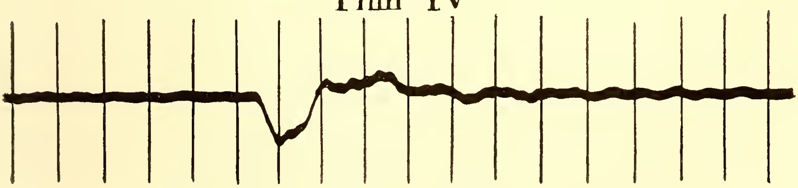
Film II



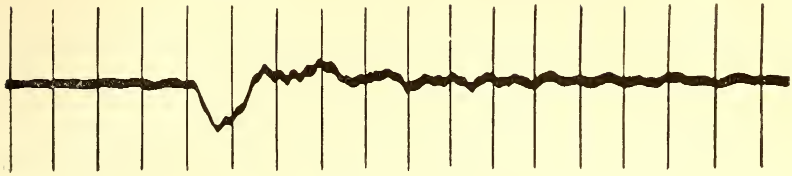
Film III



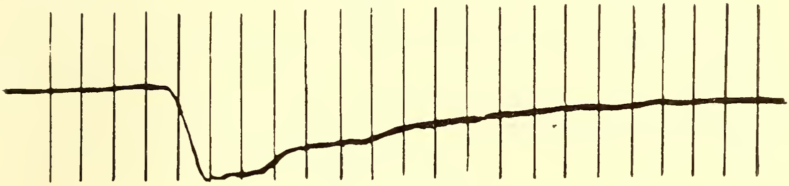
Film IV



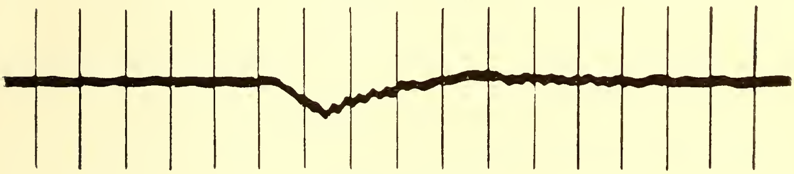
Film V[a]



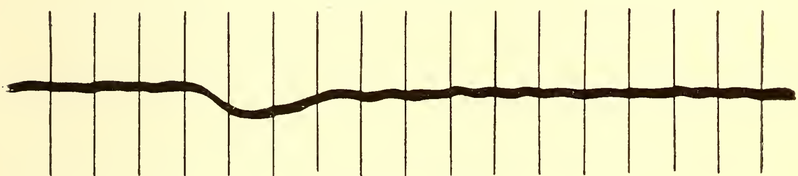
Film V^b



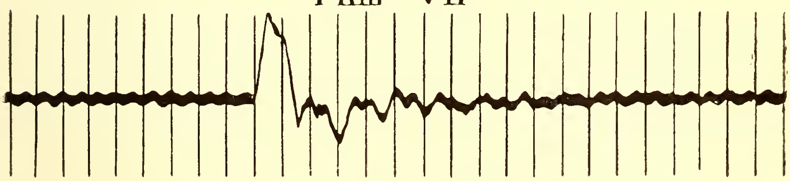
Film VI



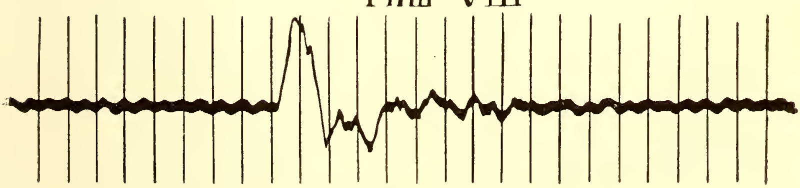
Film VII^a



Film VII^b



Film VIII



Film IX

portional to the amplitude of the fork movement. A study of the commencement of the movements (the forks were set in motion by burning through thread holding the prongs displaced) shows that the instrument record agrees well with the theoretical forced vibration effect, a heavy laboratory table being set in oscillation by a light tuning fork. On the table rests a seismomicrophone, which is in series with a cell, and the secondary of the air core transformer. The primary winding was in series with the Einthoven and 20 ohms extra resistance.

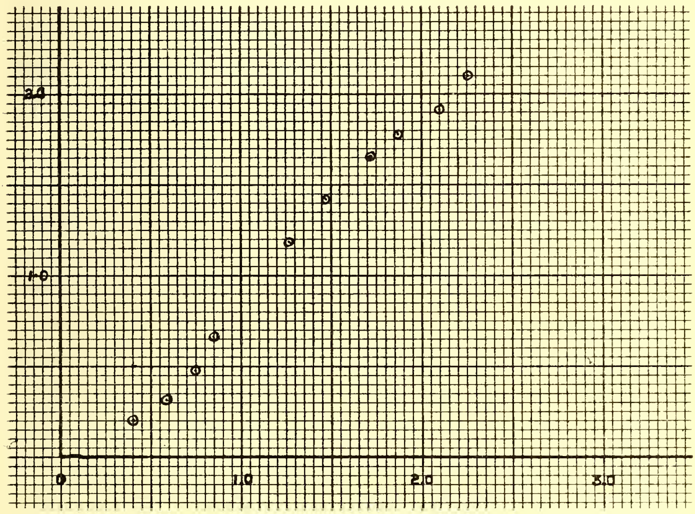


Diagram VII.

Film IV is a corresponding curve for the Télégéphone, and diagram VII. shows the relationship between fork and thread amplitudes in that case.

The other types of microphones were not satisfactory, there being obvious alterations in the conditions of contact between the carbon plate and granules during a run. Their curves are uniform in portions, then jagged as though some high frequency tremor—possibly a spark?—occurred between the surfaces, and then the conditions changed. But the Western Electric instrument is very much more sensitive to movement of extremely small amplitude than any other examined.

In the second case, a long cast iron pipe 2 inches in diameter was employed, a microphone being clamped to it near its pivots, the pipe being suspended so as to be able to be moved at one end through a small ($\frac{1}{2}$ inch) range, horizontally. The swinging beam was damped by vanes dipping into treacle, and its movement was recorded by a spot of light reflected on to the shaded half of the cinematograph film from a mirror at its free end. The motion given to the beam was caused by a touch on the free end, causing an abrupt displacement and slower return of the beam (under spring control) to its position of rest, the light curve (maximum displacement 1.5cm.) approximating to that of a Rayleigh wave. This represented a maximum displacement of a beam tip of 2mm. and a maximum microphone displacement of 0.01mm. Any bigger movement resulted in a minute oscillation of the beam as an elastic body, so that the movement was not correctly translated, the simple movement of the beam, as impressed upon it, and rendered through the microphone and Einthoven, being drowned by a damped harmonic motion of up to sixteen wave lengths. But for small amplitudes, the string movement and beam movement agreed, and the amplitudes were proportional. This pipe was later replaced by a $\frac{3}{4}$ inch pipe, the system being made as rigid as practicable, the beam as before being pivoted horizontally and kept to its rest position by springs, the movement being damped by vanes in treacle. Instead of the spot of light, a pointer cast a shadow on the film, so that the curves of beam movement and thread movement were recorded as two lines of different thickness. This was to enable the whole film to be employed for both movements. This, though satisfactory in so far as the microphone movement recorded faithfully the beam movement for small amplitudes was not otherwise so, as the beam oscillated several times before coming to rest, though well damped. On this difficulty being overcome by stronger control springs and damping, the rod as a whole vibrated and the microphone rendition was not at all in accord with the movement recorded by the end of the beam. But the beam could even be felt vibrating after its free end was stationary.

The next portion of the work was an examination of the different types of microphones, by touching or tapping them, or the table on which they stood.

The télégéphone was found to be most consistent, the seismomicrophone almost equally satisfactory, but the Western-Electric instrument, whilst giving a much bigger string movement for a small lead shot dropped on the table than did any of the others, had varying irregularities in the wave form produced. For listening purposes, and where quality was not of such great importance, this would be the best instrument. As an example of a test, take film V. (a and b):—

Télégéphone. (Resistance of order 10 ohms.)

Air core transformer. (Secondary 5,000 ohms, primary 0.290 ohms.)

Einthoven thread, resistance 60 ohms.

Current through Télégéphone of order 0.06 amps.

500 ohms additional in Einthoven-primary circuit.

Einthoven field 0.50 amps.

Taps (very light) on heavy table.

The small oscillations superimposed are not "accidental," as they are present every time; compare Va and Vb. They may be table, Einthoven, or microphone effects. A

Wheatstone network film (film VI.) of a similar effect (télégéphone, tap on table) is given for comparison, the thread being highly damped (thread resistance only) so as to prolong the return movement for examination. It is very probable that it is a microphone oscillation.

The curve (v) is practically identical with the "make" or "break," of film I., so far as the first portion is concerned, but drops to zero more rapidly (Einthoven circuit was identical). Film VII. (a) and (b) shows the effect of *touching* the télégéphone very lightly in front, once slowly, and once sharply. It will be seen that the curves are quite different. The time to maximum is approximately the same in each case—evidently the *contact* pressure is effective in the same time, "slowness" merely being in time of withdrawal.

Film VIII. and film IX. (continuing after the iron core transformer make and break, which has already been examined) show the télégéphone with the iron core transformer, and tapped very softly in front (film VIII.) and underneath (film IX.) to simulate horizontal and vertical components. The curves are identical. (The minor vibrations here throughout are due to imperfect shielding from local induction effects.)

Experiments were carried out to see if it would be practicable to employ a number of microphones in parallel, to increase the sensitiveness of the system. This was attempted first with a telephone receiver as detector, the increase in intensity being very marked when even only two similar instruments were employed. It was next performed with the full Einthoven system, and the two microphones in parallel gave a curve of much greater amplitude, but otherwise identical with that of either individual instrument. This work is not yet complete; it is not possible at this stage to say to what extent the amplitude is increased, as the wave in each case (produced by light tap on table) would not be identical as to energy.

Summary. The most satisfactory system for the examination of the nature and amplitude of small vibrations of a solid was found to be that of télégéphone, cell, resistance, secondary of transformer (either air or iron core) ; coupled with primary of transformer, resistance, Einthoven galvanometer.

It is essential that the galvanometer be aperiodic, which is best effected by variations in its field and resistance. It must not be overlooked that the thread may be too highly damped.

This system produces deflections of the Einthoven string which reproduce the form of the impressed vibration, the amplitude of the string movement being proportional to the amplitude of the microphone movement, for microseismic movements.

The sensitiveness of the system may be increased by using a number of microphones in parallel.

The Physical Laboratory,
University of Sydney.

SURFACE WAVES DUE TO SMALL ARTIFICIAL DISTURBANCES OF THE GROUND.

By Edgar H. Booth, M.C., B.Sc.,
Lecturer in Physics, University of Sydney.

(With Plates XXV.-XXVI.)

(Read before the Royal Society of New South Wales, Dec. 1, 1926.)

This investigation deals with the detection and examination of minute earth vibrations of microseismic nature by means of microphones, the behaviour of which when subjected to such movements has already been dealt with by the author in a previous paper.†

The greater part of our knowledge of earth vibrations comes from investigations of seismic disturbances in connection with earthquake movements, where the recording instrument is usually some considerable distance from the source of energy. During the war, microphones were used to detect, with the aid of a telephone head piece and the ear, minute earth disturbances, distant anything from 100 feet to a few inches; the nature—composition, hardness, moisture content—of the soil was of great variety; and there were so many other disturbances of greater energy available that it was necessary to distinguish the quality of the microseism. Also in some cases, microphones would be on the ground; in other cases they would be in deep tunnels, and even solidly buried in explosives, with which they were ultimately blown up.

An examination of possible waves is necessary.

† The Microphone as a Detector of small Vibrations. This Journal, 1926, 60, 305.

Poisson proved in 1830 that a homogeneous isotropic elastic solid body of unlimited extent can transmit two kinds of waves of different velocities, and that, at a great distance from the source of disturbance, the motion transmitted by the quicker wave is longitudinal (i.e., parallel to the direction of propagation) and the motion transmitted by the slower wave is transverse.

It was later proved by Stokes that the quicker wave is one of irrotational dilatation, and the slower one of equivoluminal distortion, characterised by differential rotation of the elements of the body, the velocities of the waves being $\sqrt{\frac{k}{\rho}}$ and, $\sqrt{\frac{n}{\rho}}$, k being incompressibility and n rigidity.

Later, when self registering instruments were systematically employed to record disturbances transmitted to distant stations, the record showed two distinct stages, the first characterised by very feeble movement, the second by a much larger movement, referred to generally as the "preliminary tremor," and the "main shock," or "principal portion."

In 1885 Lord Rayleigh showed that an irrotational displacement involving dilatation, and an equivoluminal displacement involving rotation can be such that (i) neither of them penetrates far beneath the surface, (ii.) when they are combined the earth is free from traction. Such displacements might take the form of standing simple harmonic waves of definite wave length and period, or they might take the form of a definite wave length and velocity. The surface is the theatre of transmission, the waves may be of any wave length, and gravity is neglected. It is found that wave velocity is independent of the wave length. It is these surface waves that are referred to as "Rayleigh waves.'' If the plane boundary is horizontal, the components of displacement are a vertical component, and a horizontal component, parallel to the direction of propagation; the displacement involved is two dimensional or cylindrical. The ratio of the vertical component to the horizontal component is 2:1 if the material be incompressible; it is nearly 3:2 if the Poisson's ratio is $\frac{1}{4}$.

Rayleigh shows that the disturbance is confined to a ''superficial region of thickness comparable to their wave length.'' He concludes by saying ''It is not improbable that the surface waves here investigated play an important part in earthquakes. . . . . . . Diverging in two dimensions only, they must acquire at a great distance from the source a continually increasing preponderance.''

The velocity of a simple Rayleigh wave is given by $v = 0.09\sqrt{\frac{n}{\rho}}$. The rigidity of many kinds of granite and marble has been found to be of the order 2.5×10^{11} dynes/sq. cm. and the mean surface density may be taken as 2.8 grms./c.c. So v is of the order 3×10^5 cms./sec. The wave lengths obtained then, from the period, which varies from 1-50th to 10 seconds, is of the order 6×10^3 cms. to 30×10^5 cms. This also gives an indication of the maximum depth affected.

R. D. Oldham, in 1900, suggested that the first and second stages of the preliminary tremors should be regarded as dilatational and distortional waves, transmitted through the body of the earth, travelling by nearly straight paths, and emerging at the surface; but that the ''main shock'' would be Rayleigh waves, travelling over the surface of the earth with a nearly constant velocity.

It is now recognised that the large waves of the main shock, like the preliminary tremor, show more than one phase. Love deals with this from the point of view of dispersion ("Some problems of Geodynamics," to which I am indebted in the main for the discussion), and of another set of surface waves, with horizontal movement at right angles to the direction of propagation, but *no* vertical movement. These last are generally referred to as "Love waves."

The surface phenomenon is dealt with by Jeffreys,* who examines the nature of the group velocities, and endeavours to reconcile the discordance between observed seismic effects and the theory of dispersion of surface waves.

To ensure as simple a practical case as possible, this series of experiments carried out on unmade ground at the Sydney University (clay on shale) was restricted to an examination by means of a télégéphone of the surface disturbance produced when a light "toy" pile driver was dropped on to a wooden peg in the ground. A line of pegs of hardwood, 3in. × 3in. by 2ft. long, were driven into the ground, and were left for three months. Another peg acted as a terminal post, protruding above ground level; in front of this was placed the télégéphone, connected by light leads to the post, from which leads passed off to the laboratory.

This microphone would measure a vertical component, or a horizontal component, but was so placed in this research as to eliminate the record of horizontal movements such as Love waves. As a simple impulse was given to the ground by dropping a light weight (250 grms. for the lighter pile drive) through a small height (not exceeding 30 cms.) on to a peg, it would seem that the only wave to be sent out should be the Rayleigh wave. But if the

* Jeffreys. Roy. Astr. Soc. Geophysical Supp., 1925, 1, No. 6.

dilatational wave also were received, the time would be too short for the separation of effects.

As the disturbance, then, should be only two dimensional, the amplitude y at any distance r from the origin would be given by the equation.

$$y = \frac{A}{\sqrt{r}} e^{-Kr}.$$

A being a constant, and K a damping factor.

The microphone (télégéphone) was 3 feet from the first peg, and was connected, as had been found most satisfactory, with the secondary of a transformer (either air core or iron core) through a battery and a variable resistance. The current through the microphone was of the order 0.05 amps. The primary of the transformer was in series with a variable resistance, and the string of an Einthoven galvanometer, which was aperiodic. The movement of the string was recorded on cinematograph film, being barred every 1-40th second by an interrupter driven by a phonic wheel.

Under these conditions it has been found (see previous paper) that the amplitude of the string deflection is proportional to the amplitude of the microphone deflection, and that the nature of the impressed movement—either simple harmonic motion or impulse—is faithfully recorded. Film I. shows the wave recorded.

As a comparison film II. shows the wave recorded when the blow (same energy) was given at a distance of 15 feet from the télégéphone. Attention is drawn here to the form of the waves, and not to their amplitudes—in the case of film I. the microphone besides being in series with the transformer secondary (7,100 ohms) had a further 32,000 ohms in series with it. In film II. this variable resistance was cut down to 5,000 ohms. The Einthoven circuit was left unchanged so as not to interfere with the damping. In all cases, as readings were taken at gradually increasing distances, the resistance in the microphone circuit was diminished, lock readings being taken at greater and less values so as to measure corresponding amplitudes. This variation of resistance of the microphone circuit did not produce the change in the wave form, as may be seen from film III. and IV. (5 feet from microphone), where the added microphone resistances (variable) were 32,000 and 22,000 respectively for two different blows.

Diagram I.

To see if $(\text{energy})^{\frac{1}{2}} \propto$ (amplitude of string deflection), the pile driver was dropped through varying heights on to a fixed peg. It was found that this relationship held provided the energy was below a certain small value at a given distance. For instance, with the heavier pile driver (mass 1500 grms.) the maximum fall permissible for this relationship to hold was 10 cms. at the 10 foot peg.

A graph (diagram I.) gives the relationship between the height of the driver and $\log_{10}$ string deflection for this peg. It was thought very probably that as the driver falls from greater and greater heights a smaller amount of energy, proportionately, is given to the ground. Consequently, for all runs at varying distance, the driver was allowed to fall through the *same* adjusted height, not exceeding 10 cms. This is a matter which is at present being investigated. It is obvious that the effect is due to the variation in wave form—that is, that it is incorrect to expect energy to be proportional to $(\text{amplitude})^2$ when the other factors are varying. This is apparent from the consideration of the remainder of the results in this paper, in view of the fact that the further away the disturbance be from the microphone, the greater the energy permissible in the disturbance without departing from the energy given to the ground proportional to $(\text{string deflection})^2$ relationship.

To investigate the variation in wave form with distance from the centre of disturbance, and if possible the decrease in amplitude, and consequently damping factor K, a series of runs was taken from 3 feet to 50 feet, the same energy been given to the peg at each blow (i.e., the pile driver dropped through the same height on each occasion) of which a typical run and accompanying films are given:—

Iron core transformer. Secondary, in series with microphone and 244 volt battery supply, 7,000 turns. Primary, in series with Einthoven thread plus 150 ohms, 150 turns. Peg I. (3 feet from microphone) to peg 7 (50 feet from microphone). Resistances added to microphone circuit varied from 32,000 ohms to nothing. The sensitiveness was such that the 7th peg reading on this occasion (windy weather) was not translatable, as local disturbances were of equal magnitude to those artificially produced. The records were as follows:—

Film V. 1st peg (3 feet). Compare a previous curve for another blow on this peg (same energy) film I.

Film VI. 2nd peg (5 feet). Compare film III. and IV. for this peg; same energy, film IV. same resistance in microphone circuit.
This is similar to the three feet curve, but there are not so many subsequent oscillations.

Film VII. 3rd peg (10 feet). Shorter wave length, oscillations more damped.

Film VIII. 4th peg (15 feet). Tending much more to the typical Rayleigh Wave. Compare film II., same peg, same energy, same resistance in microphone circuit.

Film IX. 5th peg (20 ft.)
Film X. 5th peg (20 ft.)
} Resistance here cut down to 2,000 ohms additional to magnify the oscillations after the first impulse, which otherwise are concealed in the thickness of the string.

Film XI. 6th Peg (30 feet).

To revert to the theory of the subject and quoting from Lamb (Phil. Trans. A., 203, 41.)—

"Again, instead of a disturbance originating at an internal point, we study chiefly the case of an impulse applied vertically to the surface. Under these conditions, the disturbance spreads over the surface in the form of a symmetrical annular wave system. The initial form of this system will depend on the history of the primitive impulse, but if this be of limited duration, the system gradually develops a characteristic form, marked by three salient features, travelling with the velocities proper to irrotational, equivoluminal, and Rayleigh waves respectively."

He further mathematically deduces that the motion received at a distant point begins suddenly at a time corresponding to the arrival of the 1st (dilatational wave). The surface rises rather sharply, and then subsides *very gradually* without oscillation. At a time corresponding to the arrival of the voluminal waves, a slight jerk occurs; and this is followed, at a time corresponding to the advent of the Rayleigh waves, by a much larger jerk after which the movement gradually subsides without oscillation. The subsidence is indefinitely prolonged.

This peculiarity of an indefinitely prolonged "tail" to the waves has been shown by Lamb (Proc. Math. Soc., 1903, 35) to be a characteristic feature of waves which diverge in two dimensions.

Examining the series of films from the first to the sixth pegs, it is clear that we are dealing here with the miniature earthquake—but the distance from the centre of the disturbance is so small that the motion of the microphone, and consequently of the Einthoven thread, is compounded of the three.

As we move out, the Rayleigh waves, being two dimensional, predominate, the other disturbances dying out to a very marked extent at 15 feet, and being practically nonexistant at 30 feet. The "period" of the first impulse has apparently increased from less than 3-80th of a second on the first peg to 9-80th of a second on the 15 feet to 30 feet pegs. The amplitudes, of course, are not to be read directly from the curves, as corrections have to be made for the changes in the resistance. This was done, as before mentioned, by taking a reading with higher and lower resistances at the same peg. If it be disregarded that the waves represent a compound movement, and amplitudes be measured throughout as the maximum displacement, a typical run gives the following values for K for a dry day, no rain within the previous week—

$$y = \frac{A}{\sqrt{r}} e^{-Kr}.$$

From.	K.	Mean Distance.
Pegs 6 to 5	0.080	25 feet
Pegs 5 to 4	0.087	$17\frac{1}{2}$ feet
Pegs 4 to 3	0.092	$12\frac{1}{2}$ feet
Pegs 3 to 2	0.106	$7\frac{1}{2}$ feet
Pegs 2 to 1	0.140	4 feet

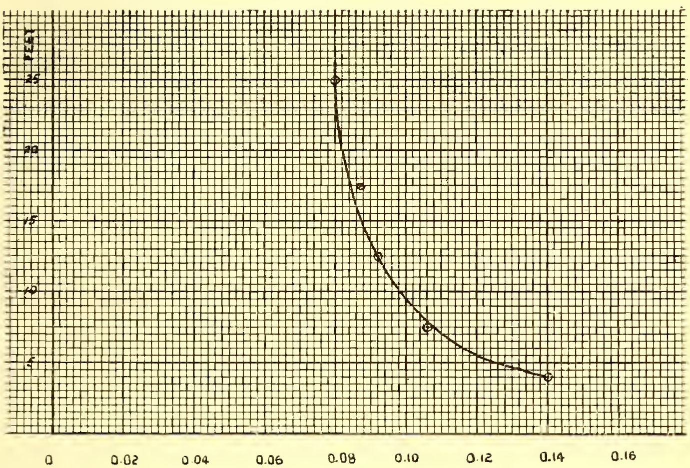


Diagram II.

Either the equation does not hold, or K is not a constant, or both. If distance from centre of disturbance be graphed against K, it is seen that the curve (diagram II.) is asymptotic to a value for K of 0.078, for this particular run, at a distance greater than 30 feet.

It would seem to be apparent then, that the Rayleigh wave alone exists at 30 feet and greater distances, the spherical waves having disappeared. That a probable value for K on this occasion was 0.079. And that, *close* to the disturbance, is a wave or waves compounded with the Rayleigh wave.

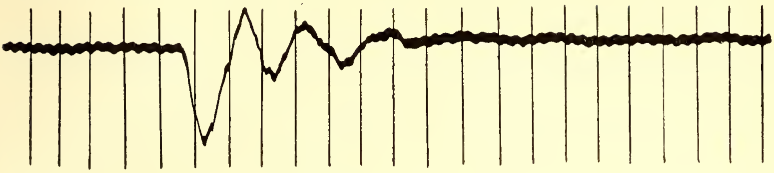
This is borne out by a number of similar runs—the wave forms undergoing precisely similar modifications, the Rayleigh wave eventually existing alone, and giving values for K dependent on soil conditions. After wet weather K is very large; on occasion, readings could not be obtained for any waves beyond the 10 feet peg.

Calculating on a value for K for the Rayleigh wave as determined beyond 20 feet, it is possible to find what is compounded with it at each other peg back to 3 feet, and consequently to recognise the other disturbances, and calculate their damping factors as spherical waves. A large number of films are being examined, and it is hoped that the results will shortly be available. The difficulty is as to how soon the Rayleigh wave develops—and what is its depth.

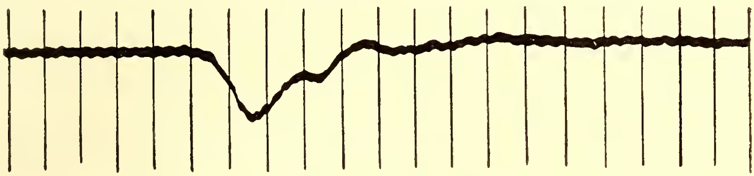
The energy appears to be in the surface layer, as the energy was not measurable at a depth of 1 foot, at 15 feet. This requires further examination, owing to variation of moisture with depth.

Attempts to get satisfactory readings beyond 50 feet have not been successful—it is quite simple to record the disturbances; but the earth movement at the University, due to road traffic a few hundred yards away, and general movement of students and buildings, is so continuous, and of such amplitude, that the artificially produced waves are drowned. A microphone record taken with a four stage valve amplification, shows the ground oscillating in a manner beyond all possible analysis.

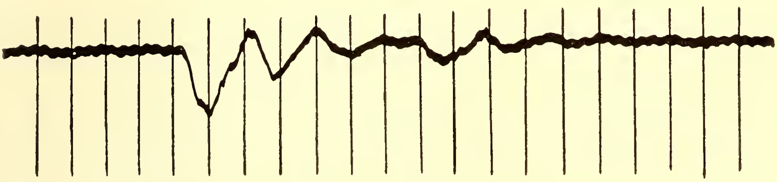
It does, however, give a practical use to the system as here devised—a record of the ground or building move-



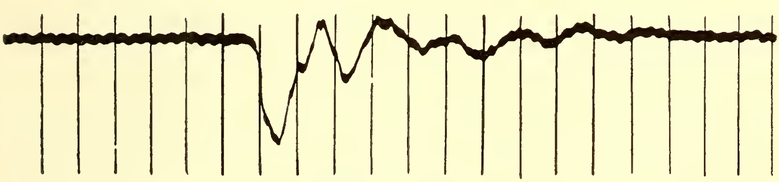
Film I



Film II



Film III



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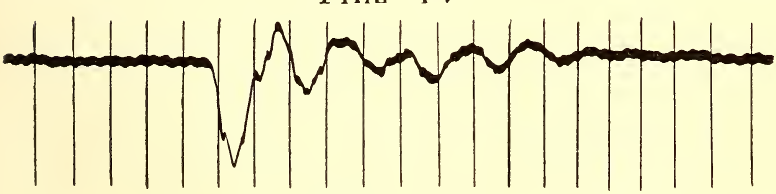

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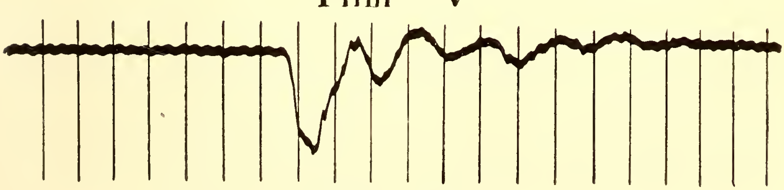

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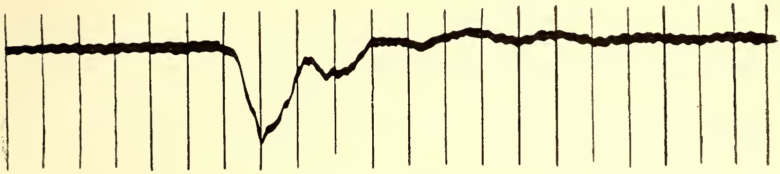

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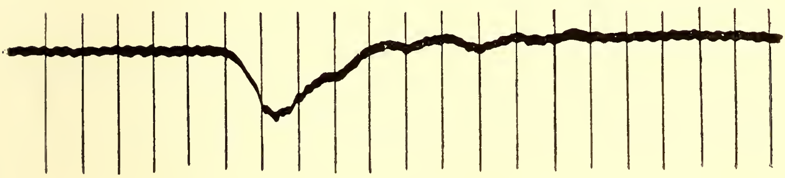

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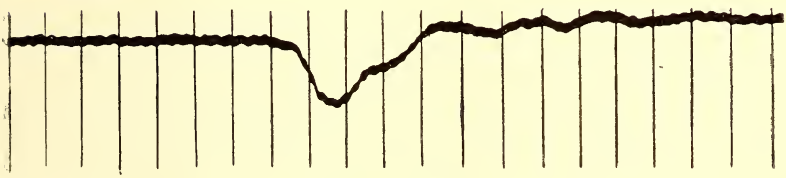

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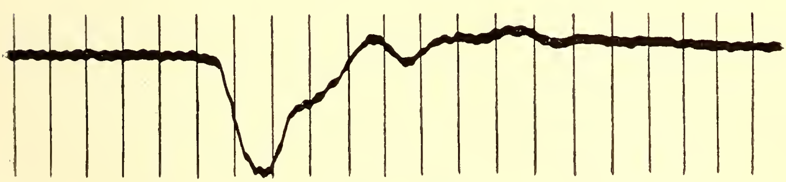
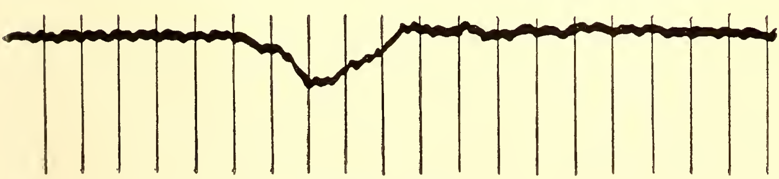


Film X



Film XI

ment at any point, due to passing trams or 'busses, is readily obtained. From this the maximum relative amplitude of the movement is read, and its period, if such is determinable, is obtained. Such amplitudes are probably of the order of 10^{-3} cm.—and those with which this work has dealt must be of the order of 10^{-6} cm. only.

Summary.

An examination of the surface waves set up by a vertical blow shows that the initial disturbance is oscillatory in character. That the oscillations are soon damped out, or dissipated more rapidly as spherical waves, than are the cylindrical or Rayleigh waves that exist alone at a greater distance.

This preponderance of the Rayleigh wave at a certain distance is in accordance with theory.

It is recognised that this paper opens up a number of points which require further investigation; in several cases these investigations have been made and results are being analysed and compiled.

It is also postulated as the result of examination of a number of records, that the final wave form would be propagated with a damping factor which may be found from the equation

$$y = \frac{A}{\sqrt{r}} e^{-Kr.}$$

A value has been found for K ranging from 0.06 upwards, for clay on shale at the Sydney University.

It is suggested that this system is of use to record the oscillation set up in tr ffic ways and adjacent buildings, sewers, etc., by various vehicles.

I have to thank the late Professor Pollock for indicating this line of research; he himself was engaged in

an endeavour to discover the damping factor for an earth wave—of any nature—by an audition method, graphing distance from disturbance against such resistance in a microphone circuit as just to render the blow audible or inaudible. Unfortunately his results were contradictory, though the papers he has left will be valuable for any other student taking up that work and undoubtedly he would have met with success if he had had time to complete his research. The error was that we were counting on K being constant from the origin, considering that only a Rayleigh wave would be developed by this method. I hope to continue his work, going to greater distances, as the microphone-ear system is extremely sensitive.

The Physical Laboratory,
The University.

THE ESSENTIAL OILS OF *ERIOSTEMON COXII* (MUELLER) AND *PHEBALIUM DENTATUM* (SMITH).

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(With Plate XXVII.)

(Read before the Royal Society of New South Wales, Dec. 1, 1926.)

ERIOSTEMON COXII (Mueller).

The botany of this extremely interesting Rutaceous shrub was described by Mueller in the "Melbourne Chemist" of December, 1884, and in the Botanisches Central-blatt, 1885, **21**, 210. (The author has been unable to secure access to these Volumes.)

It is a tall shrub growing to a height of about 10 feet, with dark green shining serrulated leaves about 1½ to 2½in. long and ½ to ¾in. broad, of a pale green colour underneath, with pretty white flowers. It is remarkable as having been recorded from one locality only, the sources of the Clyde River, southern district of New South Wales, about 3,500 feet above sea level (W. Bauerlen).

The writer, in company with Mr. F. R. Morrison, examined this shrub growing at the extreme summit of Sugar Loaf Mountain, a spur of the Clyde Mountain, Monga, near Braidwood, where the plant grows in a fairly luxuriant condition amidst a rugged quartzite outcrop.

In view of the rarity of the shrub, it was thought advisable to reproduce a photograph taken in January, 1922, which not only illustrates the plant, but also the rugged nature of its habitat.

The leaves, on crushing between the fingers, readily emit a delightful fruity odour, which very closely resembles that of the luscious passion fruit (*Passiflora edulis*).

Although the comparative rarity of the shrub precluded its economic exploitation, it was considered advisable to elucidate its composition, as the nature of its aroma would render its synthesis one of considerable value. An examination of passion fruit will shortly be undertaken by the author, who is satisfied that the composition of the essential oil of *Eriostemon Coxii*, as revealed herein, is sufficiently complete to enable anyone interested to prepare a satisfactory synthetic passion fruit flavouring essence.

Accordingly a number of collections of leaves and terminal branchlets were procured from the summit of Sugar Loaf Mountain during the period 1922-1925.

It is worth recording that leaves and terminal branchlets of this shrub were personally collected by the discoverer, Mr. W. Bauerlen, in 1898, the essential oil being first obtained therefrom on Aug. 30, 1898, by the Economic Chemist of this Institution.

The sample, when examined on Sept. 28, 1920, was found to have undergone very little change, the chemical and physical characters being practically identical with those recorded in the Table.

THE ESSENTIAL OILS.

The Essential Oils were of a pale yellow colour, sometimes almost water white, quite mobile, and possessed the pleasant passion fruit odour previously mentioned.

Altogether, 433 lbs. weight of leaves and terminal branchlets, cut as for commercial purposes, were subjected to steam distillation, the average yield of oil being 0.55%.

The principal constituents, which have so far been identified, were found to be *d*-*a*-pinene, an olefenic terpene (ocimene), butyl *iso*valerianate, amyl *iso*valerianate, linalool, ? geraniol, citronellol and darwinol, both free and combined as *iso*valerianates and caproates, sesquiterpene (cadinene), with small quantities of sesquiterpene alcohol, phenolic bodies and a paraffin of m.pt. 64-66°.

EXPERIMENTAL.

Four hundred and thirty-three lbs. of leaves and terminal branchlets collected from Sugar Loaf Mountain, Monga, New South Wales, yielded, on distillation with steam, crude oils, possessing the chemical and physical characters as shown in the table:

Date.	Weight of leaves.	Yield of oil.	$d\frac{15}{15}$	α_D^{20}	n_D^{20}	Solubility in 80% alcohol by wght.	Ester No. 1½ hrs. hot	Ester No. after acetylation.
3/2/1922	7 lbs.	0.64%	0.8810	+20.75°	1.4610	4¼ vols.	113.9	—
4/4/1922	147 lbs.	0.53%	0.8794	+20.75°	1.4600	3½ vols.	116.6	133.5
23/4/1924	132 lbs.	0.54%	0.8808	+22.10°	1.4637	8 vols.	94.1	120.0
28/8/1925	147 lbs.	0.58%	0.8798	+22.6°	1.4618	8½ vols.	107.3	126.6

A portion of the 1922 consignment was separated into two fractions during the distillation of the oil from the plant material, and on account of its interest the physical characters of each fraction are recorded:—

		d	*a*	*n*	Solubility in 80% alcohol by weight
Distillate in first 40 minutes	80% of total.	0.8735	+22.5°	1.4585	3.8 vols.
Do. in final 2 hrs. 20 mins.	20% of total.	0.9077	+20.6°	1.4842	insoluble

The crude oils were subjected to fractional distillation under reduced pressure and in order to follow the progress of the separation and identification of the various constituents, it is necessary to furnish details of the fractionation of both the 1922 and 1924 consignments:—

April 15, 1922 (1st 40 minutes' fraction).
150 c.c. distilled at 20-10 mm.

B.p.	Quantity.	$d\frac{15}{15}$	α_D^{20}	n_D^{20}	Ester No. 1½ hrs. hot sap.
55-57° at 20mm.	20c.c.	0.8593	+39.3°	1.4603	—
57-60° „ „	21 „	0.8579	+37.8°	1.4604	—
60-63° „ „	17 „	0.8563	+35.5°	1.4596	—
63-70° „ „	10 „	0.8549	+31.95°	1.4581	—
60-65° at 10mm.	11 „	0.8545	+23.45°	1.4548	115.5
65-70° „ „	15 „	0.8625	+11.40°	1.4472	170.1
70-82° „ „	29 „	0.8752	+ 4.2°	1.4410	218.2
90-114° „ „	10 „	0.8958	+ 7.5°	1.4532	175.7
114-131° „ „	12 „	0.9316	+11.9°	1.4840	95.2

April 22, 1924.
345 c.c. distilled at 20-10 mm.

B.p.	Quantity.	$d\frac{15}{15}$	α_D^{20}	n_D^{20}	Ester No. 1½ hrs. hot sap.
Below 60° at 20mm.	72c.c.	0.8591	+37.5°	1.4590	46.2
61-65° „ „	56c.c.	0.8587	+34.0°	1.4564	64.6
65-70° „ „	38c.c.	0.8587	+28.0°	1.4520	104.0
60-70° „ 10mm.	11c.c.	0.8661	+17.75°	1.4459	161.7
70-78° „ „	46c.c.	0.8715	+ 8.35°	1.4395	213.0
78-89° „ „	14c.c.	0.8862	+ 3.45°	1.4422	222.0
90-100° „ „	22c.c.	0.8977	+ 4.2°	1.4518	192.7
Above 100°C. „	60c.c.	0.9493	+11.2°	1.4950	70.7
Polymerised residue	26c.c.				

Determination of terpenes.—All the lower boiling fractions were either washed with 50% resorcin solution or treated with boiling aqueous normal potassium hydroxide solution until free from alcoholic and ester constituents. They were then subjected to steam distillation and finally repeated fractionation over metallic sodium.

d-*a-pinene.*—The 1st and 2nd fractions of the 1922 consignment yielded the following fraction distilling at 155-157° at 764 mm:

$$d\frac{15}{15}\ 0.8600,\ \alpha_D^{20}\ +\ 42.25°,\ n_D^{20}\ 1.4654.$$

Similar fractions of the 1924 consignment yielded a distillate of 155-158° at 769 mm:

$$d\frac{15}{15}\ 0.8584,\ \alpha_D^{20}\ +\ 43.2°,\ n_D^{20}\ 1.4660.$$

No matter to what treatment these pinene fractions were submitted, the specific gravity could not be raised above 0.8600. It was found, however that the fractions readily resinified and yielded gummy residues upon evaporation, and, judging from the characteristic odour and previous experience of similar mixtures, the olefenic terpene ocimene is undoubtedly present. Its identity could not be confirmed by chemical means on account of the small quantity present. The pinene fractions referred to above were oxidised with potassium permanganate (see this Journal, 1922, **56**, 195), and the pinonic acid separated as described therein. The acid distilled at 178-180° at 5 mm. and solidified immediately when placed in the ice chest. The crystals were separated, and on purification from petroleum ether (b.p. 50-60°) melted at 70°: 1.3112 g. in 10 c.c. chloroform gave a reading of + 12° $[\alpha]_D^{24°} = +91.5°$ The semicarbazone melted at 207°.

The hydrochloride was prepared in the usual way, and on recrystallisation from absolute ethyl alcohol melted at 130-131°; 1.0372 g. in 10 c.c. ethyl alcohol gave a reading of + 3.5°; $[\alpha]_D^{20°} = +33.74°$.

Presence of Ocimene.—The terpene fractions boiling higher than pinene, after removal of alcohols and esters, were found to possess a low specific gravity and to consist of mixtures of *d*-*a*-pinene with small quantities of an olefenic terpene resembling ocimene.

Determination of Butyl and Amyl iso*valerianates.*—The alkaline liquors resulting from the saponification of fractions 1 to 7 (1922) and 1 to 6 (1924) with aqueous potash solution were subjected to distillation from a sand tray using a 12 bulb fractionating column. The distillate was saturated with dry potassium carbonate and again subjected to distillation, the procedure being repeated until sufficient of the water-soluble alcohols were obtained for examination.

These were distilled at 769 mm., when the following fractions were obtained:—

	$d\frac{15}{15}$	α_D^{20}	n_D^{20}
1st fraction, b.p. 100-130°	0.8608	−1.4°	1.4140
2nd fraction, b.p. 130-135°	0.8481	−2.4°	1.4250

Although not very pure, these fractions were distinctive enough for their definite characterisation by means of napthyl*iso*cyanate. The first fraction yielded a napthyl-urethane melting at 62-63°, whilst the second gave a similar derivative melting at 49-51°. (See Schimmel & Co., Annual Report, 1922, 67.)

A careful comparison of these derivatives with those obtained with the alcohols from other sources, including the determination of mixed melting point, confirmed their identity as butyl and amyl alcohol.

Determination of Acids combined with above Alcohols.—The aqueous alkaline liquors after removal of water soluble alcohols by distillation, were acidified with dilute sulphuric acid, and the liberated acids removed by steam distillation.

The free acid was neutralised with dilute ammonia solution, the solution evaporated to a small bulk and the silver salt prepared: 0.4770 g. of the silver salt on ignition yielded 0.2466 g. silver = 51.69% silver. The silver salt of *iso*valeric acid requires 51.68% silver. The saponification liquor resulting from the separate treatment of fraction No. 5 yielded quite a large quantity of an oily acid possessing the following characters:
b.p. 174-178° (763mm.), $d\frac{15}{15}$, 0.9402, α_D^{20} + 0.35°, and n_D^{20} 1.4077: 0.7814 g. of the silver salt prepared therefrom gave on ignition 0.4028 g. silver = 51.55% silver.

There seems to be no doubt about the acid being *iso*valeric.

Presence of Linalool?—In the course of the examination of the various fractions boiling above the terpenes, after saponification to decompose the esters and subsequent fractional distillation, the following distillates were separated:—

Ex 1925 Lot.	d_{15}^{15}	α_D^{20}	n_D^{20}
85-90° at 10 mm. ..	0.8809	+ 8.6	1.4640
90-100° at 10 mm. ..	0.8780	+ 8.6	1.4562

These alcoholic fractions, although impure, did not react with phthalic anhydride, but yielded citral on oxidation with chromic acid. They possessed the characteristic odour of linalool, and despite repeated efforts with four distinct consignments of oil, I was unable to prepare confirmatory derivatives such as the phenylurethane and napthylurethane.

Determination of Geraniol, Citronellol and Darwinol (free and as esters).—The portion of 1924 oil distilling above 100° at 10 mm., 60 c.c., ester No. 70.7, was treated with alcoholic potash solution and the ester-free oil mixed with equal weights of phthalic anhydride and benzene, and heated on a boiling water bath.

The alcoholic phthalates were separated in the usual way and on decomposition with sodium hydroxide solution in a current of steam yielded 4 c.c. of an alcohol of pronounced geraniol odour. It possessed the following chemical and physical characters:
b.p. 110-113° at 10mm., d_{15}^{15} 0.8984, α_D^{20} + 3°, and n_D^{20} 1.4692
The silver salt of the phthalic acid ester, on purification from methyl alcohol, melted at 131-132°.

Another preparation of 3 c.c. from the 1925 consignment possessing a decided citronellol-darwinol odour had the

following constants:
$d\frac{15}{15}$ 0.8901, α^{20}_{D} + 14°, n^{20}_{D} 1.4655. The silver salt of the phthalic acid ester melted at 135-136°.

Another series of experiments showed these alcoholic constituents to exist in the free condition as well as in combination as esters.

The presence of citronellol was proved by the preparation of the pyruvic acid ester, the semicarbazone of which melted at 108°. (See Schimmel & Co., Semi-Annual Report, Oct. and Nov., 1904, 119.)

The small quantity of alcohols available militated against any successful separation of the components. The fact that the 1922 crude oil (fraction No. 2) yielded an alcoholic mixture of α^{20}_{D} + 18° and n^{20}_{D} 1.4700 pointed strongly to the presence of darwinol, an alcohol which has been shown to resemble geraniol closely and also to occur in admixture with it. (See this Journal, 1923, **57**, 237 and 1926, **60**, 83.)

It was not found possible to secure a derivative in confirmation, but the high specific gravity, optical rotation and refractive index provided strong evidence in support of its presence.

Acids in combination with higher boiling Alcohols.—The alkaline liquors resulting from the saponification of the various fractions (1924 lot) were treated individually. They were acidified with dilute sulphuric acid and the liberated acids separated by steam distillation, the oily acids being collected separately from the water soluble ones.

They were neutralised with dilute ammonia solution, evaporated to a small bulk and the silver salts prepared.

Shrubs of *Eriostemon Coxii* at Sugar Loaf Mountain, Monga, Braidwood, New South Wales.

Fraction No. 6.—0.5617 g. of silver salt yielded on ignition 0.2882 g. silver = 51.30%. (The silver salt of *iso*valeric acid requires 51.68% Ag.)

Fraction No .7.—Oily acid. 0.6716 g. of silver salt gave on ignition 0.3108 g. silver = 46.28%. (The silver salt of an hexylic acid would require 45.57% Ag.)

Aqueous acid.—0.5367 g. of silver salt gave on ignition 0.2774 g. silver = 51.68% Ag. (The silver salt of *iso*valeric acid requires 51.68%.)

Fraction No. 8 (60 c.c.).—Oily acid. 0.6228 g. of silver salt gave on ignition 0.3010 g. silver = 48.29% Ag. (The silver salt of caproic acid requires 48.43% Ag.)

Aqueous acid.—0.7020 g. of silver salt gave on ignition 0.3658 g. silver = 52.10%. (The silver salt of *iso*valeric acid requires 51.68% Ag.)

The alcoholic constituents appear to be present as esters of *iso*valeric, caproic, and an unknown hexylic, acids.

Determination of Sesquiterpenes.—The fractions of the various consignments distilling above 120° at 10 mm. were treated with 8% sodium hydroxide solution and alcoholic potash solution for the removal of phenolic and ester constituents.

The quantities available were too small to endeavour to determine the sesquiterpene alcohol separately, so the various fractions were distilled over metallic sodium. The 1925 consignment was found to give the best distillate: 17 c.c. were obtained of b.pt. 130-138° at 10 mm. d_{15}^{15} 0.9404, α_D^{20}, + 14.5° and n_D^{20}, 1 5070 A good yield of hydrochloride was obtained of melting point 118½-119° : 0.4390 g. in 10 c.c. chloroform gave a reading of + 1.5° = $[\alpha]_D^{20}$ + 34.17°.

The principal sesquiterpene therefore is cadinene, or one yielding cadinene dihydrochloride.

Determination of minor constituents.—The quantity of free acid present in the oil was very minute, not more than a trace of formic acid being detectable: 138 c.c. of crude oil yielded but 0.3 g. of a liquid phenol which, beyond giving an indefinite greenish black colouration with ferric chloride in alcoholic solution could not be identified.

A small quantity of a paraffin of m.p. 65-66° was separated from the residues left after removal of sesquiterpenes.

Phebalium Dentatum (Smith).

The botany of this tall Rutaceous shrub is described in Bentham's "Flora Australiensis," Vol. 1, 339. It is a very attractive shrub growing to a height of 15 to 20 feet with long narrow green leaves and yellowish white flowers. It is plentiful in the Port Jackson district, being especially abundant at Narrabeen and Middle Harbour.

The leaves, on crushing between the fingers, emit an odour closely resembling that from *Eriostemon Coxii.* On this account its essential oil was subjected to examination and the results recorded together.

THE ESSENTIAL OIL.

The essential oils were of a pale lemon yellow colour, quite mobile and possessed a pleasant passion-fruit odour.

Altogether, 589 lbs. weight of leaves and terminal branchlets, cut as for commercial purposes, were subjected to distillation, the average yield of oil being 0.21%.

The principal constituents, which have so far been identified, were found to be *d*-*a*-pinene, an unidentified terpene, butyl and amyl butyrates and *iso*valerianates, geraniol and citronellol free and as butyrate, caproate, and formate, with small quantities of citral, sesquiterpene, sesquiterpene alcohol, phenolic bodies and a paraffin of m.p. 65-66°.

EXPERIMENTAL.

Five hundred and eighty-nine lbs. of leaves and terminal branchlets collected around Port Jackson, yielded on distillation with steam, crude oils, possessing the chemical and physical characters, as shown in table:—

Date.	Locality.	Weight of leaves	Yield of oil.	$d\frac{15}{15}$	α_D^{20}	n_D^{20}	Solubility in 80% alcohol	Ester No. 1½ hours, hot sap.	Ester No. after acetylation
23/ 2/1923	Mid. Harbour	182lbs.	0.25%	0.8706	+20.25°	1.4646	6.0 vols.	69.8	114.5
18/ 6/1923	Narrabeen	64lbs.	0-17%	0.8770	+19.4°	1.4660	6.5 ,,	82.4	116.3
13/12/1923	Mid. Harbour	75lbs.	0.19%	0.8704	+20.8°	1.4666	7.0 ,,	64.4	120.3
18/ 8/1924	Narrabeen	101lbs.	0.23%	0.8713	+20.0°	1.4640	7.0 ,,	80.8	114.1
23/ 7/1926	Narrabeen	167lbs.	0.21%	0.8717	+18.5°	1.4626	6.0 ,,	90.3	129.2

Two hundred c.c. of crude oil, 23/2/1923 lot, yielded on distillation at 10 mm. the following results:—

B.p	Volume.	$d\frac{15}{15}$	α_D^{20}	n_D^{20}	Ester No.
50-60°	105c.c.	0.8533	+30.65°	1.4615	36.1
60-95°	26c.c.	0.8481	+15.65°	1.4558	40.1
95-115°	26c.c.	0.8889	+ 3.35°	1.4615	129.6
116-127°	30c.c.	0.9111	+ 6.5°	1.4755	82.6

Determination of d-α-pinene.—The fraction distilling at 50-60° was treated with both aqueous and alcoholic potash solution and then distilled over metallic sodium. Although numerous repeated distillations were made with the terpene fractions of the various consignments, the pinene could not be obtained in a condition of purity. Treatment with 50% resorcin solution appeared to remove small quantities of low boiling alcoholic bodies like amyl and butyl, but the specific gravity of the pinene could not be raised above 0.8583. The chemical and physical characters of the best sample were:—

b.p. 764 mm. 154-156°, $d\frac{15}{15}$ 0.8583, α_D^{20} + 39.80°, n_D^{20} 1.4656.

Oxidation of the pinene gave a good yield of pinonic acid of m.p. 70°: 1.0836 g. in 10 c.c. chloroform gave a reading of + 9.75°, $[\alpha]_D^{20}$ = + 90°. The semicarbazone melted at 207°.

Undoubtedly another terpene is present, but the author was unable to separate it probably on account of the nearness of its boiling point to pinene. At the same time alcoholic bodies were also detected which were not removed by distillation over metallic sodium or by shaking with 50% resorcin solution, probably due to a protective action of the pinene.

Determination of Butyl and Amyl Esters.—The aqueous alkaline saponification liquors from the treatment of fractions 1 and 2 were distilled on a sand tray, the vapours being conducted through a 12-pear column. Only very small quantities, about 2½ to 4 c.c. of colourless water-soluble alcohols being obtained. They were identified as butyl and amyl alcohols by means of napthyl*iso*cyanate, the respective melting points of their napthylurethanes being 61-62° and 50-52°.

Determination of Geraniol and Citronellol (free and combined).—Fraction No. 3 was treated with phthalic anhydride in benzene solution, both before and after saponification. A phthalate was isolated in each instance and on decomposition with sodium hydroxide solution, in the presence of steam, 7 c.c. of colourless oil with pronounced geraniol-citronellol odour were obtained. It possessed the following characters:

$$d\frac{15}{15}\ 0.8813,\ \alpha^{20}_{D}\ -\ 0.4°,\ n^{20}_{D}\ 1.4675.$$

Another preparation of 7 c.c. of alcohol from another sample of oil had $d\frac{15}{15}$ 0.8798, α^{20}_{D} − 0.5°, n^{20}_{D} 1.4657.

The silver salt of the phthalic acid ester in both cases melted at 128-129°.

Eleven c.c. of a similar alcohol fraction separated from the 1926 consignment oil had b.p. 110-113° at 10 mm., $d\frac{15}{15}$ 0.8740, α^{20}_{D} ±0°; n^{20}_{D} 1.4660 It possessed an excellent rose odour.

The silver salt of the phthalic acid ester melted at 125-126°.

The presence of citronellol was confirmed by the preparation of the semicarbazone of the pyruvic acid ester which melted at 108° (see under E. Coxii). Geraniol was determined by oxidation of the mixed alcohols with chromic acid mixture and after steam distillation, the resulting citral was removed by means of neutral sulphite solution.

The small quantity of citral regenerated from the sulphite solution by means of sodium hydroxide solution was converted into the β-naphthocinchonic acid melting at 204°.

Determination of the free and combined acids.—A small quantity of formic acid was detected in the crude oils. It was recognised by the colour reaction with ferric chloride and reducing action on silver and mercury salts.

The alkaline saponification liquors from the various fractions were acidulated with dilute sulphuric acid and steam distilled, the distillate being collected in fractions. These were neutralised with dilute ammonia solution, evaporated to a small bulk and the silver salts prepared.

Oily Acid, b.p. 176-180° at 774 mm.: 0.5212 g. of silver salt gave 0.2609 g. of silver on ignition = 50.15% Ag.

Oily Acid No. 2, b.p. over 180°: 0.4008 g. of silver salt gave 0.1980 g. silver on ignition = 49.40% Ag.

Aqueous Acid, No. 1 fraction: 0.3903 g. silver salt gave 0.2129 g. silver on ignition = 54.54% Ag.

Aqueous Acid, No. 2 fraction: 0.4160 g. silver salt gave 0.2251 g. silver on ignition = 54.11% Ag.

Aqueous Acid, No. 3 fraction: 0.5436 g. silver salt gave 0.3018 g. silver on ignition = 55.52% Ag.

Aqueous Acid, No. 4 fraction: 0.8538 g. silver salt gave 0.5290 g. silver on ignition = 61.95% Ag.

As qualitative reactions were obtained for butyric, *iso*valeric and formic acids, the author deduces from the experimental data, that the acids present represent a complex mixture of *iso*valeric and caproic (oily acids) and butyric and formic acids (aqueous).

Presence of Linalool?—After the removal of the geraniol-citronellol alcohols by means of phthalic anhydride a small quantity of an alcohol of b.p. 85-90° at 10 mm.: d_{15}^{15} 0 8573, α_D^{20} + 4°, n_D^{20} 1.4619, with a pronounced odour resembling linalool, remained. As stated under *Eriostemon Coxii,* its identity could not be confirmed.

Determination of Minor Constituents.

Citral.—About ½% of citral was detected in the various crude oils. It was removed by shaking with 35% cryst. sodium sulphite solution at room temperature, and on regeneration by means of sodium hydroxide solution, was identified by its refractive index, 1.4875 at 20°, and β-naphthocinchonic acid, melting at 202°.

The 1926 sample showed the presence also of citronellal in traces.

Sesquiterpene and Sesquiterpene Alcohol.—Both sesquiterpene and sesquiterpene alcohol were found to be present but the small quantities available did not permit of their separation and identification.

Phenolic Bodies.—0.25% of unidentified phenolic constituents yielding an indifferent colour reaction with ferric chloride in alcoholic solution, were found to be present.

Paraffin.—From the high boiling residues a small quantity of a paraffin was isolated of m.p. 65-66°.

In conclusion, I have to express thanks to Mr. F. R. Morrison, F.C.S., A.A.C.I., Assistant Economic Chemist, for much valuable assistance in the chemical examination of these oils; also to the Curator for the opportunity afforded to visit Sugar Loaf Mountain for the purpose of making field observations.

AN EXAMINATION OF DEFECTIVE NEW ZEALAND KAURI (*Agathis australis*).

M. B. WELCH, B.Sc., A.I.C.

(With Plates XXVIII.-XXX.)

(Read before the Royal Society of New South Wales, Dec. 1, 1926.)

During 1925 a large consignment of New Zealand kauri (*Agathis australis*) was received in Sydney, intended for vat building. After making up several large vats and filling them with water, it was found that some of the staves were broken across, as though they had been hit from inside. The wood had ruptured with a brash-like fracture across the direction of the grain, thus showing that it was devoid of strength. The sizes used were three inches or over in thickness, so that the failure was not due to local "cross grain" effects. In the floor of one vat a piece of wood fourteen feet in length and three inches thick, arched up to the extent of ten inches, and showed cracks, not on the convex side which would be expected if the wood were in tension, but on the concave side, showing that the shrinkage there was abnormal.

On examining a stripped stack of the wood it was also found that a number of flitches showed transverse or oblique ruptures, proving apparently that the tensile strength of the wood was less than the internal stresses due to seasoning. Longitudinal cracks or checks parallel to the grain are common in woods which are dried too quickly, due to the well-known property of wood of shrinking unequally in different planes, but in this case the failures were across the tracheids.

In appearance the wood was quite normal, varying somewhat in colour from pale straw to light brown. There was no external evidence of sap-stain or other fungal attack. The density was normal, but the lustre on a planed surface was rather less than usual, and according to the coopers the wood was "dead" and in nature resembled Powellised kauri. The whole consignment, amounting to about 100,000 super feet was condemned as useless for the purpose for which it was intended.

A rather similar experience, as the result of the use of defective New Zealand kauri, has recently been ventilated before the High Court in England.* The failure of the timber, which was proved to be swamp kauri, was also due to cracks appearing transversely in the wood, although prior to this there was nothing to indicate that the wood was not normal. It was stated in evidence that there was a diminution in cellulose and an increase in the resinous content of the swamp kauri, and further that since the New Zealand Government's restriction on the export of kauri this buried material was being used.

Apparently the Forestry Department practically prohibits the export of first-class kauri, but there is no difficulty in obtaining a permit to ship third-class or swamp kauri, although the latter wood has at present acquired such a reputation that milling it has practically ceased.

According to those engaged in the handling of New Zealand kauri, it is not necessary for the immersion in salt or brackish water to be longer than a few years before the defects noted, i.e., the appearance of "lightning-like" cracks, and the shelling and warping of the wood, occur on seasoning. It is stated also that Rimu, *Dacrydium cupressinum,* and White Pine, *Podocarpus dacrydioides,* behave

* Timber Trades Journal, London, 1926, 99, 1768.

in a similar manner when the logs are left in the water more than a few years. Much of the swamp kauri is of course buried in silt.

Tiemann* refers to experiments carried out by Janka on the effect of salt and fresh water on wood. The conclusion was that fresh water reduced the hygroscopicity and shrinkage of the wood, but weakened it slightly, whereas salt water probably reduced shrinkage. The time allowed was from one and a half to three and a half years. Tiemann also suggests that internal stresses gradually disappear by soaking the wood and mentions that in Japan, wood is commonly soaked for from two to five years in a mixture of six parts of sea-water and one part of fresh water. In the kauri in question, internal stresses were certainly not eliminated; thus one inch squares, cut for test purposes, curled so rapidly after sawing that it was practically impossible to dress them, and, in a length of a few feet, warped more than six inches from straight. Similarly quarter cut flitches over three inches thick and twelve inches wide, warped sideways, undoubtedly due to severe internal stresses; the maximum shrinkage was towards the heart.

The fact that so-called swamp kauri has been milled for many years is borne out by the following statement made by Kirk† in his description of *Agathis australis*: "In many localities as at Papakura and in the Waikato, kauri forests have been buried from unknown causes and the kauri is continually dug up, and used for railway sleepers, house framing, weather boarding, shingles, fencing, etc., with the most satisfactory results." The occurrence of these buried forests is also referred to in the report of the Kauri Gum

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* Tiemann, Kiln Drying of Lumber, 1917.

† Kirk, I. The Forest Flora of New Zealand, Wellington, 1889.

Commission,† as follows:—"Evidence of the forests of bygone ages are however afforded by the huge trunks of trees, in many cases as sound as the day they had fallen, and their branches and limbs scattered over and under the ground in the utmost confusion."

Brittleness in timber is usually due either to too rapid growth, producing a large percentage of thin walled wood-fibres or tracheids, to exposure, to too high temperatures during seasoning, or to incipient decay. That prolonged burying may cause loss of strength is shown by the brittle nature, when dry, of the blackened discolored wood occasionally unearthed at considerable depths in New South Wales. Burial for moderate periods may not apparently effect the wood, for example, apart from the kauri quoted above, Wilson‡ in reference to *Cunninghamia sinensis* var. *glauca* states that trees buried for many years in land slides yield wood often much darker than normal, but which is considered superior to newly felled timber and is largely used for coffins.

Boulger§ in reference to water seasoning, i.e., the immersion of logs in water for long periods, states that it reduces warping but renders the wood brittle and less elastic.

Two samples were originally obtained from one firm and transverse tests made on 3in. × 3in. × 36in. span, centre load, with the following results; the material was clear and free from defects:—

† Report of the Royal Commission on Kauri Gum Reserves, Wellington, 1914.

‡ Wilson, E. H. A Naturalist in Western China, 1913.

§ Boulger, Wood, London, 1902.

Test I:—Defective Kauri.

	Modulus of rupture in lbs. per sq. in. = f.	Modulus of elasticity in lbs. per sq. in. = E.	Weight per cubic foot. = W.	Moisture %
(1)	5,560	892,000	32	15.1
(2)	4,480	690,000	35	15.3
Mean	5,020	791,000	34	15.2

At about the same time transverse tests were also made on eight similar sized pieces from a different firm, six being from defective material and two from kauri previously held in stock and known to be sound.

The following results were obtained:—

Test II:—Defective Kauri.

	f.	E.	W.	Moisture %
(1)	8,310	837,000	35	14.6
(2)	8,750	921,000	37	15.1
(3)	5.140	970,000	38	12.8
(4)	5,180	595,000	38	16.6
(5)	4,180	739,000	44	16.4
(6)	5,600	1,231,000	42	16.2
Mean	6,693	882,000	39	15.3
Sound Kauri.				
(1)	11,500	1,624,000	37	10.8
(2)	9,740	1,419,000	31	10.8
Mean	10,620	1,521,500	34	10.8

Early this year six flitches which appeared to be quite sound, were selected from a large stack, and two test pieces of the same size as those above were cut from each. Transverse tests with centre load gave the following results:—

Test III:—Defective Kauri.

	f.	E.	W.	Moisture %
1A	5,660	656.200	40.0	14.0
1B	5,120	656,200	41.2	18.4

	f.	E.	W.	Moisture %
2A	5,130	709,300	40.6	18.1
2B	5,420	576,000	40.6	18.7
3A	10,770	921,300	38.5	13.5
3B	8,620	953,200	39.6	13.5
4A	4,720	800,600	37.5	11.7
4B	6,300	576,000	34.4	12.7
5A	9,820	1,256,600	35.3	11.9
5B	5,680	1,228,700	37.5	12.8
6A	7,980	864,000	33.1	15.2
6B	4,990	1,024,700	36.5	14.7
Mean	6,684	768,600	37.9	14.6

Compression tests were made on sound and defective kauri according to the method laid down in the British Standard Specifications for Aircraft Material; duplicate tests being made. The sound kauri was from the same pieces used in Test 2 and the defective kauri was from Test 3.

Test IV:—Defective Kauri.

	Breaking load in lbs. per sq. in.		Moisture %.
1	6,010	6,575	11.8
2	6,010	6,110	10.7
3	6,650	6,945	12.1
4	5,380	5,375	10.6
5	7,390	7,370	10.0
6	6,120	5,945	11.3
Mean	6,325		11.1

Sound Kauri.

1	8,320	7,530	9.1
2	7,320	6,760	9.8
Mean	7,480		9.5

Brittleness tests were also made in an Izod impact testing machine, according to aircraft specifications, the test pieces being from the same material as used in Test 4.

Test V:—Defective Kauri.

	Breaking load in foot-lbs.			Moisture %.
1	1.7	1.6		11.8
2	3.3	4.3		10.7
3	2.6	4.3		12.1
4	7.1	6.1		10.6
5	5.3	5.3		10.0
6	1.9	2.1		11.3
Mean	3.8			11.1

Sound Kauri.

1	2.8	3.3	4.8	9.1
2	4.6	2.5	4.0	9.8
Mean	3.7			9.5

For comparison the following transverse tests of New Zealand kauri are given on 3in. × 3in. × 36in. test pieces:—*

Mean f.=13,660. E.=2,159,900. W.=40. air seasoned.

The tests carried out on behalf of the Air Ministry of Great Britain gave the following mean figures.† The sizes of the test pieces are not mentioned, but if, according to the B.E.SA. specification for Aircraft Materials, the transverse tests would be on 2in. × 1in. × 30in. span with four point loading.

f.=9,325. E.=1,622,000. W.=31. Moisture.=15.1%.

Mean compression tests from the same source are:—
f.=6,190. W.=31. Moisture.=15.1%.

The very serious decrease in strength of the defective kauri is clearly shown by the transverse tests, thus the mean modulus of rupture is, in the three series of tests, 5,020, 6,693, and 6,684 lbs. per sq. in. against 10,620 and 13,660 lbs. per sq. in. for similar sized, sound test pieces.

* Welch: Notes on Strength of Timbers, Technological Museum Bulletin No. 6, 1923.

† Empire Timber Exhibition Catalogue, London, 1920.

The moisture contents of the sound test pieces in Test 2 are certainly lower than those of the defective material, but the variation in strength is too great to be accounted for by the increased moisture in the latter.

In general the strength of a wood, other factors being equal, varies directly as the density. Reducing the mean weights per cubic foot to a 10.8% moisture content basis, we have 32.7, 37.5 and 36.6 lbs. per cubic foot for the defective kauri in Tests 1, 2 and 3 respectively; whereas the sound kauri for the same moisture figure is 34 lbs. per cubic foot. The Technological Museum figure is 40 lbs., and the Air Ministry 29.8 lbs. per cubic foot, the latter at 10.8% moisture. It is apparent that the densities of the defective material are quite normal.

There is considerable variation in the strength of the various pieces, varying from a minimum modulus of rupture of 4,480 lbs. per sq. in. to 10,770 lbs. per. sq. in., and as seen in specimens 5A, 5B, 6A, and 6B of Test 3 there may be a considerable variation in strength of test pieces cut from the same flitch.

The modulus of elasticity or stiffness of the defective kauri is also extremely low in the majority of the tests, the mean figures being 791,000, 882,000, 768,600 lbs. per sq. in., against 1,521,500, 2,159,900 and 1,622,000 lbs. per sq. in. for the sound material.

The compression figures do not show such a discrepancy as the transverse tests, but this is probably partially accounted for by the smaller sized test pieces, and also by the condition of the cell walls, as will be shown later. It appears therefore that the greatest loss in strength is in tension and that the compressive strength is not greatly affected. This would be expected from the behaviour of the timber whilst seasoning and also from the method of failure without warning of the transverse test pieces. The "breaks" were all carrot-like; in the majority of cases the beams were completely broken across, pieces of wood flying out of the testing machine. It is evident that the tensile strength is very little greater than the compressive strength.

Kauri is naturally a comparatively brittle wood, but it was thought that the especially brittle nature of the defective timber would be clearly brought out by the impact tests. The mean figures were practically identical and, although test pieces 1 and 6 were extremely low, 4 and 5 gave higher results than those obtained for the sound wood. It is impossible to find any consistent agreement between the transverse and the impact test figures. Here again the considerable variation in the figures is possibly due to the small size of the test pieces.

The species belonging to the genera *Agathis* and *Araucaria* are characterised by multiseriate bordered pits on the radial walls of the tracheids, and by numerous semi-bordered pits between the ray parenchyma and the tracheids. The appearance of these multiseriate bordered pits is clearly shown in Plate XXVIII, fig. 1, representing a radial longitudinal section of sound kauri. The bordered pits are more or less circular or polygonal in outline, with an elliptical to circular opening. The longer axes of these openings do not coincide in either half of the pit, but are usually placed at right angles to each other. The openings do not extend beyond the outer limits of the border.

If we examine a similar section of the defective material, Plate XXVIII, fig. 2 it is seen that a considerable alteration in their appearance has occurred. The ends of the pit openings are now extended for a considerable distance and appear as definite short spiral cracks in the cell wall; the other half of the pit opening has also cracked in a similar manner, but at right angles to it. Cracks may also appear in the wall without any connection with the pit. The semi-bordered ray pits are also found to be similarly elongated by the extension of the openings into definite cracks. Plate XXIX, fig. 3.

An examination of a number of pieces of defective kauri showed a good deal of variation in the degree of splitting by the elongation of the pit openings, but in every case more or less of the cells were effected. In specimens 1 and 6 (Test 3), practically every pit opening was extended; in 3 and 4 the ray pits were affected more than the intertracheid pits; in 2 and 5 the intertracheid pits were almost normal.

From the examination made there does not seem to be any definite relationship between the strength of the wood and the degree of splitting of the cell walls; this is evidently due to the variation occurring in different parts of the same piece of wood.

In specimen 2A (sound kauri) a small extension was observed in some of the pits, but this was exceptional, otherwise the sound kauri did not show this defect. It appears therefore that longitudinal shrinkage of the tracheid has brought about the splitting of the cell walls to a greater or less extent, and that although such checking can occur in the sound wood, it is unusual. Apparently due to the exposure to abnormal conditions in the swamps the plasticity of the cell wall is reduced, and being unable to withstand the enormous tensile stresses brought about by shrinkage, it cracks, usually along the pit opening, which represents a line of weakness and which corresponds in direction to the longitudinal axes of the fibrils of the cell wall.

It is easy to understand, therefore, that the tensile strength of the wood is reduced to such an extent that it approximates to or is even less than the compressive strength, causing the wood to be extremely brittle. Furthermore the cumulative effect of the weakening of the individual tracheids due to internal stresses is such that they are often completely ruptured and transverse "shakes" appear in the wood.

WATER ABSORPTION TESTS.

	(a)	(b)	(c)	(d)
Defective Kauri.				
3	13.44	8.27	23.85	33.24
3	16.62	9.18	27.80	36.26
5	19.77	8.90	29.95	39.33
5	18.64	8.23	29.45	38.64
Sound Kauri.				
1A	9.05	5.83	16.92	24.41
1A	9.48	5.89	16.25	23.43
2A	28.64	8.08	39.52	49.75
2A	33.36	8.13	40.99	49.87

(a) Moisture content % after soaking in water for 3 hours.

(b) Moisture content % after drying for 41 hours at atmospheric temperature; the low moisture content is evidently due to the lack of penetration of the water during soaking (a).

(c) Moisture content % after placing in water for a further seven hours.

(d) Moisture content % after soaking for a further 20 hours.

Small duplicate pieces of kauri one inch square and two inches long were selected from the weakest and strongest of the defective material and also from the sound wood, the faces being radial and tangential. These were dried at 100° C. till the weight was constant and then, after weighing, placed in water. The object was to see whether the swamp kauri showed any marked variation from normal in the absorption or loss of water. The results from 3 and 5 are fairly consistent, but those from the sound wood 1A and 2A are considerably lower and higher respectively than the figures for the defective wood. It seems therefore that the swamp kauri shows no definite variation in the absorption or loss of moisture above or below normal wood, but that considerable variation can occur in the latter.

Bailey* in an examination of a number of North American woods found that spiral cracks in the walls of coniferous tracheids occurred in a small percentage of the dry timber, and that air passed as readily through the unruptured as through the ruptured wood. The latter result is similar to that which was found to occur in the absorption of water by sound and defective kauri. The explanation, as suggested by Bailey, is probably that the cracks are confined to the secondary thickening of the cell wall, the middle lamella remaining uninjured. Bailey found that, where present, the slits were confined to the thick walled tracheids of the late wood, whereas in the kauri now examined they may be distributed throughout the annual ring, the late wood being often only represented by a zone of a few cells in thickness.

Two g. of the shavings were boiled for one minute in 50 c.c. of water and the extracts filtered. In the specimens examined the sound kauri—even material which had been in stock in the Museum for more than ten years—gave very turbid solutions, apparently due to the presence of oily or resinous bodies. The turbidity cleared with the addition of caustic potash or alcohol. The defective material gave solutions which were almost clear or at most slightly turbid.

* Bailey, I. W.:—The Preservative Treatment of Wood, Forestry Quarterly, 1913, 11.

Caustic potash gave a bright yellow coloration with the sound material, and pale yellow to yellow with the swamp kauri. The acidity of the extracts from the sound kauri ranged from pH 4 to pH 5, whereas those from the defective material were from pH 4.5 to pH 6.5. It seems therefore that there is a slight decrease in the acidity of the swamp kauri.

No definite result was obtained from burning the shavings. In general the shavings smoulder for a long period and leave a moderately large amount of white or grey ash and a small amount of unburnt carbon, but exceptions occurred both in the sound and defective wood, the ash being extremely small with a relatively large amount of unburnt carbon.

The ash was determined in the swamp and sound kauri with the following results:

Sound kauri = 0.17%.

Defective kauri = 0.16%.

These figures suggest that there is no appreciable difference in the ash content.

On staining sections with alkannin a considerable amount of resinous or oily material was observed as globules or irregular masses, principally in the rays, although a few small globules were sometimes present in the tracheids adjoining the rays. This applied equally to the sound and defective woods. The so-called ''resin bars'' gave no indication of resin. On adding 95% alcohol, partial solution was obtained, a pale yellowish, more or less clear, amorphous residue being left which was darkened considerably by ferric chloride, the ''resin bars'' becoming especially prominent. There is thus apparently little change in the resinous contents of the ray cells, except possibly in the loss or alteration of the more volatile constituents, giving a clearer extract on boiling the shavings.

Summary:—New Zealand kauri milled from logs obtained from the swamps is liable to become worthless due to seasoning defects which not only cause the wood to check across the grain, and warp, but also produce excessive brittleness.

The weakness is evidently caused by a lowering of the strength of the cell walls with the result that they become cracked spirally when internal stresses are produced by shrinkage.

There is apparently no definite increase or decrease in the rate of absorption or loss of moisture.

In conclusion, I am indebted to Messrs. A. and C. H. Guthrie, of the Union Box Co., Ltd., of Sydney and Hokianga, New Zealand; to Mr. C. New, of Messrs. Tooth & Co., Ltd., Sydney; and to Mr. W. L. Wearne, of Empire Timbers Ltd., Sydney, for a great deal of valuable information with respect to the occurrence and usage of swamp kauri; to Squadron Leader L. J. Wackett, of the Royal Australian Air Force Experimental Station, Randwick, and to the Engineering Department, Sydney Technical College, for their assistance with the mechanical tests, and to Mr. F. B. Shambler, of the Technological Museum staff, for preparing the test specimens, and for his assistance in many other ways.

EXPLANATION OF PLATES.

Plate XXVIII, Fig. 1.—Radial longitudinal section of normal seasoned wood of New Zealand kauri. *Agathis australis,* showing typical multiseriate bordered pitting on the radial walls of the tracheids. Towards the right hand side can be seen the crossed openings of the pits which are typical of this wood. There is no evidence of cracking of the cell walls. × 190.

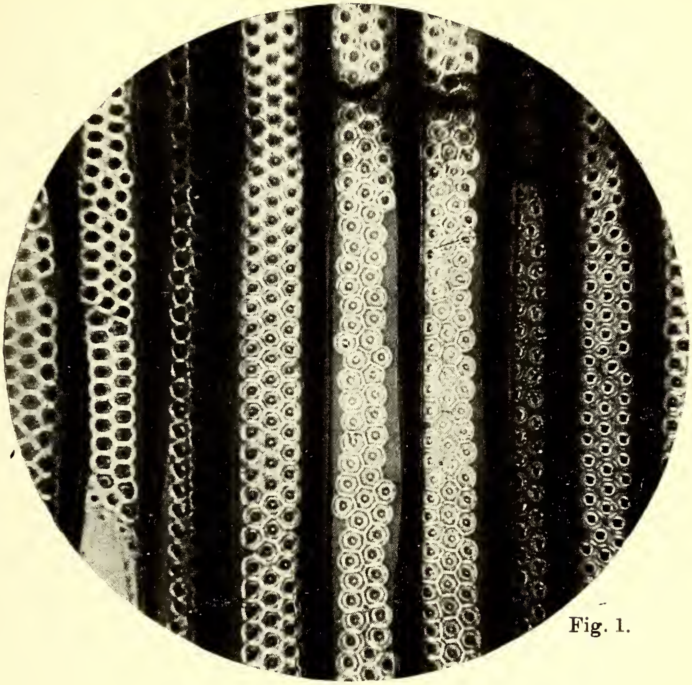

Fig. 1.

Fig. 2.

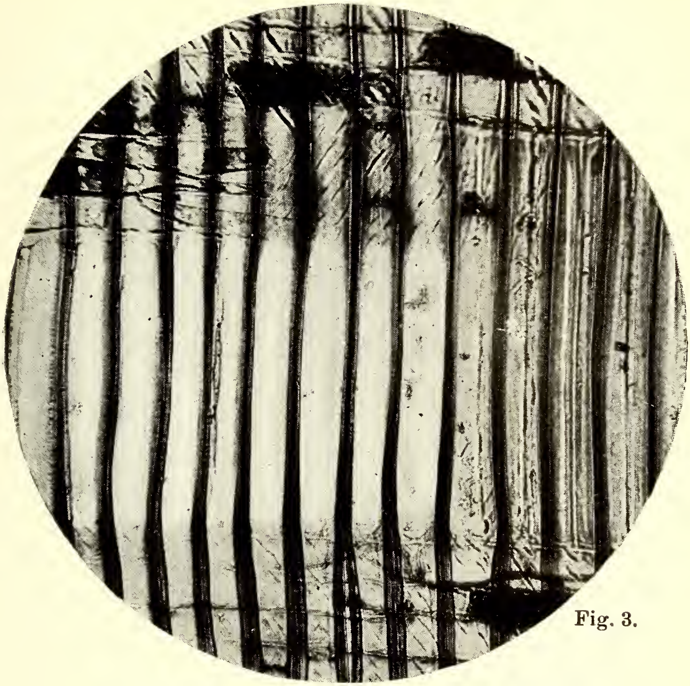

Fig. 3.

Fig. 4.

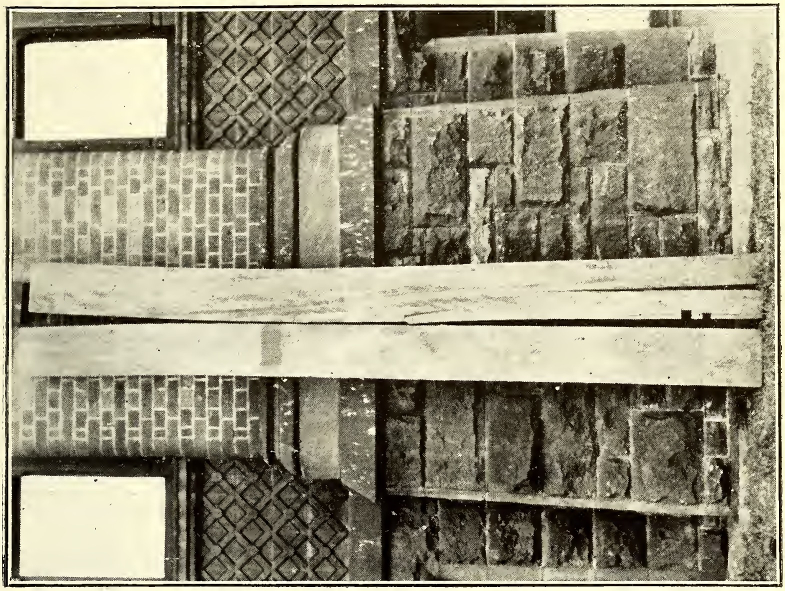

Fig. 6.

Fig. 5.

Plate XXVIII, Fig. 2.—Radial longitudinal section of defective New Zealand kauri, at junction of early and late wood, showing spiral cracks in the tracheid walls; in the majority of cases these are due to the elongation of the pit openings. × 190.

Plate XXIX, Fig. 3.—Radial longitudinal section of defective New Zealand kauri at junction of early and late wood. At the top and bottom are portions of two medullary rays in which are seen the splitting of the walls due to the elongation of the semi-bordered ray parenchyma-tracheid pits. The dark masses in the ray cells are largely oily or resinous bodies. × 190.

Plate XXIX, Fig. 4.—Tangential longitudinal section of defective New Zealand kauri showing spiral slits in several of the tracheids. × 190.

Plate XXX, Fig. 5.—Defective New Zealand kauri showing appearance of the surface after seasoning. The largest crack extended right through a flitch 3½ inches in thickness. Numerous small hair like cracks (seen as white lines) are present which will eventually open up. (Natural size.)

Plate XXX, Fig. 6.—Two flitches, 14ft. 3in. in length, 12in. wide and 3½in. thick of defective New Zealand kauri, showing the lateral warping, especially of the right hand piece. Both have numerous transverse cracks, but with a few exceptions, these are not visible in the photograph.

NOTES ON WATTLE BARKS. Part ii.

By F. A. Coombs, A.A.C.I., W. McGlynn,
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and M. B. Welch, B.Sc., A.I.C.,
Technological Museum.

(Read before the Royal Society of New South Wales, Dec. 1, 1926.)

This paper deals with two important problems connected with the stability of wattle bark tannins. The first is the question of the tannin content of stored bark, and the second refers to the estimation of tannin at high temperatures.

The subject of tannin depreciation or otherwise in stored wattle bark is an important one, and as far as we are aware nothing has been done in the investigation of this matter.

The view held by many tanners and those practically interested in tanning material is that the tanning value is increased with storage, but they are unable to advance any reasons for this belief. The theory has been advanced that, due to ageing, the bark is easier to extract on account of contraction causing small ruptures, and so allowing a readier penetration of the water. The consequent increase in the amount obtained by diffusion was therefore considered to explain the apparent increase in tannin; in other words, although the yield of extract was greater, there had actually been no increase in the tannin content of the bark. The modern idea is, in fact, that instead of any increase in tannin, the change is rather in the reverse direction, the tannins being gradually altered by prolonged storage to insoluble phlobaphenes. Such an alteration can be noted by the change of a light coloured bark or leather to a deep reddish colour on keeping. Although phlobaphenes are said to occur side by side with the tannins from which they are produced, this statement seems to require modification. Whilst phlobaphenes undoubtedly occur in the outer corky layers of the bark, we have rarely found them in the living cells in which tannin is present. The bark when freshly cut, immediately after stripping, is white or at the most a light pink, and practically devoid of any pronounced colouring matter, and in the Callitris barks a very sharp line of demarcation separates the living light-coloured bark from the brown outer non-living portion. In wattle the secondary phloem is often slightly darker than the fan-shaped medullary rays. The action of water on the dark-coloured contents of the cells of the dry bark shows that these pass readily into solution.

Wattle bark, after storing for some time, gradually changes in colour from a light yellow or pink to a very dark reddish brown; the change being apparently dependent on temperature, light and time of exposure. Although the change proceeds slowly when stored away from light, it becomes rapid in sunlight and it also increases with temperature. Similarly if pelt be tanned with pale-coloured wattle tannins, the resulting leather is usually also pale, but on keeping, it gradually but surely changes to a red colour. These changes are common to all catechol tannins, and at times are a considerable disadvantage; thus leather book-bindings obtained by such tannages change, after a few years, from a soft and light-coloured condition to a hard, brittle and dark-coloured state. This brittleness, apparently due to the instability of these tannins or of the products of their combination with hide-substance, is so pronounced that all catechol tannins are considered unsuitable for book-binding leathers.

The chemical structure of these tannins is practically unknown, and no chemical formulae can be supplied to show the reactions which take place when the catechol tannins change to the dark red colour. The physical properties of a leather, tanned with these materials, also undoubtedly change with the colour.

A wet pelt before tanning may be described as an elastic, fibrous structure, possessing considerable tensile strength. Such a structure would possess its maximum strength in tension when the load is evenly distributed over all the fibres, and conversely its minimum strength when the load is unevenly divided, so that a few fibres are stressed beyond their ultimate strength, thus causing their failure; this is followed by the breaking of other small sections of the structure until the whole is broken. When a strip of wet pelt is subjected to tensile forces the fibre groups which bear the maximum loads are stretched on account of their elasticity, and so the load is more or less uniformly distributed over the section before any failure of individual fibres occurs.

When a pelt is placed in a tannin solution one of the physical changes is in the gradual partial loss of this elasticity, and the decrease in this property in the fibres and grain surface of a vegetable tanned leather varies inversely as the amount of fixed tannin. It is possible to understand, therefore, that in the book-binding leathers, where the amount of tannin, fatty matters and mechanical work are so regulated to give a soft, pliable, tough product, if the fibres lose their elasticity and become brittle, the leather cracks and crumbles away when subjected to any severe handling which is sufficient to cause even moderate internal stresses.

Of the catechol tannins, wattle is the most important commercially, and this change to the "reds" or phlobaphenes evidently still takes place even after the tannins have been fixed in the leather. It is possible that the brittleness noted above may be due to combination of the tannin particles to form more solid masses.

Over thirty years ago a very complete investigation was made into the tannin content of the Acacia barks by the late J. H. Maiden. Numerous samples from different localities were stored in a dry place at the Technological Museum, and it was thought of interest to repeat the analyses to determine whether any appreciable alteration in the tannin content had occurred. Unfortunately the only figures available on the specimens were the tannin contents. It should be understood that the figures given for the original analyses refer to the Löwenthal method, since at that time the modern hide-powder method adopted by the Society of Leather Trade Chemists had not been introduced.

	Date of collection.	Original analysis % tannin.	Tannin.	Non-tannins.	Insolubles.	Water.
A. mollissima	8/11/92	30	42.72	10.39	35.39	11.50
A. pycnantha	1899	40	51.96	10.21	26.33	11.50
A. decurrens var. *Leichhardtii*	17/10/92	26	40.24	9.55	38.71	11.50
A. decurrens var. *Leichhardtii*	8/10/92	26	32.32	7.86	48.32	11.50
A. mollissima	17/10/92	30	40.16	10.13	38.66	11.50
A. decurrens var. *pauciglandulosa*	8/11/92	24	25.91	8.23	54.36	11.50
A. decurrens	12/8/92	29	38.09	9.32	41.09	11.50
A. decurrens	8/7/92	30	39.38	8.82	40.30	11.50
A. dealbata	1893	—	24.60	6.33	57.57	11.50
A. mollissima	1893	—	46.47	8.82	33.21	11.50

The last two specimens were sent from Nilgiris, India, to the late Mr. Maiden, but no record could be found of any analyses.

The tannin content of sample, *A. pycnantha,* is remarkably high and as far as we are aware is the highest yet recorded for any sample of wattle bark. From the fact that only four samples show under 40% tannin it is obvious that there can have been little if any depreciation, especially in view of the exceptionally high figure obtained for *A. pycnantha.* At the same time it is impossible to say definitely whether any increase has occurred.

The mean figures for the analyses of a number of barks of *A. mollissima, A. decurrens* var. *normalis* and *A. decurrens* var. *pauciglandulosa,* recently collected were found to be tannin, 33.36%; non-tannins, 8.62%; the maximum percentage of tannin being 50.72 and the minimum 23.28. If we assume an increase in the tannin content has taken place, it must have come either from the soluble non-tannins or from the insolubles.

In the old barks the ratio of $\frac{\text{tannins}}{\text{non-tannins}} = 4.30$

In the new barks the ratio of $\frac{\text{tannins}}{\text{non-tannins}} = 3.87$*

These figures are not close enough to suggest that there has been no alteration in the amount of soluble non-tannins present.

It seems, therefore, that prolonged storage of wattle bark for periods up to about thirty years has not resulted in any loss of tannin; on the other hand there is possibly a slight increase at the expense of the non-tannins.

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* Proctor (Leather Trade Chemists' Pocketbook) gives the ratio for Mimosa as 2—3.

A microscopic examination was also made of portions of the old barks. Without some preliminary treatment it is impossible to obtain satisfactory sections, on account of the hardness of the tissue. After soaking the bark in a saturated aqueous solution of potassium bichromate and then transferring to a glycerine-alcohol mixture, sections were obtained which showed, as was to be expected, that there was no alteration in the distribution of the tannin, from what was found to occur in the fresh bark (cf. Part i this Journ. 1923, **57**, 313). Portion of the bark was also softened in glycerine-alcohol without any preliminary treatment with potassium bichromate. A certain amount of tannin was evidently removed from the cells, judging by the colour of the solution. Transferring the sections direct to potassium bichromate or ferric chloride, showed tannin to be distributed throughout the tissues with the exception of the bast-fibre zones and the collapsed sieve-tube areas. As was found in the fresh bark the precipitate was much more marked in the outer portion of the secondary phloem and in the cortex than near the cambium. After allowing the sections to remain in water for one minute, however, there was practically no reaction for tannin in any of the cells, nor was there any insoluble matter which might be taken as an alteration product of the tannin to phlobaphenes. Collapsed sieve tube zones showed a light brownish colouration, but this is found also in untreated sections. Sections after boiling in water and treated with bichromate were even more clear, with the exception of the collapsed sieve tube areas. No oily bodies were shown to be present by the aid of alkannin. Starch grains are, however, numerous throughout the parenchymatous cells of the secondary phloem, medullary rays and in the cortical tissue. It has been suggested that the occurrence of starch in the cells in which tannin is normally found, might be connected with the formation of certain glucosides which are linked up in the formation of the tannins. Surrounding each group of bast-fibres are parenchyma cells containing crystals of what is evidently calcium oxalate.

An examination of the barks failed to reveal any small cracks or checks which might allow the readier penetration of water during extraction. Portion of the bark was also macerated by Schulze's method and no evidence was found of any rupture of the cell-walls due to stresses brought about through uneven shrinkage.

These old barks were very dark reddish brown in colour and it is reasonable to suppose that the tannins had changed to the red condition already described. The high percentage of soluble tannin obtained by analysis seems to show that for tanning purposes this long storage and change to the red condition does not affect the solubility of the tannins, thus confirming the results obtained by a microscopic examination of the bark structure.

The effect of high temperatures on tannin solutions.

The view usually accepted is that catechol tannins, on boiling with acids, generally yield ''reds'' insoluble in water but soluble in alkaline liquors and in alcohol, and are closely allied to resins. These tannin reds or phlobaphenes are regarded as anhydrides of tannin, i.e., tannin from which water has been removed, and consequently are formed by any agency which tends to split off or abstract water, such as high temperatures or prolonged boiling. The reds are much more soluble in hot than cold water, this being one of the reasons why a liquor made by the aid of heat is generally darker in colour than when extracted cold. The reds occur in large quantities in hemlock and in quebrachs, and are said to occur also in wattle.*

* Proctor, Principles of Leather Manufacture.

Although it is usually considered that high temperatures are necessary to extract these difficultly-soluble red tannins from wattle barks, as far as this work has gone the existence of such tannins has not been proved. It seems rather that the high temperature, necessary to counteract adsorption effects during extraction, causes the formation of these red substances. At temperatures above 40°, wattle liquors begin to change to a deep red colour, and since temperatures above this are necessary for extracting the so-called difficultly-soluble tannins, we have no evidence that these existed originally in the bark before extraction: moreover, the light colour of freshly-stored bark does not suggest that they do occur to any appreciable amount, if at all.

As pointed out above, it is generally accepted that prolonged boiling or extraction at high temperatures causes the formation of these insoluble phlobaphenes, and in order to test this conclusion wattle tannins were boiled for long periods. The experiment was carried out as follows: sufficient bark was added to a Proctor's extractor to give a litre of tan liquor at approximately 20° barkometer (sp. g. 1.02). After extraction the concentration was adjusted, and 100 c.c. of the filtered solution at 18° was placed in each of four one-litre flasks. Two of these flasks, B_1 and B_2, were then fitted with reflux condensers and the contents boiled for 20 hours, then made up to 1 litre with hot water and analysed. The two check flasks, A_1 and A_2, were not boiled, but received sufficient hot water to make one litre of tannin solution and were then analysed. The results thus obtained might be expected to show whether the boiling had caused any loss of tannin.

Analyses of tannin solutions.

	Not boiled.		Boiled 20 hours.		
	A1	A2	B1	B2	
Tannin	4.405	4.423	4.427	4.402	g. per litre
Non-tannin	1.109	1.097	1.075	1.090	,, ,, ,,
Insolubles	0.026	0.032	0.000	0.024	,, ,, ,,
Total solids	5.540	5.552	5.496[1]	5.516	,, ,, ,,

It would be possible for the loss of tannin, assuming that such did occur, to be made up by the alteration of non-tannins to tannins by the prolonged heating, but experiments previously made and referred to in Part i of this series[2] did not show any evidence of such a change.[3]

The results do not prove that any loss of tannin has occurred, the variation of the figures given in the above analyses being within the limits of experimental error. The pH value of the tan liquors A_1 and A_2 was 4.8, and at this degree of acidity, the tannins appear to be stable, but further work is contemplated at different hydrogen-ion concentrations within the limits of acidity obtaining in an extraction battery.

During an investigation of the tannins of the Black Cypress Pine *Callitris calcarata*,[4] it was shown that the presence of starch could be considered as an important factor in the destruction of tannin at high temperatures, and an experiment was conducted on somewhat similar lines with the wattle tannins. One hundred c.c. of a wattle bark liquor (approx. 20° barkometer) were measured into each of four one-litre flasks. Two of these received 0.5 g.

[1] In this case total solubles were slightly in excess of total solids.

[2] Welch, McGlynn and Coombs; Notes on Wattle Barks, Part i; This Journ., 1923, 57, 313.

[3] Williams (Composition of Natal Wattle Bark, Dept. of Agric., South Africa, Bull No. 1, 1920) shows a slight loss, scarcely beyond the limit of experimental error, on boiling a tannin solution for one hour.

[4] Coombs, McGlynn and Welch. The Tannins of the Black Cypress Pine (*Callitris calcarata* R. Br.), This Journ., 1925, 59, 356.

of starch dissolved in 200 c.c. of water, and were then made up to the mark with boiling water; the other two were similarly treated but without the addition of starch. After shaking and allowing to cool, they were analysed with the following results:

	Without Starch.		With Starch.	
	1	2	1	2
Tannin	3.775	3.789	3.508	3.481
Non-tannin	2.203	2.177	2.230	2.261

The total tannin without starch was 7.564 as against 6.989 with starch—a difference of 0.575 or 7.6% decrease in the tannin content. The amount of starch added was apparently all used up to form the starch-tannin combination and the filtrate gave no reaction for starch. It is probable therefore that if more starch had been added an even greater loss of tannin would have resulted.

In the experiments carried out with the *Callitris calcarata* tannins the loss by the addition of starch was 11.7% of the tannins. It is evident that in the case of the wattle also, starch can play an important part in the destruction of tannin, and the presence of starch granules in these barks has already been noted.

The formation of this tannin-starch compound, insoluble at ordinary temperatures, was clearly proved during the operation of a battery of 8 vats working on the Press Leach system with wattle bark. In this case the three tail-end vats containing almost spent bark were maintained at a temperature of about 98°. One liquor was drawn off each day, the battery being in operation for eight hours between each charge. As the liquor flowed beyond the three tail-end vats, the temperature decreased and a heavy jelly-like precipitate of this tannin-starch compound gradually accumulated, which was evidently soluble at higher temperatures. This compound was too insoluble at atmospheric temperatures to reach the leading vat into which the fresh bark was placed, the system being a progressive one. On treating this tannin-starch combination with iodine a definite starch reaction was obtained.

Reference is made to the precipitation of tannin by the carbohydrate, tragasol, in a paper by Stocks and Greenwood.[1]

Hough[2] has stated that rice starch is used to thicken gambier extract and noted also that when no rice starch is used the insolubles are considerably reduced. Gambier tannins are mellow and are used with more astringent tannins to prevent "drawn grain."

The presence of starch has been detected in block gambier extract; a sample with a high percentage of insolubles and a correspondingly low tannin content, gave a positive reaction.

The fact that starch is present in large quantities in gambier extract and that this extract is used to mellow more astringent liquors, suggests that the addition of starch might have a similar effect when added to a wattle tannage which is itself astringent.

Proctor and Parker[3] found that by extracting wattle bark at 100° for 2½-3 hours there was a loss of tannin amounting to 8.1%; it is important to note that the liquor was in contact with the bark at this temperature. Since it has been shown that boiling a tannin solution for 20 hours has resulted in practically no loss of tannin, and that wattle bark has been proved to contain starch, it is suggested that the loss shown by Proctor and Parker was

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[1] Stocks and Greenwood, Journ. Soc. Leather Trades Chemists, 1925, 315.

[2] Hough, Collegium, London, 1915, 343.

[3] Proctor and Parker: Effect of different Temperatures on the Extraction of tanning Materials. Journ. Soc. Chem. Ind., 1895, 635.

due, not to the destruction of the tannin at high temperatures, but to the combination of tannin and starch, the latter having been removed from the parenchymatous cells by boiling.

Summary.

Analyses of a number of wattle barks stored for over 30 years in a dry place seem to indicate that no loss of tannin has occurred. The ratio of tannins to non-tannins is much higher than that obtained in freshly stripped bark and suggests the possibility of an actual increase in tannin at the expense of the non-tannins. The high tannin contents also show that, although the barks have changed in colour from pale yellow, or at most a light pink, to a deep red, there has been no apparent decrease in the solubility of the tannins; this is confirmed by a microscopic examination.

The suggestion that high temperatures are necessary for the extraction of the difficultly-soluble red tannins in wattle bark can be discarded; it seems rather that the high temperature necessary to overcome adsorption forces actually turns the tannins red. There is no proof that difficultly-soluble red tannins occur in fresh wattle bark, and at temperatures above 40° a colour change to red occurs. Below 40°, however, a complete extraction of these tannins is impossible, so that any process giving approximately a complete extraction must use a higher temperature, and must therefore bring about this change to the reds.

The loss shown by various writers when solutions of wattle tannins in contact with partially spent bark are exposed to high temperatures is probably due to an insoluble starch-tannin combination, and not to a want of stability of the tannins under these conditions. This starch-tannin compound is partially soluble at temperatures approaching boiling point, but separates out on cooling.

THE HYPERSTHENE-ANDESITE OF BLAIR DUGUID, NEAR ALLANDALE, N.S.WALES.

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(Read before the Royal Society of New South Wales, Dec. 1, 1926.)

In his monumental work on the Hunter River Coal-Measures[1] Professor Sir Edgeworth David makes reference to a mass of hypersthene-andesite constituting a group of low hills lying a little over a mile south of Allandale Railway Station, 8 miles beyond West Maitland on the Great Northern Line. The outcrop is depicted on the map accompanying the memoir, the boundaries being sketched in: on this map the group of hills is named Blair Duguid, though locally no definite name seems to be attached to them.

Some years ago, in the course of a trip across the outcrop made by one of us (W.R.B.) in the company of Prof. David, certain resemblances were noted between the hypersthene-andesite and the rock composing the pebbles of the massive conglomerate outcropping in the railway-cutting about half-a-mile east of Allandale Station, and further investigation revealed certain features of petrological and stratigraphical interest which were considered worthy of record.

Field-Notes.

The hills are of low relief, rising by gentle soil-covered slopes to a height of 200 feet above the level of the creek that flows to the north of the mass, the highest point of which is about 370 feet above sea-level, and the total area covered by the outcrop is about 1½ square miles.

A field-examination reveals that there are a number of variations of the rock-type, some phases being almost black and basaltic-looking, others bluish or brown, and others again various shades of grey. These variations, it will be shown, represent alterations of the very dark phase, which is the fresh, unaltered rock.

Most of the andesite is massive, but a good deal of it is amygdaloidal, this feature being more conspicuous to the north and west of the mass than to the south and east. The texture is surprisingly uniform, the rock through all its phases exhibiting very abundant tiny phenocrysts, mostly of felspar, in a stony groundmass.

Throughout the mass there is an absence of natural sections, and, save for some shallow excavations, of artificial sections too, so that the mutual relations of the different phases cannot be properly made out, but from a study of the surface-outcrops it would appear that the light-grey phase in particular is quite irregularly distributed through the mass, and that in general there exists no regularity in the distribution of the different phases.

The vesicular portions of the mass are blue-grey or pale grey, sometimes light brown, in colour, and the vesicles are as a rule small and very elongated and flattened. The principal visible lining is translucent and opaque chalcedony, and the cavities are not always completely filled. In many cases a vesicular rock when split open is found to have in the cavities calcite and a rusty brown, earthy substance, probably representing a former lining of chlorite. It should be noted that the very dark-coloured phases have never been found to be amygdaloidal or vesicular, and that on the other hand the lighter-coloured phases are often perfectly massive.

More particularly in connection with the light grey phase there appears to be a very considerable local development of chalcedony. Much of this mineral is strewn over the surface in a fragmental condition, and some of it seems to have occurred in cracks, while some, showing beautiful banding, evidently formed the lining of large cavities with quartz-filled centres. In one case a mass of this chalcedony was found to have a cellular structure, due to the dissolving out of calcite crystals, round which it had been moulded, and indeed it is possible that the empty centres of some of the vesicles may once have been filled with calcite, now weathered away.

Petrography.

Measurements on a thin section of the fresh andesite show the following approximate volume-percentages of phenocrysts and groundmass:—

Plagioclase	27
Pyroxene	5
Groundmass	68

A slight fluxional arrangement of the phenocrysts causes variation in the measurement results for different directions, but the figures given represent the mean of sets in two principal directions, and are probably not very far from the truth.

The plagioclase ($Ab_{30}An_{70}$) is columnar and well-formed, showing both Carlsbad and albite twin-lamellae, as well as occasional cruciform interpenetration-twinning, and there is slight zoning. The majority of the crystals range between 2 and 0.5 mm. in length, but there are others down to 0.1 mm., which may be regarded as phenocrysts, and these appear to be as basic in composition as the larger ones.

The hypersthene prisms rarely exceed 2 mm. and the majority are smaller; a very little monoclinic pyroxene seems to be present.

The groundmass, which is very fine-grained, is composed largely of laths of plagioclase with prisms of pyroxene, both rhombic and monoclinic, and abundant cubelets of magnetite, which according to the chemical analysis is probably titaniferous. The felspar has a refractive index above that of Canada balsam, but other measurements are not possible; a calculation from the analysis, however, indicates oligoclase about $Ab_{75}An_{25}$. A felspathic mineral with refractive index lower than that of oligoclase, and forming irregular micro-poikilitic patches, may be orthoclase, and a very little quartz and some apatite in tiny needles are to be seen.

It is not certain whether any glassy base is present, but in places there is what looks rather like interstitial devitrified glass: if this is so the fabric, although now best described as pilotaxitic, was originally hyalopilitic.

A little alteration of the rock is evident, resulting in the production of chlorite and carbonates.

Slides cut from a number of the different phases illustrate the processes of alteration of the rock. Albitisation of the phenocrysts has proceeded in the usual way, along cracks and cleavage-planes: in no case examined is the transformation to albite complete. So far as can be made out, the phenocrysts have suffered much more than the more acid felspars of the groundmass, which is in accord with the observations of Bailey and Grabham.[2] In the most altered rocks felspar is thinly spangled with sericite.

Concomitantly with the alteration of the felspars there have been progressive changes in the pyroxene. The first alteration apparently is into a bright green to brownish-green platey mineral with one perfect cleavage, straight extinction, strong pleochroism, very small optic axial angle and fairly high negative birefringence. These characters correspond closely with those of iddingsite as given by Johannsen.

This mineral is usually regarded as secondary after olivine, but in the present instance it has very clearly been derived from hypersthene. One of us (W.R.B.) has observed the same mineral taking the place of olivine in rocks which had suffered deuteric alteration, and the question suggests itself whether iddingsite rather than ordinary serpentine is the usual alteration-product of these silicates under such circumstances.

In some other slides of the Blair Duguid rock the iddingsite becomes bleached and pale, and loses strength of double refraction, showing at the same time a tendency to pass over into sheaves of what look like ordinary serpentine, which is constantly accompanied by granules of secondary sphene, a rather surprising alteration-product of a mineral which is supposed to be fairly free from lime.

In other slides the iddingsite has partly changed into an aggregate of what appear to be exceedingly minute scales of pale chlorite, and yet another change is that to a carbonate—evidently calcite, since it effervesces freely in cold acid. The substitution of calcite for iddingsite is very well shown indeed.

The iron ore as a rule remains well disseminated through the groundmass during the earlier stages of alteration: in the most altered phases of the rock it has disappeared as such, but little granules may represent secondary sphene after titaniferous magnetite. In one of the slides of altered rock the magnetite is much more abundant than usual, and is bunched or clotted in a fashion which suggests hydrothermal introduction.

In the brown-coloured phases of the rock the colour is due to extensive staining with haematite and limonite.

In the thin sections of the amygdaloidal phases of the andesite the vesicles are seen to be lined with chalcedony, while their centres are filled with granular quartz or with chalcedony in beautifully radiating aggregates.

But for the fact that specimens are available showing all stages of alteration from the fresh rock, the most altered phase might well be called a keratophyre, and it was in fact so called before its antecedents were known.

Chemical Composition.

Two specimens of the rock have been analysed by one of us (H.P.W.) with the results given in columns I and II.

	I.	II.	III.	IV.	V.	VI.
SiO_2 ..	59.20	61.12	60.26	58.79	59.48	57.75
Al_2O_3 ..	15.98	18.71	16.46	17.51	17.38	17.68
Fe_2O_3 ..	3.30	1.65	1.15	2.11	2.96	1.55
FeO ..	3.69	1.08	4.87	3.87	3.67	1.01
MgO ..	3.10	1.77	3.09	2.23	3.28	1.67
CaO ..	7.02	3.84	5.25	6.18	6.61	3.63
Na_2O ..	3.31	6.13	4.23	4.84	3.41	5.79
K_2O ..	1.26	2.11	0.98	0.68	1.64	1.98
H_2O+ ..	1.13	1.23	2.22	2.61 }	0.74	1.16
H_2O- ..	0.73	1.39	0.22	0.71 }		1.31
CO_2 ..	0.48	abs.	abs.	tr.	—	abs.
TiO_2 ..	0.55	0.65	0.84	1.21	0.48	0.62
P_2O_5 ..	0.17	0.23	0.29	—	0.20	0.22
MnO ..	0.30	0.21	0.08	—	0.15	0.20
S ..	—	—	0.03	—	—	—
	100.22	100.12	99.97	100.74	100.00	94.57
Sp.gr. ..	2.74	2.59	—	—	—	—

I. Fresh hypersthene-andesite, Blair Duguid.

II. Albitised hypersthene-andesite, pebble from conglomerate in railway cutting, ½-mile east of Allandale.

III. Andesitic pitchstone, Currabubula. Analyst, W. N. Benson. Proc. Linn. Soc. N.S.W., 1920, 45, 417.

IV. Andesitic pitchstone, Pokolbin. Analyst, W. R. Browne. This Journal, 1911, 45, 404.

V. Osann's Average of hypersthene-andesite. Quoted by Daly—Igneous Rocks and Their Origin.

VI. Analysis II recalculated as explained in the text.

The second analysis is that of a very much albitised specimen, a conglomerate-pebble identical with the albitised phases of the rock outcropping at Blair Duguid: this was collected in the railway-cutting west of Allandale and analysed before the presence of the albitised rock *in situ* had been observed.

For comparison are cited analyses of Carboniferous pyroxene-andesites from other parts of the Hunter Valley and from Currabubula, about 100 miles to the north, as well as Osann's average analysis for hypersthene-andesite. The similarity of the fresh rock from Blair Duguid with this last is very striking and indicates its typical character.

With the Carboniferous pyroxene-andesites the fresh Blair Duguid rock shows many points of resemblance, but there are also some differences. In many of the essential oxides it is very close indeed to the Currabubula rock, but the lime is higher and the soda lower. Though not suspected when the analyses were first published, there can be little doubt that the high figures for soda and the low figures for lime in the Currabubula and the Pokolbin rock are due to slight albitisation, and if allowance is made for this the correspondence between these and the Blair Duguid rock is all the closer.

The norms of the rocks I and II are as follows:—

	I.		II.
Quartz	16.74%	..	7.26%
Orthoclase	7.78	..	12.23
Albite	27.77	..	51.87
Anorthite	25.02	..	17.24
Diopside	4.73	..	0.86
Hypersthene	9.07	..	4.00
Magnetite	4.87	..	2.32
Ilmenite	1.06	..	1.22
Apatite	0.34	..	0.34
Calcite	1.10	..	—
	98.48	..	97.34
Classification	II. 4.3.4 Tonalose.		I. 5.2.4 Larvikose.

On the whole the fresh rock has a fairly normative mode. As observed above, the quartz and orthoclase probably occur in the groundmass, though it must be confessed an inspection of a thin slice does not suggest the presence of so much quartz as is revealed by the norm. It is evident that at least half of the pyroxene is in the groundmass, and probably the bulk of the diopside occurs in this way.

From the norm of II it is evident that the rock has not been completely albitised, as there is still much of the anorthite molecule present. The mode is not normative in respect of the dark constituents, the normative hypersthene and diopside combining with water and appearing as serpentinous material.

It is interesting to note that this albitised rock finds without difficulty a place in the C.I.P.W. Classification, which is intended for fresh rocks only.

A comparison of the analyses I and II reveals some interesting features. Taking the figures as they stand, it is sufficiently evident that there has been in the partially albitised phase a loss of lime, iron and magnesia, and a gain of soda, but a more accurate comparison is desirable.

Merrill[3] has pointed out that a reasonably reliable comparison of analyses in the case of a fresh rock and the same rock decomposed is possible only if we standardise the analysis of the altered rock by means of some of the constituents which can be assumed to have remained approximately constant through being insoluble in the weathering solutions; this principle he has used with much success.

In the present instance this method cannot be used, for we cannot be sure that any constituent has not suffered either increase or diminution, since the solutions affecting the rock have evidently been constructive as well as destructive. However, an approximate comparison may perhaps be made if we take specific gravity into account. This has decreased by about 5½% in the altered as compared with the fresh rock, and though this change is no doubt partly in consequence of recombination of the oxides to form minerals of greater specific volume, it will probably not be very incorrect if we assume that it is mainly due to the actual increase of some oxides and diminution of others.

If then we recalculate analysis II so that its sum is about 94.5, we can compare the result directly with analysis I, since the figures now represent the weights of the various oxides present in the same volume of both rocks. When this is done there is seen to have been in the altered rock a loss of SiO_2, Fe_2O_3, FeO, MgO, CaO and CO_2, and a gain of Al_2O_3, Na_2O, K_2O and H_2O as well as of the minor oxides P_2O_5 and TiO_2.

Even if the assumption on which these calculations have been based is not quite correct, there is indicated for the altered rock, in addition to the gain in soda, a gain of potash of at least 25% of the amount present in the fresh rock.

This may be demonstrated in another way, for if we assume that the potash has remained constant, and recalculate the analysis II accordingly, an altogether improbable total removal of most of the other oxides is seen to have occurred.

The ultimate fate of the removed material we can determine only in part. Doubtless some or all of the silica was deposited in vesicles and cracks as chalcedony and quartz, though the quantities of these minerals present seem greater than can be accounted for by the removal of silica; and some of the magnesia and iron probably reappeared as the vesicle-filling chlorite which has since been removed from the outcropping rocks by weathering.

The absence of notable quantities of carbonates from the altered rocks is somewhat surprising. True it is that in some of the altered phases calcite replaces the pyroxene, that calcite occurs in some of the cavities, and that there is evidence of the former presence of this mineral with chalcedony in other cavities, but on the whole the carbonates are not prominent. It may be, of course, that the parts of the mass extensively carbonated have been removed by erosion or are not yet revealed, or else that most of the carbonates have been dissolved out by weathering solutions.

Origin of the Albitising Solutions.

It is abundantly clear from the field-evidence that the albitisation is not due to mere surface-weathering, because the unalbitised andesite weathers in very distinctive fashion, the alteration being limited to a superficial layer about $\frac{1}{8}$ of an inch thick which is rusty and slightly pitted on the outside, and dotted with kaolinised and decomposed phenocrysts underneath. Below this thin outer layer the rock is perfectly fresh, with a dark, almost basaltic look and glassy felspars. The grey albitised rock, on the other hand, is grey right through, and the felspar phenocrysts are always greyish white and opaque. Further, there are never gradations to be seen in any specimen from the surface inward through blue, brown or grey phases to the fresh rock. The various phases are, as emphasised above, distributed irregularly through the mass, and in some of the shallow excavations it appears, though it cannot be definitely proved, that the grey rock has a vertical disposition. The occurrence of chalcedony, it would seem, is confined largely to the altered phases of the rock, both as vesicle-filling and as fissure-filling. In a specimen which was secured showing both the grey and a less altered phase, there is a continuity of texture from one phase to the other, but a rather abrupt change of colour along an irregular boundary, showing that the grey phase is not a subsequent intrusion but the result of the action of very potent solutions acting on the dark rock.

The question next arises as to whether these phenomena are the work of groundwater or of magmatic solutions. It has for a long time been recognised that the formation of albite and zeolites, chlorite, serpentine, calcite and other alteration-products in igneous rocks, is often due to the activity of magmatic solutions operating during or immediately after the consolidation of the rock, and indeed it seems doubtful whether the temperatures requisite for albitisation are normally attained by ordinary groundwater solutions. It is noteworthy that the alterations of igneous rocks by hydrothermal action discussed by Lindgren[4], Leith and Mead[5], and others usually involve the loss of soda. In the present instance the outstanding feature of the alteration is the gain of soda, and this in itself would point to the action of solutions of a particular nature and origin.

The phenomena observed at Blair Duguid then are such as may best be explained as being deuteric in character, the result of the activity of the residual waters of the andesitic magma; these may have worked upwards, as appears to have been the case in the Permo-Carboniferous latite at Port Kembla (to be described in a later communication), perhaps along joint-planes, altering the rock only locally where it was solid, but effecting more extensive alteration where the rock was vesicular and percolation more easy. Unfortunately for this view the Permo-Carboniferous tuffs lying some distance above the andesite are likewise albitic and have quite possibly been albitised; still this is not improbably a coincidence, since there is no reason why the same magmatic processes should not have been repeated.

Age and Relations of the Mass.

In his Hunter River Memoir Professor David interprets the Blair Duguid mass as representing the site of a submarine volcano in the Lower Marine Permo-Carboniferous sea, which emitted both andesitic lava and volcanic ash The discovery that the rock constituting the pebbles of the Allandale conglomerate is identical with certain phases of the Blair Duguid andesite makes it pertinent to inquire into the geological age of the latter. In a later paper[6] Professor David looks upon the mass as an inlier of Carboniferous rock, and this is the view which commends itself to us.

Mantling the flanks of the hills and in the creeks cutting through or flowing round the mass one may see tuff or tuffaceous sandstone, usually weathered to a warm brown or sandy colour, but probably light bluish-grey when fresh, like that at Harper's Hill, and in places quite richly fossiliferous in *Eurydesma cordatum, Aviculopecten,* etc.; here and there this tuff may be observed to pass down into a heavy conglomerate. In one creek on the western side of the mass and flowing parallel to it there appears such a conglomerate with angular and rounded boulders up to three feet in length, packed closely together with very little matrix and that tuffaceous. This conglomerate rests directly on the solid andesite, and a little distance away it has passed into a facies with smaller pebbles and containing Lower Marine fossils. At the house of Mr. Barnard, vigneron, at the extreme southern end of the mass, there is an excavation which shows a section of boulders of andesite or albitised andesite, some amygdaloidal, up to 2½ ft. in diameter, well-rounded and set in a very subordinate tuffaceous matrix, the whole evidently resting directly on the solid andesite. This conglomerate would appear to be overlain by a coarse tuff and fine conglomerate, some phases of which are very highly fossiliferous.

Other patches of tuffaceous conglomerate containing highly rounded andesite pebbles have been observed in creeks round the andesite, and it is very probable that the conglomerate is continuous round the mass, but that the presence of so much soil prevents one from distinguishing between weathered blocks of solid andesite and andesitic boulders weathered out from the conglomerate.

The various bands of conglomerate exposed in the cuttings east of Allandale and separated by beds of tuff have very similar characters to those just described. In some places the boulders are big and angular, elsewhere they are well-rounded, and on a number of horizons in tuff and conglomerate there are bands of fossils, particularly *Eurydesma cordatum.* Professor David's map shows that this conglomerate and tuff can be traced in a north-west direction as far as Harper's Hill, where there is a good exposure in a cutting on the Great Northern Road. Thence it goes obliquely across the road, forming a high bank overlooking the flood-plain of the Hunter, and appears eventually to be cut off by the river. South or south-east from the railway-cutting the conglomerate can be traced with difficulty for some distance, forming a low ridge more or less parallel with the railway-line, but it cannot be definitely identified as far round as Lochinvar railway station. The heavy conglomerate, which gives rise to a prominent ridge where best developed, would thus appear to thin out and die away when followed along its strike in either direction from Allandale; in other words, it is purely local in its occurrence, and such as might be developed round the shore-line of an island in a shallow sea.

There is thus a strong probability that the Allandale conglomerate is to be linked with that surrounding Blair Duguid, though the details of the connection are obscure. In Professor David's map the Greta fault is shown cutting through between Blair Duguid and the railway-line, with a throw to the north, and near the crest of the hill on the road connecting Allandale Station to the Great Northern Road a fault is to be seen with a throw of unknown amount to the south. These faults probably explain why the conglomerate is found about 1½ miles north of Blair Duguid and about the same level as the highest point of the andesite.

The fact that the andesite formed an island in the Lower Marine sea does not settle the question of its age. The island may have been a remnant of the submerged Carboniferous land or it may have arisen like some of the present-day volcanic islands, from the sea, and suffered wave-erosion during the geological period in which it originated.

At Drake's Hill, Pokolbin, some 8 miles south-west from Blair Duguid, there is a mass of rhyolite and rhyolite-breccia, trachyte (or keratophyre) and andesite, obviously of Carboniferous age, since the same types not far away are overlain by *Rhacopteris*-bearing tuff.[1] The hill is mantled in places by a heavy conglomerate, composed of rounded and angular boulders of keratophyre, etc., and containing *Eurydesma cordatum, Aviculopecten* and other Lower Marine fossils. It is clear that this Drake's Hill mass was an island of Carboniferous rocks which suffered erosion in a Lower Marine sea, and as this provides a close parallel to Blair Duguid in the matter of occurrence, even to the probable stratigraphical horizon of the fossils occurring in the conglomerate, it may perhaps be taken to present a complete parallel and to furnish evidence of the Carboniferous age of the Blair Duguid andesite.

In Professor David's memoir the andesite and the Harper's Hill tuff are evidently considered to have been derived from the same volcanic centre, but this contiguity of tuff and lava may well be accidental, for tuff is found on other horizons in the Lower Marine Series. In addition, the tuff itself is different petrologically from the andesite, being composed largely of chips of albite and fragments of a trachytic rock, with a fair proportion of angular quartz grains and no definitely recognisable dark minerals except magnetite. While, therefore, the fossiliferous tuff is indubitably Permo-Carboniferous, it does not follow that the andesite belongs to the same period.

What may be called the internal evidence may now be considered. Chemically, as shown above, the andesite is comparable with Carboniferous andesites from elsewhere in the Hunter River valley, if one allows for changes due to partial albitisation; petrologically it bears very close resemblance to the pilotaxitic pyroxene-andesites of Pokolbin and Currabubula. Further, there are no similar rocks of known Permo-Carboniferous age with which the Blair

Duguid rock can be compared, and this is in itself significant.

Reviewing all the available evidence, then, we are strongly disposed to regard the Blair Duguid andesite as an inlier of Kuttung rock rather than as a flow contemporaneous in the Lower Marine Series.

Summary.

(1) It is shown that the hypersthene-andesite composing the Blair Duguid hills is locally altered to a rock of keratophyric affinities.

(2) The alteration is believed to have involved *inter alia* the addition of potash as well as soda to the rock, and the change of the hypersthene in some places to iddingsite and in others to carbonates.

(3) The solutions effecting the change are considered to have been probably of magmatic origin.

(4) The available evidence is considered to point to a Carboniferous rather than a Permo-Carboniferous age for the andesite.

REFERENCES.

[1] David—Mem. No. 4, Geol. Surv. N.S.W., 1907, 123.

[2] Bailey and Grabham—Geol. Mag., N.S., Dec. V., 1909, 6, 251.

[3] Merrill—Rocks, Rock-Weathering and Soils, p. 187.

[4] Lindgren—Mineral Deposits, Chap. XXII.

[5] Leith and Mead—Metamorphic Geology, p. 46.

[6] David—Pan-Pacific Science Congress, Australia, 1923: Guide-Book to Hunter River Excursion, p. 29.

COOLING CURVES IN THE BINARY SYSTEMS, (a) *p*-TOLUIDINE—SALICYLIC ACID, (b) *p*-TOLUIDINE—BENZOIC ACID.*

By Evelyn Margery Bartholomew, B.Sc.
and Ian William Wark, D.Sc., Ph.D.
(Communicated by Professor C. E. Fawsitt, D.Sc.)

Accepted for Publication, November 24, 1926.

In the course of some work on metallic hydroxy-acid complexes (J.C.S., 1923-1925), which one of us has carried out during the past few years, the function of the hydroxyl group in hydroxy-acids has come under consideration. It was thought that a study of the binary compounds formed by such acids and certain organic bases might throw some light on the matter. It would obviously be an advantage to compare the results so obtained with those from some acid which does not contain the additional alcoholic hydroxyl group and also with those from some alcohol or phenol, which does not contain the carboxyl group. As a suitable hydroxy-acid, salicylic acid was selected, and the results which it gave were compared with those from benzoic acid and with Philip's results from α-naphthol. As a matter of fact, all three behave in a similar manner towards *p*-toluidine, and consequently the method is not suitable for bringing out the differences sought between these three types of compound.

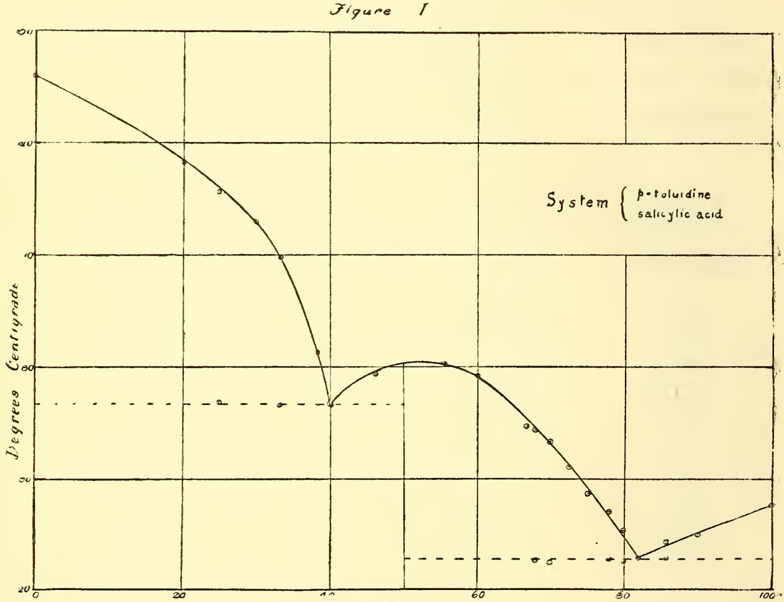
The procedure adopted was that described by Philip (J.C.S., 1903, 83, 814). Various mixtures of the two components containing different molecular proportions were weighed out, and after fusion in an oil or water bath, the mixture was lagged with cotton wool and the rate of cooling carefully observed. The first "arrest" in the rate of cooling corresponds to the melting point of the mixture, the second to the eutectic point.

The results for each system are tabulated below. The temperatures given are probably correct to within one or two degrees. Owing to the fact that super-cooling readily occurs, they are more likely to be low than high. To avoid excessive supercooling it is advisable to cool slowly and, if necessary, to "seed" with the appropriate solid. All compositions have been reported as molecular percentages.

System.		System.	
p-toluidine—salicylic acid.		*p*-toluidine—benzoic acid.	
Percentage. of *p*-toluidine.	Melting point.	Percentage. of *p*-toluidine.	Melting point.
0	158	0	122
20	135	20	101
25	127	24	97
30	119	30	88
33.33	109		
38.4	84		
40	70	40	67
		42.8	58
46.6	78	46	48
50	80	50	50
55.5	81	55	47
60	77.5	60	43
		62.5	38
66.66	64	66.66	33
68	63		
70	60	70.5	28
72.5	54	72	23
75	46	75	26.5
78	41		
80	36	80	29
82	29		
85.7	33		
90	35	88.8	35
95	38		
100	43	100	43.

System, p-*toluidine—salicylic acid*: The results of the above table are plotted in figure I. It will be seen that one compound only is formed between these two components, corresponding to the maximum in the curve at 50 per cent. It contains the two components in equimolecular proportions and its melting point is about 81°. The eutectic points are 70° and 28°, the percentages of *p*-toluidine being 40 and 82 respectively.

Figure I

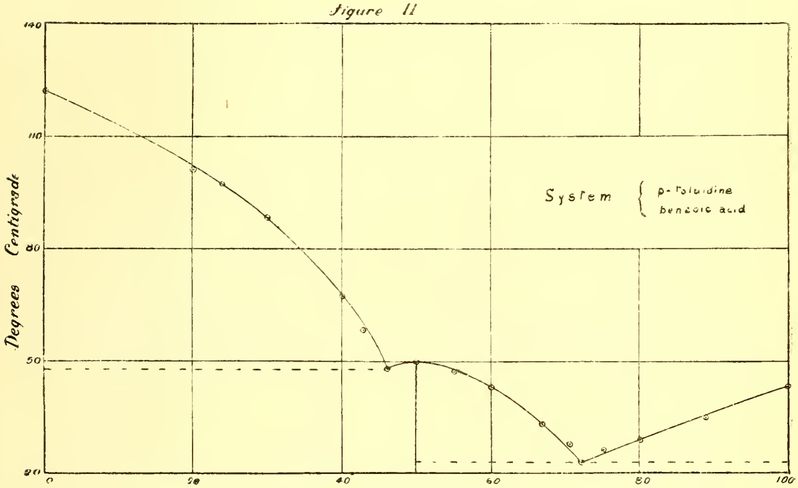


Percentage of p-toluidine.

System, p-*toluidine—benzoic acid*: The results are plotted in figure II. As in the preceding system, one compound only is formed, containing the two components in equi-molecular proportions. Its melting point is 50°; the eutectic points are 48° and 23°, containing 46 and 72 per cent. of *p*-toluidine respectively.

System, p-toluidine—α-naphthol: This system has already been investigated by Philip (l.c.). Our results are in close agreement with his, and show that again one compound only is formed, in which the components occur in equi-molecular proportions. Its melting point is 50° according to our work, and 53° according to that of Philip, who claims greater accuracy than was attained in our measurements.

Figure 11



Percentage of p-*toluidine.*

Conclusions.—Salicylic acid, benzoic acid and α-napthol all give similar melting point curves with *p*-toluidine, indicating in each case, the formation of a compound containing the two components in equi-molecular proportions.

ABSTRACT OF PROCEEDINGS

ABSTRACT OF PROCEEDINGS

OF THE

Royal Society of New South Wales.

MAY 5, 1926.

The Annual Meeting, being the four hundred and sixtieth General Monthly Meeting of the Society, was held at the Society's House, 5 Elizabeth Street, Sydney, at 8 p.m.

Professor R. D. Watt, President, in the Chair.

Fifty-four members and two visitors were present.

The Minutes of the General Monthly Meeting of the 2nd December, 1925, were read and confirmed.

The certificates of five candidates for admission as ordinary members were read for the first time.

It was announced that the following members had died during the recess:—Professor W. H. Warren and Dr. William Bateson, an Honorary Member.

The Annual Financial Statement for the year ended 31st March, 1926, was submitted to members and on the motion of Professor H. G. Chapman, seconded by Mr. R. W. Challinor, was adopted.

GENERAL ACCOUNT.

RECEIPTS.

	£ s. d.	£ s. d.	£ s. d.
To Revenue—			
Subscriptions		647 15 0	
,, Rents—			
Offices	601 5 0		
Hall and Library	207 4 7		
		808 9 7	

,, Sundry Receipts		22 17 10	
,, Government Subsidy for 1925 ...		400 0 0	
			1879 2 5
,, Clarke Memorial Fund—			
Loan to General Fund (interest)			63 15 4
,, Building Loan Fund			530 19 1
,, Building Investment Fund—			
Loan to General Fund			300 0 0
,, H. G. Smith Memorial Fund ...			118 9 6
,, Balance—31st March, 1926.			
Union Bank of Australia Ltd.			
Overdrawn Account, Head Office		1261 6 2	
Less Petty Cash on Hand ...		1 16 7	
			1259 9 7
			£4151 15 11

PAYMENTS.

	£ s. d.	£ s. d.	£ s. d.
By Balance—31st March, 1925 ...			2003 2 4
,, Administrative Expenditure—			
,, Salaries and Wages—			
Office Salary and Accountancy Fees	271 15 0		
Assistant Librarian	58 0 0		
Caretaker	247 13 8		
		577 8 8	
,, Printing, Stationery, Advertising and Stamps—			
Stamps and Telegrams	35 2 9		
Office Sundries, Stationery, &c.	2 10 8		
Advertising	13 16 6		
Printing	61 14 3		
		113 4 2	
,, Rates, Taxes and Services—			
Electric Light	60 5 8		
Gas	11 1 11		
Insurance	32 13 10		
Rates	210 18 2		
Telephone	13 3 4		
		328 2 11	

,, Printing and Publishing Society's Volume—			
Printing, &c.	271 14 0		
Bookbinding	41 10 0		
		313 4 0	
,, Library—			
Books and Periodicals	97 0 8		
Bookbinding	108 11 6		
		205 12 2	
,, Sundry Expenses—			
Repairs	5 9 6		
Lantern Operator	8 10 0		
Bank Charges	4 7 2		
Sundries	41 14 9		
		60 1 5	
			1597 13 4
,, Interest—			
Union Bank of Australia Ltd.		74 18 0	
Clarke Memorial Fund... ...		63 15 4	
Building Loan Fund		112 6 11	
			251 0 3
,, Building and Investment Fund ...			300 0 0
			£4151 15 11

CLARKE MEMORIAL FUND,

BALANCE SHEET AS AT 31st MARCH, 1926.

LIABILITIES.

	£ s. d.	£ s. d.
Accumulation Fund—		
Balance as at 31st March, 1925	965 8 3	
Additions during the year—		
Interest and General Fund	63 15 4	
		1029 3 7
		£1029 3 7

ASSETS.

	£ s. d.
Loan to General Fund	1029 3 7
	£1029 3 7

STATEMENT OF RECEIPTS AND PAYMENTS FOR THE YEAR ENDED 31st MARCH, 1926.

Receipts.

	£	s.	d.
To Interest—Loan to General Fund	63	15	4
	£63	15	4

Payments.

	£	s.	d.
By Loan to General Fund...	63	15	4
	£63	15	4

BUILDING AND INVESTMENT FUND.
BALANCE SHEET AS AT 31st MARCH, 1926.

Liabilities.

	£	s.	d.	£	s.	d.
Accumulation Account—						
Balance as at 31st March, 1925	400	0	0			
Additions during the year—	300	0	0			
				700	0	0
				£700	0	0

Assets.

	£	s.	d.
Loan to General Fund	700	0	0
	£700	0	0

Compiled from the Books and Accounts of the Royal Society of New South Wales, and certified to be in accordance therewith.

(Sgd.) HENRY G. CHAPMAN, M.D.,
Honorary Treasurer.

(Sgd.) W. PERCIVAL MINELL, F.C.P.A.,
Auditor.

On the motion of Mr. E. Cheel, Mr. W. P. Minell was duly elected Auditor for the current year.

The Annual Report of the Council was read, and on the motion of Dr. G. A. Waterhouse, seconded by Professor Douglas Stewart, was adopted.

Annual Report of the Council for the Year 1925-1926.

(1st May to 28th April.)

The Council regrets to report the loss by death of three ordinary members and one honorary member. Ten members have resigned and five names were removed from the list of members through non-payment of subscriptions. On the other hand, ten ordinary members have been elected during the year. To-day (28th April, 1926) the roll of members stands at 370.

During the Society's year there have been eight general monthly meetings and ten Council meetings.

The Building Committee has held several meetings during the year with representatives of the Linnean Society of New South Wales and the Institution of Engineers, Australia, to discuss the question of building a Science House in which all the various scientific institutions can be accommodated, but no complete scheme has yet been formulated.

Four Popular Science Lectures were given, namely:—

July 16—"The Elements and their Spectra," by Prof. O. U. Vonwiller, B.Sc.

August 20—"Vitamines," by Assoc.-Prof. H. Priestley, M.D., Ch.M.

September 17—"The Influence of Organic Chemistry on Economic Conditions," by Prof. J. Kenner, Ph.D., D.Sc., F.R.S.

October 22—"The Hawaiian Islands," by Sir Joseph Carruthers, K.C.M.G., M.L.C., LL.D.

Meetings were held throughout the Session by the Sections of Geology, Agriculture, Industry and Physical Science.

Twenty-six papers were read at the Monthly Meetings and covered a wide range of subjects. In most cases they were illustrated by exhibits of interest.

The following members have been honoured during the year:—R. H. Cambage, C.B.E., Commander of the Most Excellent Order of the British Empire (Civil Division); Sir Edgeworth David, Honorary Degree of Doctor of Science by the Senate of the Cambridge University and the Patron's Medal by the Royal Geographical Society.

On Friday, 14th August, 1925, an informal meeting of members was held to wish bon voyage to Sir Edgeworth David, who was leaving for England to publish his book on the Geology of Australia.

On Monday, 14th September, 1925, an informal meeting of members was held for the purpose of extending a welcome to Sir Ernest Rutherford, O.M., M.A., D.Sc., LL.D., F.R.S., of England, who was visiting Australia and New Zealand.

The President and members welcomed Professor E. R. Embree, of the Rockefeller Foundation, and Dr. Clark Wissler, head of the Department of Anthropology in the American Museum of Natural Science, on Monday, 2nd November, 1925, who were visiting Australia to investigate the question of Anthropological Research in relation to the native races of the Pacific.

Owing to the State Government coming to a decision to close the Sydney Observatory, a deputation from the Council headed by the President waited on the Hon. Mr. W. J. McKell, Minister of Justice, representing the Premier, on 3rd December, 1925, and urged that the Sydney Observatory be not closed. Representatives of the New South Wales Branch of the British Astronomical Association joined the deputation, which received a very sympathetic hearing, Mr. McKell undertaking to place the representations before the Premier. Finality in the matter has not yet been reached.

The New South Wales Chamber of Agriculture having terminated its tenancy in the Society's House, the room formerly occupied by that body has been let to the Australian Chemical Institute, and the New South Wales Rod Fishers' Society have become co-tenants with the Dental Association of New South Wales.

The donations to the Library have been as follows:—41 volumes, 1578 parts, 38 reports, 4 maps and 4 calendars.

The President announced that the following Popular Science Lectures would be delivered this Session:—

June 17—"Sound Waves," by Mr. E. T. Fisk.

July 15—"Drifting Continents," by Prof. L. A. Cotton, M.A., D.Sc.

August 19—"The Sydney Harbour Bridge," by Dr. J. J. C. Bradfield, M.E., M.Inst.C.E.

September 16—"Some Chemical Wonders of Australian Native Plant Life," by A. R. Penfold, F.A.C.I., F.C.S.

The following donations were laid upon the table:—390 parts, 16 volumes, 11 reports, 1 map and 2 calendars.

The President, Professor R. D. Watt, then delivered his address.

There being no other nominations, the President declared the following gentlemen to be officers and council for the coming year:—

President:

W. G. WOOLNOUGH, D.Sc., F.G.S.

Vice-Presidents:

E. C. ANDREWS, B.A., F.G.S. | C. ANDERSON, M.A., D.Sc.

C. A. SUSSMILCH, F.G.S. | Prof. R. D. WATT, M.A., B.Sc.

Hon. Treasurer:

Prof. H. G. CHAPMAN, M.D.

Hon. Secretaries:

R. H. CAMBAGE, C.B.E., F.L.S. | R. GREIG-SMITH, D.Sc., M.Sc.

Members of Council:

J. J. C. BRADFIELD, D.Sc.Eng., M.E., M.Inst.C.E.
R. W. CHALLINOR, F.I.C., F.C.S.
E. CHEEL.
Prof. L. A. COTTON, M.A., D.Sc.
Prof. C. E. FAWSITT, D.Sc., Ph.D.
G. HARKER, D.Sc., F.A.C.I.
Prof. J. KENNER, Ph.D., D.Sc., F.R.S.
J. NANGLE, O.B.E., F.R.A.S.
Rev. E. F. PIGOT, S.J., B.A., M.B.
Prof. J. DOUGLAS STEWART, B.V.Sc., M.R.C.V.S.

Professor R. D. Watt, the out-going President, then installed Dr. W. G. Woolnough as President for the ensuing year, and the latter briefly returned thanks.

On the motion of Dr. G. Harker a hearty vote of thanks was accorded to the retiring President for his valuable address.

JUNE 2, 1926.

The four hundred and sixty-first General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Dr. W. G. Woolnough, President, in the Chair.

Twenty-seven members and one visitor were present.

The Minutes of the preceding meeting were read and confirmed.

The certificates of five candidates for admission as ordinary members were read for the second time.

The following gentlemen were duly elected ordinary members of the Society:—Kenneth James Fergus Branch, Frederick William Booker, Arthur Neville St. George Burkitt, Alexander James Gibson, and William Johnstone Newbiggin.

It was announced that since the last meeting the following members had died:—Joseph James Fletcher, elected in 1921, and Hector Kidd, elected in 1901.

A letter was read from Mrs. William Bateson expressing thanks for the Society's sympathy in her recent bereavement.

The President announced that Mr. E. T. Fisk would deliver a Popular Science Lecture upon "Sound Waves" in the Society's Hall on June 17th.

The following donations were laid upon the table:—217 parts and 8 volumes.

The President called the attention of members to the fact that the Council was considering the advisability of obtaining more suitable premises, and invited members to draw the attention of any persons who might purchase the property, to the desirable qualities of the situation and of the building.

THE FOLLOWING PAPERS WERE READ:

1. "A note on the Rate of Decomposition of Commercial Calcium Cyanide," by M. S. Benjamin, D.I.C., A.A.C.I.

2. "Reactions depending upon the Vapour at the Interface of Two Immiscible Liquids," by G. Harker, D.Sc., F.A.C.I., and R. K. Newman, B.Sc.

Remarks were made by the President and Mr. A. R. Penfold.

3. "Notes on the Essential Oils from some Cultivated Eucalypts," by A. R. Penfold, F.A.C.I., F.C.S.

Remarks were made by Messrs. E. Cheel, A. E. Stephen, R. H. Cambage and Dr. R. Greig-Smith.

4. "An Investigation on the Optical Properties of Selenium in the Conducting Form," by Miss P. Nicol, M.Sc.

The paper was communicated by Professor O. U. Vonwiller, B.Sc. Remarks were made by Mr. J. Nangle and Rev. E. F. Pigot.

EXHIBIT:

On behalf of Mr. J. Barling, Mr. R. H. Cambage exhibited a chart showing the Sydney Rainfall over a number of years from 1858 to the present time, and referred to Russell's 19-year cycle.

Remarks were made by Professor Vonwiller.

JULY 7, 1926.

The four hundred and sixty-second General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Dr. W. G. Woolnough, President, in the Chair.

Twenty-seven members were present.

The minutes of the preceding meeting were read and confirmed.

The certificate of one candidate for admission as an ordinary member was read for the first time.

Letters were read from Mrs. J. J. Fletcher and Mrs. Hector Kidd expressing thanks for the Society's sympathy in their recent bereavements.

The President announced that Professor L. A. Cotton, M.A., D.Sc., would deliver a Popular Science Lecture upon "Drifting Continents," in the Society's Hall on Thursday, July 15.

The following donations were laid upon the table:—208 parts, 6 volumes and 5 reports.

THE FOLLOWING PAPER WAS READ:

"The Essential Oils of *Leptospermum lanigerum*" Smith, Part I, by A. R. Penfold, F.A.C.I., F.C.S.

Remarks were made by Messrs. R. H. Cambage, R. Grant, R. W. Challinor, M. B. Welch and the President.

EXHIBITS:

1. Action of Wood on a Photographic Plate, by M. B. Welch, B.Sc.
2. Abscesses and Ulcerations in Oysters from Beds where a heavy Mortality occurred, by Mr. T. C. Roughley.

3. Mr. A. R. Penfold exhibited large crystals of Synthetic Thymol manufactured by Messrs. D. Thomas and L. D. Cameron from Piperitone ex Oil of *Eucalyptus dives,* at Mortlake. The crystals were obtained from the crystallising vat and weighed from 14 to 19 grams, and measured $1\frac{1}{2} \times 1\frac{1}{2} \times \frac{3}{4}$ inches. Unfortunately, crystals of these dimensions are rarely obtained in commerce as they are broken up by the manufacturers to meet the demand for small crystals.

4. Portion of an Acacia leaf, the movements of whose leaflets continued for ten days after being severed from the plant to give considerable response to the changes of day and night, by R. H. Cambage, C.B.E., F.L.S.

AUGUST 4, 1926.

The four hundred and sixty-third General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Dr. W. G. Woolnough, President, in the Chair.

Twenty-nine members and three visitors were present.

The minutes of the preceding meeting were read and confirmed.

The President announced the death of Mr. William Freeman, who was elected a member in 1907.

The certificates of three candidates for admission as ordinary members were read: one for the second and two for the first time.

The following gentleman was duly elected an ordinary member of the Society:—Sydney Ernest Bentivoglio, B.Sc.Agr.

The President announced that a public meeting would be held at the Royal Society's House on Thursday, 12th August, at 4 p.m., to consider the question of providing some suitable memorial for the late J. H. Maiden, and members were invited to be present.

The President announced that Dr. J. J. C. Bradfield, M.E., M.Inst.C.E., would deliver a Popular Science Lecture upon "The Sydney Harbour Bridge" in the Society's Hall on Thursday, 19th August.

The following donations were laid upon the table:— 8 volumes, 170 parts, 12 reports and 1 map.

THE FOLLOWING PAPERS WERE READ:

1. "Acacia Seedlings," Part XII, by R. H. Cambage, C.B.E., F.L.S.

Remarks were made by Mr. G. H. Halligan, Prof. J. D. Stewart, Dr. R. K. Murphy and the President.

2. "The Essential Oil of *Zieria macrophylla* and the presence of a New Cyclic Ketone," by A. R. Penfold, F.A.C.I., F.C.S.

Remarks were made by Dr. R. K. Murphy, Mr. R. Grant and Dr. G. Harker.

3. "The Fixed Oil of the Kidney Fat of the Emu," by F. R. Morrison, A.A.C.I., F.C.S.

Remarks were made by Mr. R. H. Cambage and Mr. A. R. Penfold.

4. "Mountain Lagoon and the Kurrajong Fault," by Miss Alexa Grady, B.Sc., and H. Hogbin, B.A. (communicated by Professor Griffith Taylor).

Remarks were made by the President and Mr. A. D. Ollé.

SEPTEMBER 1, 1926.

The four hundred and sixty-fourth General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Mr. E. C. Andrews, Vice-President, in the Chair.

Twenty-one members were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of two candidates for admission as ordinary members were read for the second time.

The following gentlemen were duly elected ordinary members of the Society:—Hamilton Bartlett Mathews and Robert William Tannahill.

A letter was read from Mrs. Barker-Woden expressing thanks for the sympathy extended to her family in the death of her father, Mr. William Freeman.

A letter was read from Professor Liversidge thanking the Society for greetings sent from members at the Annual Dinner.

It was announced that a Popular Science Lecture entitled "Some Chemical Wonders of Australian Native Plant Life" would be delivered by Mr. A. R. Penfold, F.A.C.I., F.C.S., in the Society's Hall on Thursday, September 16.

The following donations were laid upon the table:—6 volumes, 147 parts, 1 report and 1 map.

THE FOLLOWING PAPERS WERE READ:

1. "The Internal Structures of some of the Pentameridae of New South Wales," by F. W. Booker, B.Sc.

Remarks were made by Mr. W. S. Dun.

2. "The Wood Structure of certain Eucalypts belonging to the 'Ash Group'," by M. B. Welch, B.Sc., A.I.C.

Remarks were made by Messrs. A. D. Ollé and E. Cheel.

OCTOBER 6, 1926.

The four hundred and sixty-fifth General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Dr. W. G. Woolnough, President, in the Chair.

Twenty members and one visitor were present.

The minutes of the preceding meeting were read and confirmed.

The President announced the death of Mr. Charles Hedley, who had been a member of this Society since 1891, who was President in 1914 and who was the Clarke Medallist of 1925.

The President announced that the following resolution had been passed by the Council:—

> "The Council desires to place on record its appreciation of the valuable services of the late Mr. Charles Hedley, F.L.S., as a member for thirty-five years, as a Councillor from 1908 until 1923, and as President in 1914. The members are greatly indebted to Mr. Hedley, for his untiring efforts in promoting the welfare and forwarding the interests of the Society, for his inspiration in the augmentation of the biological sciences and especially for the "Check List of the Marine Fauna of New South Wales," of which Part I, Mollusca, was published as a supplement to the Journal in 1917."

A letter was received from Mrs. Hedley thanking the Society for its letter of sympathy.

The certificates of three candidates for admission as ordinary members were read for the first time.

The President announced that a Donovan lecture would be given by Mr. G. F. Dodwell, B.A., on a date to be announced later.

The following donations were laid upon the table:— 88 parts, 1 volume, 1 report and 1 map.

THE FOLLOWING PAPER WAS READ:

"The Germicidal Values of some Australian Essential Oils and their Pure Constituents, together with those of some Essential Oil Isolates and Synthetics," Part IV, by A. R. Penfold, F.A.C.I., F.C.S., and R. Grant, F.C.S.

Remarks were made by Messrs. R. W. Challinor, A. D. Ollé and M. B. Welch.

EXHIBITS:

1. Professor J. Kenner exhibited some models illustrating the crystalline structure of sodium chloride, ice, the diamond and graphite, and explained the recent ideas regarding the structure of these substances.

Remarks were made by Professor Douglas Stewart, Messrs. R. W. Challinor, A. R. Penfold and the President.

2. Professor Stewart introduced Mr. I. Clunies Ross, B.V.Sc., and emphasised the importance of a study of animal parasites. Mr. Clunies Ross described the life cycle of the Liver Fluke and of the common hydatid.

Remarks were made by Messrs. R. Grant and A. D. Ollé.

3. Mr. J. G. Burrows exhibited an apparatus for comparing the densities of liquids and also a series of cobalt-ammines.

Remarks were made by Professor Kenner.

NOVEMBER 3, 1926.

The four hundred and sixty-sixth General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Dr. W. G. Woolnough, President, in the Chair.

Twenty-four members and one visitor were present.

The minutes of the preceding meeting were read and confirmed.

The President announced the deaths of Mr. Francis John Thomas, who had been a member since 1878, and Dr. Sydney Dodd, who had been elected in 1913.

A letter was received from Mrs. F. J. Thomas thanking the Society for its letter of sympathy.

The certificates of three candidates for admission as ordinary members were read for the second time.

The following gentlemen were duly elected ordinary members of the Society:—Joseph Bannon, Ernest Marklow Mitchell and William Saunderson.

The following donations were laid upon the table:—5 volumes, 136 parts and 1 calendar.

THE FOLLOWING PAPERS WERE READ:

1. "Descriptions of Fifteen New Acacias, and notes on several other species," by the late J. H. Maiden, I.S.O., F.R.S., and W. F. Blakely.

   In the unavoidable absence of Mr. Blakely through illness, the paper was taken as read.

2. "The Solution Volume of a Solute in Liquid Mixtures," by G. J. Burrows, B.Sc.

Remarks were made by Prof. C. E. Fawsitt.

3. "The Preparation of certain Iodo-bismuthites," by Miss E. M. Bartholomew, B.Sc., and G. J. Burrows, B.Sc.

The paper was read by Mr. Burrows and remarks were made by Prof. Fawsitt.

4. "Notes on the Salinity of the Water of the Gulf of Carpentaria," by G. J. Burrows, B.Sc.

Remarks were made by Dr. Harker, Prof. Browne, Prof. Fawsitt and the President.

5. "The Geology of the Gosforth District, N.S.W.," Part I, General Geology, by Assist.-Prof. W. R. Browne, D.Sc.

Remarks were made by Messrs. C. A. Süssmilch, G. D. Osborne and the President.

6. "Note on the occurrence of Triplets among Multiple Births," by Sir George Knibbs, C.M.G.

   In the absence of the Author the paper was taken as read.

The President called the attention of the meeting to a series of post cards with coloured illustrations of Australian birds issued by the Australian Museum.

DECEMBER 1, 1926.

The four hundred and sixty-seventh General Monthly Meeting was held at the Society's House, 5 Elizabeth Street, at 8 p.m.

Dr. W. G. Woolnough, President, in the Chair.

Twenty-one members were present.

The minutes of the preceding meeting were read and confirmed.

A letter was received from Mrs. Sydney Dodd thanking the Society for its letter of sympathy.

The following donations were laid upon the table:—

2 volumes, 161 parts, 4 reports, 2 calendars and 1 map.

THE FOLLOWING PAPERS WERE READ:

1. "The Geology of the Flinders Ranges, South Australia, in the neighbourhood of Wooltana Station," by W. G. Woolnough, D.Sc., F.G.S.

Remarks were made by Assist.-Prof. Browne.

2. "The Microphone as a Detector of small Vibrations," and

3. "Surface Waves due to small artificial Disturbances of the Ground," by Edgar H. Booth, M.C., B.Sc.

4. "The Essential Oils of *Eriostemon Coxii* Mueller, and *Phebalum dentatum* Smith," by A. R. Penfold, F.A.C.I., F.C.S.

Remarks were made by Dr. G. Harker, Messrs. E. Cheel and A. D. Ollé.

5. "An Examination of Defective New Zealand Kauri (*Agathis australis*)," by M. B. Welch, B.Sc.

Remarks were made by Messrs. A. D. Ollé, J. E. Bishop and J. Nangle.

6. "Notes on Wattle Barks," Part 2, by F. A. Coombs, F.C.S., W. McGlynn and M. B. Welch, B.Sc., A.I.C.

Remarks were made by Messrs. R. W. Challinor and A. D. Ollé.

7. "On the Hypersthene-Andesite of Blair Duguid, near Allandale, N.S.W.," by Assistant-Professor W. R. Browne, D.Sc., and H. P. White.

Remarks were made by G. D. Osborne and the President.

GEOLOGICAL SECTION.

ABSTRACT OF THE PROCEEDINGS

OF THE

GEOLOGICAL SECTION.

Annual Meeting, May 21, 1926.

Dr. C. Anderson in the Chair.

Eleven members and one visitor were present.

Mr. E. C. Andrews was elected Chairman for the year, and Mr. G. D. Osborne, Hon. Secretary.

EXHIBITS:

1. By Mr. W. Poole—(a) Sample of rock from a bore 160 miles west of Winton; (b) Lava from Vesuvius.
2. By Mr. W. S. Dun—Map of the Sydney District based on field-work by T. L. Willan.
3. By Mr. T. Hodge-Smith — Wiikite from Finland, Striverite from Madagascar and Griphtite from S. Dakota.
4. By Dr. C. Anderson—Skulls of *Thylacoleo* and of an extinct kangaroo from Wellington Caves.
5. From the Mining Museum—Specimens of the country rock from the Passagem Gold Mine, Brazil.

Dr. Woolnough gave an address on "The Three Glacial Stages of South Australia," in which he traced the growth of knowledge upon the glacial rocks of S.A. since the important discovery of Permo-Carboniferous glaciation by Selwyn. Evidence supporting the existence of a Cretaceous glaciation was presented in detail. The paper was discussed by Prof. Cotton, Dr. Anderson, Rev. Wade, and Messrs. Süssmilch and Osborne.

June 18, 1926.

Mr. E. C. Andrews in the Chair.

Congratulations were offered to the Chairman on his having been chosen to deliver the Silliman Memorial Lectures, in America in 1927.

EXHIBITS:

1. From the Mining Museum—(a) Cassiterite and (b) Green and yellow uranium ores from Katanga, Belgian Congo.
2. By Assist.-Prof. Browne—Tillite and glacially-striated pebbles from the Kuttung Series at Pokolbin.

Rev. R. T. Wade exhibited a fine series of Triassic fossils collected from the Brookvale quarry. These comprised remains of insects, fish and plants. Mr. Wade described the fish fossils and Dr. A. B. Walkom spoke upon the plants. The insects were discussed by Dr. G. A. Waterhouse and Mr. A. J. Nicholson. Others who spoke upon the importance of the collection, included Prof. Cotton and Mr. Dun.

July 16, 1926.

Mr. E. C. Andrews in the Chair, and fourteen members and twenty-two visitors were present.

EXHIBITS:

1. By Dr. Walkom—Ironstone concretions having an ellipsoidal shape and peculiar internal structure.
2. By H. F. Whitworth—Series of ultrabasic and altered ultrabasic rocks from the Lucknow Goldfield.
3. By G. D. Osborne—Iron sands from the beach at New Plymouth, New Zealand.
4. By Prof. Cotton—Tertiary fossil leaves and insect-wings in ironstone from Penrose, N.S.W. Also marine fossils from the Permo-Carboniferous beds at Bundanoon.

5. By Assist.-Prof. Browne—Radiating wollastonite from the contact metamorphosed limestone at the Old Lime-kilns, Marulan.

6. By Mr. L. L. Waterhouse—(a) Two photographs of silicified limestone occurring at Marulan, showing the preservation of original rhythmical banding. (b) Cherts from Tallong showing miniature faulting, and chiastolite slate from Tallong.

DISCUSSION:

Two important problems in the Geology of the Tallong-Bundanoon District were discussed. (i) The relationship of the Permo-Carboniferous rocks. This was opened by Mr. Morrison and discussed by Messrs. Cotton, Browne, Woolnough, Andrews, Dun and Osborne. (ii) The occurrence and origin of the bauxite deposits. In opening this Mr. Waterhouse reviewed some of the theories that have been put forward to account for the occurrence of this material, and was inclined to the view that the Tallong-Wingello deposits were formed under lake conditions. Dr. Woolnough spoke on the origin of the laterites of Western Australia and considered that there was a general uniformity about the origin of all the lateritic and bauxitic cappings which occur in West and East Australia. Other speakers included Assist.-Prof. Browne and Messrs. Andrews, Dun, Morrison, and Raggatt.

September 17, 1926.

Mr. W. S. Dun in the Chair.

Eleven members were present.

Dr. Walkom referred to the death, since the last meeting, of Mr. Charles Hedley, and on his motion a vote of sympathy to Mrs. Hedley was carried in silence.

EXHIBITS:

1. By Dr. Walkom—Verticil of *Glossopteris* leaves from Boolaroo, N.S.W.
2. By Assist.-Prof. Browne — Briquette of coal from Morwell, Victoria, as used for domestic purposes in Victoria.
3. By Rev. R. T. Wade—Two fossil insects and a number of fossil fish from Brookvale quarry.
4. By Mr. H. G. Raggatt—Breccia and altered country rock from volcanic neck, north of Cowan.
5. By Mr. H. F. Whitworth—(a) Pebble of chiastolite slate from Penrose, probably originally Ordovician in age, and incorporated in later sediments. (b) Pyritous shale nodule from the State Brick Quarry. (c) Porphyritic basalt from Mullumbimby and olivine basalt from Bexley. (d) Scale leaves of *Glossopteris* from Gloucester.
6. By Mr. L. L. Waterhouse—(a) Desert sands from Ooldea and Barton, S.A., from along the Trans-Australian Railway. (b) Concretionary travertine and Tertiary fossiliferous limestone from Ooldea. (c) Gypsum crystals encrusting a piece of synthetic roofing material from the desert country of S.A. (d) Cubical block (with one face polished) of red granite from Vinkkila, Finland. Also photographs showing quarry where the granite is obtained. This rock is being used in the construction of the Head Office of the Government Savings Bank.

Mr. G. D. Osborne spoke to the section on the structure of the Carboniferous rocks near Singleton and discussed the evidence concerning the faults of the Lower Hunter district. He pointed out the probability of there having been two main periods of faulting, the former being characterised by normal faulting, which was of late Palaeozoic age, and the latter being characterised by overthrusting of a distinctly later date.

Subsequent discussion was contributed by Messrs. Browne, Morrison and Raggatt.

October 15, 1926.

Mr. W. S. Dun in the Chair, and ten members and four visitors were present.

The chairman offered congratulations to Dr. A. B. Walkom on his appointment to a research fellowship in Palaeo-Botany at Cambridge.

EXHIBITS:

1. By Mr. G. D. Osborne—(a) Specimen of *Phyllotheca* showing nodes and ringlets proceeding therefrom. (b) Two specimens of *Glossopteris ampla* and two of *Glossopteris indica.* All specimens from the cliffs, Newcastle.
2. By Mr. L. L. Waterhouse—(a) Concretionary ironstone from the rock platform, Maroubra, showing a shell of haematite on the outer surface of which were cemented a number of pebbles. (b) Chert from Nobby's, Newcastle, showing minute contemporaneous contortions. Also tuffaceous sandstone from the same locality showing the presence of much carbonaceous material.

Assistant-Professor Browne addressed the section on the following: "Tectonic geology and igneous action of the Carboniferous and Permo-Carboniferous of N.S.W." The geological history of eastern N.S.W. in general, and the Hunter District in particular, throughout the Upper Palaeozoic, was summarised, and the salient features of the igneous rocks, which were produced from time to time, were commented upon.

The paper was discussed by Messrs. Dun and Osborne.

November 19, 1926.

Mr. C. A. Süssmilch in the Chair, and fifteen members and thirteen visitors were present.

EXHIBITS:

1. By the Geology Department, University—An extensive collection of rocks, minerals and fossils from South Australia and West Australia. These were used to illustrate the remarks made later on during the evening.

2. By the Mining Museum—Staurolite schist, garnet schist and cyanite schist from Cullalla, W.A.

3. By Mr. L. F. Harper—Large quartz crystal showing pronounced distortion, from decomposed rhyolite, Pambula.

Mr. L. L. Waterhouse gave a lantern address upon the salient geological features of the Kalgoorlie and Southern Cross districts, Western Australia, and described the physiography and geography along the Trans-continental Railway.

Mr. G. D. Osborne gave an account, illustrated by lantern views, of the geology of the Coastal Plain near Perth, and also of the Irwin River District, W.A.

Remarks concerning the recent Science Congress at Perth were then made by Mr. Süssmilch, Dr. Browne and Mr. Stephen.

December 10th, 1926.

Assistant-Professor Browne in the Chair, and twelve members and five visitors were present.

EXHIBITS:

1. By Rev. R. T. Wade—Triassic shale from Queenscliff, Manly, showing plant fossil, probably one of the *Taeniopteridae.*

2. By Mr. H. G. Raggatt—Breccia and basalt from a volcanic neck south of Woy Woy.

3. By Mr. G. D. Osborne—Pebbles from Permo-Carboniferous conglomerate at Fassifern, showing presence of numerous indentations, the origin of which is a matter of doubt.

4. By Assist.-Prof. Browne—(a) Specimens of granite, pegmatite and metamorphosed sedimentary rocks from Albury. (b) Permo-Carboniferous specimens from Ulan, and Burragorang.

5. By Mr. L. L. Waterhouse—Specimens of Permo-Carboniferous rocks from the Capertee Valley.

DISCUSSION.

The main business of the evening was a discussion on "The western margin of the great Permo-Carboniferous basin of central eastern N.S.W." Mr. L. J. Jones introduced the subject and summarised the general features of the stratigraphy and structure along the greater part of the western side of the basin. Other speakers were Messrs. Harper, Kenny, Morrison, Osborne, Waterhouse, Whitworth, Dr. Woolnough and Professor Browne.

Among the chief points discussed during the evening were the stratigraphical succession, the relationships between the coal seams and the glacial beds, the range of *Glossopteris,* and the structure of the strata, particularly in the north-west of the basin.

SECTION OF AGRICULTURE.

ABSTRACT OF THE PROCEEDINGS

OF THE

SECTION OF AGRICULTURE.

Annual Meeting, June 14, 1926.

Mr. E. A. Southee presided.

The election of officers resulted as follows:—*Chairman*—A. D. Ollé, F.C.S.; *Vice-Chairman*—Professor R. D. Watt, M.A., B.Sc.; *Honorary Secretaries*—P. Hindmarsh, M.A., B.Sc.Agr., R. J. Noble, Ph.D., B.Sc.Agr.; *Committee*—Professor J. D. Stewart, B.V.Sc., M.R.C.V.S.; E. A. Southee, O.B.E., M.A., B.Sc.Agr.; A. E. Stephen, F.C.S. W. L. Waterhouse, M.C., B.Sc.Agr., D.I.C.

Mr. Southee addressed the meeting on the subject of the "Organisation of research in relation to Agriculture." Agricultural research still suffers from a lack of appreciation by the general public. The recent visits of Sir Ernest Rutherford and Sir Frank Heath had drawn attention to the necessity in many different directions. Too much was accepted from research abroad; more should be accomplished in Australia. Financial aid was lacking and there was a great opportunity for private individuals and organisations to provide money for research work. The speaker referred to the Federal Government's proposals in connection with the reconstructed Council of Scientific and Industrial Research, and suggested that their activities might be well directed toward the selection of problems, selection of individuals and institutions for special research activities, concentration of research workers where necessary, the avoidance of duplication and the arrangement by co-operation. Some of the problems in relation to agriculture were outlined.

Dr. Fiaschi moved a vote of thanks to the Chairman for his year of office.

June 29, 1926.

Mr. A. D. Ollé presided.

Dr. H. L. Russell, Dean and Director of the Agricultural Experiment Station, University of Wisconsin, addressed the meeting on the subject of "Agricultural Organisation and Education in America." The American system of agricultural education, research, and extension differs fundamentally from that of New South Wales inasmuch as in the United States, these three functions come under the province of the Agricultural Colleges, whereas research and extension in New South Wales, was the function of the State Department. The American Agricultural Colleges, from their inception in 1862, had been faced with two prejudices—the mistrust of the farmer for anything beyond his educational scope, and the unwillingness of the typical university man to be associated with agricultural work. The work of the colleges, originally of a low standard, eventually made rapid development. The efficiency of these colleges rests on a threefold basis: (1) resident instruction, (2) research work, (3) the agricultural extension service. From field excursions, problems come in firsthand, and results of investigations were immediately made available to the farmer. In two decades, the operation of the system had entirely transformed the agriculture of the more progressive States.

August 23, 1926.

Mr. A. D. Ollé presided.

Professor R. G. Stapleton addressed the meeting upon "Grassland Research."

The problem could be considered from three aspects—

(1) Chemical—including problems of soil fertility, and the inherent chemical properties of soil fertility.

(2) Ecological—the problems of plant succession and the biotic factors—effects produced by grazing animals, etc.

(3) Genetical—the questions of strains and varieties in plants.

Taking examples from common clover, cocksfoot and rye grasses, the speaker dealt with the development of eco-types which are now recognisable in various localities throughout the world. Generally speaking, locally grown seed was preferable to imported seed for local requirements. Top-dressing of pastures, particularly with phosphatic manures, had given excellent results in New Zealand and also in Australia. It was important that grazing areas should be of such size that the pastures be fed off at the most nutritious periods.

December 4, 1926.

An interesting excursion, under the leadership of Mr. Ollé, was made to Glenfield, where the Veterinary Research Station and the Agricultural High School were visited.

SECTION OF INDUSTRY.

ABSTRACT OF THE PROCEEDINGS

OF THE

SECTION OF INDUSTRY.

It was decided that the Section should, during the year, devote its attention to visiting several of the many industrial establishments. Manufacturers welcome these visits and are most cordial in greeting the members and showing them all there is to see: in many cases going to special pains to prepare exhibits exemplifying a particular branch of the firm's activity, although that special process may not have been in commission at the time of the visit.

May 11, 1926.

The Raritan Hosiery Mills (George A. Bond & Co. Ltd.).

The members saw the various steps in the production of natural silk and natural and artificial silk hosiery, and also cotton underwear. The spinning and knitting machines were shown and their working explained by Messrs. A. McIntyre, Taylor and Williams. An interesting machine formed the stocking leg, then the foot, and automatically returned to reinforce the heel and wearing parts.

June 15, 1926.

Lever Bros. Sunlight Works, Balmain.

The party was first shown the oil being pressed from disintegrated copra, then the boiling of the oil with soda-lye and subsequent salting out and drying of the soap in frames. From this raw material the members saw the making of the firm's numerous products, such as Monkey Soap, Hudson's Extract, Lux and Sunlight soap. The automatic machines for making the containers, filling them with a definite weight of soap powder, closing and pushing them on to a conveyor, were seen in action.

July 13, 1926.

Wunderlich Ltd.

The Section visited the factory in Baptist-street, Redfern, and saw the manufacture of art metal ceilings, fittings for shop fronts and numerous ornamental metal products. The process of the production of the metal ceilings was followed from the drawing to the cast, then to the heavy iron mould and finally to the pressed metal sheet.

August 10, 1926.

Metter's Ltd.

A visit was made to this firm's factory in Alexandria, where the manufacture of the various household appliances and fittings was seen. The production of an enamelled bath was followed from the foundry, where the moulds were fashioned by means of a slinger which, under eighty pounds air pressure, blew the moulding sand into place. The manufacture of gas stoves, washing coppers, bath heaters, enamelled saucepans and aluminium ware of various kinds, was seen in operation.

September 14, 1926.

The Australian Rope Works.

Mr. F. D. Thorpe, of A. Forsyth and Co., invited the members to see the manufacture of rope and cordage. From the raw material such as Java and Manila hemp, New Zealand flax, cocoa nut fibre and cotton, Mr. Marshall showed the party the combing, oiling and spinning of the fibres into threads, yarns and strands which were finally twisted into rope. The production of twine for agricultural reapers and binders was in evidence.

October 14, 1926.

Newspaper Printing Establishment.

Following the invitation of Mr. E. G. Knox, of S. Bennett Ltd., and under the guidance of Mr. Goddard, the members of the Section saw the production of the 3 p.m. edition of the *Evening News* of Thursday, October 14. The visitors were interested in the working of the linotype machines, the production of the matrix, the casting of the rolls and the printing, folding, cutting and final counting of the folder papers.

November 9, 1926.

Peter's American Delicacy Co.

Through the courtesy of Mr. F. A. Peters, the Section visited the works in George-street, Redfern, and under the guidance of Mr. Kinross, saw the production of ice cream on the large scale. Milk is pasteurised at 140°F. for 30 minutes in ''glass''-lined vessels, then mixed with cream, obtained by passing fresh butter through viscolysers, and with gelatine to stabilise the solids. After maturing for 48 hours it is again mixed, pressed into tins and frozen in cold chambers. The cutting of the frozen cream, the covering with a coating of chocolate and the packing of ''chocolate ice blocks'' in cardboard boxes were seen.

SECTION OF PHYSICAL SCIENCE.

ABSTRACT OF PROCEEDINGS

OF THE SECTION OF

PHYSICAL SCIENCE.

May 19, 1926.

During the year six meetings of the Section were held, the average attendance being thirteen members and visitors.

At the Annual Meeting, held prior to the May monthly meeting, the following office-bearers were elected for 1926-27:—

Chairman, Rev. E. F. Pigot, S.J., B.A., M.B.; *Hon. Secretary,* Major Edgar H. Booth, M.C., B.Sc.; *Committee,* J. J. Richardson, A.M.I.E.E., Assoc.-Professor V. A. Bailey, M.A., D.Phil., Assoc.-Professor E. M. Wellish, M.A., Professor O. U. Vonwiller, B.Sc.

It was resolved that meetings of the Section should be held at 4.30 o'clock on the third Wednesday in each month.

The first paper, entitled "An Investigation of the Optical Properties of Selenium in the Conducting Form," was presented by Miss Phyllis Nicol, B.Sc.

A method suitable for the determination of the optical constants of selenium in the conducting form was devised, which gave results in which the error did not usually exceed 3% for ν_0 and 5% for κ_0. The values of ν_0 and κ_0 depend on the method of preparation of the reflecting surface (casting on glass, polishing, grinding, etc.), and have since been communicated in a paper presented at a general meeting of the Society.

Some preliminary work in the infra-red indicated that $\nu_0 = 2.6$ and $\kappa_0 < 0.1$. There was no definite indication that the optical properties depend on the temperature of transformation to the conducting form, and the changes, if any, in the optical constants with length of exposure to light, and age, lie within the experimental error.

The second paper, entitled "Recent Work in Spectrophotometry," was presented by H. L. Brose, M.A., D.Phil.

Recent measurements of the relative intensities of spectroscopic doublets, triplets, etc., have shown that these intensities bear simple ratios to each other. Accurate determinations of the relative intensities have rendered it necessary to devise improved types of micro-photometers. The most successful are those of Moll, in which a special form of galvanometer is used in conjunction with a thermopile, and those of Koch, which consist of a photo-electric cell combined with an electrometer, one of the latter instruments was described in detail, and its application to the measurement of the darkening of photographic plates was considered.

June 16, 1926.

Rev. E. F. Pigot in the Chair.

A paper, entitled "Earth Ripples," was presented by Major Edgar H. Booth, M.C., B.Sc.

The paper was in two portions—(1) An examination of the relationship between the motion impressed on the recording apparatus, and the record; (2) preliminary results in connection with an examination of the surface waves produced by a blow normal to the earth's surface, from the origin to a distance of fifty feet. The apparatus employed was exhibited and discussed. Completed papers have since been published in this Journal (pp. 305-330).

July 21, 1926.

Professor O. U. Vonwiller in the Chair.

A paper, entitled "Some Recent Developments in Physics," was presented by H. L. Brose, M.A., D.Phil.

The origin of the various quantum numbers, n^I, k, n, j, m, was discussed. The methods of designating spectroscopic terms were described, and simplifications were suggested. The arbitrary introduction of the inner quantum number j in order to account for the existence of multiplets was shown to be justified by interpreting j in terms of the moments of momentum of the electrons moving in orbits around the nucleus. The relation of the magnetic quantum numbers to the spacial quantising was explained and the possibility of introducing fresh quantum numbers to account for finer details of spectroscopy was referred to. The quantum weight was defined as $2j + 1$, when j, the inner atomic number, has the values assigned to it by Sommerfeld, which differ from those of Lande. The intensity laws of Burgers and Dorgelo for doublets and triplets were enunciated, and their extension to multiplets was indicated by an arithmetical proposed by Sommerfeld, which was subsequently confirmed experimentally.

August 18, 1926.

Professor P. J. V. Madsen, D.Sc., B.E., in the Chair.

A paper, entitled "On the Attachment of Electrons to Molecules," was presented by Assoc.-Professor V. A. Bailey, M.A., D.Phil.

In a previous paper read before the Section, an apparatus was described in which the behaviour of electrons moving under an electric force z and in a gas at pressure p could be studied by measuring the fractions s_1 and s_2 of the narrow streams of them which passed through equal slits in successive chambers of equal dimensions.

If R is the fraction for a stream of ions, then in general $S_1 < S_2 < R$ if the electrons progressively attach themselves to molecules to form permanent negative ions, and conversely. If $S_1 = S_2 < R$, then only electrons are present, *i.e.,* no attachments occur.

Experiments in HCl gas dried over H_2SO_4 showed that attachments occurred over the whole range $z/p = 10$ to 40 and also gave values of the energy factor k from 3.2 to 25, and of the attachment coefficient α/p from 0.133 to 0.54 in the same range.

Experiments in NH_3 gas dried over metallic sodium (or over caustic potash) indicated the following:—

(a) between $z/p = 6$ and 10 only free electrons exist, while for $z/p < 6$ or > 10, ions are formed by attachments.

(b) for $z/p = 8$ and 9 , k *increases* with p.

(c) for $z/p = 8$ S_1 is in general *greater* than S_2.

(b) and (c) are anomalous results, and require the introduction of new considerations in order to be interpreted.

Among various hypotheses to account for (b) a probable one is suggested by the fact that NH_3 has an exceptionally high value for the quality k—I where k is the dielectric constant. The hypothesis suggested is that the molecular distortion by the force z is sufficient to affect the behaviour of a molecule towards a colliding electron and this effect must increase with p when z/p is constant.

To account for (c) we are left with the following hypotheses:—

(1) Some of the electrons attach themselves immediately after the emission from the copper surface, and subsequently free themselves progressively.

(2) In some way collisions with NH_3 molecules progressively *alter an electron or its state* so that its behaviour at subsequent collisions is also altered.

The consensus of evidence obtained to date appears to favour (2), especially as it simultaneously accounts for (b). Further experiments are in progress to elucidate the situation.

September 15, 1926.

Rev. E. F. Pigot in the Chair.

A paper, entitled "Some Notes on Interference of Light in Mica," was presented by Professor O. U. Vonwiller, B.Sc., and Mr. F. L. Arnot.

Professor Vonwiller dealt with the theory of a new method for determining the optical constants of mica, showing how from elementary considerations of the wave theory of interference, expressions for the three principal indices could be obtained.

A description of the technique of the experiment was given by Mr. Arnot. The chief difficulty encountered was the precise determination of p in the fundamental formula $2 \mu e \cos \gamma = p\lambda$.

This was finally solved by a photographic method. The accuracy of the results was of the order 1 : 10,000; but the chief advantage of the method lay in the accuracy with which the dispersion curves for each index could be drawn, since values were obtained for each interference band in the spectrum.

October 29, 1926.

This meeting was held at the University of Sydney.

Miss Phyllis Nicol, M.Sc., in the Chair.

Dr. Brose continued his discussion of present research and theory in connection with spectroscopy and atomic structure, clearing up points of interest to members, and explaining the work in hand.

The Chairman and several other members being absent in Japan, it was decided not to hold meetings in November or December.

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